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3rd Edition

# Supply Chain Management

for  
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Understand how supply chain models are applied

Use technology to automate processes

Mitigate business risks and improve sustainability

**Daniel Stanton**

Just call him "Mr. Supply Chain"



# Supply Chain Management

3rd Edition

by Daniel Stanton

**for**  
**dummies**<sup>®</sup>  
A Wiley Brand

## **Supply Chain Management For Dummies®**, 3rd Edition

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# Introduction

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Supply chain management is about seeing your business as an interconnected system. *Supply Chain Management For Dummies* covers the tools, rules, and language that you need to understand how the parts of your company's supply chain fit together. This book also shows you how to plan and manage your supply chain in ways that reduce costs, increase profits, and minimize risk.

## *About This Book*

Many books treat supply chain management as part of operations, logistics, or procurement, but this book takes a broader approach, showing that those functions are interconnected parts of a system. I include lots of everyday examples that make it easy to understand each step in any supply chain and how virtually any company can employ supply chain principles.

Most people get to see only a small part of the supply chains that they work in. This book helps you understand all the other processes and systems in a supply chain, as well as how decisions you make affect others up and down the supply chain, including your customers and suppliers. This book uses language that's easy to follow and is organized in a way that makes it simple to find the information you need quickly.

## *Foolish Assumptions*

In writing this book, I assumed that supply chain management is important to you because

- » You need to understand it for your current job.
- » You need to understand it for a future job.
- » You need to explain it to other people so that they can do their jobs better.

I assume that you have some connection to supply chain management, probably because you've studied or worked in logistics, operations, or procurement. I assume that you may have been taught to see supply chain management from a narrow, functional perspective rather than as an end-to-end, integrated system.

I assume that you want to understand how decisions made in one part of a supply chain can influence the results in another. Many companies have made bad choices with expensive consequences simply because they didn't recognize the effects of those choices on their supply chains. When you consider that more than 70 percent of costs and 100 percent of revenue depend on supply decisions, it's clearly worth the time and energy to understand how to manage a supply chain well.

## *Icons Used in This Book*

Icons emphasize a point to remember, a danger to be aware of, or information that you may find helpful.



**TIP**

The Tip icon marks tips (duh!) and shortcuts that you can use to make supply chain management easier.



**REMEMBER**

Remember icons mark information that's especially important to know. To siphon off the most important information in each chapter, skim the paragraphs that have these icons.



**TECHNICAL  
STUFF**

The Technical Stuff icon marks information of a highly technical nature that you can normally skip.



**WARNING** The Warning icon tells you to watch out! It marks important information that may save you headaches.

## *Beyond the Book*

For some helpful information about how to describe supply chain management, how to lead supply chain projects, and how to use the SCOR Model, check out the Cheat Sheet for this book by visiting [www.dummies.com](http://www.dummies.com) and entering the book's title in the search field.

## *Where to Go from Here*

You can read this book in different ways, depending on why you're reading it. You can certainly start at the beginning and skip the things you already know, but I've written the book so that you can start reading anywhere that catches your eye and then hunt for additional bits that sound interesting.

If your goal is to discover what supply chain management is, start with [Part 1](#). If you're trying to get a sense for how to organize the processes in a supply chain with frameworks, jump to [Part 2](#). If you need to get a handle on the technologies that are key to supply chain management, check out [Part 3](#). If you're looking for ways to drive strategic value for your company by using supply chain management tools, jump into [Part 4](#). Finally, [Part 5](#) is packed with information that can help you grow your career in supply chain management.



**TIP** The material in this book will be very useful if you're preparing for a supply chain certification such as Certified Supply Chain Professional or SCPro (see [Chapter 21](#)).

No matter how you go through the book, you'll eventually want to read all the chapters. Each chapter is useful on its own, but the chapters work together to help you see how interconnected the parts of a supply chain are and why you need to think about all of them when you make decisions that affect your business, your customers, and your suppliers.



## Part 1

# Getting Started with Supply Chain Management

## IN THIS PART ...

Simplify the concept of supply chain management by breaking it into pieces.

Analyze supply chain management from different perspectives to see why it's important.

Align supply chain management with the goals of your business.

Optimize supply chain performance to drive better results for you, your suppliers, and your customers.

# Chapter 1

## The Growing Demand for Supply Chain Management

---

### IN THIS CHAPTER

- » Making sense of supply chain complexity
  - » Focusing on supply chain tasks
  - » Adopting supply chain management principles
  - » Building supply chain capabilities
  - » Getting started with the New Supply Chain Agenda
- 

These days, it's hard to find a copy of *The Wall Street Journal* that doesn't have the phrase *supply chain* somewhere on the first page. You hear about supply chains everywhere: in company reports, on the news, and even in casual conversation. But it hasn't always been that way. Only in the past 40 years has supply chain management gone from being a vague academic concept to a critical business capability. In this chapter, I cover why supply chain management has become so important and explain the process for building best-in-class supply chain management capabilities into your company.

### *Defining Supply Chain Management*

Over the past few years, supply chains have been blamed for shortages of toilet paper, computer chips, and baby formula. Supply chains have been targeted by politicians and policy experts who were concerned about the environment and the economy. Supply chains have even become part of popular culture, with rock star Jack White naming his 2022 concert tour, "The Supply Chain Issues Tour."

In spite of the current hype, supply chains aren't really that new. Entrepreneurs have been buying things from suppliers and selling products to customers for almost as long as people have inhabited the earth. Supply chain *management* is new, however, and that's because the world is changing.

The basic principles of supply chain management began to take shape in the 1980s as researchers saw how interconnected the world was becoming. At that time, the world population was only about 4.5 billion, with a majority of people living in rural areas. Today the population has grown to 8 billion people, and the majority of us now live in urban areas. There are a lot more people on the planet today than there have been in the past, and we all want lots and lots of stuff.

*Supply chains* are the complex systems made up of people, processes, and technologies that we engineer and manage to deliver the goods and services customers value. *Supply chain management* is the planning and coordination of the relationships between all the people, processes, and technology involved in creating that value. Managing a supply chain effectively involves aligning all the work inside your company with the things that are happening outside your company. In other words, it means looking at each business as a single link in a long, end-to-end chain.



**TIP** The word *value* shows up a lot when people talk about supply chain management. Basically, *value* means *money*. If a customer is willing to pay for something, it has value.

Negotiating prices, scheduling manufacturing, and managing logistics all affect the value created by a company, and they're critical to a supply chain, but because they're so interdependent, it's a bad idea to manage them separately in silos. As companies grow larger, supply chains get longer, and the pace of business gets faster, it has become more important to align the various functions in a supply chain. Ironically, many of the strategies and metrics that businesses relied on in the past,

and that managers have been taught to use, can actually create serious problems for a supply chain. A sales rep might hit their quota by landing a huge deal with a customer, for example, but the deal might be unprofitable for the company because of the costs it will drive to the logistics and manufacturing functions. A buyer might negotiate a volume discount from a supplier without considering how much more it will cost to store and protect all of that extra inventory. Supply chain management helps sales, logistics, manufacturing, procurement, and all your other functions get aligned to ensure that decisions are good for the whole business.



**TIP** The difference between the amount of money your company brings in (revenue) and the amount of money it spends (costs) is your profit. In other words, your profit is the value that you have captured from your supply chain.

Companies that do a good job of managing their supply chains are better able to take advantage of value-creation opportunities their competitors might miss. Implementing lean manufacturing, for example, can help companies reduce inventories. Being responsive to customer needs can help them grow their sales. Collaborating with suppliers can ensure better access to materials.

Some supply chain management professionals are generalists, and others are specialists. Generalists look at the big picture; specialists focus on a particular step in the supply chain. At the end of the day, they all need to understand the effects of their decisions in order to ensure that revenue is greater than costs while meeting the needs of their customers. That's why supply chain management has become so important.

## ***Making Tough Business Decisions***

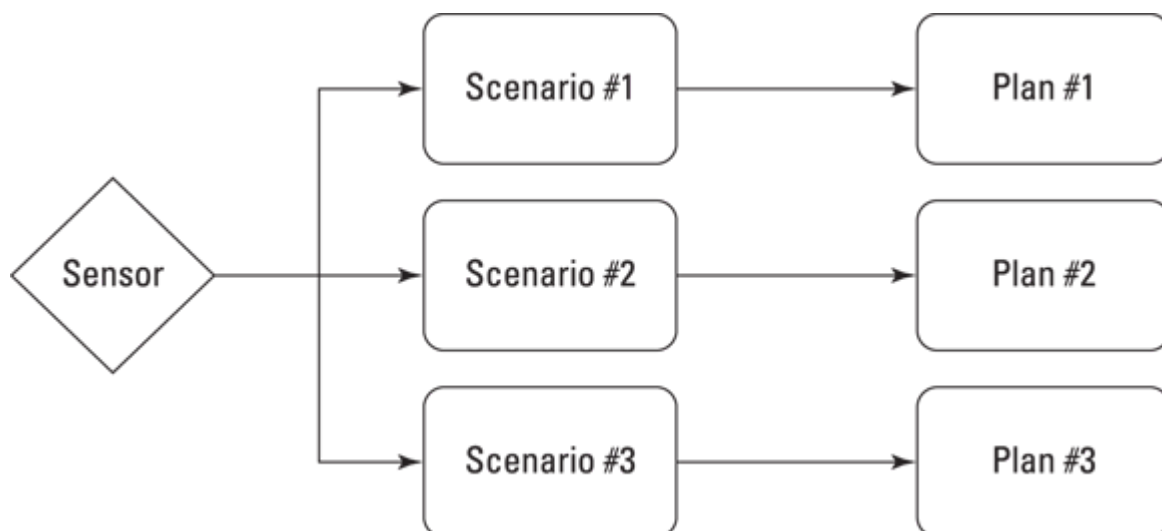
Managing a supply chain is complicated: So many moving pieces are involved, and so many things can change in an instant, that making long-term plans seems virtually impossible. How can you really plan for

commodity price swings, natural disasters, and financial meltdowns, all at the same time? But you can't ignore those possibilities, either. Instead, you need to think about them and design your supply chain so that it can function well under a range of scenarios. In other words, you want your supply chain to be *resilient*.

A good way to start improving resilience is to practice scenario planning. Think about the many possibilities that the future holds, try to imagine each one as a series of events, and then think about how those events would affect your business. To use scenario planning to prepare for the unknown and the unknowable, you need to understand three really important things:

- » Which scenarios are most important to you.
- » What you'll do — and how — in each scenario. (Each scenario calls for a different plan.)
- » How you can tell when a scenario is becoming reality.

It helps to have sensors that tell you what's happening, and triggers that help you decide when to implement which plan. When you use scenario planning, supply chain management becomes a process of planning ahead, sensing changes, and responding to triggers. [Figure 1-1](#) shows how sensors help you recognize which scenario is unfolding so that you can implement the proper plan.



**FIGURE 1-1:** Scenario-planning model.

I can explain this concept with a few practical examples:

- » You run a manufacturing company that imports products from overseas, so you need to consider what you'd do if one of your inbound shipments is lost at sea, impounded by customs, captured by pirates, or caught in a port strike. Your sensor could be a notification system that sends alerts about your shipments. One plan might be shutting down your factory until the issue is resolved. You might also consider placing a new order with a different supplier. In an extreme case, you might declare *force majeure* and tell your customers that you won't be able to fulfill your commitments to them.



TECHNICAL  
STUFF

*Force majeure* is a legal term that means you are free from liability if you are unable to meet obligations due to an extraordinary circumstance.

- » You work for a wholesaler that has been selling a product at a steady rate for months, and one month, the company sells twice as much as normal. You don't have enough inventory to fill all your customer orders, and now you also have back orders to fill. You may even be at risk of losing sales and customers. You might decide to place bigger orders in the future and keep more inventory on hand. That means you'll be investing more working capital in inventory.
- » You work for a transportation company. The company's customers pay you to deliver their products around the world, and they count on your deliveries to help them meet their commitments to their own customers. Therefore, your ability to deliver on time is essential to them. Suddenly, a volcano in a distant part of the world spews ash far into the sky, making it dangerous for airplanes to use a heavily traveled flight path. You could reroute your planes, but this is expensive because you would need to develop new flight plans, reschedule airplanes, and find available crews. Alternatively, you

could tell your customers that their deliveries are on hold until normal operations can resume.

Thousands of companies have had to face every one of these scenarios in the past few years. In every case, making the right decision about how to respond required understanding supply chains and supply chain management. As you read this book, you will discover topics that can help you create more accurate scenarios and better plans for responding to them.



**TIP** You can find more information about supply chain scenario planning, as well as a link to the MIT Scenario Planning Toolkit, in [Chapter 15](#).

The next sections cover ten supply chain management principles, five supply chain tasks, six supply chain capabilities, and the five steps for implementing a new supply chain agenda. Each section provides a slightly different perspective on supply chain management, but the sections explain the same challenge in different ways. The supply chain management principles express the essence of supply chain management. The five supply chain tasks are like the job description of a supply chain manager. And the New Supply Chain Agenda is a strategy for planning and implementing effective supply chain management practices.

## *Operating Under Supply Chain Management Principles*

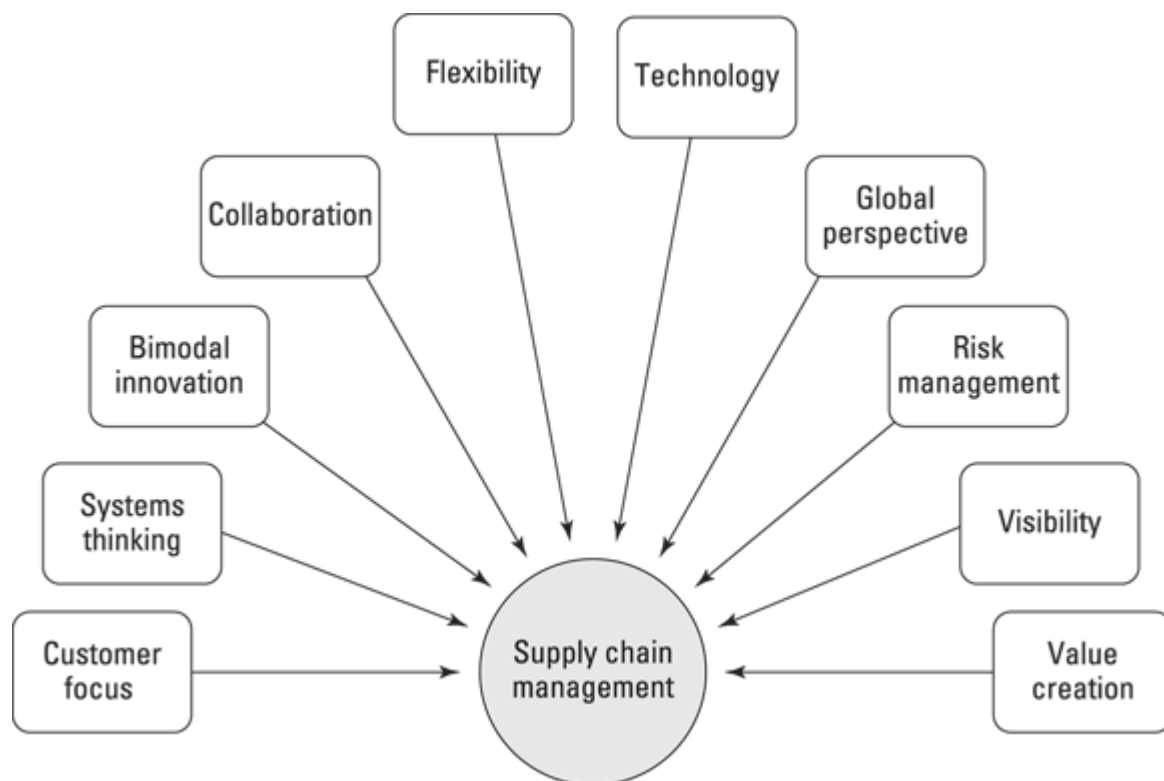
Many people try to define supply chain management by talking about what they do, which is a bit like describing a cake by giving someone a recipe. A different approach is to explain what supply chain management creates. To continue the cake analogy, that approach communicates how the finished cake tastes and what it looks like.



The key supply chain management principles illustrated in [Figure 1-2](#) are good places to start.

## *Customer focus*

Supply chain management starts with understanding who your customers are and why they're buying your product or service. Any time customers buy your stuff, they're solving a problem or filling a need. Supply chain managers must understand the customer's problem or need and make sure that their companies can satisfy it better, faster, and cheaper than any competitors can.



**FIGURE 1-2** Supply chain management principles.

## *Systems thinking*

Supply chain management requires understanding the end-to-end system — the combination of people, processes, and technologies that must work together so that you can provide your product or service. Systems thinking involves appreciation of the series of cause-and-effect relationships that occur within a supply chain. Because these systems are

complex, supply chains often behave in unpredictable ways, and small changes in one part of the system can have major effects somewhere else.

## ***Bimodal innovation***

The world of business is changing quickly, and supply chains need to keep up by innovating. Two kinds of innovation are important for supply chains:

- » **Sustaining innovation:** *Sustaining innovation* is built on continuous process improvement techniques such as Lean, Six Sigma, and the Theory of Constraints (see [Chapter 16](#)). Sustaining innovation isn't sufficient, though, because new technologies can disrupt industries. So you also need to pursue disruptive innovation.
- » **Disruptive innovation:** *Disruptive innovation* introduces a product, process, or service that creates new markets and destroys established paradigms. When a disruptive solution is accepted, it becomes the new dominant paradigm.

If you're in the business of making buggy whips, you need to figure out how to make buggy whips better, faster, and cheaper than your competitors do, as well as what the new dominant paradigm is going to be so that you'll know what to do when buggy whips are replaced by a different technology.

## ***Collaboration***

Supply chain management can't be done in a vacuum. People need to work across departments inside an organization, and they need to work with suppliers and customers outside the organization. A "me, me, me" mentality leads to transactional relationships in which people focus on short-term opportunities while ignoring the long-term results. This situation costs more money in the long run because it creates lack of trust and unwillingness to compromise. An environment in which people collaborate for shared success is much more profitable than an environment in which each person is concerned only with their own

success. Also, a collaborative type of environment makes working together a lot more fun.

## *Flexibility*

Because surprises happen, supply chains need to be flexible. Flexibility is a measurement of how quickly your supply chain can respond to changes, such as an increase or decrease in sales or an interruption of supply. This flexibility often comes in the form of buffers such as extra capacity, multiple sources of supply, and alternative forms of transportation. Usually, flexibility costs money, but it also has value. The key is understanding when the cost of flexibility is a good investment.

Suppose that only two companies in the world make widgets, and you need to buy 1,000 widgets per month. You may get a better price on widgets if you buy all of them from a single supplier, but then if that supplier experienced a disruption you would be in serious trouble. Buying some of your widgets from a second supplier is a way to increase flexibility.



**TIP** Think of the extra cost that you pay for the second supplier as a kind of insurance policy. You're paying more up front, but you're increasing your supply chain flexibility and protecting yourself from a possible disruption.

## *Technology*

The rapid evolution of technology has transformed the way that supply chains work. A few years ago, we ordered things from catalogs, mailed in checks, and waited for our packages to be delivered. Today, we order products on our phones, pay for them with credit cards, and expect real-time updates until those packages are delivered to our doorsteps. Supply chain management requires understanding how technologies work and how to integrate them to create value at each step in the supply chain.

## *Global perspective*

The ability to share information instantly and to move products around the world cheaply means that every organization today operates in a global marketplace. No matter what product or service you provide, your company is global in some way. As a supply chain manager, you must recognize how your business depends on global factors to supply inputs and drive demand for outputs. You also need to think globally about competition. After all, your company's real competitive threat could be on the other side of the planet.

### *Risk management*

When you combine high-performance requirements with complicated technologies and dependence on global customers and suppliers, you have a recipe for chaos. Lots of variables mean that many things can go wrong. Even a small disturbance, such as a shipment that gets delayed, can lead to a series of problems farther down the supply chain — stockouts, shutdowns, penalties, and more. Managing a supply chain means being aware of risks and implementing processes to detect and mitigate threats. Stability may be the key to making supply chains work smoothly, but risk management is the key to minimizing the costs of dealing with surprises. Risk management can even help you grow your business during times of uncertainty.

### *Visibility*

You can't manage what you can't see, so supply chain management makes visibility a priority. Knowing what's happening in real time (or close to real time) lets you make better decisions faster. Visibility comes at a cost, however: You have to build your supply chain in a way that lets you capture data about key steps in the process. The value of visibility is that it lets you make decisions based on facts rather than on intuition or uncertainty.

### *Value creation*

Supply chain management is about creating value — meeting your customers' needs in the right place, at the right time, at the right level of quality, for the lowest cost. This value is the heart of supply chain

management. If I had to pick just one principle to describe the whole process of supply chain management, it would be value creation.

## *Introducing Five Supply Chain Tasks*

James B. Ayers is a supply chain management expert who works with manufacturers, service companies, and government agencies. In *Handbook of Supply Chain Management*, 2nd Edition (Auerbach Publications, 2006), Ayers says that supply chain managers should concentrate on five tasks:

- » **Designing supply chains for strategic advantage:** Consider how your supply chain can help you create value by operating better, faster, and cheaper than your competitors. Think beyond just lowering costs, and consider ways in which your supply chain can help you grow revenue, innovate, and even create new markets.
- » **Implementing collaborative relationships:** Consider how you can get teams to work together toward a goal rather than compete for conflicting objectives. If your sales team is trying to improve customer service by making sure that plenty of inventory is available, and your logistics team is trying to reduce inventory to lower costs, both teams are probably going to waste a lot of energy.
- » **Forging supply chain partnerships:** Consider how you can build and sustain strong relationships with customers and suppliers. When companies understand that they depend on one another for success — and perhaps survival — working well together becomes a priority.
- » **Managing supply chain information:** Consider how you share information with others in ways that create value for everyone. When retailers share sales data with their upstream partners, the manufacturers and distributors do a better job of scheduling production and managing inventory. When manufacturers share data about commodity prices and capacity constraints, retailers can do a better job of managing pricing.

- » **Making money from the supply chain:** Consider how you can use your supply chain design, relationships, partnerships, and information to capture value for your company. In supply chains, a process change in one part often creates value for someone else. Find ways to share this value so that everyone has an incentive to work together.

## *Creating Six Supply Chain Capabilities*

Supply chains are evolving quickly, and the authors of the book *Digital Supply Networks* (McGraw Hill, 2020) argue that we need to combine technologies into a digital core that provides a business with six capabilities:

- » **Digital development:** Using digital tools such as computer-aided design (CAD) and 3D printing to accelerate product development
- » **Synchronized planning:** Sharing goals across business functions and adapting to changes quickly
- » **Smart factory:** Using sensors and robots to automate production processes
- » **Intelligent supply:** Having visibility to your suppliers, and their suppliers, while automating purchases and payments
- » **Dynamic fulfillment:** Using tools such as an order management system (OMS) to quickly fill orders from customers, ensuring that you deliver the right products to the right place, at the right time, and at the lowest cost
- » **Connected customer:** Using technology such as customer relationship management (CRM) systems to remember what customers have purchased and anticipate their future needs



**TIP** In [Part 3](#) of this book there's a detailed explanation of these technologies, and many others, and how they work together to create a digital supply network.

## *Implementing the New Supply Chain Agenda*

One of my favorite books about supply chain management is *The New Supply Chain Agenda*, by Reuben Slone, J. Paul Dittmann, and John T. Mentzer (Harvard Business Review Press, 2010). It breaks down the challenge of supply chain management from the point of view of senior executives. The authors talk about working capital and liquidity, strategy, and alignment, and then lay out a five-step system for making a company better at supply chain management. The five steps of *The New Supply Chain Agenda* are:

- » **Placing the right people in the right jobs:** To implement supply chain strategies, everyone needs to understand how their job affects other people inside your company, as well as the people up and down the supply chain.
- » **Putting the right technology in place:** Supply chains depend on technology. Each business, and each function within each business, has different technology needs.
- » **Focusing on internal collaboration:** Adopting a supply chain perspective helps you break down the silos that keep people in your company from collaborating with one another effectively. Everyone needs to understand the company's strategy and work toward common goals.
- » **Directing external collaboration:** Traditional business relationships are transactional and often self-centered. Buyers and suppliers approach each deal as a win-lose game: The suppliers are trying to

inflate their profits, and the buyers are trying to squeeze them on price. When building supply chain relationships, each partner helps to maximize total value along the entire supply chain.

- » **Applying project management:** Supply chains are dynamic and companies respond to changes with projects. Teaching people how to manage projects well and having professional project managers involved are the keys to ensuring that your supply chain evolves as your customers, suppliers, and company change.



## Chapter 2

# Seeing Supply Chains from Different Perspectives

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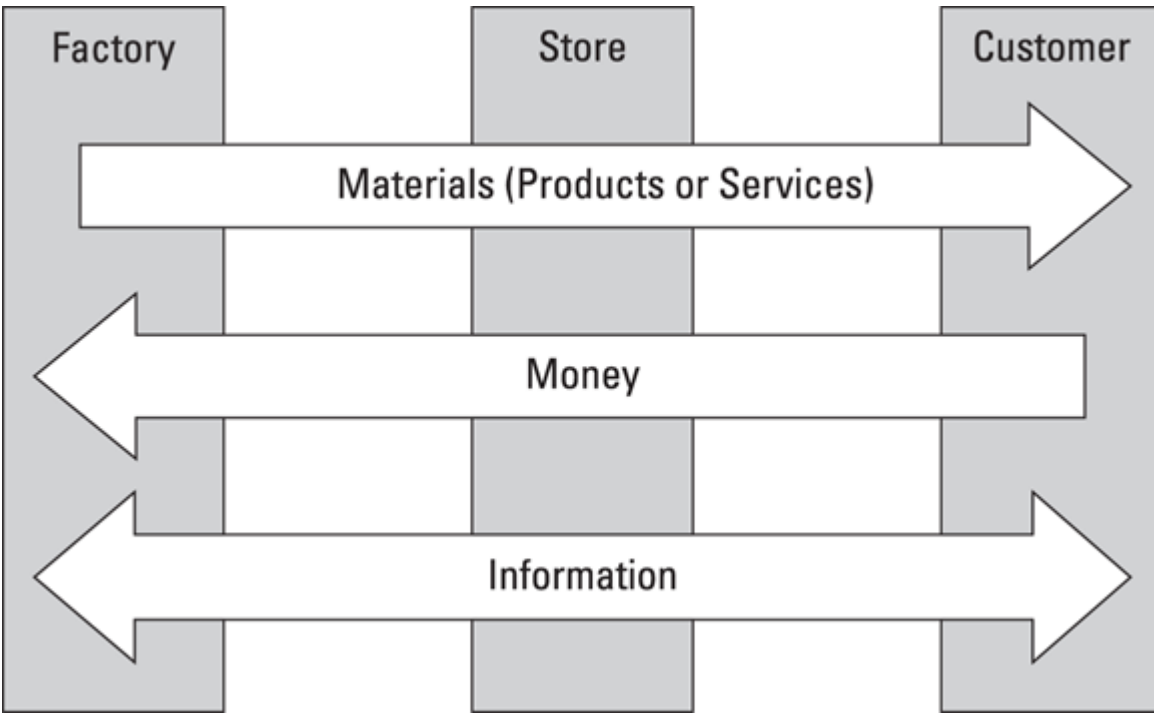
### IN THIS CHAPTER

- » Looking at the three flows in every supply chain
  - » Aligning key supply chain functions and groups
  - » Designing and monitoring supply chain performance
- 

There are several ways to analyze what's happening in a supply chain. Each of these perspectives can help you understand how your supply chain really works and reveal opportunities for improvement. Because there are so many ways to look at the same issue, supply chain managers can encounter confusion and miscommunication about which options are the best. In this chapter, you see several of these approaches and examples that illustrate how useful they can be for managing your own supply chain.

## *Managing Supply Chain Flows*

One great way to explain a supply chain is to think of it as three rivers that flow from a customer all the way back to the source of raw materials. These rivers, or *flows*, are materials, money, and information, as shown in [Figure 2-1](#). Materials flow downstream in the supply chain, starting with raw materials and flowing through value-added steps until a product finally ends up in the hands of a customer. Money flows upstream from the customer through all the supply chain partners that provide goods and services along the way. Information flows both upstream and downstream as customers place orders and suppliers provide information about the products and when they will be delivered.



**FIGURE 2-1:** Three supply chain flows.



**TIP** Every product and service has a supply chain, and the concepts in this book apply to both. But it's often easier to illustrate supply chain concepts using examples of physical products rather than services.

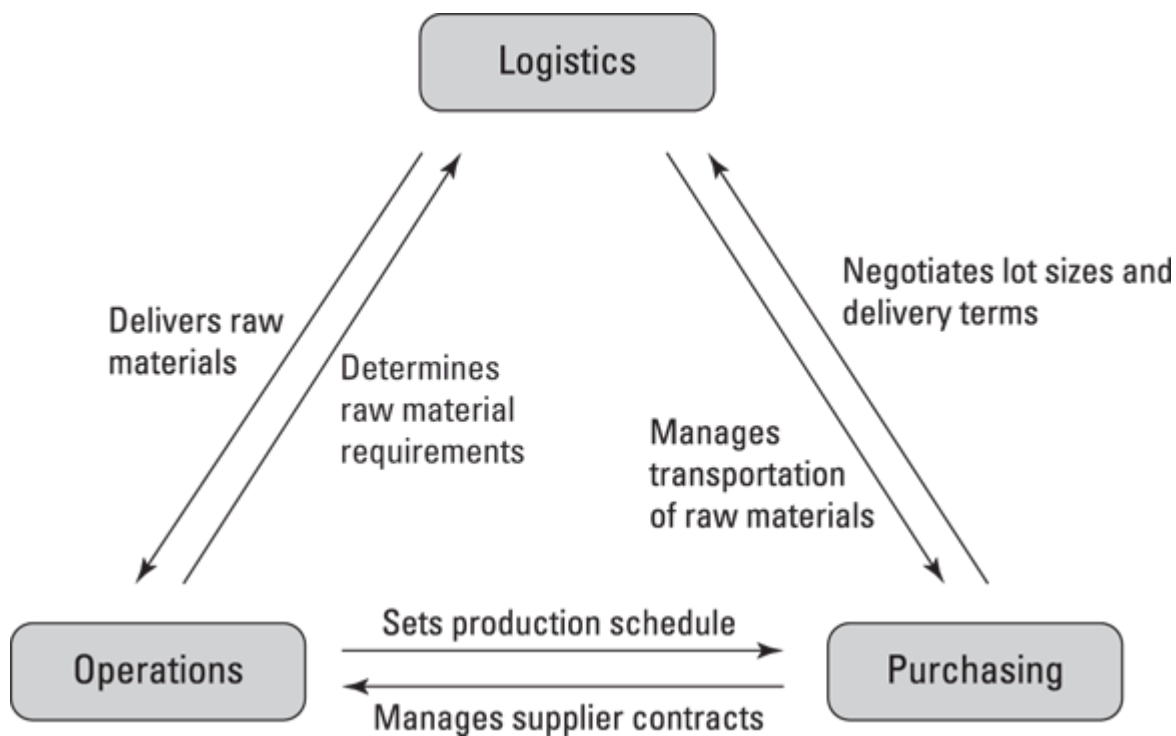
Managing a supply chain effectively involves synchronizing these three flows. You have to determine, for example, how long you can wait between the time when you send a physical product to your customer and when the customer pays you for the product. You also have to determine what information needs to be sent each way — and when — to keep the supply chain working the way you want it to.



**REMEMBER** Every dollar that flows into a supply chain comes from a customer and then moves upstream. The companies in the supply chain have to collaborate to capture that dollar, but they're also competing against each other to see how much of that dollar they get to keep as their own profit.

## *Synchronizing Supply Chain Functions*

Supply chain management can also be described as integrating three of the functions inside an organization: purchasing, logistics, and operations. Each function is critical in any company, and each has its own metrics. Because these functions are interdependent (see [Figure 2-2](#)), making good decisions in any of these areas requires coordination with the other two.



**FIGURE 2-2:** Logistics, purchasing, and operations are interdependent.



**REMEMBER** The purchasing, logistics, and operations teams have conflicting goals — often without realizing it. Managing these functions independently can lead to poor overall performance for your company. To meet top-level goals, supply chain managers need to make sure that the objectives of these groups are aligned.



**TIP** The simplest top-level goal for many supply chain decisions is return on investment. Focusing on this one objective can often help everyone see the big picture and look beyond functional supply chain metrics such as capacity utilization or transportation cost.

## *Purchasing*

*Purchasing* (or *procurement*) is the function that buys the materials and services that a company uses to produce its own products and services. The basic goal of the purchasing function is to get the stuff that the company needs at the lowest cost possible; the purchasing department is always looking for ways to get a better deal from suppliers. Some of the most common cost-reduction strategies for a purchasing manager are

- » Negotiating with a supplier to reduce the supplier's profit margin
- » Buying in larger quantities to get a volume discount
- » Switching to a supplier that charges less for the same product
- » Switching to a lower-quality product that's less expensive

On the surface, any of these four options looks like a simple, effective way to reduce costs and therefore increase profitability, but each can have negative long-term effects. Driving a supplier's profit margin too low, for example, could make it hard for them to pay their bills — or even force them out of business. Although you'd save money in the short term, having to find a new supplier in the future could cost you a lot more, increasing your total cost. Many purchasing decisions can also

have direct effects on the costs of other functions within your company. Sourcing lower-quality raw materials might lead to higher inspection and testing expenses, for example.



**REMEMBER** Your total costs include all the investments and expenses that are required to deliver a product or service to your customer.

## *Logistics*

*Logistics* covers everything related to moving and storing products. This function involves physical distribution, warehousing, and transportation. *Inbound logistics* refers to the products that are being shipped to your company by your suppliers. *Outbound logistics* refers to the products that you ship to your customers. *Intralogistics* refers to moving and storing products within your own facilities.



**TIP** Supply chain professionals refer to intralogistics as happening “within the four walls” meaning that it occurs inside one of your buildings.

Logistics adds value because it gets a product where a customer needs it when the customer wants it. Logistics costs money too. Transporting products on ships, trucks, trains, and airplanes has a price tag. Also, whether a product is sitting on a truck or gathering dust in a distribution center, it’s an asset that ties up working capital.

The goals of the logistics function are to move things faster, reduce transportation costs, ensure reliability, and decrease inventory. Following are some ways that a logistics department might try to achieve these goals:

- » Consolidating many small shipments into one large shipment to lower shipping costs
- » Breaking large shipments into smaller ones to increase velocity

- » Switching from one mode of transportation to another, either to lower costs or increase velocity
- » Increasing or decreasing the number of distribution centers to increase velocity or lower costs
- » Outsourcing logistics services to a third-party logistics (3PL) company

You can see the conflicts that can occur between logistics and purchasing. Logistics wants to decrease inventory, which may mean ordering in smaller quantities, but purchasing wants to lower the price of the purchased materials, which may mean buying in larger quantities. Unless purchasing and logistics coordinate their decision-making and align their goals these two functions can end up working against each other and against the best interests of your company, your customers, and your suppliers.

## *Operations*

*Operations* is the third key function in supply chain management, involving the processes that your company focuses on to create value. Here are some examples:

- » In a manufacturing company, operations manages the production processes.
- » In a retailing company, operations focuses on managing stores.
- » In an e-commerce company or 3PL, the operations team may also be the logistics team.

Operations managers usually focus on capacity utilization by asking “How much can we do with the resources we have?” Resources can be human resources (people) or land and equipment (capital). The operations department is measured by how effectively and efficiently it uses available resource capacity to produce the products and services that your customers buy. Common goals for operations teams include

- » Reducing the amount of capacity wasted due to changeovers and maintenance
- » Reducing shutdowns for any reason, including those caused by running out of raw materials
- » Aligning production schedules and orders for raw materials with forecasts received from customers

Although increasing operations efficiency sounds like a great idea, sometimes it actually creates supply chain problems and does more harm than good. Companies may invest in increasing their capacity only to find out that their suppliers or logistics infrastructure can't support the higher production levels or that they're making more product than they can sell.

## TOILET PAPER CAPACITY

At the start of the COVID-19 pandemic, the global supply chain for toilet paper was disrupted. The demand for toilet paper is usually easy to predict, and the sourcing, manufacturing, and distribution processes have just the right amount of capacity to meet this stable demand. However, as consumers prepared for lockdowns, they purchased extra toilet paper. This led to stockouts in stores, which caused many people to panic and buy even more, which led to worldwide toilet paper shortages. Toilet paper manufacturers faced a serious business challenge: They wanted to meet their customers' needs, but there was not enough capacity in the toilet paper supply chain to keep up with this unexpected demand. These manufacturers also knew the increase in demand was temporary because consumers were not actually using more toilet paper. It didn't make business sense invest in building new capacity. Instead, the toilet paper manufacturers, distributors, and retailers worked together to increase capacity utilization, speed up distribution, and limit the amount consumers could buy. After a few months, the toilet paper supply chain was stable again.

## *Connecting Supply Chain Communities*

If you've ever taken a personality test, such as the Myers-Briggs Type Indicator, you know that these tests can reveal important differences in

the way that people approach problems and make decisions. It turns out that groups of people have personalities too. These personalities form the culture of a group, and culture matters a lot when it comes to managing a supply chain.

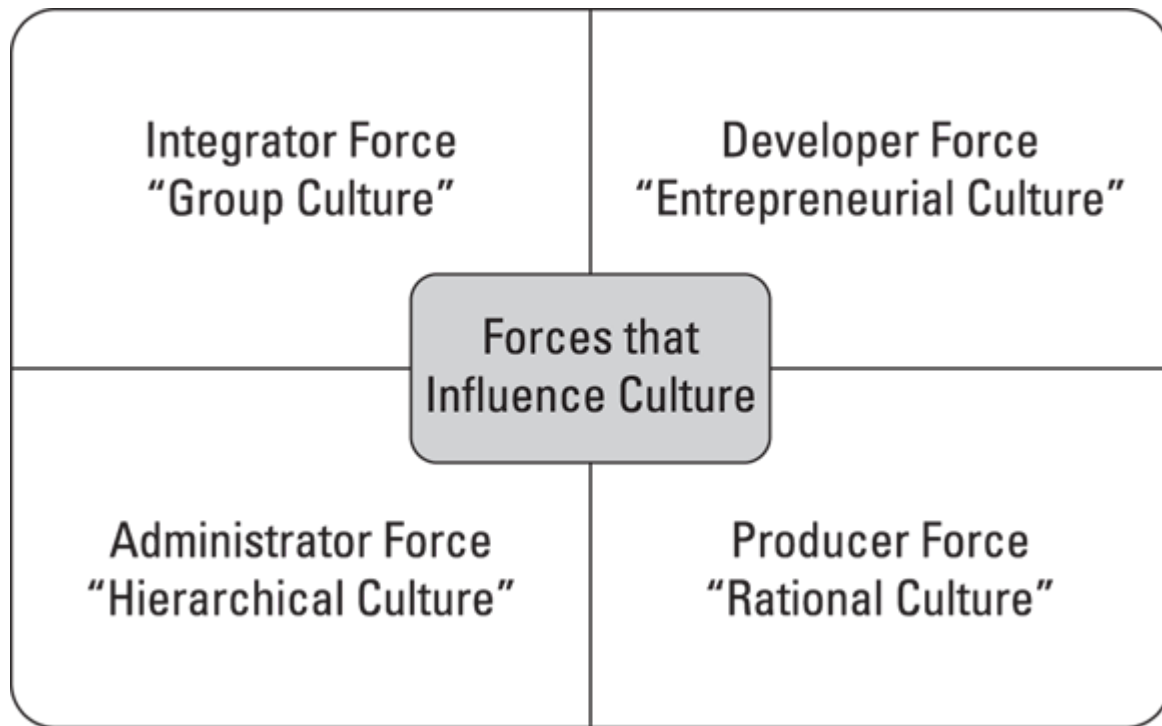
Suppose that you work for a company that really values reliability. You would want your suppliers to deliver exactly what was ordered, exactly the same way, every time. The culture of your group — the things that your company values — determines how it judges suppliers. Now suppose that you have a choice between two suppliers: one that's known for consistent quality and another that's known for flexibility and innovation. The first supplier would probably be a better cultural fit because of the value that your company places on reliability.

The impact of culture can also apply to the functions within your organization. Different departments — such as purchasing, logistics, and operations — often develop cultures of their own. If the values of these departments clash, it's difficult for the company to manage its supply chain effectively.

One useful way to think about the culture of a company or a department is to use a framework that was developed by John Gattorna in *Dynamic Supply Chains: Delivering Value through People*, 2nd Edition (FT Press, 2010). Gattorna says that four major behavioral forces determine the culture of a group (see [Figure 2-3](#)) and are often related to the style of a group's leader and the norms of a particular industry:

- » **Integrator:** Force for cohesion, cooperation, and relationships
- » **Developer:** Force for creativity, change, and flexibility
- » **Administrator:** Force for analysis, systems, and control
- » **Producer:** Force for energy, action, and results





**FIGURE 2-3:** Dominant group personalities.

The strength of these personality forces leads to differences in the culture of a team or organization. The most accurate way to measure culture is to formally interview people on a team and then analyze their responses. But in many cases, you can get a good sense for a team's culture simply by working with the team for a little while.

Teams that are driven by the Integrator force tend to have a *group* culture, in which everyone is encouraged to develop personal relationships and informal communications. In a group culture, people feel that they're part of a family. But a group culture also tends to be exclusive: the team against everyone else.

Teams that are driven by the Developer force form an *entrepreneurial* culture, in which everyone focuses on realizing a common vision. Communications are informal, and ideas are exchanged with people inside and outside the group. Unfortunately, an entrepreneurial culture may tolerate bad behaviors as long as they don't interfere with achieving the shared goal.

Teams that are driven by the Administrator force create a *hierarchical* culture, in which communication is formal and shared through official channels. Hierarchical cultures are good at developing processes and ensuring consistency, but they're often slow and inflexible.

Teams that are driven by the Producer force develop a *rational* culture, in which communications are concise and fast. Plans are made, plans are executed, and updates are sent out to keep stakeholders in the loop. Rational cultures are good at keeping teams focused and delivering results. But these cultures often find it hard to deviate from a plan, even when the circumstances around them change.

A useful exercise for analyzing your supply chain is to list the groups that work together and try to determine the dominant culture of each group. This exercise can help you anticipate conflicts that might emerge when these groups interact and find ways to use differences to your advantage. Here are some examples:

- » Purchasing departments often have a hierarchical culture, whereas operations departments have a rational culture. The purchasing department may feel frustrated because operations doesn't follow the rules. Operations may feel frustrated because purchasing is slowing it down. So you could create a small team of expeditors, made up of representatives of both operations and purchasing, to manage urgent orders while ensuring that all the proper policies are followed.
- » Large companies often have strict rules that lead to a hierarchical culture. Startup technology companies that focus on innovation have an entrepreneurial culture. To take advantage of the latest technologies, large companies often create dedicated programs that have more flexibility to collaborate with smaller, entrepreneurial suppliers.
- » Human resources teams often have a group culture, whereas consultants may have a rational culture. The human resources team may find the consultants rude and disinterested, and the consultants may view the human resources team as being nosy and unprofessional. For these groups to work effectively through a

corporate merger, for example, you may need to schedule time for their members to interact in a social setting, such as a kickoff celebration.

You can also use an understanding of group personalities to choose teams to partner with in your supply chain. If your priority is creativity and innovation, for example, you're likely to work best with supply chain partners that are driven by an entrepreneurial culture, and you're probably going to be disappointed by a supply chain partner with a hierarchical culture.

Gattorna makes the point that supply chains are dynamic, so balancing these forces is an ongoing process. One way to create balance is to build teams of people that include each of these tendencies. If the team has a diverse set of personalities, its members are more likely to appreciate the strengths of diverse supply chain partners and find ways to build effective relationships with other teams.

## *Designing Supply Chain Systems*

The most complicated way to understand a supply chain is to look at it as a system. (I think that this perspective is often the most useful.) Like many other systems that we encounter every day, supply chains are made up of interconnected components that can behave in surprising ways.

Your car is a good example. You expect your car to move you from Point A to Point B. In fact, you probably take for granted that your car will take you to Point B any time you want to go there. But your car is a system, so a dead battery, a broken fuel pump, or worn-out brakes could bring the whole thing to a halt (or, in the case of the worn-out brakes, *not* bring it to a halt).

Supply chains are systems too. The components that make up supply chains are people, processes, and technologies. Each of these components needs to be prepared and managed correctly for the system to operate as expected.

When you look at them as systems, you begin to see that supply chains have underlying rules and patterns that are key to understanding how they work. A good example of one of these patterns occurs when a company experiences wild swings in inventory levels. It can be difficult for people in the company to understand why these swings occur until you look at the supply chain as a system. Then you can recognize a pattern called the *Bullwhip Effect*, in which inventory peaks and valleys are amplified as they move upstream from one step to the next in a supply chain. The Bullwhip Effect, which occurs often in supply chain systems, is a normal, predictable phenomenon that occurs even when everyone in the supply chain makes decisions that seem to be logical from their point of view. To fix the problem, you need to change the system, which means understanding what is really happening.

Here's a scenario that explains one way that the Bullwhip Effect can occur. A customer comes in to buy a widget, which turns out to be the last widget in the store, so the store needs to order more inventory from its wholesaler. But the wholesaler doesn't sell individual widgets; it sells widgets in cases. That means the store has to buy a case with 100 widgets even though it sold only one. If that case was the last one in the warehouse, the wholesaler will replenish its inventory by ordering more widgets from the factory. But the factory has a minimum order quantity of 100 cases.

How many widgets did the factory sell? 10,000. How many did the wholesaler sell? 100. And how many did the customer buy? 1. A small amount of demand at the end of the supply chain became amplified at every step, creating a Bullwhip Effect on inventory. No one knows whether the customer will buy more widgets in the future, and all that extra inventory costs money for companies in the supply chain.

Here are three ways that you could change this system to reduce the Bullwhip Effect:

- » **Make batches smaller.** The fewer widgets that the store and the wholesaler need to buy, the less amplification occurs when orders move up the supply chain.

- » **Improve forecasting.** If all the partners in the supply chain have a better forecast, there's less chance of ordering widgets that no one will buy.
- » **Improve communications.** If the store, the wholesaler, and the manufacturer know exactly how many widgets are being sold, they can do a better job of planning ahead and managing their inventories.

An important point to notice is that some of the things you could do to reduce the Bullwhip Effect might seem odd to a functional manager. In fact, they might even interfere with some of the objectives of your team members. Smaller batches, for example, are likely to increase costs for both purchasing and logistics.

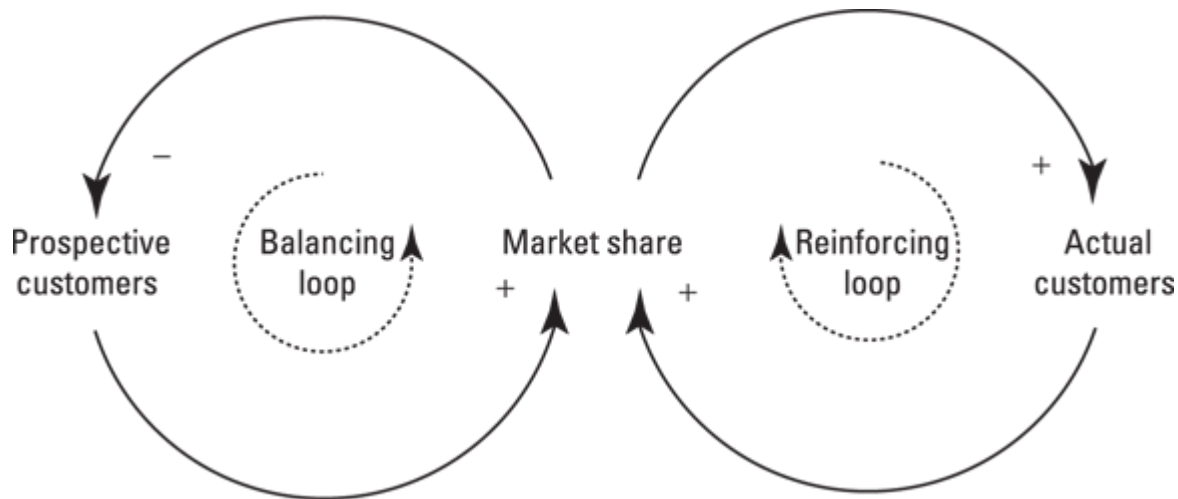


**REMEMBER** Supply chains are systems in which the people, processes, and technologies interact in complex ways. Managing a supply chain as a system may require taking a different approach to measuring success than what functional teams normally use.

In some cases, it helps to build a model of your supply chain to show how the parts of the system interact. These models can show cause-and-effect relationships — how one thing affects another, which causes something to happen, which causes something else to happen, and so on. In other words, these models can show causal relationships. Very often, systems models reveal *reinforcing loops*, in which a series of events repeats over and over, getting stronger each time. Or they can show *balancing loops*, in which a series of events gets weaker over time.

[Figure 2-4](#) shows a causal loop diagram, which is one of the most common tools for modeling the dynamics of a system. In this example, you see how two important supply chain dynamics affect the market share for a company. As the number of customers increases, the market share grows higher. But as the market share goes up, the number of prospective customers gets smaller because the prospects have now become customers. As the number of prospects gets smaller, the increase

in market share slows and eventually stops. (For more information about supply chain modeling and simulation, see [Chapter 15](#).)



**FIGURE 2-4:** Example of a causal loop diagram.



**TECHNICAL  
STUFF**

A few universities require their supply chain management students to take classes in system dynamics, which includes a set of tools for predicting how supply chains behave over time. The concept of system dynamics was developed in the 1950s by MIT professor Jay Forrester.



**TIP**

System dynamics modeling usually requires special software. You'll find reviews of several options at [www.systemdynamics.org/core-software](http://www.systemdynamics.org/core-software), but if you're looking for a simple tool that lets you build your own system dynamics model for free, check out Insight Maker at <https://insightmaker.com>.

## *Measuring Supply Chain Processes*

Supply chains can be viewed in terms of flows, functions, communities, or systems. But no matter how you look at it, effective supply chain management requires being able to measure what's happening. Every process in a supply chain can be measured with quantitative or qualitative metrics.

*Quantitative metrics* are objective, numerical indicators. *Qualitative metrics* describe intangible characteristics. Quantitative metrics might include things like current inventory levels or the amount of money spent on transportation. Qualitative metrics could describe the level of employee engagement or customer satisfaction. [Table 2-1](#) lists some common types of qualitative and quantitative metrics.

Collecting measurements costs money and takes time, so it's important to decide which metrics you really need. You need to identify the steps in each supply chain process that will show how things are working and what decisions you need to make. The metrics that give you this insight are called *key performance indicators* (KPIs). The KPIs in one business or facility can be very different from the KPIs in another. (For more information about metrics, see [Chapter 14](#).)

**[TABLE 2-1](#) Quantitative versus Qualitative Metrics**

<i>Quantitative</i>	<i>Qualitative</i>
Times	Degree of satisfaction
Rates	Likelihood of doing something
Values	Perceptions
Amounts	Desire or need
Frequencies	Level of agreement

A good way to look for improvement opportunities in any process is to compare your own performance with that of someone else. If you use the same KPIs in every facility, then you can compare one facility to another, or one company to another. Comparing KPIs is an example of benchmarking.



**WARNING** Companies (even competitors!) share benchmarking data all the time. But sharing business information can lead to problems if it violates laws such as the Clayton Antitrust Act. Before you start benchmarking with other companies, it's a good idea to talk to your corporate attorney.

There are lots of ways to look at a supply chain. To manage a supply chain well, you need to understand these perspectives and select KPIs that give you visibility into how your supply chain is performing. Benchmarking those KPIs against other facilities and other companies can illuminate areas in which you're doing well and also reveal opportunities for improvement.



# Chapter 3

## Evaluating Your Supply Chain Strategy

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### IN THIS CHAPTER

- » Establishing your supply chain priorities
  - » Balancing cost and value
  - » Compromising to improve results
- 

Before you can manage something, you have to understand how it works and what you want it to do. A supply chain is no exception. Many kinds of supply chains exist, and each of them needs to deliver a different kind of product or service to meet customers' needs. In this chapter, I cover the factors that define how a supply chain performs and how each factor affects costs. Then I discuss how trade-offs are managed in every supply chain.

### *Prioritizing Supply Chain Goals*

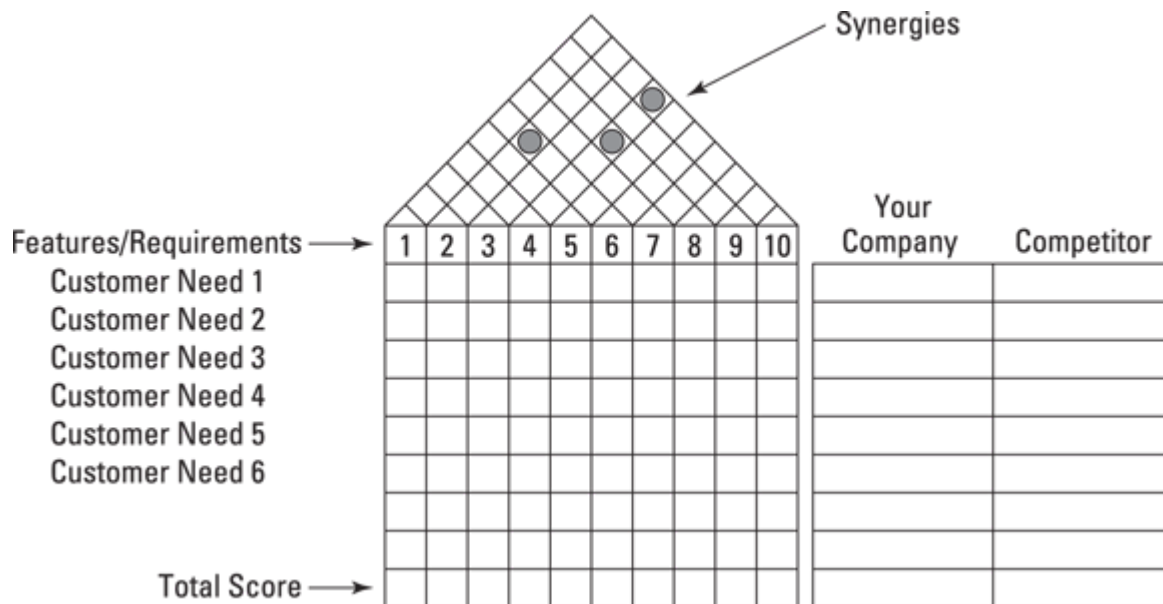
A friend of mine has a sign on her desk that reads “Good, Fast, Cheap ... Pick Any Two.” When you're managing a supply chain, you have to figure out what's most important to you and be willing to compromise on the rest.

#### *Step 1: Understand what customers value*

To set priorities in a supply chain, start with your customers. The purpose of a supply chain is to deliver value to a customer, so your first step in engineering and managing a supply chain should be to understand exactly what your customers value. They may value having a wide assortment of products to choose among, or they might prefer to

have a smaller number of options at a lower price. Your customers may value having products available immediately for pickup or having them delivered at a time they choose. Your customers may want “all of the above,” but each choice creates different requirements for a supply chain, and meeting these requirements costs money.

Some great techniques are available to help you identify what customers value most. One of the most popular of these techniques is officially called quality function deployment (QFD), but many people call it the House of Quality (HOQ). [Figure 3-1](#) shows an example HOQ, which looks like a bunch of boxes with a roof on top. To build an HOQ, first you interview customers to determine which characteristics or features they value most. Then you match those features with your design to ensure that you’re focusing on delivering products and services that genuinely meet your customers’ needs.



**FIGURE 3-1:** Example HOQ.



**TIP**

For more information on how to build an HOQ, visit <https://hbr.org/1988/05/the-house-of-quality> or watch my LinkedIn Learning course at

[www.linkedin.com/learning/project-management-foundations-quality-2020](http://www.linkedin.com/learning/project-management-foundations-quality-2020).

Another common technique for determining customer preferences is called *A/B testing*. To perform an A/B test, you give your customer a choice between two options: A or B. Once you know the option they prefer, you can target your strategy to meet their needs. Online shopping sites frequently use A/B testing to see which products or ads are most attractive to customers, but A/B testing can also be used in face-to-face experiments.

### ***Step 2: Recognize your competitors***

The next step in prioritizing your supply chain goals is recognizing your competitors. Because of the Internet, your competitors may not be who you think they are. Traditional retail stores need to compete with websites like Amazon.com. Amazon.com isn't competing only with retailers, however; it's also competing with trucking companies, warehousing and distribution companies, and even technology companies such as Apple and Microsoft.

To understand who your real competitors are, you need to stop thinking about the product or service that you sell and start thinking about the problem that it solves. Clayton Christensen of Harvard Business School called this approach the Jobs to Be Done Theory. Think about what "job" your product or service does for your customers and what other products or services might be able to do that same job better, faster, cheaper, or more reliably. These alternative products (or services) are your product's real competitors.

### ***Step 3: Understand your products or services***

The next step in prioritizing your supply chain goals is understanding the characteristics of your products or services. The easiest way to illustrate this step is to show how different kinds of products need to achieve different goals to deliver the greatest value to their customers.

[Table 3-1](#) and the sections that follow describe supply chain priorities for different kinds of products. These examples are definitely not an

exhaustive list of supply chains, but they illustrate why the supply chain for corn, for example, has different priorities from the supply chain for computers.

## WHAT JOB DOES A MILKSHAKE DO?

Professor Clayton Christensen gave a great example of his Jobs To Be Done Theory by telling a story about a fast-food restaurant that sold milkshakes. The restaurant was selling lots of milkshakes early in the morning, and the managers couldn't understand why. After interviewing their customers, they discovered that people were buying milkshakes at the beginning of their commute because it gave them something to do while they were stuck in traffic. In other words, the milkshake wasn't just food; it was also entertainment! Understanding what their customers truly valued about the product helped the managers of the fast-food restaurant think differently about how to package the product, manage their business, and design their supply chain.

**TABLE 3-1 Supply Chain Priorities**

<i>Product Type</i>	<i>Supply Chain Priorities</i>
Commodities	Low price, high availability, minimum quality standards
Luxury goods	High quality, uniqueness
Fashion goods	Fast throughput, low inventory, wide variety
Durable goods	Balance between transportation/inventory cost and customer needs
Technology	Speed, flexibility, security

### *Commodities*

Commodities are things that are easy to find and easy to substitute. Common examples are food crops, metal ores, and gasoline. Because it's so easy to substitute commodities from one supplier for commodities from another supplier, most people buy commodities wherever they can get the lowest price. Therefore, commodity supply chains need to be cheap, have high availability, and meet minimum quality standards.

### *Luxury goods*

Luxury goods like high-end cars and jewelry are all about quality and customization. When customers are purchasing luxury goods, they want

something in just the right size and color, and they don't want everyone else to have the same item. Also, ensuring that luxury goods are free of defects and damage is essential. Supply chains for luxury goods need to accommodate a wide assortment of products with plenty of protection to keep them safe.

### ***Fashion goods***

Fashion goods like shoes and purses are all about selection and timing. Because styles change quickly, fashion supply chains need to transform ideas into products and get them sold to customers before the products become passé. Keeping the right amount of inventory is a delicate balance: If you don't have products in stock, you can't sell them. But if an item sits around, it may fall out of style. So fashion supply chains focus on speed and flexibility.

### ***Durable goods***

Durable goods, like household appliances, are heavy, and they need to last a long time. They're expensive to own, so they consume lots of capital when they're sitting in inventory, and they're expensive to ship. Making durable goods takes a long time, and customers often won't want to wait. (If your refrigerator goes out, you want to have a new one delivered right away.) And once a customer makes a purchase, they probably won't buy another one for several years. So durable goods supply chains need to position inventory carefully in order to ensure high availability while minimizing total costs.

### ***Technology***

Technology products — such as computers, television sets, and electronics equipment — are light and expensive. They become obsolete quickly, are sensitive to moisture, and are vulnerable to theft. Supply chains for technology products need to be fast, flexible, and secure.

## ***Building the Right Supply Chain***

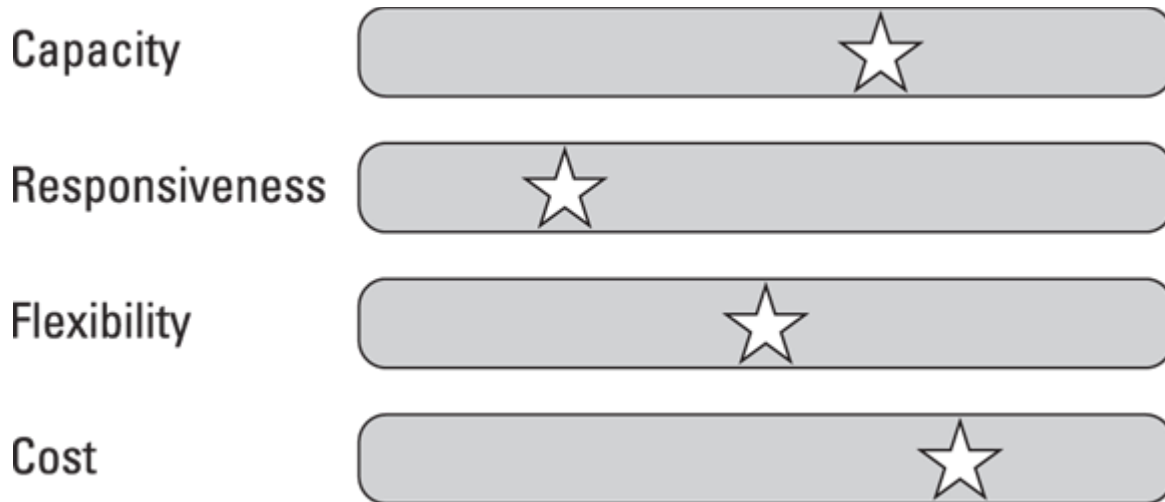
There's really no such thing as a "perfect supply chain" because supply chain performance depends on so many factors. But there are clear

differences between a good supply chain and a bad one. A good supply chain will give your customers what they want for a price that they're willing to pay, while leaving a sufficient profit margin for your company.

That definition may sound simple, but actually designing and managing a supply chain that can profitably meet your customers' expectations is tricky for a couple of reasons. First, the real world is full of surprises that force you to choose whether to spend more money to fill an order or take a chance on disappointing your customers. Second, over time, your customers' priorities will change, and your business will evolve, so your supply chain will need to adapt to those changes.

Four goals can help you evaluate how your supply chain should be designed: capacity, responsiveness, flexibility, and cost. All these goals are important, but many supply chain decisions will require you to make trade-offs between them. To understand how important they are for your supply chain, it may help to rank them. You could create a chart, like the one shown in [Figure 3-2](#), that shows how important each of these factors is for your customers. In this chart, the farther to the right a star is, the more important that supply chain attribute is to your customers.

Prioritizing your supply chain goals in this way can help everyone on your team understand what it will take for your supply chain to meet your customers' needs while enabling your company to make a profit.



**FIGURE 3-2:** Supply chain objectives.

Let's take a closer look at these four goals:

» **Capacity:** *Capacity* refers to how much product or service your supply chain can produce in a given period. One of the main goals of supply chain management is to provide your customers with as much of your products or services as they're willing to buy. If you don't have enough capacity, your customers will have to go without the products they want, or they'll buy from your competitor. But if you have too much capacity, you're tying up capital without generating a return.



**REMEMBER** Closely related to capacity is the concept of *availability*, which is the capability of a system to provide products or services when customers want them. Customers don't really care about your supply chain's capacity; what matters to them is product or service availability. The more capacity you have, the easier it is to maintain high availability. When you don't have enough capacity, or when you don't manage your capacity well, your availability becomes low, which means that customers can't get your products or services when they want them.

» **Responsiveness:** *Responsiveness* is the measure of how quickly your supply chain can provide a product or service to a customer. You measure responsiveness from the time that your customer places an order to the time when you deliver it to them. Some products, such as ships, can take years to design and build. Those products' supply chains aren't very responsive. Other products, such as pizza, can be made and delivered to a customer's doorstep in 30 minutes. Obviously, responsiveness varies a lot, depending on the kind of product that your supply chain is delivering. But within a particular industry, responsiveness is often a key differentiator between competitors. The most responsive company — the one that can deliver its product the fastest — has the best chance of getting a customer's order.





**REMEMBER** Supply chain responsiveness is important for driving top-line revenue because it's often a critical factor in a customer's purchasing decision.

- » **Flexibility:** *Flexibility* is the measurement of how well your supply chain scales up or ramps down in response to change. If customers always wanted the same stuff in the same quantities and at regular intervals, supply chain management would be a whole lot simpler. But that's not the way things work in the real world. One week, everyone is buying doughnuts, and no one is buying ice cream. The next week, everyone is buying ice cream, and no one is buying doughnuts. Supply chains must have the flexibility to respond to those changes in demand.

Supply chains also need to have flexibility when it comes to supply. In other words, your supply chain has to be able to deliver value to your customers even if your suppliers have low availability.

- » **Cost:** *Cost*, of course, is the amount of money it takes to operate your supply chain. Supply chain management needs to provide the capacity, responsiveness, and flexibility that your customers need at the lowest possible cost. The cost metric is the ultimate test of supply chain management. You have a goal of delivering value to your customers; the less you spend to achieve that goal, the bigger your monetary reward is.

## *Looking at Cost Drivers*

Most supply chain managers spend a lot of their time looking for ways to reduce costs. Four decision areas drive most of the costs in any supply chain, and I describe them in the following sections. It's important to remember that supply chains are interconnected systems, so making a change in one area to lower costs can cause a change somewhere else that actually increases costs. That's why it helps to think about all these items together.



## *Procurement costs*

One of the most obvious costs for any supply chain is the amount that you pay for the products and services you buy. Some common ways to reduce procurement costs are to negotiate better prices from your suppliers, agree to buy larger quantities over a longer period, or switch to a supplier that agrees to accept lower prices. Also, each supplier that you work with costs you money, because someone has to find the supplier, sign all the contracts, keep track of the supplier's performance, and make sure the supplier gets paid. So the cost for procurement also includes the salaries and overhead for your procurement team. Reducing the number of suppliers you work with and streamlining your procurement processes can often reduce procurement overhead costs.

## *Transportation costs*

Moving a product from one place to another costs money, and different modes of transportation have different costs. These modes have different speeds, which can be just as important as transportation cost. A faster and more expensive transportation mode might actually save you money by decreasing the amount of inventory that you have in transit, for example. It's also common to use more than one mode of transportation to move a single product through a supply chain. Changing from one mode to another by using multimodal transportation can optimize transportation costs. Another common way to reduce transportation costs is to pack more products into each load, thereby improving capacity utilization. The important thing to remember is that choosing a transportation mode that is slower and less reliable may reduce transportation costs, but it will increase your inventory and consume more working capital. Transportation modes are discussed in more detail in [Chapter 8](#).

## *Inventory costs*

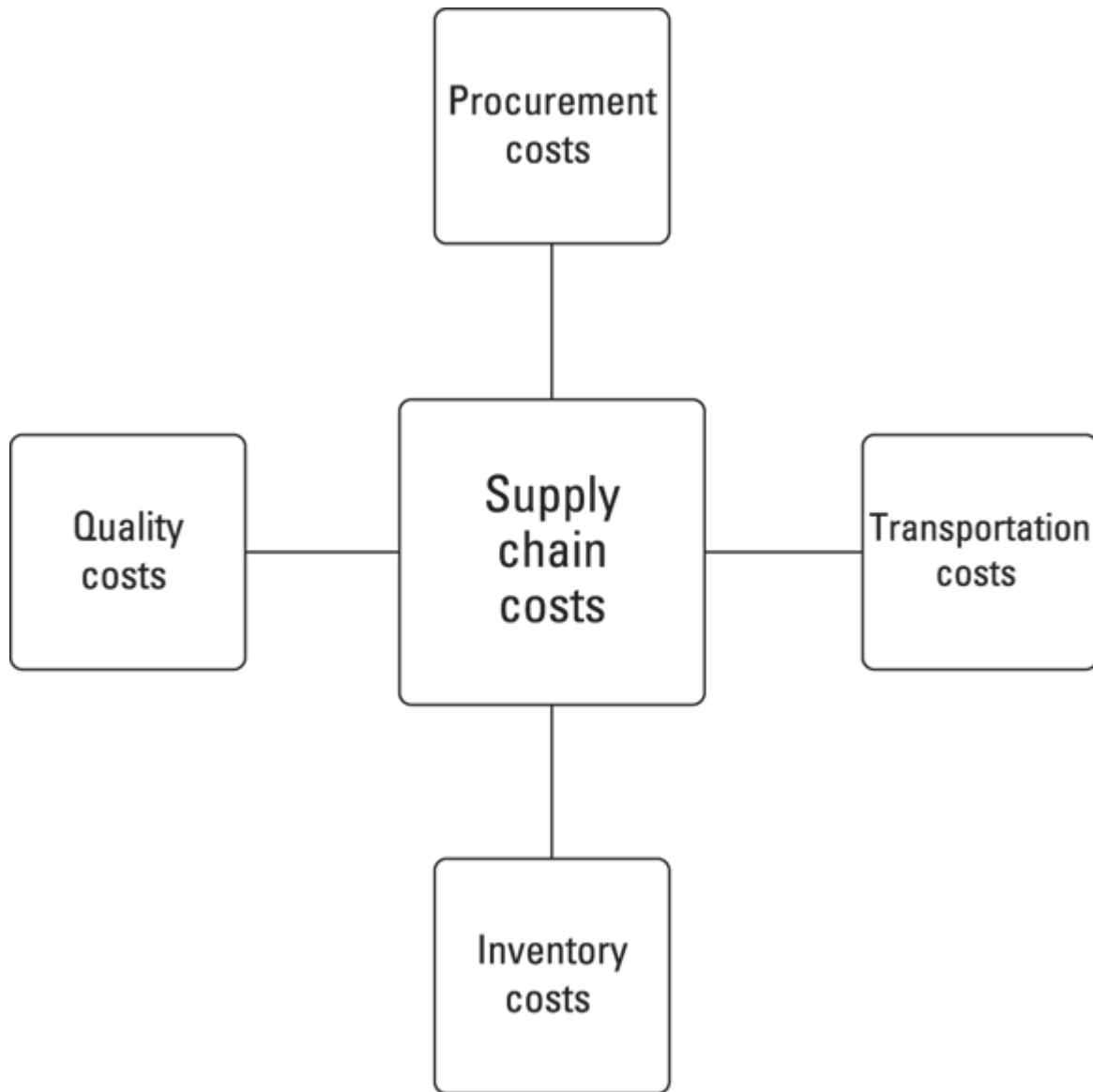
Keeping products in inventory costs money. If you're borrowing money from the bank to pay for that inventory (which is often the case), your inventory costs you whatever interest rate you're paying to the bank. Other costs include paying for a building to keep the inventory safe and

paying people to move the inventory around inside the building. You also run the risk that products could be lost, damaged, or stolen. This problem, often called *shrinkage*, also creates a cost to your company. Finally, products can expire, deteriorate, evaporate, or become obsolete if they sit in a warehouse or a retail store for too long. These all contribute to your *inventory holding cost*.

## ***Quality costs***

When you buy a product, you expect it to meet a certain level of quality. In some cases, you may need to have formal inspection and quality assurance processes in place to make sure that the products you receive from suppliers and the products you send to your customers meet these requirements. Any product that doesn't meet these standards costs you money, and the more closely you have to look for quality problems, the more money you spend. Reducing the variation in manufacturing and distribution processes through techniques such as Lean and Six Sigma, which are discussed in [Chapter 16](#), can reduce the quality costs in a supply chain.

[Figure 3-3](#) shows that the four supply chain cost drivers are interdependent; changes in any of the buckets can affect the others.



**FIGURE 3-3:** Supply chain cost drivers.

## *Dealing with Trade-Offs*

Supply chain management involves making choices and trade-offs that help you maximize your profits over the long term. When you get right down to it, conflicts occur between any two functions in a business, as well as between any two businesses that work together as a part of a supply chain. Six conflicts, or trade-offs, are so common that every supply chain management professional needs to understand them and

know how to manage them effectively (see [Table 3-2](#)). I discuss these trade-offs separately in the following sections.

### *Sales versus operations*

Salespeople often say that you can't sell a product you don't have. So salespeople want to make sure that you have enough product to meet all the customer demand that they can possibly generate, plus a little bit more. That scenario is seldom realistic.

Meanwhile, the operations and logistics people are responsible for the costs of making, moving, and storing products. They want to make and store only as many products as are needed because that helps them keep manufacturing and logistics costs low.

**TABLE 3-2 Common Supply Chain Management Trade-Offs and Solutions**

<i>Conflicts and Trade-Offs</i>	<i>Solutions</i>
Sales versus operations	Sales and operations planning (S&OP)
Customer versus supplier	Collaborative planning, forecasting, and replenishment (CPFR)
Engineering versus procurement	Cross-functional teams
Inventory versus customer service (wholesale/retail)	Forecasting
Inventory versus downtime (manufacturing)	Lean manufacturing
Procurement versus logistics	Total cost analysis

This trade-off between sales and operations can lead to major conflicts in a company. For example, a sales department might create an unrealistic forecast, and the operations department is blamed for having too much inventory. Or the sales department might not meet its revenue targets because the operations team was too conservative in its production and inventory planning.

A common solution for this problem is a process called *sales and operations planning (S&OP)*, which bring the sales and operations teams together to coordinate and agree on their goals and targets. S&OP usually starts with a sales forecast for a certain planning horizon. The sales team might estimate that it could sell 1,000 widgets per month for the next 12 months, for example. This forecast is called an *unconstrained forecast* because it's based on a best-case scenario.

When the unconstrained forecast has been established, the operations team decides whether the numbers are reasonable and what it would take to manufacture that many products. In some cases, operations may not have enough capacity to make all the widgets that are called for in the unconstrained forecast. They could be limited by the staffing, the equipment, or the raw materials needed. In that case, the operations team would ask the sales team to reduce its forecast based on all the constraints that have been identified. Alternatively, the operations team may need to make changes or investments to increase their capacity so that they can meet the sales forecast.



**TIP** S&OP is sometimes called supply chain planning (SCP), Integrated Business Planning (IBP), or sales and inventory operations planning (SIOP).

S&OP is an iterative process that needs to be repeated so that the constrained sales forecast and the manufacturing production plan stay in sync. In many cases, the S&OP process involves senior executives from a company to ensure that trade-offs are understood and aligned with the corporate strategy.

### ***Customer versus supplier***

Each company in a supply chain has an effect on all the others. If your company surprises one of your suppliers with a big order, that order is likely to create problems — and cost the supplier money. But if your supplier has a pretty good idea of what you're going to buy and when you're going to buy it, the supplier can plan in such a way to meet your

needs while keeping its own inventory and transportation costs low. In other words, everyone wins when supply chain partners collaborate and share information.

One way for supply chain partners to help one another is through a process called *collaborative planning, forecasting, and replenishment (CPFR)*. In the CPFR process, companies share information about how much they expect their customers to buy and how much inventory they have on hand so that they can help each other achieve high service levels with lower amounts of inventory.



TECHNICAL  
STUFF

CPFR is a registered trademark of GS-1, a not-for-profit association that maintains supply chain communication standards.

## ***Engineering versus procurement***

Engineering teams are always looking for ways to innovate, make changes, and improve products. For their innovation processes to work well, engineers often develop relationships with suppliers that can be flexible and collaborative, but this flexibility and the time invested in understanding the engineers' needs have a cost. Typically, the suppliers that are best at innovating and collaborating are also the most expensive. Meanwhile, the procurement team is always looking for ways to get products that meet the minimum specifications at the most favorable price. The lowest prices typically come from suppliers that produce at the minimum quality level with highly standardized systems and processes. The conflicting goals between engineering and procurement can lead to tension within a company.

One of the best ways to manage this tension is to create cross-functional product management teams. Engaging procurement professionals during the design phase of a product can help you ensure that you're considering the costs of each step in a product's life cycle. Likewise, engaging engineering teams throughout the procurement process can

help you ensure that lower-cost options that meet the needs of your company and your customers are properly vetted.

Another way to manage the trade-off between engineering and purchasing is to use a design-build strategy. With design-build, a single contract is awarded to a supplier that both designs and makes a product.

### *Inventory versus customer service*

Inventory costs money because it ties up working capital, consumes labor and real estate, and depreciates quickly. Many supply chain professionals and business analysts will even tell you that inventory is the enemy. You may wonder why everyone doesn't eliminate all inventory. Wouldn't supply chain management be a whole lot easier if you didn't have to deal with warehouses, distribution centers, and stock rooms?

That approach has one major problem: Companies make money by selling products to their customers, and if they have no product to sell, they earn no revenue. When you think about what customers value — what they're willing to pay for — the product itself is only part of the equation. You have to consider, for example, whether customers would be willing to pay the same amount for your product if they had to pick it up 100 miles away or had to wait for it for a year. In other words, the placement and availability of a product have a big effect on its value to your customers and on your revenue. Inventory acts as a buffer against uncertainty about who's going to buy your product, how much they're going to buy, when they're going to buy it, and where they're going to want it.

Whether your customers buy your product in a store or through a website, your ability to provide them all the products they want when they order them is called your *service level*. Customers tend to buy more from suppliers that meet their needs quickly, so high service levels can increase revenue and grow market share. But to maintain a 100 percent service level, you'd need to have an infinite amount of inventory, which is unrealistic, so you need to find ways to manage the tension between

reducing inventories to lower costs and increasing inventories to maintain acceptable service levels.

Inventory optimization is a process of reducing inventories to the minimum level necessary to maintain the desired service level. Inventory optimization starts with *forecasting*, the process in which you try to guess how much product you're going to sell and when you're going to sell it. Companies have many ways to generate forecasts, ranging from rules of thumb to sophisticated statistical modeling. No matter what forecasting method you use, your forecast is still just a guess about what will happen in the future.



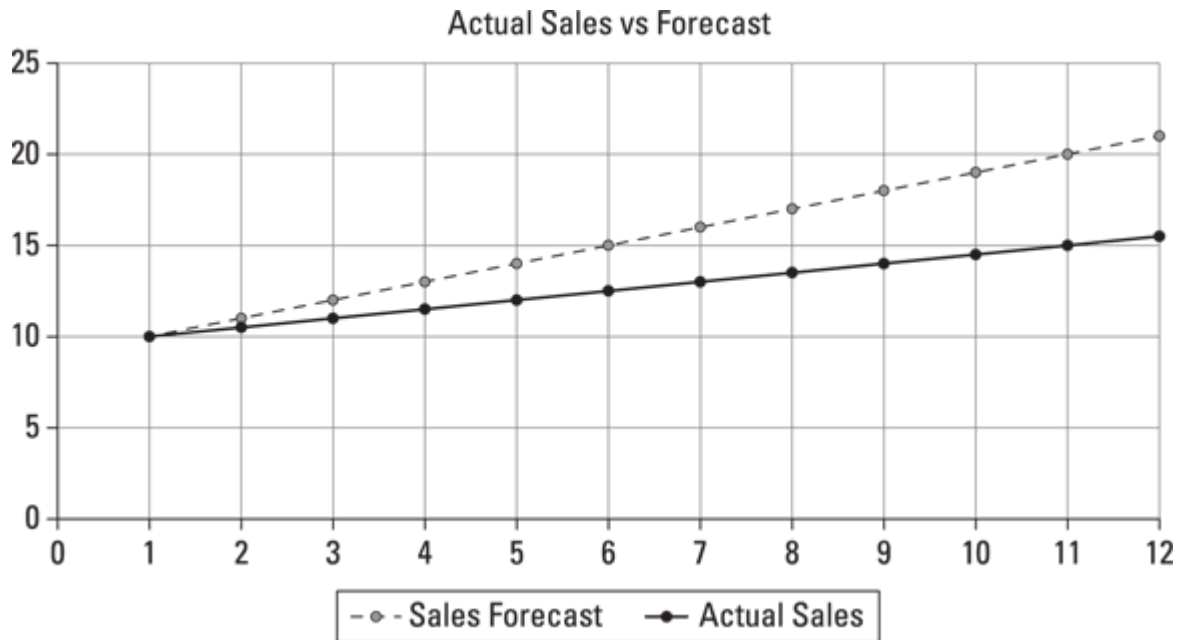
**TIP** A common joke among supply chain professionals is that the First Law of Forecasting is that the forecast is always wrong.

The way to deal with potential errors in a forecast is to keep extra inventory on hand. The better the forecast is — the more confidence you have in it — the less extra inventory you need. The degree to which a forecast is wrong is called *forecast error*. Two kinds of errors can occur in a forecast:

- » An unbiased error is random and generally is a result of imperfect information.
- » A biased error is an error that occurs in a pattern. A forecast might always be higher or lower than actual sales, for example.

[Figure 3-4](#) shows an example of a biased forecast that's always higher than the actual sales. If you can measure the amount of bias, you can take the bias into account and adjust the forecast.





**FIGURE 3-4:** Biased forecast.



**TIP** It's often easy to spot forecast bias by creating a graph that compares forecast data with actual data.



**TECHNICAL STUFF** The degree of forecast accuracy is often measured as the mean absolute percentage error (MAPE).

When everything is said and done, the real way that most companies deal with the potential for errors in a forecast is by increasing their inventory. So the better the forecast is — the more confidence that you have in it — the less extra inventory you need to keep to meet your desired customer service levels. But if you don't trust your forecast, and you want to make sure that you have products to sell when customers want them, you need to invest in extra inventory. Inventory that you hold because of uncertainty about the future is called *safety stock*.

## *Inventory versus downtime*

Manufacturing operations focus on maximizing the amount of product that they're able to make in a given period. Sometimes, manufacturing processes need to be shut down. Planned shutdown times typically are scheduled around the shifts that people work or so that the company can perform maintenance or change over equipment to make different products.

Unplanned shutdowns also happen for a variety of reasons, all of which are bad. An unplanned shutdown could be caused by a power outage, a broken piece of equipment, a strike, or a new government regulation. An unplanned shutdown also can be the result of running out of raw materials. You can't make a product unless you have the components that go into it.

One way to prevent unplanned shutdowns due to maintain high inventory levels. But that extra inventory ties up working capital and requires additional warehouse space. Lean Manufacturing techniques can help to minimize the number of unplanned shutdowns caused by inventory stockouts while also minimizing the amount of inventory in a supply chain.

One of the key elements of Lean Manufacturing is the use of a *kanban* for inventory replenishment. A *kanban* is an automatic reorder trigger for inventory. Containers can be used as kanbans, for example. When the last item is pulled from a container, it's time to order a new shipment. This process provides a smooth, step by step flow of inventory. When you use a kanban system, there's no way for inventory to be pushed down to the next step in a supply chain; it can only be pulled by the downstream kanban.



TECHNICAL  
STUFF

Toyota developed a unique approach to managing the flow of products through its manufacturing process, allowing the company to minimize inventory costs and unplanned shutdowns. This approach involves tools and techniques that are collectively known as the Toyota Production System. As other companies adopted this

approach, it became known as Lean Manufacturing. [Chapter 16](#) includes more information about Lean.

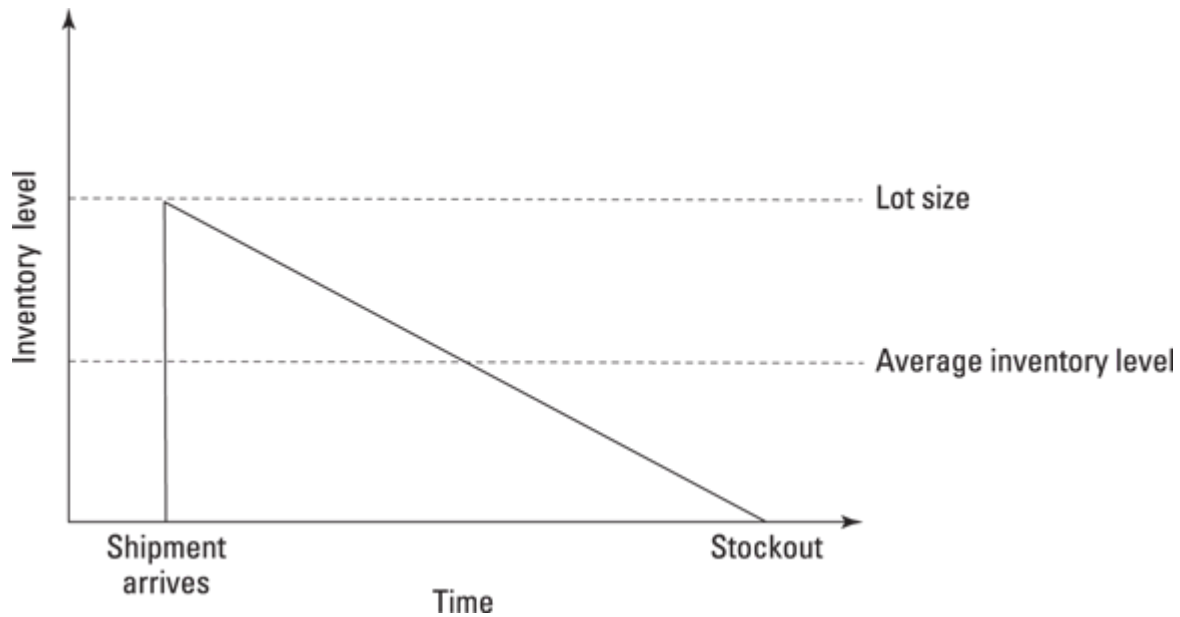
## SEMICONDUCTOR SHORTAGES

Semiconductors are the brains inside of consumer electronics, industrial equipment, health care devices, and cars. They are manufactured in expensive factories that take a long time to build. In the past few years, the demand for semiconductors has been growing faster than supply, and that has led to shortages around the world. In some cases, automotive factories have been closed down for weeks at a time simply because they were not able to buy enough semiconductors to make new cars.

### *Procurement versus logistics*

Procurement teams look for ways to get the same materials at lower cost. Two common ways to reduce costs are to buy in larger quantities or to buy from a supplier in a low-cost region. Both of these options can have the unintended result of increasing logistics costs.

For one thing, increasing the amount of material that you order each time, called the *lot size*, also increases the amount of inventory that you own. You start with no inventory; then you receive a shipment of whatever lot size you agreed to purchase from your supplier. You gradually use that inventory to make products, or sell that inventory to customers. Eventually, you run out of inventory. Over that period, how much inventory did you have on average? The average amount of inventory — and the average amount of working capital tied up in inventory — is half your lot size. Therefore, the more you order at one time, the more inventory you end up with. You can see how this process works in [Figure 3-5](#).



**FIGURE 3-5:** Average inventory level.

Ordering in larger quantities also means that you need more space to store inventory and more people to manage it. So increasing the lot sizes may get you a lower cost up front, but it could increase your total costs.

A similar problem appears when you consider suppliers located farther away. The price per unit may be lower, but the increased transportation costs can eat up those savings. Shipping items a longer distance can also force you to buy in larger quantities. The farther you have to move something, the more things can go wrong along the way. To compensate for this risk, you'll probably need to — yep, you guessed it — increase inventory.

The way to balance the priorities of purchasing and logistics is to use a total-cost analysis approach. Make sure that you're evaluating all the elements that will cost your supply chain money. You may find that a more expensive nearby supplier that can deliver in small batches and at a low transportation cost is a better option than a lower-cost supplier in a distant location that would require you to spend more money on transportation and inventory.

## Part 2

# Managing Supply Chain Processes

## IN THIS PART ...

Use the SCOR Model to break your supply chain into high-level processes.

Look at how different kinds of supply chains plan, source, make, and deliver products and services.

Explore opportunities for capturing value and reducing waste with reverse supply chains.

Think about the range of other processes that enable a supply chain to operate effectively.

# Chapter 4

## Connecting Supply Chain Processes

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### IN THIS CHAPTER

- » Breaking the supply chain into processes
  - » Finding out about the GSCF and APQC frameworks
  - » Organizing processes with the SCOR Model
  - » Identifying the SIPOC attributes
- 

In [Chapter 2](#), I cover several different ways you can describe a supply chain, and one of the options is to look at it as a series of processes. In this chapter, I go deeper into that process-focused perspective, showing how processes can help you define your business goals and make better management decisions.

*A supply chain process* is any series of activities that adds value to a product or service. Making a hamburger is a supply chain process, for example, because customers are willing to pay more for a cooked patty with lettuce and tomato inside a sliced bun than they are for the individual ingredients. Serving a hamburger is a supply chain process, too; customers who eat a hamburger in a restaurant, with a server carrying it to the table, will pay more than when they purchase the same burger at a drive-through. Anything that adds value — anything that moves or changes a product or service in some way that a customer is willing to pay for — is a supply chain process.

When you start thinking about supply chains in terms of processes, you begin to see more clearly how all the pieces fit together. You have a process to order the components before you can make your products. Then you have manufacturing processes, sales processes, and delivery

processes. Each of these processes depends on other processes; they are interdependent.

Although the details of supply chain processes vary wildly among industries and companies, there are process frameworks that can be useful for designing supply chains and measuring performance. A group of researchers at the Ohio State University Global Supply Chain Forum (GSCF) have created one popular framework, and the American Productivity & Quality Center (APQC) has created another. The best known framework is the Association for Supply Chain Management's Supply Chain Operations Reference (SCOR) Model.

These frameworks try to capture the important steps necessary for creating and delivering value in a supply chain. There are a lot of similarities between these three models, so learning one approach will help you understand the others. Likewise, as you study the differences among these models you can better understand why supply chain professionals sometimes struggle to communicate with one another.



**TIP** Using a process framework to analyze the steps in a supply chain can help you pinpoint trade-offs and ensure that your decisions align with the results you want. Using a process framework also gives you the ability to identify and focus on the metrics that are critical for managing your supply chain effectively. [Chapter 14](#) has more information about supply chain metrics.

## *Introducing the GSCF Framework*

A group of researchers at the Ohio State University Global Supply Chain Forum (GSCF) created a supply chain management framework that focuses on eight processes:

- » Customer relationship management
- » Supplier relationship management



- » Customer service management
- » Demand management
- » Order fulfillment
- » Manufacturing flow management
- » Product development and commercialization
- » Returns management

The GSCF framework emphasizes the importance of managing the transactions that occur between companies, and managing relationships with customers and suppliers. It also includes product development and commercialization as an important supply chain process.



**TIP** You can read more about the GSCF Framework on Dr. Douglas Lambert's website at <https://drdouglaslambert.com/supply-chain-management>. Steven Brown explains these processes in a LinkedIn Learning course at [www.linkedin.com/learning/supply-chain-foundations-managing-the-process](http://www.linkedin.com/learning/supply-chain-foundations-managing-the-process).

## *Introducing the APQC Process Classification Framework*

The American Productivity & Quality Center (APQC) has developed a cross-industry process classification framework (PCF) with 13 categories. These categories are:

- » Develop vision and strategy
- » Develop and manage products and services
- » Market and sell products and services
- » Manage supply chain for physical products

- » Deliver services
- » Manage customer service
- » Develop and manage human capital
- » Manage information technology (IT)
- » Manage financial resources
- » Acquire, construct, and manage assets
- » Manage enterprise risk, compliance, remediation, and resiliency
- » Manage external relationships
- » Develop and management business capabilities

Each of these categories is made up of process groups, which contain processes, activities, and tasks. [Figure 4-1](#) shows the PCF hierarchy.



**TIP** You can download a free spreadsheet containing the APQC PCF at [www.apqc.org/resource-library/resource-listing/apqc-process-classification-framework-pcf-cross-industry-excel-10](http://www.apqc.org/resource-library/resource-listing/apqc-process-classification-framework-pcf-cross-industry-excel-10).



**FIGURE 4-1:** The APQC Process Classification Hierarchy.

## *Introducing the SCOR Model*

The SCOR Model is a framework that you can use to map out the processes in any supply chain. It contains six top-level processes — the

key activities that are involved in creating and delivering value to a customer. Because each of these processes contains many levels of subprocesses, they are sometimes called *process groups*. The six top-level process groups are:

- » Plan
- » Source
- » Make
- » Deliver
- » Return
- » Enable

All supply chain activities should be planned, so the Plan process connects with all of the others. Then there is a logical sequence from Source, where you buy materials, to Make, where you manufacture products, to Deliver, where you get those products to your customers. At any point in the Source, Make, or Deliver processes, you may need to send some of your products back up the chain, so the Return process sits underneath all of them.

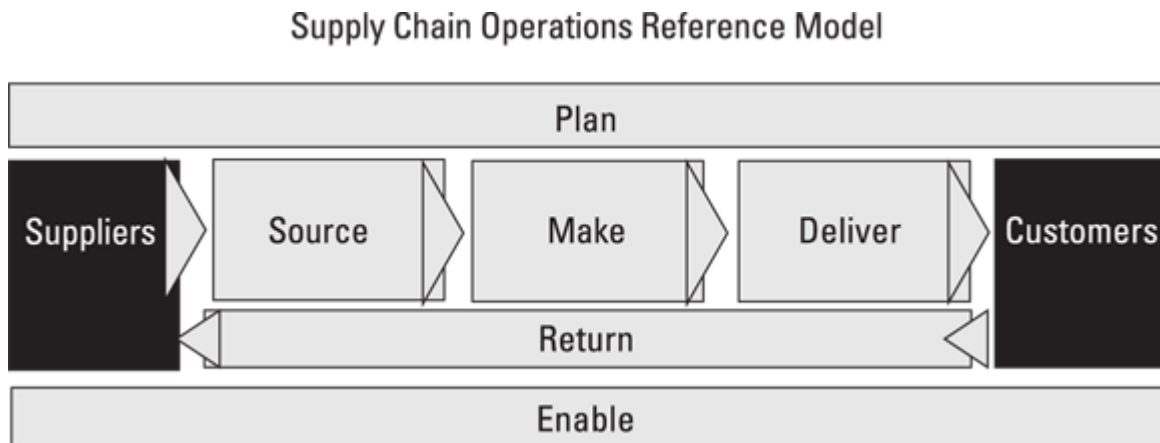
And because the SCOR Model is designed to describe a supply chain, not just an individual company, these processes also have to link to your customers and suppliers. So the Source process for *your company* connects to the Deliver process for *your suppliers*, and the Deliver process for *your company* connects to the Source process for *your customers*. To make all that work, you need to have the right talent and information technology in place to Enable these processes.

[Figure 4-2](#) shows how these processes connect within your company and how they connect your company to the rest of your supply chain.

## SCOR DIGITAL STANDARD

The SCOR Model has evolved over time. The original SCOR Model was developed by a consulting company called PRTM. PRTM transferred their intellectual property to a nonprofit association called the Supply Chain Council, which later merged with APICS,

which is now called the Association for Supply Chain Management (ASCM). Most supply chain professionals are familiar with SCOR version 12, so that is the version I refer to in this book. But ASCM recently released a new version called the SCOR Digital Standard (SCOR DS), which changed “Make” to “Transform” and separated “Deliver” into “Order” and “Fulfill.” You can find the most up-to-date information about the SCOR Model at <https://scor.ascm.org>.



**FIGURE 4-2:** The six top-level supply chain processes in the SCOR Model.

A good way to illustrate how the SCOR Model works is to apply it to a supply chain that you already know. Suppose you are suddenly in charge of a hamburger restaurant. [Table 4-1](#) shows how the top-level processes of the SCOR Model could help you think through issues that you’d need to address.

**TABLE 4-1 Example Top-Level SCOR Processes**

<i>Process</i>	<i>Description</i>
Plan	You need to estimate how many hamburgers you are going to make, decide where you are going to make them, and determine your supply chain priorities. You may need to choose whether to focus on quality and freshness, customer service and convenience, or low cost. These choices will influence the other decisions and trade-offs that you make throughout the supply chain.

<b>Process</b>	<b>Description</b>
Source	You need to decide where you will buy ingredients and supplies. You need to negotiate with your suppliers to get the best prices, along with the best quality and service. It might be better to have suppliers close by, so that transporting products is fast and cheap. Or it might make sense to choose suppliers that are farther away who can provide the products at a lower cost or in larger quantities.
Make	You need to manage the process of making your hamburgers. It will help if you can define the stages of your manufacturing process and how long each stage will take. You may also need to decide whether you should make the hamburgers by hand or buy a machine that can make them better, faster, and cheaper than a person can.
Deliver	You need to manage the logistics of getting your hamburgers into your customers' hands. That means you'll need to decide whether you want customers to pick up their hamburgers at a counter or employ a server to carry the hamburgers to the table. Or perhaps you need to have a drive-through window, or deliver your hamburgers to your customers' homes or offices.
Return	For many products, it's important to think about what will happen to them after your customer is finished using them. In the case of hamburgers, you may need to think about washing the plates and recycling napkins.
Enable	You need to decide what else you need to make the supply chain work. You may need to hire people with specific skills, which means you need to think about how you will find them and how you will measure their performance. And there may be other processes that you need to have in place for your supply chain to achieve its goals, such as marketing programs or accounting policies.

You can see from this table how the SCOR Model helps you drill down into the choices you need to make, and how these choices will affect the design of your supply chain.

## *Identifying the SIPOC Attributes*

When analyzing what a supply chain process really does, it's often useful to identify five key attributes that are referred to by their acronym, SIPOC:

- » *Suppliers* are people, groups, or systems that provide inputs to a process. This could include companies that you buy supplies from, but it could also include a computer system that provides necessary data.
- » *Inputs* include anything that goes into a process, a system, or a machine. Inputs could include raw materials, components, packaging materials, information, and instructions.
- » *Process* is the step in a supply chain that you're trying to analyze. The process could be a planning process (like setting inventory targets) or an execution process (like picking an item in a fulfillment center).
- » *Outputs* are what a process produces. Outputs include the product or service that the process is supposed to deliver but may also include information and waste.
- » *Customers* are people, groups, or systems that use the outputs of a process. The customer in a SIPOC doesn't have to be the customer that buys your finished product.

A SIPOC analysis helps to show the dependencies between the processes in a supply chain. A good way to illustrate a SIPOC is to look at the process of picking orders in a fulfillment center:

- » *Suppliers* include the receiving department, which puts inventory into the warehouse, and the warehouse management system, which keeps track of inventory.
- » *Inputs* include the products that are stored in inventory, along with instructions about where to find the products in the warehouse.
- » *Process* in this case could be "Pick item from inventory." You could also break the process down into detailed steps, such as "Print pick sheet, travel to first pick location, place item on cart," and so on.
- » *Outputs* could include the item that is picked, where it is delivered, and how long it takes to complete the process. The outputs might also include updating the warehouse management system and creating a packing list for the shipment.

» *Customers* in this case will be the shipping department, which is responsible for the next process in the supply chain.

This example shows that you can think about a supply chain as being a series of SIPOCs. The customer from one process is the supplier for the next process. The shipping department is the customer of the picking process, but in the next process — shipping — the shipping department is the supplier, and the transportation provider is the customer.

Clearly articulating SIPOCs is especially helpful when automating a process, because you need to consider how suppliers and customers of the process could be affected by a change. A useful tool for communicating this information is a SIPOC diagram, like the one shown in [Figure 4-3](#).



**FIGURE 4-3:** SIPOC diagram.

## Chapter 5

# Planning the Supply Chain

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### IN THIS CHAPTER

- » Setting high-level targets for supply and demand
  - » Focusing on your customers' needs
  - » Developing plans for Source, Make, Deliver, and Return
- 

Before you can engineer and manage a supply chain, you need to plan what it's supposed to do. Planning gives you an opportunity to set goals, evaluate options, and make decisions; it also helps ensure that you invest your time and money wisely. Supply chain planning is not a one-time event; planning is an ongoing and iterative process that ensures your supply chain adapts to changes in your business.

In this chapter, I cover how to plan a supply chain by looking at it as a complete system, which means thinking about it from several angles: what your resources, requirements, customers, and products are; how you'll make and deliver your products; and how you'll handle returns of used or defective products.

## *Balancing Supply and Demand*

The fundamental question at the heart of every supply chain plan is, "How are we going to balance supply with demand?" There are three main approaches to balancing supply and demand:

- » Make-to-stock
- » Make-to-order
- » Engineer-to-order



When your supply chain plan is based on a *make-to-stock* approach, you start by forecasting how much you think customers are going to buy. This forecast drives all your manufacturing and distribution planning. The work is done and the products are ready to go before you receive an order from a customer. This approach is sometimes called a *push system* because you're pushing products toward your customers even though they haven't yet placed orders.

When your supply chain plan is built on a *make-to-order* approach, all your manufacturing and distribution services are standing by, waiting for an order to come in. The product design work is complete, but you don't make or move a product until you get the order for it. This approach is an example of a *pull system* because an order has to pull the products through the supply chain.

When your supply chain plan uses an *engineer-to-order* approach, you're making a customized product for each order, so you can't finish the product design until your customer gives you the specifications. The final engineering work, manufacturing, and distribution are triggered by the customer order. Like make-to-order, engineer-to-order is a pull system.



**TIP** You'll find more details about implementing make-to-stock, make-to-order, and engineer-to-order in [Chapter 7](#).

Make-to-stock, make-to-order, and engineer-to-order are different ways to plan a supply chain. A company can have more than one supply chain; many companies operate all three types of supply chains while using many of the same supply chain assets.

A good way to see how these three approaches work is with the example of buying a new car. You could drive to your local car dealership and buy any of the cars on the lot. Each car was manufactured based on a forecast; the manufacturer guessed that someone would want to buy it. After the manufacturer forecasted the demand, it pushed inventory down

the supply chain to the dealer in order to meet that demand. All those cars, therefore, came from a make-to-stock supply chain.

You may not like any of the cars that the dealer has in stock, however. Maybe you want a car with a specific combination of features, such as silver paint, tan interior, and the high-end entertainment package. The dealership will be delighted to get you that car, but it needs to order it from the factory. The supply chain for a car you order this way is a make-to-order supply chain. The flow of material, information, and money is quite different from the flow in a make-to-stock supply chain.

Suddenly, one of your friends hears about your new car and gets jealous. She wants a similar car, but she wants the rear seat to be converted to a kennel for her Newfoundland. The factory doesn't offer this configuration as a standard feature but (for a price) has agreed to do it. The manufacturer has to design the kennel compartment and source all the materials, so the process takes a while. The manufacturer wouldn't have designed the kennel until a customer ordered it and provided her requirements. Now that it has an order and knows exactly what the customer wants, the factory can produce a car that meets the customer's needs perfectly. This system is an engineer-to-order supply chain.

To a customer, the finished cars may look similar, but in terms of the supply chain, the processes to make them are very different. Making sure those processes are aligned is the result of supply chain planning.

## *Recognizing Different Supply Chain Models*

Every company is a part of many different supply chains, and each of these supply chains may need to be managed differently. Supply chains can also fall into more than one category. Following are some of the common types of supply chains:

- » **Manufacturing:** A manufacturing supply chain delivers raw materials and components to a factory.

- » **Business-to-business (B2B):** In a B2B supply chain, the customer for a product or service is a company. B2B supply chains may also be called *industrial supply chains*.
- » **Business-to-consumer (B2C):** In a B2C supply chain, the customer for a product or service is a person. B2C supply chains are also called retail supply chains.
- » **Consumer packaged goods (CPG):** A CPG supply chain involves products that people buy on a regular basis, such as food or cosmetics.
- » **E-commerce:** In an e-commerce supply chain, products and services are ordered online and delivered to the customer.
- » **White goods:** Appliances such as refrigerators and stoves are called white goods. They are large and heavy, and require special handling to prevent damage. They often need to be delivered and installed by trained technicians.
- » **Agricultural:** Agricultural supply chains handle grains, fruits, vegetables, and livestock. They may also involve herbicides, pesticides, and fertilizers. These supply chains are often seasonal.
- » **Cold-chain:** A cold chain supply chain is designed to handle refrigerated goods such as perishable food and medicine.
- » **Hazardous materials (hazmat):** Products that are flammable, explosive, corrosive, or radioactive often require special handling, licenses, and permits.
- » **Medicine and medical equipment:** Medicines and medical equipment often require special storage and handling, monitoring of expiration dates, and compliance with government regulations.
- » **Maintenance, repair, and overhaul (MRO):** An MRO supply chain delivers service parts and tools to repair or maintain equipment.
- » **Government:** Government agencies buy huge amounts of material. Their supply chains are often bureaucratic and slow with lots of rigid processes, and harsh penalties for errors.

- » **Military:** Military supply chains need to deliver equipment and weapons over very long distances with short notice. These supply chains often rely on a combination of military and civilian resources.
- » **Humanitarian logistics and disaster response:** After emergencies, disasters, and wars it is necessary to create supply chains to provide food and medicine to victims and refugees.
- » **Project:** A project is any temporary endeavor such as building a house or opening a store. Project supply chains are unique because they involve many vendors who are each filling a small number of orders, and projects often finish in a relatively short time.
- » **Reverse:** A reverse supply chain moves products from a customer back to their supplier.

Understanding the differences between these supply chains can help as you begin to define your requirements.



TECHNICAL  
STUFF

The U.S. military often uses the term “spares” to describe service parts, and “sustainment” to describe their MRO supply chains.

## *Aligning Resources with Requirements*

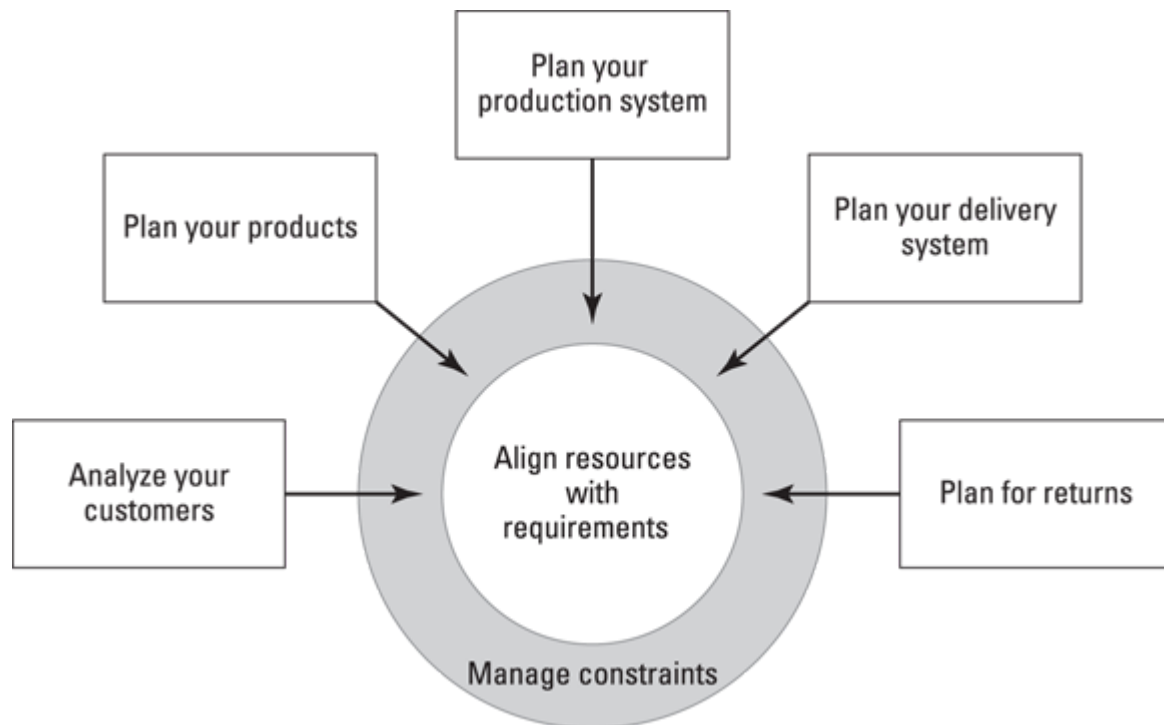
Supply chain plans are built around goals, or *requirements*. Anything you use to make a supply chain work is a *resource*. People are resources. Facilities are resources. Machines are resources. Inventory is a resource. Every resource has constraints — things it can’t do. The constraints may be physical limitations, or they may be limits imposed on the supply chain by financial, safety, and policy rules. Here are some examples of constraints that may exist for your supply chain resources:

- » Employees can work only 40 hours per week unless you pay overtime.
- » A machine needs to be serviced after every 1,000 hours of operation.
- » Operators must be certified on a piece of equipment before using it.
- » Finished-goods inventory can't be stored outside during the winter.

Each of these factors limits the capacity of your resources, so your supply chain plan needs to take these constraints into account. A plan that assumes a 45-hour workweek but doesn't include the additional cost of overtime will cause you to miss your financial targets. A plan that involves storing inventory outside may work during the summer but not during the winter. Constraints are not always obvious; it takes research and judgment to understand all the constraints that affect a supply chain's performance. Identifying and managing constraints is critical for effective planning.

The plan you create explains how you intend to meet your requirements while taking your resources and constraints into account. Suppose your requirement is to make 100 widgets per day. You will need manufacturing equipment, skilled employees, raw materials from your suppliers, and many other resources. Each of these resources is subject to constraints. Perhaps the manufacturing equipment can produce only ten widgets per hour, the raw materials won't be delivered for five weeks, and your employees are available only on Tuesdays. Your supply chain plan needs to explain how you will meet your requirements with the resources you have available.

The supply chain planning model shown in [Figure 5-1](#) illustrates the factors involved in aligning resources with requirements and shows that all those factors are subject to constraints.



**FIGURE 5-1:** Supply chain planning model.

## *Analyzing Your Customers*

I define a supply chain as “a complex system made up of people, processes, and technologies that is engineered and managed to deliver value to a customer.” Supply chain planning requires that you align plans with the needs of your customers. Each customer is unique, and the better you understand your customers, the better chance you have of ensuring that your supply chain delivers the value they expect.

Some customers have specific needs or tastes and are willing to wait — and pay — for a custom product that’s just perfect for them. These customers would be dissatisfied with a generic product, even if it were cheaper and immediately available. If you have customers like these, you probably need to have an engineer-to-order supply chain. Other customers are more interested in getting the lowest cost, which might lead you to implement a make-to-order supply chain. Still other customers need to have your product immediately, which forces you to implement a make-to-stock supply chain. Understanding your customers’ expectations helps you make better decisions.

There are three common ways to analyze customer needs:

- » Market segmentation
- » Persona development
- » Key customer analysis

With market segmentation, you group customers based on demographic characteristics. If your customers are people, their demographics may include where they live, how much money they make, and how old their children are. If your customers are businesses, their demographics may include their industry classification, annual revenue, and the number of employees. Once you have defined your customer segments, you can check to ensure that your supply chain plan will align with each segment's needs.

Another way to study your customers is to create personas for them. A *persona* (or customer profile) is a description of an imaginary customer that represents characteristics of many of your real customers. The following example is a persona that a consumer products company might create to describe a target customer for its laundry soap:

Bob is a single man who works 60 hours a week and has an active social life outside work. He's drawn to hacks that can solve problems quickly and easily. For him, washing clothes is a chore, but a necessary one. He buys his laundry soap in a drugstore near his apartment.

Analyzing a persona can help you identify what customers value so that you can make a supply chain that better meets their needs. Perhaps customers like Bob would prefer laundry soap that was packaged differently and delivered directly to their homes.

A third way to define customer requirements is to identify the customers who are most likely to buy your products — your *key customers*. By studying your key customers, you can get a better idea of what they want or need, how much they'll buy, and how much they're willing to pay.



A customer relationship management (CRM) system can provide useful data for studying your customers by tracking purchases and other interactions with customers. CRM data can be used to create personas, to analyze market segments, or to study key customer behaviors. (See [Chapter 11](#) for more information about CRM systems.) Additionally, many CRM systems allow you to run experiments that provide insights into customers' preferences. You could gather data through A/B testing, for example, by offering two versions of a promotion and tracking how customers respond to each version.

## *Planning Your Products*

Part of supply chain planning is being clear about what you're going to make and how you'll make it. The supply chain for a product can change based on demand-related factors such as customer feedback. Supply chains can also change based on supply-related factors such as supplier quality problems. Resources and constraints in your supply chain may force you to make changes to your product. Knowing which materials are readily available, where to get them, and how much they cost are important factors in making design decisions for many products. Product characteristics often evolve over time, and those characteristics should be incorporated into your planning.

A good example of how product characteristics need to be considered during supply chain planning comes from the catalytic converter that goes into the exhaust system of a car. There are two metals that can be used as the catalyst in a catalytic converter: platinum and palladium. The prices for these metals change significantly over time. When platinum becomes expensive, automakers opt for catalytic converters that are made from palladium. When palladium becomes expensive, automakers switch back to platinum. In other words, as the prices of platinum and palladium fluctuate, automakers change their product designs and replan their supply chains.

Another good example of how product characteristics can influence supply chain requirements occurs in the fast-food business. The seasonings used by restaurant chains can differ depending on where each



restaurant is located. So even though the logo, uniforms, and menus may look the same wherever you go, a different supply chain provides the seasonings used in different regions.



**TIP** A bill of materials (see [Chapter 6](#)) lists the parts that go into a product and can help you identify resources to include in your supply chain plan.

Yet another example of how products affect the supply chain is package size and quantity. Knowing whether you're going to be packaging a box of crayons for individual sale or shipping crayons in huge tubs can be an important factor in determining the requirements of your supply chain and defining the resources you need. Small boxes need to be easy for store associates to handle. Large tubs need to be compatible with the material handling equipment at each step in the downstream supply chain.

## *Planning Your Production Systems*

Your production plan determines when, where, and how to make products so that you can meet your requirements without violating your production constraints. Your production system will involve planning for inventory. *Raw materials inventory* is material that you have received from suppliers at the start of your production process, and *finished goods inventory* is material at the end of the production process that you can sell to customers. Partially assembled products between manufacturing steps are called *work-in-process* (WIP, pronounced *whip*) *inventory*.

You could plan to ship all the raw materials to a single facility and manufacture your products there, for example. This scenario is an example of *centralized production*. When manufacturing requires large investments in capital equipment (such as expensive factories), a plan for centralized production may make sense. Centralized production tends to make manufacturing more efficient but often leads to long delivery times and high transportation costs.

When customer or product requirements demand short lead times and low transportation costs, a *distributed production* plan may make more sense. Distributed production involves manufacturing products at multiple sites to satisfy demand in each region.



**TIP** 3D printing (see [Chapter 12](#)) has the potential to make distributed production a good option for many products that are manufactured centrally today.

If one of your manufacturing facilities doesn't have the capacity to manufacture your entire product, you could split the manufacturing process among several factories. Splitting manufacturing steps across multiple factories can be a good way to increase your access to resources and overcome constraints (such as not having enough space or enough people) in each production facility. Splitting manufacturing can also give you access to local expertise and lower-cost resources.

One issue to consider when splitting up the steps in a manufacturing process is the effect it will have on inventory. The farther one manufacturing step is from the next one, the more WIP you're likely to accumulate between the steps. So you need to weigh the benefits of dividing a manufacturing process against the potential of that change for increasing WIP, along with additional transportation costs.

## *Planning Your Delivery Systems*

Making your products is one thing; getting them to your customers is quite another. Factors such as the locations involved, the characteristics of your product, and the needs of your customers can constrain your delivery system. The work of delivery (which includes moving and storing products) is called *logistics*. The collection of resources you use to do this work is a *logistics* (or distribution) *network*.

Logistics networks come in many shapes and sizes. If you're making small widgets and selling them directly to consumers via the Internet, for

example, you might put an e-commerce fulfillment center next to your factory. That arrangement makes it easy to ship products to your customers when they place an order. In this case, your logistics network starts at your suppliers, flows through your factory to your fulfillment center, and ends with your customers. Any resource that you use along the way to move or store the products is part of your logistics network.

But if you're selling your widgets through a big-box store chain, your factory probably needs to ship product by the truckload. If you're sending widgets to stores internationally, you may need to ship them by the containerload. Depending on where you ship the products, you may need to think about issues such as tariffs and international trade rules. In each case, you have a different logistics network and need different resources to support your logistics processes.



**TIP** [Chapter 8](#) provides more information about what's involved in delivering a product.

## *Planning for Returns*

When you plan your supply chain, you need to account for returns. Returns are normal in most businesses, but they're often overlooked during the planning process. For many industries, 5 to 10 percent of all the products sold may be returned by customers. In e-commerce, this figure can be 30 percent or higher.



**TIP** Many e-commerce retailers make it easy for customers to return products because this policy increases sales.

The network for returned products is called a *reverse supply chain* because the flow goes from the customer back to your company. Reverse supply chains, however, involve more than just customers returning products they don't need, don't want, or are dissatisfied with. Reverse

supply chains can also be used to repair, remanufacture, or recycle products, as well as ensure that hazardous products are disposed of safely. As in any other supply chain, the goals of a reverse supply chain include minimizing costs and maximizing the value. In many cases the value of a reverse supply chain is measured by the amount of money that is recovered from returned products.

Companies that make computers, for example, have reverse supply chains. If you buy a computer that stops working during the warranty period, you can usually send it back to the manufacturer. The manufacturer wants to make the return fast and easy for you as a customer so that you buy more of its products in the future. It may even send you a new replacement computer. But now the company has an almost-new computer that doesn't work. If it does nothing with the returned computer, the defective computer is a write-off. The company, however, may be able to recover most of the value of the returned asset by planning the reverse supply chain properly. For example, it can run a series of tests, repair the defects, and then resell the computer as a refurbished unit.



**REMEMBER** A well-planned reverse supply chain for returned products creates value in two ways: It keeps customers happy, and it reduces losses from disposing of used, damaged, or defective products.

Another strategy for reverse supply chains focuses on recycling. Many products contain valuable materials that can be recovered when the product reaches the end of its life. Electronic devices, for example, contain precious metals such as silver and gold that can be recovered. Perhaps the best example of a reverse supply chain are the junkyards and scrap recyclers that collect everything from old cans to old cars to be melted down and turned into new products.

Automobiles, airplanes, and heavy equipment have many components that can be remanufactured. These used components, called *cores*, become raw materials for a remanufacturing process that makes like-

new parts. Remanufactured parts typically are much cheaper to make than new parts, and those savings can be passed along to customers.

In addition to being good for business, reverse supply chains can benefit the environment, especially for products that contain harmful chemicals (as batteries and some electronic devices do). Given the opportunity to recapture value from used products and the environmental benefits, many companies are striving to design closed-loop supply chains, which means that all their products can be recycled.



**TIP** There's more information about building sustainable supply chains in [Chapter 19](#).

# Chapter 6

## Sourcing, Purchasing, and Procurement

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### IN THIS CHAPTER

- » Evaluating total costs for purchasing
  - » Creating supplier categories and segments
  - » Managing relationships with your suppliers
  - » Addressing procurement risks
- 

For your company to sell things to your customers, it first needs to buy things from other companies. In the SCOR Model discussed in [Chapter 4](#), this process is called *source*, but it is often called *purchasing* or *procurement*. The companies that sell you goods and services are your *suppliers* or *vendors*. Because the materials in a supply chain flow from raw materials down to a customer, your suppliers are *upstream* in your supply chain.

Procurement professionals add value to the supply chain by continually evaluating the marketplace and selecting sourcing strategies that minimize risk and cost for their companies. One of their responsibilities should include calculating the total cost of each option, because the up-front savings from any one change is often offset by additional costs down the road.

In this chapter, I discuss the issues you need to consider as part of your purchasing process. Supply chain management includes decisions about what to buy, where to buy it, when to buy it, and how much to purchase at one time. These choices have a big effect on the cost of providing your customers the products and services they need. The money you

save by making good decisions about purchasing allows you to lower the prices you charge customers and increase profits for your business.

## *Understanding Strategic Sourcing*

Purchasing departments used to focus exclusively on buying stuff as cheaply as possible. As executives have come to understand the effect that purchasing has on supply chains, awareness has grown that procurement needs to be strategic. Smart companies now compile their purchasing data to evaluate what they buy, who they buy it from, and what they could change to improve their supply chain. This process is called *strategic sourcing*.

It seem like every consulting company has its own model for strategic sourcing, but these models have some basic steps in common:

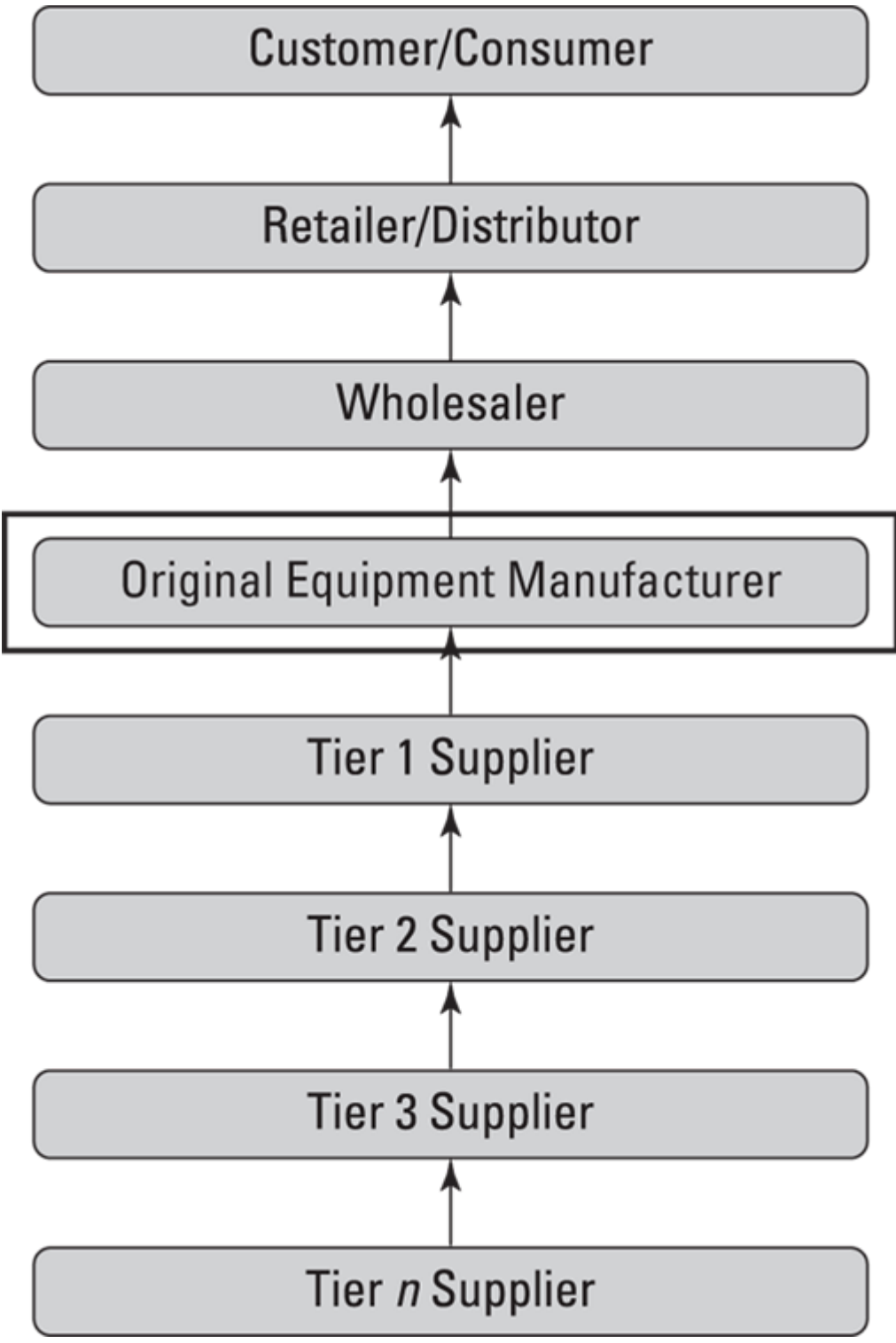
1. Collect and analyze data about what you bought in the past.
2. Collect and analyze forecasts about what you'll buy in the future.
3. Evaluate how past suppliers have performed in terms of cost, quality, reliability, sustainability, and social responsibility.
4. Investigate whether other suppliers could provide the same products and services at better prices, higher quality levels, more reliably, or more sustainably.
5. Consider opportunities to outsource or insource the products or services.
6. Determine how important the product or service is and how available it is in the marketplace.
7. Evaluate the effect of payment terms on your working capital.
8. Assess risks associated with each supplier.
9. Make changes.
10. Repeat Steps 1–9.

The value of strategic sourcing can be measured by looking for costs — and missed revenue opportunities — that have occurred in the past. Applying the principles of strategic sourcing helps to ensure that you're optimizing the future performance of your entire supply chain.

## *Segmenting Your Supply Chain*

It's easier to analyze purchasing data when you understand the characteristics of your suppliers. One way to segment suppliers is to place them in tiers based on how far upstream they are in your supply chain. The companies that you buy from are your tier 1 suppliers; the companies from which your tier 1 suppliers buy goods and services are your tier 2 suppliers, and so on, as shown in [Figure 6-1](#). The company that makes the final product, at the end of all of the tiers, is called the *original equipment manufacturer (OEM)*.





**FIGURE 6-1:** Tiers in a supply chain.

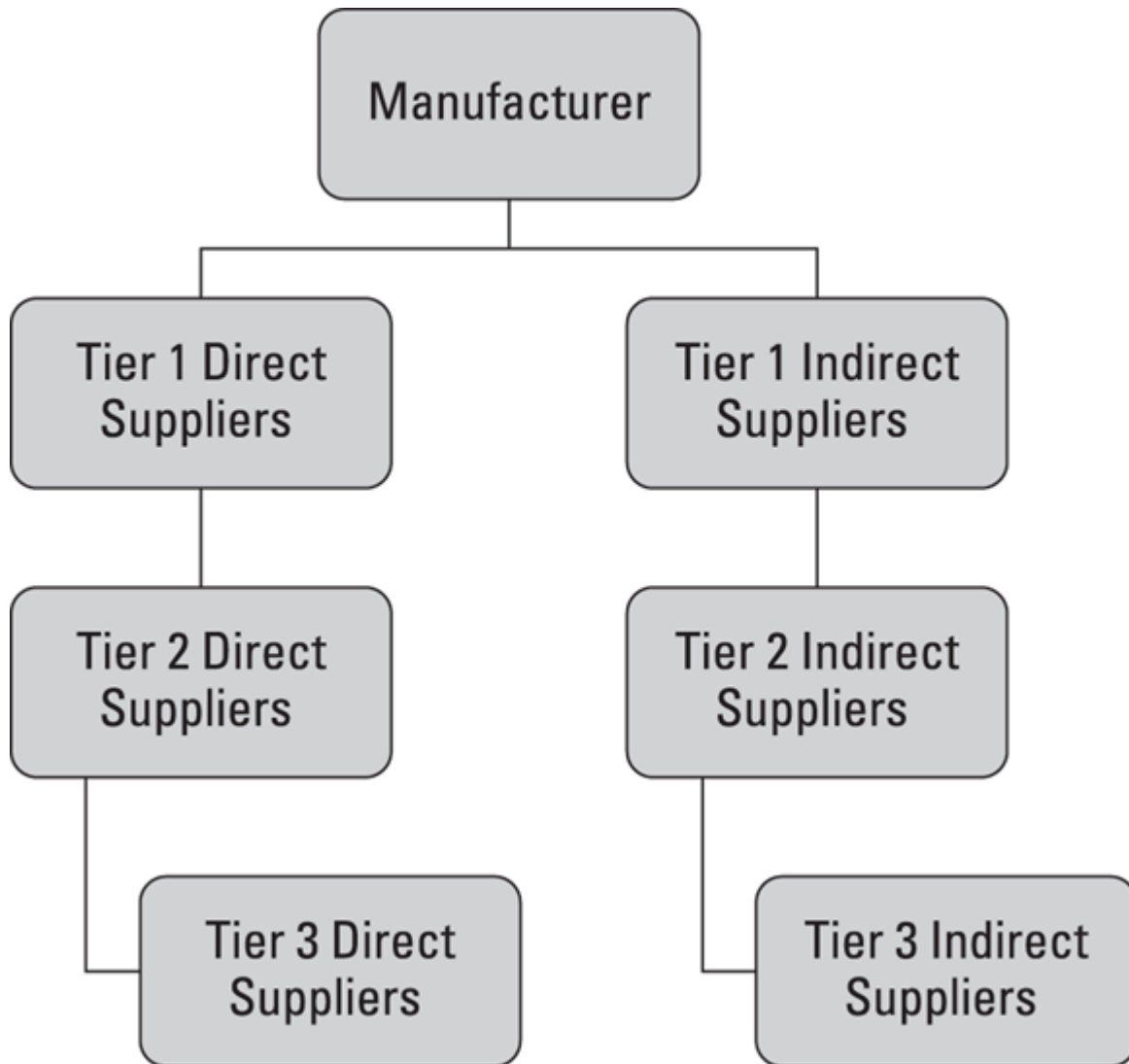
Suppliers can also be segmented into *spend categories* based on how your company uses the goods and services that they provide. If a

supplier is providing things that get included in your products, this company is a *direct supplier*. The things you buy from that supplier are *direct materials* and *direct services*. If a supplier is providing things that aren't going to be included in the goods and services you sell, it's categorized as an *indirect supplier*.

Suppose that you have a fast-food restaurant. The companies that sell you hamburger patties, lettuce, and buns are tier 1 direct suppliers. You buy things from those suppliers that go directly into your products. The company that sells your supplier flour for the buns is one of your tier 2 suppliers. You may have no idea what company is that tier 2 supplier, but it plays an important role in keeping your supply chain working correctly.

On the other hand, the companies that sell you napkins, hand soap, and floor wax are tier 1 indirect suppliers because their products aren't incorporated into the products and services you sell. These indirect suppliers are just as important as your direct suppliers, and they're still part of your supply chain.

[Figure 6-2](#) shows part of an automotive OEM supply chain. The suppliers are categorized as either direct or indirect and are organized in tiers.



**FIGURE 6-2:** Tiers of direct and indirect suppliers.

## *Managing Total Costs*

Making a product or service requires you to purchase other products and services as inputs. The list of things you need to make a product is called the *bill of materials* (BOM). In other words, the BOM is like a shopping list.

An important part of purchasing is analyzing and understanding the total cost of everything you buy. The total cost is almost always much higher than what people would expect. Following are some of the costs that

factor into the total cost of your products and services and affect your company's finances:

- » Purchase price for materials
- » Transportation
- » Inventory holding costs
- » Quality inspection and defect resolution
- » Insurance
- » Shrinkage, security, and loss prevention
- » Duties, tariffs, and taxes
- » Permits
- » Licensing fees

The purchase price for materials is just one factor to consider when you calculate how much something is really going to cost. Combining all of the factors involved in purchasing materials gives you the *total landed cost*.

Many products continue to cost money after you have purchased them, and even after you have used or sold them. Consider these additional costs:

- » Maintenance
- » Disposal and recovery
- » Product liability, recalls, and warranties

These additional costs contribute to the *total cost of ownership* (TCO), or the life-cycle cost for a product. Understanding TCO can help you make purchasing decisions that deliver the greatest value over the long term, rather than just the lowest purchase cost or the lowest landed cost up front.

## ***Minimizing input costs***

Purchasing can have a huge effect on the profitability of any company. The products and services that your purchasing department buys are the inputs for your company, and every dollar you save by reducing input costs increases your profit. Here are some common ways to reduce costs:

- » Negotiate a long-term agreement in exchange for lower costs
- » Increase order quantities in exchange for a volume discount
- » Accept lower-quality products in exchange for a price reduction
- » Request new price quotes from lower-cost suppliers

More creative purchasing managers might explore additional alternatives that could translate into savings:

- » Extend the lead time that suppliers have to fill an order
- » Share information with suppliers that allows them to plan farther ahead
- » Change product or packaging designs to use less-expensive inputs
- » Provide financial guarantees to support a supplier's investment in facilities and equipment



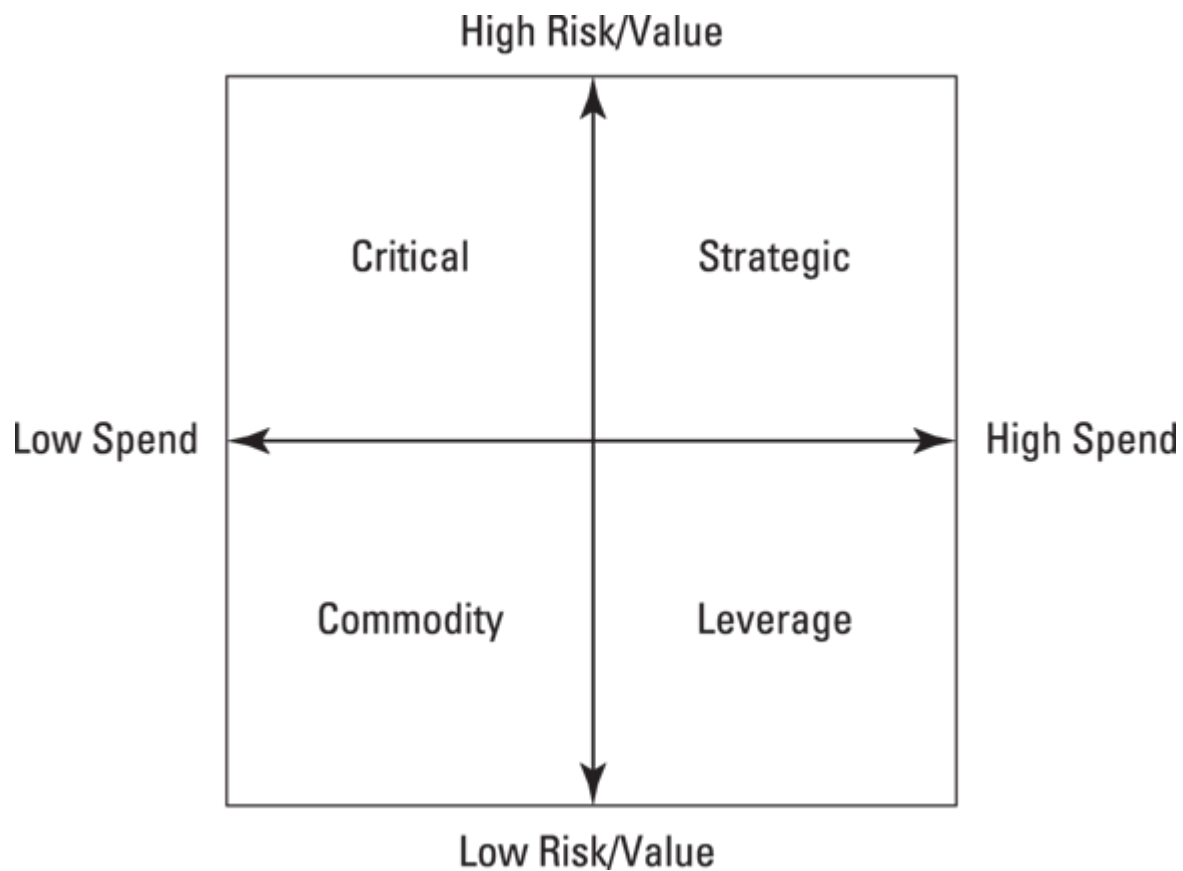
**REMEMBER** Minimizing input costs is an ongoing process. Purchasing managers should continually analyze the products and services they purchase, and collaborate with suppliers and internal teams to find new ways to reduce costs.

## *Sourcing your inputs*

Choosing where to buy your inputs can affect the quality of your products and services and the profitability of your company. You don't want to pay more than you need to for any of your inputs; doing so would be a waste of money. On the other hand, sometimes you get what you pay for. Trying to save money by choosing a low-cost supplier can

lead to higher transportation costs, unreliable deliveries, increases in inventory, or quality problems.

One way to approach this challenge is to segment your inputs into spend categories. You can segment inputs in lots of ways, but one common approach is to compare how important or risky each input is with how much money you spend on it. [Figure 6-3](#) shows an example of this kind of segmentation diagram.



**FIGURE 6-3:** Segmentation of inputs to a process.

Here are some guidelines for managing the procurement of goods and services in each of these categories:

- » **Leverage:** If you spend a lot of money on a particular input, but you can buy it from lots of places and have it delivered quickly, this input is an opportunity for leverage. In other words, this item is a negotiating chip that you can use to get better prices for other things.

- » **Commodity:** If you don't spend a lot of money on an input, and the item is easy to get when you need it, it's a commodity. Get the best deal you can, but don't worry too much about the supplier relationship. Make sure that you aren't buying something that is made unethically, of course.
- » **Critical:** If you don't spend a lot of money on a particular input, but the item is hard to get when you need it, it's a critical component with a high chance of creating bottlenecks. The same applies if your quality standards for an input are especially high. For critical components, you need to build and maintain strong relationships with your suppliers.
- » **Strategic:** If you spend a lot of money on an input, and that item is hard to get, it's a strategic input. Managing strategic inputs properly can be one of your biggest opportunities to increase profitability and reduce the risk in your company's supply chain. In addition to building strong relationships, you should think about the suppliers of strategic products and services as candidates for a merger, acquisition, or joint venture.



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This segmentation tool is often called a “Kraljic Matrix” because it was described in detail in an article by Peter Kraljic in the *Harvard Business Review*. You can read the article here:

<https://hbr.org/1983/09/purchasing-must-become-supply-management>.

## ARE HOME APPLIANCES A COMMODITY?

Home construction resembles a manufacturing supply chain. Construction contractors are the OEMs, and they source many different materials in order to build and sell their products.

Each home they build needs to have a stove and a refrigerator installed before a government inspector will issue a certificate of occupancy and allow the home to be sold. Because appliances are available from many different stores and distributors,

contractors usually treat appliances as commodities. But during the COVID-19 pandemic, there were times when appliances were unavailable throughout the United States. This meant construction companies were stuck with fully completed homes — some of them worth millions of dollars — that could not be sold.

As a result, many home building companies changed their sourcing strategy. They began to treat appliances as critical items, built stronger relationships with their suppliers, and purchased additional inventory in order to protect themselves from future supply chain disruptions.

## *Forecasting your demand*

The difference between buying 1 piece per week and buying 100 pieces per day could have a huge effect on which supplier you should be buying from and how much you should pay. Estimating how much of an item that you're going to need is called *demand forecasting*. Actual demand often fluctuates depending on many factors, such as how many finished products your customers decide to buy. Your forecast is an educated guess that helps you choose the best suppliers and negotiate the right terms.

## *Insourcing, outsourcing, and offshoring*

It's hard for a company to be successful when it tries to be a jack of all trades. Instead, each company needs to figure out which characteristics make it truly valuable in a supply chain. In the context of supply chain management, your *core competencies* are the things that your company can do better than others.



**REMEMBER** Core competencies determine your competitive position in a supply chain. Companies usually focus on building their core competencies through research and development and through continuous process improvement. Generally speaking, any work that's directly related to your core competencies should be done by employees working for the company. In other words, this work should be *insourced*.



Some work is important for your company but isn't a core competency. Other companies can do that same work better, faster, and cheaper than your company can. Because this work isn't your core competency, you may be better off *outsourcing* that work to another company.

In some cases, there are good business reasons to *offshore* work — take work that's being done in one country and move it to a different country. Offshoring can reduce costs and improve quality, as well as allow your company to access talent and open new markets.

Offshoring can also create challenges. Longer supply chains lead to higher transportation costs and the need to carry more inventory. Communication and coordination become more difficult when people are separated by distance, time zones, and languages. Offshoring can also create complex challenges for protecting intellectual property and complying with government regulations.

Your company may have decided a few years ago that offshoring made sense, but because of changes in the market, offshoring no longer provides the same benefits to your supply chain. In that case, you may decide to move the work from a foreign source to a domestic source, which is called *reshoring*.

To shorten their global supply chains, many companies are moving sourcing to a neighboring country. This is called *nearshoring*. Because of the geopolitical conflicts that have complicated supply chains in the past few years, there is also a growing trend to work with suppliers in countries that are political and military allies. This approach is called *friendshoring*. Some global companies manufacture the same products in different parts of the world. This allows them set up separate supply chains in each of those places, which is called *regional sourcing*.

A good example of an industry that does a lot of insourcing, outsourcing, and offshoring is automotive manufacturing. Most of the big auto brands see the design, assembly, and marketing of cars as their core competencies. The parts that go into their cars are often made by other companies. In other words, the automakers outsource the manufacturing of their components to their tier 1 suppliers. It might make sense to

purchase components from suppliers that are close to the automotive assembly facilities, because they'd have low transportation costs and short lead times. But in many cases it's much cheaper to manufacture components or even entire cars in another country, so the companies offshore these processes. Later, they may decide that it's better to do manufacturing in their home country and reshore these processes.

## *Managing Supplier Relationships*

From the standpoint of your suppliers, you're the customer. That fact may be obvious, but it's amazing how often people forget it. Think about all the things your customers do that make your life easier — or harder. Good customers give you plenty of notice when they want to buy something; they buy in predictable quantities; and they're willing to pay you a reasonable amount of money. Difficult customers order everything at the last minute, place huge orders, change or cancel orders at the last minute, and fight you over every penny. What kind of customer are you for your suppliers?

You might expect your suppliers to live by the saying “The customer is always right,” but you need to balance that with the saying “You get what you pay for.” As a customer, your purchasing behaviors affect both the costs that your supplier has to pay and your supplier's willingness to negotiate with you. If you can share an accurate forecast with your supplier far enough in advance, the supplier can safely reduce the amount of inventory it carries without concern about whether it can fill your orders — a definite win-win situation. If you understand this dynamic and use it to your advantage, your suppliers may pass some of their savings along to you. This scenario requires both sides to share some information, which requires trust.



**TIP**

Building and maintaining good relationships with suppliers can be a strategy for getting market intelligence and early access to new innovations. Your suppliers probably sell the same stuff to your

competitors that they sell to you. So they may know a lot more about trends and new technologies in the industry than you do, but they'll share that information only if they trust you.

Here are four things that you should focus on to build trust with your suppliers:

- » **Be honest.** Share information that will help your suppliers be more successful. If there's information that you can't share, just say so. But never lie to them.
- » **Be reasonable.** Your suppliers need to make money, so try to be reasonable when negotiating prices. Make it clear that you want your suppliers to be successful, but they need to help you be successful too.
- » **Ask WIIFM?** Ask yourself "What's In It for Me?" (WIIFM). Be clear about what you're getting out of the relationship with a supplier and what you would like to get.
- » **Ask WIIFT?** Ask yourself "What's In It for Them?" (WIIFT). Understand how your supplier benefits from doing business with you. Suppliers can choose not to accept your business, and that could make it harder to manage your whole supply chain.

Every supplier relationship eventually comes to an end. Often, this is a result of changing markets and technologies, but it can also be the result of a dispute. When you need to terminate a supplier relationship, make sure that you're following the terms and conditions of any contracts that you have in place. You should consider getting your attorney involved to make sure you aren't creating liability for your company.



**REMEMBER** There are two very good reasons why you should try to end supplier relationships on the best note possible:

- » You may need that supplier again in the future.

- » You don't want other suppliers to think your company is difficult to do business with.

## *Managing Procurement Processes*

The process that companies use to buy products and services is called the *procure to pay* (P2P) cycle. There are three main steps in the P2P cycle:

1. You send out a request for proposals (RFP). The RFP explains what you want to buy. Each potential supplier can respond to the RFP with a proposal that describes its products or services and how much it will charge for them. The proposal might also include information about the company's qualifications and why you should buy from that company.
2. You issue a purchase order (PO) to a supplier. The PO is an official document from your company authorizing the purchase. The PO includes details about the things you're buying, how much you want, when you want it delivered, and how much you're agreeing to pay. If the details on the PO match the information on the proposal, then the supplier will provide you with the products or services and send you an invoice.
3. You audit the supplier's invoice to make sure it is accurate. The audit should confirm that the prices and quantities on the invoice match the details on your PO. If everything looks right you pay the invoice.

Managing how you pay your invoices can have a big effect on your costs, cash flow, and supplier relationships. The longer you wait to pay an invoice, the more money you'll have sitting in your bank account. That's great! On the other hand, paying a supplier early will make them want to do more work with you. Some suppliers will even give you a discount for paying early. And if you don't pay your bills before the due date, you might end up paying late fees, which will increase your costs. If you're consistently late in making payments, suppliers might require

you to pay in advance, increase the amount they charge you, or refuse to do business with you.

## *Establishing Supply Contracts*

When you enter into an agreement with a supplier, you create a contract. Here are some of the common types of supply contracts:

- » **Firm-fixed-priced contract:** A firm-fixed-price contract sets out the amount of products or services that will be purchased and how much they will cost. This type of contract can include adjustments for inflation and can include incentives for meeting goals.
- » **Cost-plus contract:** A cost-plus contract reimburses a supplier for their costs and allows them to charge an additional fee. The fee is often a fixed percentage of the costs.
- » **Time and materials contract:** A time and materials contract is often used for repairs. The buyer agrees to pay the supplier specific rates for all of the parts and labor that they use on a project.



**TIP** You probably sign a time and materials contract when you take your car to the repair shop.

- » **Indefinite delivery contract:** An indefinite delivery contract is used when the buyer doesn't know how much they're going to order or when they'll need the materials delivered. These contracts usually provide minimum and maximum quantities for the supplier, while giving the buyer flexibility to purchase what they need, when they need it.



**TIP** Indefinite delivery contracts are useful when your production schedule is likely to vary.

## *Selecting contract terms*

From a supply chain perspective, there are two questions to keep in mind any time you establish the terms and conditions of a supplier contract:

- » How do you want things to work if everything goes as planned?
- » How will you handle surprises or changes?

For example, imagine the sorts of issues that a fast-food restaurant would need to consider when establishing contract terms with the company that supplies its hamburger buns:

- » How many buns does the supplier need to deliver?
- » How much will we pay for the buns?
- » How will we, and the supplier, measure quality?
- » How quickly does the supplier need to deliver orders?
- » How long will the contract last?
- » Can the supplier sell the same buns to other restaurants?
- » When will we pay for the buns?
- » How will we resolve issues and disagreements?

This list isn't complete, of course, but it gives you a sense of some of the issues involved when developing the terms of a contract with your suppliers.



**WARNING** I'm not a lawyer, so none of this information should be treated as legal advice. Before entering into a contract, you need to get advice from a lawyer. Making sure that your contract is written properly can protect both you and your supplier if things don't go the way you planned.

## *Selecting payment terms*

The terms that govern when you pay a supplier for the things you purchase can have a big effect on the financial performance of your supply chain. Of course, suppliers want you to pay them as soon as possible. But the longer you can wait before paying your suppliers, the better it is for your company's finances. A major concern for any supplier is that a customer won't pay an invoice, which is called a *default*. Payment terms come in four main types:

- » **Payment in advance:** Some companies want to have your money in their hands before they provide you with a product or service. This eliminates the risk of default,
- » **Payment on delivery:** A company may ask its customers to pay as soon as it delivers a product or service. With payment on delivery there's a small risk of default.
- » **Net payment terms:** Suppliers may be willing to wait for you to pay them. This is a form of credit called *net payment terms*. For example, a supplier may ship an order and expect you to pay the invoice in 30 days, which is called a *net 30 payment term*.
- » **Hybrid payment terms:** Many supply chain transactions involve a combination of payments terms. Combining payment terms can help both companies manage cashflow and risk. For example, a supplier may ask for a down payment when an order is placed, a partial payment when the order is delivered, and a final payment 30 days later.

Supplier payment terms affect your cash flow and working capital. The time between when you collect money from your customers and the time when you pay your suppliers is called the *cash conversion cycle*.

Following are three examples that show how the cash conversion cycle can affect your business:

- » **Zero cash conversion cycle:** Suppose that you get paid when customers place an order and that you instantly place an order with your supplier and pay for it at the same time. In other words, you get paid, and your supplier gets paid, at the instant when your customer

places the order. In this case, your cash conversion cycle is zero. Many consignment relationships work this way.

- » **Positive cash conversion cycle:** Suppose that you buy products from suppliers on net 30 terms and sell to your customers on net 60 terms. That means that you pay your suppliers 30 days before you get paid by your customers. This is an example of a positive cash conversion cycle scenario. In this case you need to have 30 days' worth of working capital to finance your sales. Positive cash conversion cycles are common in all kinds of businesses. They're also expensive because that working capital often needs to be borrowed from a bank, and it limits the amount of money available to invest in other business activities.
- » **Negative cash conversion cycle:** Suppose that your customers pay you for a product today, but you can wait 30 days to pay your suppliers. In other words, you get to hang on to the money for 30 days, for free. Rather than paying a bank to borrow money, you can have the same bank pay you interest. Negative cash conversion cycles are rare, but they can be a powerful way for supply chains to drive value to a business.

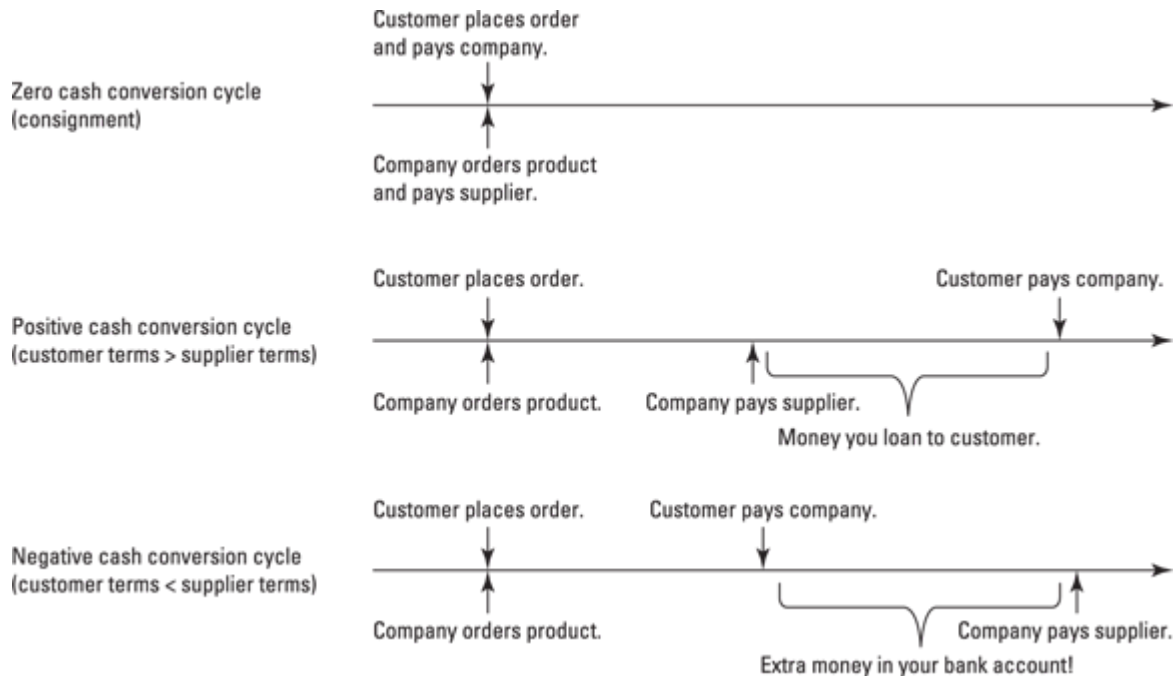


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The negative cash conversion cycle was one of the secrets to success in the early days of Dell Computer. They required customers to pay when an order was placed but negotiated net payment terms with its vendors. In effect, Dell Computer got to keep its customers' money sitting in the bank earning interest for a while before paying its suppliers.

[Figure 6-4](#) illustrates these cash conversion cycles.





**FIGURE 6-4:** Cash conversion cycles.

At first glance, it seems obvious that you want to have short payment terms with your customers and long payment terms with your suppliers, but that strategy may not be the best choice in the long run. Extending credit to customers may be necessary for you to earn their business. If you insist on getting your customers' money up front, and your competitors offer them net 30 terms, you may lose business. On the other end, you may think you're getting free credit by asking your suppliers to extend their payment terms, but it will eventually lead to higher prices.

## *Mitigating Supplier Risks*

One of the most challenging aspects of sourcing — and also one of the worst-managed — is dealing with risk. Calculating whether one supplier is cheaper than another is fairly easy. But how much would it cost if a supplier doesn't deliver on its promises? How will it affect your bottom line if the materials you buy are damaged, low-quality, counterfeit, or if they don't show up when you need them? That's why you need to consider the cost of supplier risk.



**TIP** Companies that outsource manufacturing need to consider the risk that a supplier might make unauthorized copies of their products and sell them through different channels. This is a common form of intellectual property theft that is often difficult to detect.

In general, you can think of *risk* as meaning *uncertainty*. Supply chains are full of uncertainty, so you're never going to identify and mitigate every risk. You can get a pretty good sense of what the most likely risks are, however, and develop strategies to minimize their effects.

### *Dealing with supplier risks*

You may think that there are lots of ways to handle a risk, but there are actually only four options, called *risk treatments*:

- » **Accepting the risk:** If you accept the risk, you know that it exists, but you're willing and prepared to live with the consequences if it occurs.
- » **Avoiding the risk:** Sometimes, you can make a choice to avoid the risk.
- » **Transferring the risk:** There are many risks that are unavoidable but potentially expensive, and you may want to transfer those risks to someone else.
- » **Mitigating the risk:** In many cases, there are things you can do to mitigate a risk — to make it less severe or less probable.



**TIP** You can find a more detailed explanation of risk treatments in [Chapter 18](#).

### *Implementing supplier development*

Sometimes, suppliers need your help to provide the products and services you need when and where you need them. When you help your suppliers do their job better, you're practicing supplier development. One common example of *supplier development* is to send your engineers and quality improvement specialists to help your supplier improve their processes. Supplier development can also include financial support, such as providing favorable payment terms. Supplier development is useful when there are a limited number of suppliers who can meet your requirements, such as when you're trying to source products in a region where there aren't many suppliers.

Robert Handfield, Daniel Krause, Thomas Scannell, and Robert Monczka wrote a good article about supplier development in MIT Sloan Management Review (<https://sloanreview.mit.edu/article/avoid-the-pitfalls-in-supplier-development>). They recommend a seven-step process for supplier development:

1. Identify critical commodities.
2. Identify critical suppliers.
3. Form a cross-functional team.
4. Meet with supplier top management.
5. Identify key projects.
6. Define details of agreement.
7. Monitor status and modify strategies.

When the process works properly, both your company and your suppliers will benefit from supplier development initiatives.

### ***Increasing supplier diversity***

Many companies have programs in place to increase the diversity of their supply base. Some companies even include *supplier diversity* in their sustainability goals. In the United States, regulations require many government contractors to buy products and services from businesses that are owned by veterans, people of color, women, people with

disabilities, and others. In addition to promoting social justice goals, supplier diversity can help companies build supply chains that are more resilient and more closely aligned with the customers and communities that they serve.



**TIP** The Diverse Manufacturing Supply Chain Alliance (DMSCA) is an association that helps companies improve the diversity of their supply base by implementing supplier development. DMSCA offers a corporate certification program for small suppliers called the Corporate Mentoring Program. Participating in this program shows diverse suppliers how to analyze and optimize their supply chains. The organization helps certified suppliers build stronger customer relationships with global manufacturing companies like Johnson & Johnson, Intel, and Abbott. To learn more about the Corporate Mentoring Program, check out [www.dmsca.us](http://www.dmsca.us).

## *Establishing Purchasing Ethics*

Because the purchasing process involves big decisions about large amounts of money, it's important to ensure that decisions are made in a fair and ethical way. People may not always recognize ethical dilemmas, however, or may have different judgements about right and wrong. To ensure that no confusion exists related to appropriate behavior in purchasing, it is common for companies to have a formal, written code of ethics that everyone who makes purchasing decisions is required to follow.

Your purchasing ethics policy may include the following situations:

- » Accepting gifts from suppliers
- » Supporting small businesses
- » Dealing honestly with suppliers
- » Avoiding slave labor and child labor

- » Complying with laws
- » Encouraging competition
- » Reporting conflicts of interest
- » Complying with payment terms
- » Evaluating how suppliers treat employees



**TIP** To find guidance on creating and implementing a purchasing ethics policy, consult a professional organization such as the Institute for Supply Management ([www.ismworld.org](http://www.ismworld.org)) or the Chartered Institute of Procurement and Supply ([www.cips.org](http://www.cips.org)).

## *Sustainable Sourcing*

Supply chain sustainability has become an important goal for many companies, but it can mean different things. At its most basic level, sustainability focuses on ensuring that your business can survive, or be sustained, for a long time. Some companies focus their sustainability efforts on reducing the use of nonrenewable resources. Other companies take a broader view and include social issues such as modern slavery and child labor, or environmental issues like genetically modified crops and organic farming. Many companies now use the 17 sustainable development goals adopted by the United Nations as a baseline. You can read more about these goals at

<https://sustainabledevelopment.un.org>.

No matter how you define sustainability, many of the things that a company can do to improve require a change in what they buy, how they buy it, or who they buy it from. As a result, sourcing plays a huge role in the sustainability of your supply chain.



TIP

There is more detailed information about the SDGs and sustainable sourcing in [Chapter 19](#).

To know whether the products and services that you purchase are sustainable, you need to work with suppliers who collect and share this information. This process can be a challenge, because your suppliers may not want to share information about where they buy their products. In some cases, suppliers may not have good systems for tracking this information. A common solution is to work with third-party certifying organizations — companies, not-for-profit organizations, or government agencies that do inspections and verify that a supplier's products and practices comply with sustainability standards. One example is the Rainforest Alliance (<https://rainforest-alliance.org>), which audits farms and forests to ensure that they are being managed sustainably.



TIP

Sustainable sourcing is most effective when you have transparency in your supply chain, but it can be hard to collect and share data from all the different companies involved. Many experts predict that blockchain will help provide this transparency and improve sustainable sourcing. (See [Chapter 13](#) for more information about blockchains.)

# Chapter 7

## Making Your Products or Services

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### IN THIS CHAPTER

- » Deciding what to make, how much to make, and when to make it
  - » Selecting the right manufacturing processes for your supply chain
  - » Improving quality and reducing waste
- 

Every business makes something — a product or a service — and every product or service has a supply chain. This chapter describes how the steps you follow to make *anything* can be broken down into a handful of subprocesses so that you can measure and manage them effectively. In terms of a process framework such as the SCOR Model (see [Chapter 4](#)), *Make* refers to the group of processes that transform inputs into a new product or service that has value for a customer. The job of overseeing these processes is called *operations management* and the study of these processes is called *operations research*.

In this chapter, I explain how to design your operations so that you make the right number of products at the right time. First, you look at planning a production schedule. Then you examine the two main environments for making products: *discrete manufacturing*, in which items are made individually or in batches, and *continuous manufacturing*, where items are made in a stream. After that, you consider whether to make products before or after a customer places an order. Finally, you look at some of the key elements of managing quality and sustainability because these important strategic issues are heavily influenced by your *Make* processes.

Honestly, a lot of the terminology related to the Make process can be tough for folks to wrap their heads around, and different companies use the same words to mean different things. I've kept the definitions simple and provided examples based on things in your daily life, such as running a fast-food restaurant. But these exact same terms and concepts are used daily in the supply chains for cars, appliances, microwave dinners, and basically every other product and service that you buy. Throughout the chapter, try to think about how each topic relates to some part of your own business and whether your Make processes are aligned with what your customers truly value.



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A good place to go for precise definitions of many operations management terms is the Association for Supply Chain Management's *Supply Chain Dictionary*. There is also an ASCM Supply Chain Dictionary app, which includes quizzes, flashcards, and other activities that can help you build your operations management vocabulary. Visit [www.ascm.org/learning-development/certifications-credentials/dictionary](http://www.ascm.org/learning-development/certifications-credentials/dictionary) for more information.

## *Planning and Scheduling*

### *Production*

The process of making anything starts when you decide what to make, how much to make, and when to make it. In a manufacturing company, this process is (conveniently) called *production planning and scheduling*. Service companies make life more complicated by finding creative names for this process, but most of them sound a lot like “service planning and scheduling.”





**TIP** If you're working in a services supply chain, try not to get hung up on the word *Make*. Just remember that the point of any Make process is to transform inputs such as raw materials and technical skills into outputs for a customer. For a doctor, the Make process would be performing a surgical procedure. For an artist, it would be creating a painting.

## *Planning production*

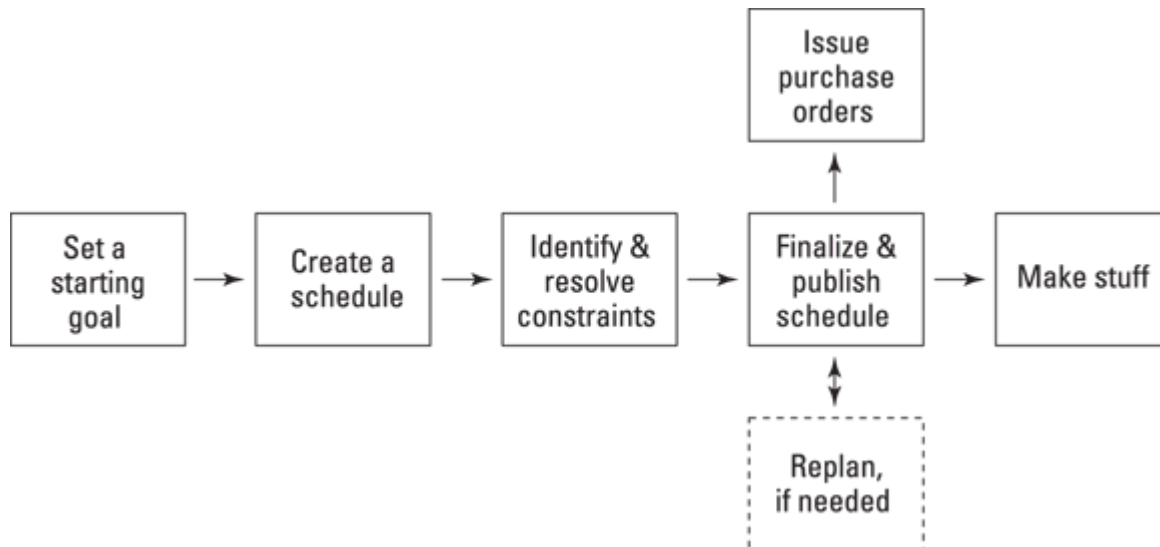
Before you can create a good production plan, you need to take a lot of factors into account. Here are ten examples of the kinds of information that you really, truly need to consider before you can tell whether a production plan will work:

- » When customers need the product and whether they're waiting for it now.
- » How long it'll take you to make the product.
- » The capacity of your manufacturing process.
- » The setup time required to make the product and whether that time will affect the setup time for other products.
- » How to prioritize the order in which you'll make products.
- » What parts, components, or supplies you need to have on hand so that you can make a particular product.
- » Whether you already have the parts you need or have to order them.
- » If you must order parts, the supplier's lead time and the shelf life of the products.
- » Risks that could disrupt production.
- » Whether you need to schedule time for breaks, holidays, changeovers, and equipment maintenance.

This list isn't complete, but it's enough to make the point: You have so many factors to consider that production planning can quickly become

overwhelming. The only way to make it work is to develop a production planning process and set some rules. You also need to ensure that the rules give you enough flexibility to change the plan when necessary.

[Figure 7-1](#) is a high-level view of the steps involved in creating a production schedule.



**FIGURE 7-1:** Production scheduling process flow.

### ***Setting a demand goal***

Production planning starts with a high-level goal: how much you want to sell. You can think of this goal as the “in a perfect world” scenario. If you think you’ll have 1 million customers next month in your fast-food restaurant, you’d start with a demand goal of 1 million hamburgers. This high-level demand goal is called the *master demand schedule* (MDS).

It’s okay if your MDS is optimistic, but try to keep it reasonable. There’s no point in building a production plan for a sales target that you’d never be able to meet.

### ***Creating a production schedule***

After determining your demand goal, you break that sales goal down into a *master production schedule* (MPS). In other words, building the MPS is how you to decide what you’ll need to make each day to meet the MDS goal. Creating an MPS forces you to look more closely at the materials you need and when you need them. It also drives you to look at the people and equipment you have available to make your products.

As you build your MPS, you begin to uncover *production constraints*, which are bottlenecks or problems that may interfere with production. You may not be able to order as much of the raw materials as you want because your suppliers don't have enough capacity, for example. Or perhaps your manufacturing equipment can't produce the materials quickly enough. In the example of a fast-food restaurant, two obvious constraints that the MPS will need to address are space and time. You have a limited amount of room to store buns, meat patties, and lettuce, and these ingredients are perishable, so you need to use them before they spoil.

Each constraint that you find requires you to make some decisions. You need to consider whether you can do something to resolve or eliminate the constraint, such as find a new supplier or rent extra storage space. Or you may need to change your production schedule. It's common to repeat this constraint resolution process several times, because each time you change the MPS to resolve a constraint, you need to check whether that change affects other constraints. In other words, production scheduling is an iterative process.

### ***Finalizing the production schedule***

When you know what materials you need to order, and you're confident that they can be delivered on time, you can finalize, publish, and execute your production schedule. The final production schedule gives your team its actual production targets: how much you expect to make and when you expect to make it. Your production schedule also drives purchase orders to authorize buying the components you need from your suppliers. The schedule may be broken into jobs or batches of products that are similar or that are being made for the same customer. When the jobs are scheduled, you can sequence the delivery of parts so that they show up just in time (JIT) for you to use them.



TIP

Lean Manufacturing often combines parts sequencing and just-in-time deliveries. In an automotive assembly plant, for example, many kinds of upholstery are used for car seats, so the seats are sequenced to show up in a particular order and are delivered to the assembly line right when they are needed (or as close as possible).

If everything works properly, your production schedule won't change and should be stable. But things don't always work that way. Even after the production schedule is published, there's a good chance that you may end up making changes if things don't go as you expect — if a shipment of supplies gets delayed or a machine breaks down, for example. When you revise the schedule, you may have to change the order of production jobs or adjust your production targets. This replanning affects both your suppliers and your inventory levels, because it changes the order in which you use each component. Because so many activities are driven by the production schedule, frequent replanning can cause confusion and frustration. A production schedule that changes too often is called a *nervous schedule*.



TIP

Nervous production schedules create waste in a supply chain, such as unnecessary work and excess inventory.

Most companies make a choice about how far in advance they can realistically change the production schedule without creating chaos for their supply chain. This threshold, usually measured in days or weeks, is called a *time fence*. A company might decide that it's okay to make a change to the production schedule with at least one week's notice. In this case, it would be possible (but not desirable) to make changes to the production schedule outside the one-week time fence. But when the company crosses that time fence — is less than one week out from a production run — the schedule is frozen, and no more changes will be allowed.



**REMEMBER** The earlier in the process you can identify a constraint and replan the production schedule, the better off you'll be. In most cases, changing the production schedule after you've already issued purchase orders for the supplies means that you'll end up with extra inventory, which increases your costs.

You can think about the challenge of production scheduling for a fast-food restaurant. Suppose that something unexpected happens: You sell fewer burgers than you expected, everyone asks for extra pickles, or there's a recall on lettuce. In each case, you need to see whether these differences change your goals or create constraints; if they do, you'd need to replan your production schedule.



**TIP** Your production targets should always be aligned with your sales goals to ensure that you aren't making too much or too little to satisfy your customers. This process, called sales and operations planning, is discussed in [Chapter 3](#).



**TECHNICAL STUFF** In the old days, people prepared and updated production schedules manually, which was a complex, time-consuming process. Today, most companies update schedules automatically by using material requirements planning (MRP) software. See [Chapter 11](#) for a more detailed explanation.



**TIP** Supply chain instructor Steve Christensen says, "It's silly to create rigid production plans to support an unpredictable environment." He is certified by the Demand Driven Institute, which argues that the way most MRP systems plan production

causes nervousness and extra inventory in the supply chain. You can find information about the Demand Driven Institute in [Chapter 21](#).

## ***Considering capacity***

Every person, every group of people, and every machine in the world has a limit to how much it can process or produce in a particular amount of time. You refer to this limit as your *capacity*. There are lots of ways to measure and define capacity, but when you strip away the fluff, every supply chain manager needs to understand three concepts because they factor into your production plan: design capacity, operating capacity, and capacity utilization.

### ***Design capacity***

*Design capacity (or theoretical capacity)* is the maximum that a machine (or person) can possibly produce. The design capacity of your imaginary fast-food restaurant is the amount you could make if every person and every machine were running continuously, every minute of every day.

### ***Operating capacity***

Most processes don't run at their design capacity (at least not for very long!). People need to take breaks. Facilities shut down for shift changes. It takes time to perform equipment maintenance and upgrades. When you take these constraints into account, you end up with a much lower limit on how much you can make. This is your *operating capacity (or effective capacity)*.

Unless you're making only one product over and over, you probably need to shut down some machines and make changes between jobs, such as switching tools or bringing in different components. This setup time affects how much operating capacity is available for making products. And, of course, things can go wrong: A machine could break down, you could run out of inventory, or someone could be late for a shift. Any of these issues — and many others — can slow a manufacturing process, and eat away at your efficiency.



TECHNICAL  
STUFF

Manufacturing companies often focus on reducing the time it takes to change over equipment between production runs. This approach is called Single-Minute Exchange of Die (SMED).

Operating capacity is one of the main constraints on production processes. In many cases, you can do things to increase operating capacity, such as running extra shifts or changing your maintenance procedures. Therefore, you may have some flexibility when managing the operating capacity for your production plan. A common goal for supply chain managers is to increase operating capacity and get it as close as possible to the design capacity.



**TIP** Delaying maintenance on equipment can sometimes provide a short term increase in operating capacity, but this could lead to breakdowns and damage that will reduce operating capacity in the future.

### *Capacity utilization*

With all the factors that can constrain production, the actual output of a manufacturing process is often a fraction of how much you think it could make. This percentage is called *capacity utilization*. If your process is running at full speed, making as many widgets as it possibly can, your capacity utilization is 100 percent. A common way to measure production output, or *yield*, is the percentage of operating capacity that you actually use.



TECHNICAL  
STUFF

The U.S. Federal Reserve tracks production across many industries. You can find the latest capacity utilization rates at [www.federalreserve.gov](http://www.federalreserve.gov).

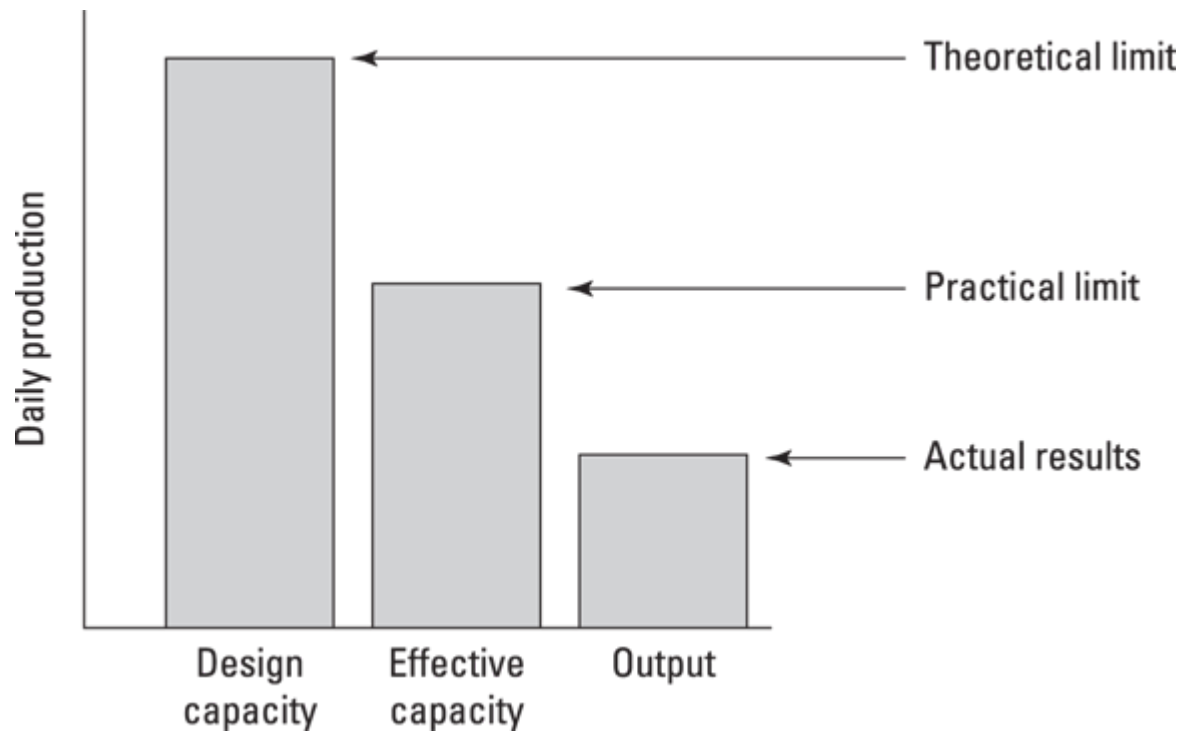


**REMEMBER** A common goal of supply chain management is to increase capacity utilization. The more capacity you use, the more products you're producing and the more money you're able to make with the assets you have.

You can see how these concepts are related for a fast-food restaurant. The number of burgers you make is your production output, which is a smaller quantity than your operating capacity, which in turn is smaller than your design capacity. [Figure 7-2](#) illustrates the relationship of production output (capacity utilization) to operating capacity and design capacity.

Increasing capacity utilization always sounds like a good idea at first. But when you look at it more closely, increasing capacity utilization can actually increase your costs and decrease your efficiency. Your car, for example, probably has the capacity to drive at 100 miles per hour, but it gets much better gas mileage at 50 miles per hour. (Let's ignore traffic laws for now and focus on the mechanical issues.) In addition to burning more gas, driving your car at 100 miles per hour is going to cause many of the parts to wear out more quickly, and it gives you less time to react to potholes in the road. So even though the car has the *capacity* to go faster if you need it to, you'll probably choose a slower pace for day-to-day commuting. In other words, you'll decide that it's better overall to operate your car well below its capacity.





**FIGURE 7-2:** Manufacturing capacity and output.

Manufacturing processes often become less efficient when they get close to their capacity limits. One obvious reason is that equipment may wear out faster, which causes breakdowns. Also, increasing capacity utilization (in other words, making more products) can create an inventory problem if the rest of your supply chain can't keep up. (Refer to the Theory of Constraints in [Chapter 16](#).) Your real goal as a supply chain manager is to make only as many products as your customers will buy — to provide enough supply to meet demand. If your output is high, but your sales are low, then you are spending money faster than you are making money. In that case, increasing manufacturing capacity utilization means that you'll build up unneeded inventory and tie up your company's cash.



**REMEMBER** The goal of production planning is to make products your customers will buy at the time they need them. Building your production schedule around customer demand and supply chain constraints ensures that you use capacity efficiently while keeping your inventory as low as possible.

## DEFENSE PRODUCTION ACT

In some cases, supply chain management is actually a matter of national security. The Defense Production Act (DPA) is a U.S. law that gives the president broad powers over companies when there is an emergency. The DPA was originally created to ensure that the U.S. industrial base would be able to respond quickly in the event of a war, but during the COVID-19 pandemic it was invoked to increase production of face masks, ventilators, and later, infant formula.

# *Identifying Manufacturing Process Types*

The world of supply chain management has two types of processes for manufacturing products:

- » **Discrete:** Some products are manufactured as separate items or in batches. In other words, they're made by a *discrete* process.
- » **Continuous:** Other products can't be easily separated into individual units or batches, so they're made by a *continuous* process.

In your imaginary restaurant, the burgers and fries are made with a discrete process, and the soft ice cream is made with a continuous process. Each burger and each French fry will be slightly different. But the soft ice cream is all mixed together. Understanding the basic differences between discrete and continuous manufacturing processes

will help you think about ways to manage your supply chain more effectively.

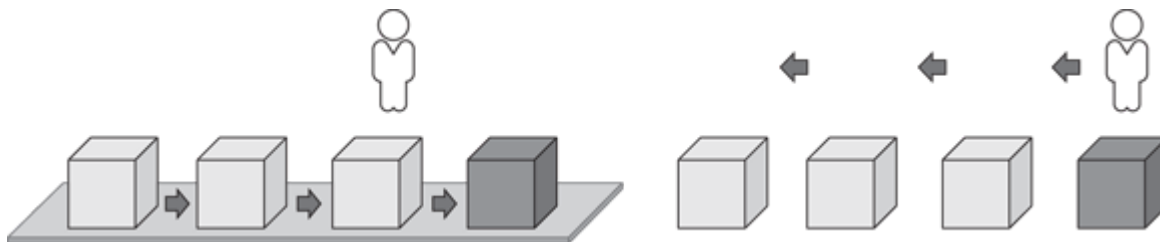
## *Operating a discrete manufacturing process*

Televisions, cars, guitars, furniture, and clothing are all made using discrete manufacturing processes. The output of a discrete manufacturing process is measured by the number of items produced during a certain period, such as per hour or per day. This metric is the *production rate*.



**REMEMBER** Many principles of discrete manufacturing also apply to the supply chains of service companies. A call center may measure its production rate as the number of calls handled per day; a cleaning service may measure its production rate by the number of houses cleaned each week.

Discrete manufacturing usually is broken into steps that are repeated for each product. There are two ways to execute this work: with an assembly line or with cellular manufacturing. [Figure 7-3](#) illustrates the difference.



**FIGURE 7-3:** Assembly line versus cellular manufacturing.

You can bring the work to the workers by using an assembly line. With an assembly line, the same production steps are repeated at each station while the products keep moving down the line from one station to the next. The time required for each step in an assembly-line process is called *takt time* (pronounced *tacked time*). To create a smooth flow on an assembly line, all of the process steps need to have a similar takt time.

Adjusting process steps to achieve consistent takt times is called *balancing* or *leveling* a line.



TECHNICAL  
STUFF

*Takt* is the German word for the baton a symphony conductor waves to set the tempo for an orchestra.

The time required for all the production steps to be completed is called the *cycle time*. In other words, the cycle time is the minimum amount of time required to make each product or batch of products. Cycle time is calculated by adding up the takt times from all the steps in the process. Ford Motor Co. pioneered the use of moving assembly lines with the Model-T in 1913. The cycle time for Ford's production process was just 93 minutes, and the production rate was one car every three minutes. (Some automotive historians have claimed that Model-Ts had to be painted black because black paint dried faster than other colors.)

For products that are bulky and difficult to move or that require a lot of time and customization, using an assembly line may not be the best approach. It may be easier to build the entire product in one place by bringing the tools and components to that spot. The place where these products are built is called a *manufacturing cell* (or *manufacturing stall*), and this approach is called *cellular manufacturing*. You'll find manufacturing cells in factories for big products such as airplanes and mobile homes. You can also find manufacturing cells in factories that produce small artistic items, such as jewelry or hand-painted crafts.



TECHNICAL  
STUFF

The use of the word *cellular* in this case goes back to the days before cellphones. It's ironic, but you'd never use a cellular manufacturing process for manufacturing a mass-production product like a cellular phone.

Whether you're using cellular manufacturing or an assembly line, the capacity of discrete manufacturing is relatively flexible. You can operate

a manufacturing line for a single shift (or even part of a shift) and then shut down the line. If you need more capacity, you can add a second or third shift to that same line without buying new equipment or changing the process.

On the down side, discrete manufacturing is inherently inefficient because the equipment sits idle any time you aren't using it to make products. You pay to have the equipment 24/7, even if you use it for only part of a shift each day.

Another challenge in discrete manufacturing is that gaps occur between steps because each step takes a different amount of time. It might take three minutes to cook a hamburger, but the next step — slapping it on a bun with ketchup and mustard — takes only a few seconds. So you could say that discrete manufacturing is “lumpy” and the variations in time between processes create waste and inefficiency. When applying Lean Manufacturing principles, supply chain managers often look for ways to reduce the gaps between process steps and even out the flow of products throughout the entire supply chain. (For more information on Lean Manufacturing, see [Chapter 16](#).)



**TIP** Many of the principles of Lean Manufacturing increase the efficiency of discrete manufacturing processes by making them behave more like continuous manufacturing processes.

## ***Operating a continuous manufacturing process***

Lots of manufacturing processes don't involve individual items. Breweries, chemical manufacturers, gasoline refineries, food-processing plants, and even electrical power plants that burn coal or natural gas are examples of businesses that use continuous processes. With a continuous process, you feed material into one end and get a steady stream of product out the other end.

When they're running, continuous manufacturing processes tend to be highly efficient, because the capacity of each step in the process can be sized for the same rate of material flow, or *throughput*. Starting and

stopping continuous processes, however, is often slower and more expensive than starting and stopping discrete processes.

Another common challenge in continuous manufacturing is that there is a minimum amount of flow required for the process to work. It's like a car engine that stalls out if it falls below a certain minimum speed. Also, in continuous manufacturing, it's harder to switch from making one product to start making another. You probably need to shut the line down, clean all the equipment, and then restart the entire line. So even though they're generally more efficient than discrete manufacturing, continuous manufacturing processes may not give you as much flexibility to adjust your production rate or change the types of products that you make.

## *Choosing Your Production Environment*

Choosing the right production environment is based on two factors: what you're making and what your customers need. To give customers what they want when they want it, you need to decide whether to make the product before customers are ready to buy it or whether you should wait until they place an order. You have three types of production environments to choose among:

- » Make-to-stock
- » Make-to-order
- » Engineer-to-order

The *total lead time* for a product (also called *customer response time*) is the time between when a customer places an order and when you deliver the product to them. The total lead time is made up of several smaller chunks of lead time, including the time it takes to process an order, the time it takes to make a product, and the time it takes to deliver the product to the customer. In other words, total lead time includes order processing lead time, manufacturing lead time, and delivery lead time.

[Figure 7-4](#) compares these production environments and shows how each of them affects both the amount of customization that is possible and the lead time for your products.



**FIGURE 7-4:** Make-to-stock, make-to-order, and engineer-to-order production.



**REMEMBER** When you decide which production environment to use, you need to consider how soon your customers need the product, how long it'll take to make it, and how much customization will be required.

### ***Make-to-stock***

If your customers need a product right away, and the product doesn't require customization, you probably want to have some finished goods inventory in stock ready for them to buy. This approach is called *make-to-stock*.

If you don't have products available for a customer to buy, they may take their business to your competitors. So the biggest benefit of a make-to-stock strategy is that customers can get their orders filled quickly. A make-to-stock strategy has some challenges, however:

- » When you make a product before you receive an order, your customers need to take the product the way it is; you can't customize

it for them.

- » You need to forecast how much your customers will buy and when they'll buy it. In other words, you're taking a risk and speculating that there'll be future demand.
- » After you make products, they sit in inventory and tie up cash until they're sold. You also have to consider the costs of the warehouse space and the people required to move, manage, and maintain the inventory.
- » Inventory can be stolen or damaged, and it can become obsolete.



TECHNICAL  
STUFF

You'll often hear supply chain professionals talk about the amount of money lost due to *shrinkage*. This is a nice way of describing products that are stolen, damaged, or wasted. They're called shrinkage because they lead to a reduction of inventory — and money!



REMEMBER

Inventory adds costs to the supply chain but also creates value by reducing lead times for your customer. In most cases, the goal of a supply chain manager is to maintain just enough inventory to meet their customers' needs.

## *Make-to-order*

If your manufacturing lead time is shorter than your customer's required response time, you may not need to have any inventory. Instead, you can wait until an order comes in and then produce the product for your customer. This *make-to-order* strategy has many benefits over the make-to-stock approach. Make-to-order eliminates finished goods inventory and warehousing costs, thereby freeing up cash and increasing profits.

Hamburgers are a good example of a make-to-order product. Your restaurant has all the ingredients ready, but you wouldn't want to make



hamburgers ahead of time and hope that someone will buy them. Instead, you'd wait for a customer to place an order and then cook it for them. Business cards are another good example of a make-to-order environment; the printer has all the materials ready, but they can't actually print your business cards until they know what to print on them.

To apply a make-to-order approach successfully, you need to address three challenges:

- » You must know the expected customer response time.
- » Your total lead time must be shorter than your customer's requirement.
- » Your manufacturing process must be reliable and have sufficient capacity to meet customer demand.

If a customer wants orders filled in 48 hours, and making the product takes you two weeks, a make-to-order strategy clearly won't work. But if you can make the product in 48 hours and your customers can wait two weeks after the order is placed, then make-to-order is an attractive option because it can reduce finished goods inventory costs without affecting product availability.

### ***Engineer-to-order***

In some cases, customers want specific products and services that really can't be preplanned, such as yachts, racing engines, or custom cabinets. When your customers want this type of customization, you must wait until they place an order before you even know what you'll be making. This production environment is called *engineer-to-order*.

With an engineer-to-order approach, you usually don't have a lot of finished product inventory to worry about, and your customers get the product or service exactly as they want it. But you also have a longer lead time before delivering the product to the customer, and demand forecasting and production scheduling are very difficult.

# PROCESS TYPES VERSUS PRODUCTION ENVIRONMENTS

You may be trying to sort out the differences between process types and production environments. *Process type* usually is determined by the type of product you're making. Discrete processes are used to make products that need to be assembled, and continuous processes are used to make products that need to be mixed, blended, or separated. The type of production environment has to do with how much lead time your customers will accept and how much customization they require. If the lead time needs to be short, you don't have time for customization; the production environment will be make-to-stock, and your customers will buy products from your inventory. If customers want some customization and can tolerate a longer lead time, your production environment will be make-to-order. When your customers want something unique and are willing to give you the time to design and make it, you'd choose an engineer-to-order production environment. The matrix shown in the figure gives examples of products that fit into each process type and each production environment.

Production environment is usually determined by customer needs and manufacturing lead time.

		Make-To-Stock	Make-To-Order	Engineer-To-Order
Process type is usually determined by product characteristics.	Discrete Manufacturing	Cell Phones	Hamburger	Custom Home
	Continuous Manufacturing	Gasoline	Asphalt	Specialty Paints



TIP

These are simple explanations of the different production environments. In the real world you will often see elements of make-to-stock, make-to-order, and engineer-to-order at different steps in the manufacturing process.

# *Implementing Quality Control and Quality Assurance*

Whether your process is continuous or discrete, and whether you operate a make-to-stock or make-to-order environment, your customers expect a certain level of quality. Ensuring that your supply chain produces high-quality products can have a big effect on the success of your business.

## *Considering the risks of poor quality*

Here are a few examples of the potential costs of poor quality:

- » Repairing, reworking, and scrapping poor-quality products
- » Returning, repairing, and replacing defective products
- » Refunding money to customers

Poor-quality products also create serious risks for your business:

- » Dissatisfied customers who won't buy your products in the future
- » Negative reviews that discourage potential customers
- » Liability for damages caused by defective products

You can probably think of many other ways that poor quality can suck profits from your company's bottom line. When you add together all the costs of poor quality, you can see why companies are so interested in improving quality in their manufacturing processes.

## *Controlling quality and variability*

Think about your imaginary fast-food restaurant and how your customers might describe the quality. Here are a few things that customers probably value in your French fries:

- » Ingredients that are clean and safe to eat
- » Food that is fully cooked

- » Consistent portion sizes (neither too big nor too small)
- » Reliable availability (prepared quickly and served hot)

To meet your customers' needs, you need to deliver high quality French fries every time someone places an order. Customers *might* forgive cold fries once or twice, but if they keep getting poor-quality products from you, they're going to stop coming to your restaurant.

You can measure the quality of a product — and how much variability you have in a process to make a product — through quality control (QC) and quality assurance (QA).

*Quality control* involves testing and measuring the outputs to make sure they're acceptable. QC might involve pulling a few products off of the line every hour and taking them to the laboratory for testing, or you might test-drive every new car to make sure that it works properly.

*Quality assurance* is about looking at each step in a production process and ensuring that things are working properly by measuring variability. QA starts with the realization that products are the output of a process. If the process is exactly the same all the time, the products will always be exactly the same. If a production process changes it creates differences in the finished products.



**TIP** Many companies use the terms *QC* and *QA* interchangeably. Strictly speaking, QC is about testing the products, and QA is about managing the process.



**REMEMBER** In any manufacturing process, controlling variability is at the heart of QA.

A small amount of variability in any process is natural. For example, the customers in a restaurant won't notice whether they receive their French fries in 3 minutes, or in 3 minutes and 10 seconds. Lots of things in a

production environment change throughout the day, such as temperature and humidity, and these changes result in small variations in a process. The result is *controlled variability*. The amount of variability that you choose to accept is called the *control limit* or *tolerance*. As long as your process is within its control limits, you can maintain an acceptable level of quality for the products you make.



**REMEMBER** Continuous process improvement methods such as Six Sigma can help tighten the tolerances for a process so that your outputs will be more consistent.

A little bit of variation may be okay, but variability is a problem when it's unexpected and your process exceeds your control limits. This type of variability is *random variability* (or *uncontrolled variability*). A customer in your restaurant would definitely notice if everyone else got served in 3 minutes but it took an hour for them to get their food. If a process is generating random results, there's a good chance that many of the products won't meet your quality standards or your customers' requirements. Investigating the root cause of uncontrolled variability often reveals hidden risks or problems in a process. If it took an hour to cook a hamburger, something went wrong in your process. Maybe the order got misplaced, or the chef took a break. You need to identify the root cause; then you can change the process to prevent that issue from occurring in the future.



**REMEMBER** Identifying and eliminating one root cause of uncontrolled variability can often help you fix several problems throughout a supply chain.



TECHNICAL  
STUFF

Quality gurus also talk about common-cause variability, which is similar to controlled variability, and special-cause variability, which is similar to random variability. Common-cause variability comes from something in the environment, like the temperature, whereas special-cause variability can be assigned to a specific source or event, like a misplaced order.



REMEMBER

QC and QA cost money and take time, but they protect against defects that can lead to even greater costs. Understanding the true costs of poor quality, such as rework, brand erosion, and warranty repairs, can help in calculating the benefits that you generate by investing in quality management.

## ISO 9001 CERTIFICATION

Companies that focus on implementing and managing quality in their processes often seek ISO 9001 certification. The International Organization for Standardization (ISO) manages this certification for quality management systems. Earning the ISO 9001 certification is a way to show your customers that you have a process in place to make products consistently. Because quality issues have effects up and down the supply chain, many manufacturing companies require their suppliers to be ISO 9001–certified. You can learn more about the ISO 9001 standard at [www.iso.org/iso-9001-quality-management.html](http://www.iso.org/iso-9001-quality-management.html).

# Chapter 8

## Delivering Your Products or Services

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### IN THIS CHAPTER

- » Choosing modes of transportation
  - » Integrating warehousing and inventory management processes
  - » Selecting material handling equipment
  - » Getting help from third-party logistics providers
- 

When was the last time you picked up an item from a store shelf and asked, “How did this get here?” Most people never ask that question, but the answer might give them a new perspective on the importance of logistics.

Take the example of a simple tub of margarine. Margarine is made from vegetable oils, so this supply chain starts with farms that plant, fertilize, grow and harvest vegetables and send them by truck or train to factories for processing. The oils are processed into margarine and then packaged in small containers that are placed in larger containers, which are placed on pallets. The pallets of margarine are shipped by truck or train, in refrigerated containers, to distribution centers. The distribution centers break apart the pallets and send smaller amounts of the margarine to individual stores. Last but certainly not least, someone in the store unloads the truck, and the margarine is stocked on the store shelves. Every step in this supply chain involves several players and many decisions. Every step needs to work properly; otherwise, customers won't get their margarine.

In this chapter, you examine the different kinds of transportation you can use and the steps involved in moving products through a distribution

network, including different ways to replenish inventory. You also discover the important role third-party logistics providers can play in your supply chain.

## *Understanding Modes of Transportation*

Moving products from one place to another involves transportation. Products that are being transported are called *cargo* or *freight*. If you're the one sending the freight, you're the shipper. The place from which you ship the freight is the origin. If you're the one to whom the freight is being sent, you're the recipient. The place where you have the freight delivered is the destination. Each combination of an origin (O) and a destination (D) is called an *O-D pair*, and the time that it takes cargo to get from its origin to its destination is *transit time*.

The method you use to ship products from an origin to a destination is called the mode of transportation. When you choose a transportation mode for an O-D pair, you create a lane. There are seven primary modes of transportation that cover the vast majority of logistics scenarios:

- » Pipeline
- » Cargo ship
- » Barge
- » Rail
- » Truck
- » Parcel
- » Air

An additional transportation mode is *multimodal*, which combines other modes to move a product from origin to destination. Moving a shipment from one mode to another is called *transloading*. A shipping container



may be loaded onto a truck, transloaded to a ship, transloaded again to a train, and then delivered to its destination, for example.

## *Pipeline*

For liquids and gases, pipelines are often the cheapest, safest, and most reliable form of transportation. Most people are familiar with the pipelines that deliver water and natural gas to homes. On a larger scale, pipelines are used around the world to transport huge amounts of water, petroleum, fuel, and natural gas over long distances. For example, the United States alone has 190,000 miles of petroleum pipeline!

## **THE COLONIAL PIPELINE CYBERATTACK**

The Colonial Pipeline carries gasoline, diesel, and jet fuel from refineries in Texas to customers along the East Coast. Many people did not realize how important the Colonial Pipeline was for their supply chains until it was shut down by a cyberattack in 2021. Gasoline shortages meant people were stuck at home, diesel shortages kept trucks from moving cargo, and jet fuel shortages caused airlines to cut service and reroute flights.

## *Cargo ship*

For most products moving from one continent to another, cargo ships or freighters are the lowest-cost option. Even though most freighters are powered by diesel engines, they're still commonly called steamships. The companies that operate these cargo vessels are called steamship lines.

Different kinds of ships are designed to carry specific kinds of cargo. The most common freighters these days are container ships; bulk carriers; tankers; and roll-on, roll-off vessels. Cargo ships are often limited in which ports they can serve because of factors such as the depth of the water and the equipment available on the pier.

Most cargo is either liquid or dry goods. Tanker ships haul liquids, such as petroleum and liquefied natural gas. Anything that isn't liquid is called dry goods cargo. Container ships are designed to carry dry goods that are loaded in standardized sea containers. Bulk carriers, called

*bulk*ers, haul bulk dry goods such as ores. Roll-on, roll-off vessels, called *ROROs*, are used to transport cars and other large items that need to be driven or dragged on and off the ship.



**TIP** Ocean shipping and shipbuilding are important for a country's national defense. During times of war it is often necessary for civilian vessels to support military operations, and for the military to protect civilian shipping.

## *Rail*

For big, heavy cargo that needs to travel long distances over land, railroads are often the way to go. The type of railroad car you use depends on the type of cargo you're shipping. Boxcars are enclosed, providing the greatest flexibility and protection for cargo. Refrigerated boxcars are used for food products that need to be temperature-controlled. Hopper cars are used for bulk cargo such as grain and coal. Tankers haul liquids and compressed gases. Flatcars haul just about everything else.

## **CONTAINER SHIPPING**

There are two kinds of dry goods cargo: bulk and break bulk. *Bulk dry goods* are commodities such as coal and iron ore that can be poured into the ship's storage area, called the hold. *Break bulk dry goods* are placed in containers. In the old days, shippers put break bulk cargo in barrels, buckets, bags, and just about every other kind of custom-made packaging that you can imagine. A huge amount of manual labor was involved in loading a ship with individual packages, which created many jobs for longshoremen and stevedores. Since the 1950s, a growing amount of break bulk freight has been transported by container ships in standardized 20- and 40-foot sea containers (see the following figure). These sea containers can be loaded and unloaded quickly by means of gantry cranes, greatly increasing the speed and efficiency of global supply chains.



If you ship an entire container from one destination to another, the transportation mode is called *full container load* (FCL). Sometimes, several smaller shipments are combined in a single container; this mode is called *less than container load* (LCL). Because it's complicated to combine multiple shipments in one container, LCL tends to be more expensive than FCL.

Most sea containers are 40 feet long, but the size of container ships is measured by the number of 20-foot containers they can carry. One 40-foot container takes the same amount of room as two 20-foot containers, of course. The largest container ships can carry almost 20,000 20-foot equivalent units (TEUs). These ships are too large for most ports and canals.

When you send shipments by rail, you're at the mercy of the railroad's schedule and the location of railroad tracks. Your railcar will travel with other railcars that are heading in the same general direction, but the train will stop along the way to drop off some railcars and pick up others. Your railcar may end up sitting idle, waiting for a train to take it on the next leg of its journey. So rail cargo is relatively slow, and transit times can be unpredictable.

For a train to pick up and deliver railcars, it needs railroad tracks. Some factories and distribution centers have a dedicated set of tracks, called a rail spur. If your facility doesn't have a rail spur, then cargo needs to be loaded on trucks and delivered to a railroad *ramp* — a facility for loading rail cars.

## *Truck*

Semitrucks are the most common way to ship cargo overland. You will often see trucking called over-the-road (OTR) transportation. Some people call these trucks semis or 18-wheelers, but the professionals refer to them as rigs or tractor-trailers. Companies that operate trucks are called carriers. The truck itself is a tractor or a power unit, and the trailer is called ... well, a trailer.

The amount of cargo that a single truck can carry is limited by two things: size and weight. Trailers have to be small enough to fit under bridges and short enough to turn corners. Also, loaded trailers can't be so heavy that they damage the roads. That's a complicated problem because weather conditions such as freezing and thawing can change the strength of a road. As a result, regulations limit the amount of weight you can load onto a trailer, and these regulations might change depending on the location and the time of year. Also, regulations called hours of service (HOS) rules govern how long truck drivers can spend behind the wheel and how often they need to stop for breaks. Drivers are often required to use electronic logging devices (ELDs) to track their location and whether they are driving or resting.



TECHNICAL  
STUFF

During a disaster it is common for governments to issue an emergency declaration that temporarily loosens weight limits and HOS rules.

An important aspect of trucking in the United States is understanding who owns the trucks and what they are licensed and insured to carry. There are three types of truck fleets to be aware of: dedicated fleets, contract carriers, and common carriers.

Dedicated fleets, or private fleets, are owned by manufacturers, distributors, and retailers who operate their own trucks and trailers and hire their drivers as full-time employees. Walmart is an example of a retail company that has a dedicated fleet. With a dedicated fleet you have control over your truckload capacity and the price you pay for

transporting goods. But you need to have a lot of freight volume to justify the costs, and you need to manage the team of drivers and support staff that make it all work.

An alternative to having a private fleet is to hire a trucking company to operate a fleet for you, which is called contract carriage. With contract carriage you don't need to invest the money to buy the trucks, and you don't need to hire the drivers as your own employees, but you have a bit less control over your costs and capacity.



**TIP** You will often hear professionals refer to trucking companies as “asset-based third party logistics services.” That is just a fancy way to say that they own assets (trucks) and they provide logistics services (driving trucks).

The third approach is hire common carriers. Common carriers can haul loads for anyone. Common carriers in the United States compete for the opportunity to haul loads. That creates a market in which shippers have an opportunity to select carriers based on cost, as well as safety, reliability, and other factors.



**TIP** Carrier Assure is a program that tracks issues such as a carrier safety, regulatory compliance, and fraud.  
(<https://www.carrierassure.com/>)

Some common carriers hire drivers as full time employees, while others act as brokers or subcontract with smaller companies. Many drivers own or lease their own trucks, and operate as small businesses. They are called owner operators, and they accept loads from brokers or directly from shippers. Employee drivers, called company drivers, can easily move from one trucking company to another, so there tends to be a high rate of turnover.

There are actually two different trucking modes for common carriers in the United States: *full truckload* (FTL) and *less than truckload* (LTL). Even though the trucks and trailers are virtually identical, the process and the pricing for FTL and LTL are different.

With FTL, you can choose any origin and destination, and pay a flat rate per mile. It doesn't matter whether you're shipping a single shoebox or enough shoeboxes to fill the trailer to the top; you pay the same price either way. Therefore, it's in your best interest to pack trailers as full as possible. In other words, you should maximize utilization of your trailer capacity. Because FTL shipments travel directly from the origin to the destination without stopping in between, they're generally the fastest, most reliable way to ship a load.

With LTL, your cargo is combined with other shippers' cargo in the same trailer. The cargo will generally get loaded and unloaded onto several different trucks before it reaches its destination. Depending on the carrier, you'll be charged for some combination of the weight and dimensions of your shipment, as well as the distance over which it's being sent.

Trucking prices are called *rates*, and they change all the time. Trucking prices are also different depending on origin and destination. A shipment from Spokane, Washington, to Savannah, Georgia, could cost more than a shipment from Savannah to Spokane. The rate that you'd pay to hire a truck today is called the *spot market rate*. If you ship frequently, you can negotiate lower rates, called *contracted rates*, with a carrier. Negotiating rate contracts with trucking carriers provides some protection against price swings, but those rates might not be honored if the spot market price goes up quickly.

Prices for trucking can go up when the economy is strong, companies are shipping a lot of freight, and there are not enough trucks haul it. When that happens, you have to pay the higher price or your freight will get left behind while carriers make more money hauling something else. But high trucking prices also lead to more trucks — and more truckers — in the market. Prices for trucking go down when there are more trucks available and there is less freight being shipped. When prices fall,

carriers will be forced to accept lower profits but will still try to collect the highest rates they can for each shipment.

FTL is more economical for large shipments, and LTL is better for small shipments. But figuring out exactly where the breakeven point will be is hard because it depends on the size and weight of the cargo, as well as the rates charged by each carrier. To make this easier, it's common to set a threshold weight to decide which mode you should use. Many shippers use 10,000 pounds as their threshold. Any shipment that's lighter than 10,000 pounds should be LTL; any heavier shipment should be FTL.



TECHNICAL  
STUFF

Using a threshold weight for FTL shipments is an example of a *heuristic* or a business rule. There is more information about business rules in [Chapter 10](#).

Large shippers and large carriers often have direct relationships, while smaller shippers and smaller carriers may rely on brokers to match freight with trucks. If a shipper hires a broker to move a load from point A to point B, then the broker needs to find a carrier to transport the shipment. The broker charges the shipper one amount, pays the carrier a smaller amount, and gets to keep the difference. Freight brokerage is an example of *arbitrage*, where a company makes money by purchasing a product or service for a low price and reselling it for a higher price.



**TIP** Look at [Chapter 11](#) to learn more about how digital load boards are disrupting the traditional freight brokerage business model.

## TYPES OF TRAILERS

The three types of trailers that are most common in the United States are dry vans, flatbeds, and refrigerated trailers.

*Dry vans* are basically big aluminum boxes with wheels on the bottom. You can ship virtually anything in a dry van as long as the cargo fits inside and isn't too heavy. Because

the doors are in the back of the trailer, you have to load from front to back; you can't get to the cargo in the front of the trailer until you unload everything behind it.

*Flatbeds* are a good alternative for long cargo like pipes or heavy items like bricks, because these trailers are easier to load and unload from the side. When the cargo on a flatbed needs to be protected from the elements it can be covered with tarps.

For perishable foods, you need *refrigerated trailers* (or, as we say in the biz, *reefers*). Reefers are similar to dry vans except they are insulated and have a refrigeration unit mounted in the front that cools the air inside. It is more expensive to ship in a reefer than it is to use a dry van.

If you do a lot of shipping by truck, you can compare the rates you're paying with the amounts other shippers are paying. Below are three companies that provide information about rates and rate trends:

» Cass Information Systems ([www.cassininfo.com](http://www.cassininfo.com))

» Chainalytics ([www.chainalytics.com](http://www.chainalytics.com))

» FreightWaves ([www.freightwaves.com](http://www.freightwaves.com))

Shippers can use services like these to ensure that they aren't paying more (or less) than they should. For carriers, these services can help them decide how much to charge and where to send trucks in order to make the most money.

## *Parcel*

If you're sending a relatively small load, such as a couple of boxes, you'll probably choose a parcel carrier. In the United States, the parcel market is dominated by four companies: United Parcel Service (UPS), FedEx, DHL, and the U.S. Postal Service (USPS). The price you pay for a parcel shipment is determined by four things: weight, dimension, O-D pair, and speed. If you're sending a big, heavy box far away and need it to arrive tomorrow, that shipment will be expensive. If you're shipping a small, light box across town and don't care when it arrives, that shipment will be relatively cheap.





TIP

Parcel shipping was not a major concern for many supply chains in the past, but today the rise of e-commerce has made parcel shipping especially important for retail supply chains. As more customers order products online and have them delivered to their homes, retailers have been forced to spend more money on parcel shipping. If you're in the retail business, it's a good idea to review your parcel rates frequently and look for ways to save money.

## *Air*

For cargo that needs to travel long distances quickly, the best option usually is air freight. Air freight is often a good choice for small, light, expensive items such as cellphones. It may also be useful for heavier items if you need them urgently. Air cargo is often loaded into special containers called igloos that are designed to protect both the cargo and the airplane. Sometimes air cargo is carried on airplanes that are used only for freight; at other times, it's carried in the lower section of passenger airplanes. When freight is carried on a passenger plane, it's called *belly cargo*.



TECHNICAL  
STUFF

Belly cargo makes up about half of the air cargo capacity in the world. When passenger airlines cancelled flights during the COVID-19 pandemic, the amount of global air cargo capacity dropped and it became much harder to ship critical supplies including PPE and vaccines.

## *Selecting Modes of Transportation*

Managing logistics throughout your supply chain includes selecting the best modes of transportation for each of the products that you ship. Your choice of transportation mode for your freight shipments depends on three factors:

- » **Product characteristics:** You need to think about what modes make sense for the product that you're shipping, and what type of container you need to ship it in. Small, light, valuable products can be shipped cheaply by air, for example, but air freight usually isn't a practical choice for big, heavy, products unless you need them urgently. LTL may be cheaper than FTL, but your freight is more likely to be damaged because it'll be loaded and unloaded several times during its journey. Some food products can be shipped in a dry van; others require a reefer. Some bulky products, such as lumber and bricks, are easier to load and unload from a flatbed than from a dry van trailer.
- » **Facility characteristics:** You need to consider the design and capabilities of the facilities that the product will flow through, including the origin and destination facilities, distribution centers, ports, and cross-docks. Some facilities have rail spurs, but many don't. Loading docks have different designs and heights in different facilities, and every distribution center has its own material-handling equipment.
- » **Time constraints:** You need to factor in issues related to time. Naturally, speed is an important consideration in transportation; faster modes usually cost more money. But spending more money on transportation can have other benefits. It's relatively cheap to ship computers in sea containers that take 30 days to cross the ocean, for example. Shipping computers by air would be more expensive, but it could increase revenue and decrease inventory costs.

By evaluating these factors, you can calculate the total costs of each transportation mode to determine which one makes the most sense for a particular shipment — in other words, which lane provides the most value for the lowest price. Many companies create a document called a *routing guide* that specifies rules about which modes to use and which carriers to select based on factors such as the type of cargo, the size of the load, and the O-D pair. The routing guide ensures that everyone in the company uses the same rules when making shipping decisions.

If you don't ship much cargo, you're going to have to pay spot market rates for your freight. If you ship often, you may be able to negotiate a better price from your carriers. These negotiations lead to contracts, and contracted rates can save you a lot of money on transportation.

If you're a large shipper, you may even be able to get carriers to bid against one another to give you the lowest price. Carriers base their bids on the location of the O-D pairs and the amount of freight you expect to ship. In other words, bids are based on the expected freight volume for each lane. The process of picking up a load at Point A and dropping it off at Point B seems to be pretty straightforward, but carriers also need to find a customer that will pay them to pick up a load at Point B and bring it back to Point A. This arrangement is called a *backhaul*. If your carriers think that they can find backhauls to match with your loads, they'll offer to move your freight for a lower cost. If the carrier can't find a backhaul, and its truck has to return empty, the carrier might need to charge you enough to cover the cost of their mileage in both directions.

## INTERNATIONAL COMMERCIAL TERMS

When you arrange to ship products to someone in another country, you need to agree on many details such as where it will be picked up, where it will be dropped off, who will pay duties, who will pay for insurance, and who will pay the shipping costs. These details are spelled out in a contract between a shipper and a carrier called a *bill of lading* (BOL). The BOL is issued by the carrier to the shipper and serves as a receipt to prove that the carrier has picked up the material and agreed to deliver it.

The 11 most common combinations of these options are defined by a shorthand called International Commercial Terms (Incoterms). Each Incoterm is a three-letter code that represents a particular shipping arrangement, so when you specify the Incoterm, it immediately becomes clear who will pay for each part of the shipping process. The DDP (Delivered Duty Paid) Incoterm, for example, means that everything — including shipping costs and all duties — will be paid by the shipper, whereas the DAP (Delivered at Place) Incoterm means that shipping will be paid by the seller, but duties will be paid by the recipient.

Incoterms are used around the world and are updated every ten years by the International Chamber of Commerce. The latest update, published in 2020, is available at <https://iccwbo.org>.

# *Managing Warehousing and Inventory*

In virtually every supply chain, gaps exist between when something is made and when a customer is ready to buy or receive it. Those gaps mean that products end up sitting around. The problem is that someone owns those products and has money tied up in them. In addition, someone needs to keep track of where those products are and protect them from damage or theft. In other words, even when products are sitting around in a warehouse or distribution center, they still cost a lot of money. That's why inventory management is so important.

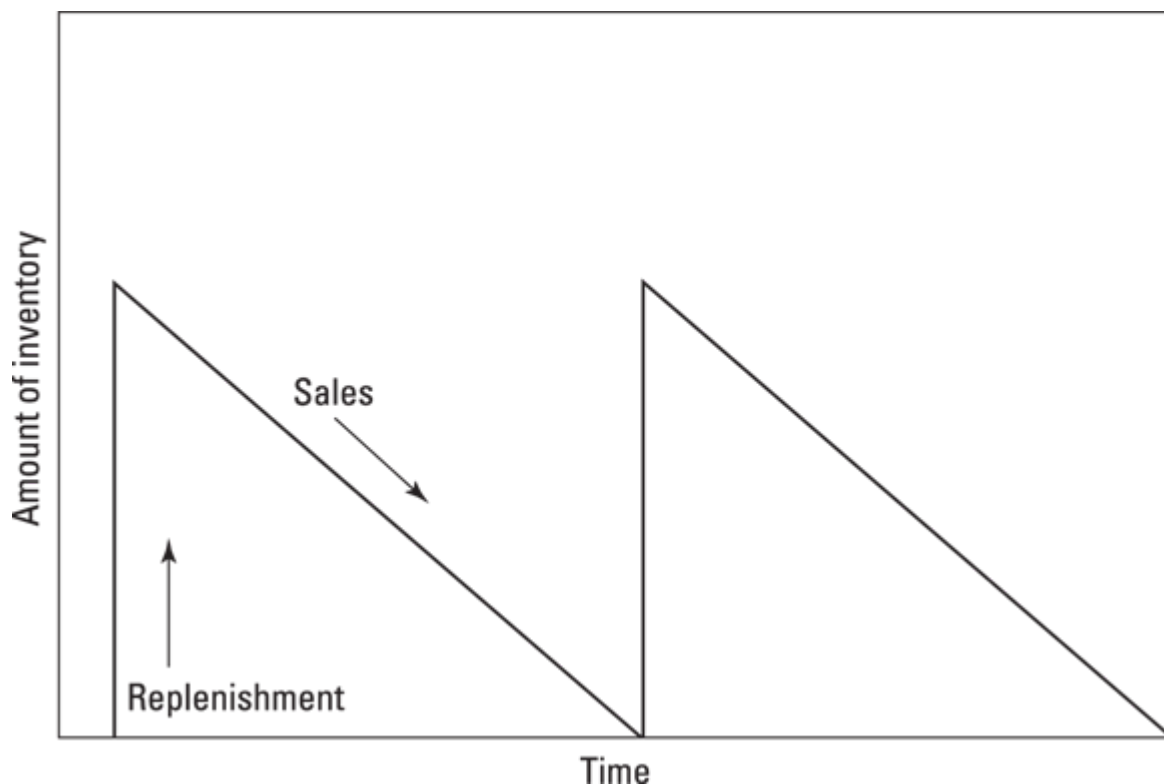
The goal of inventory management is to balance the needs of your customers with the cost of meeting their needs. The higher your customers' expectations are, the more you'll need to spend on inventory to meet their needs, and the more they'll need to pay you to have those needs met.

Suppose that you run a fast-food restaurant. You know that it's very important to never, ever run out of French fries. You have to decide how many French fries to keep in inventory. (The only way to guarantee that you'll never run out of French fries would be to have an infinite amount of inventory, which would be silly!) In order to decide how much inventory to carry you need to understand both demand (how much your customers are going to buy) and supply. You can start by looking at demand. How much do your customers buy in an average week? How much did they buy in your best week ever? Then you can look at supply. If you know that your suppliers can ship a load of French fries in 24 hours, you don't need to keep much inventory in your restaurant. But if it takes your supplier a week to send you a new shipment, you probably need to have more inventory on hand as a buffer against a surprise spike in demand.



**TIP** Think about inventory in terms of the chart shown in [Figure 8-1](#). Every time a new shipment of French fries arrives, the amount of inventory goes up. As you sell French fries to customers, inventory gradually goes down. You need to make sure that a new shipment shows up before your inventory level reaches zero; otherwise, you'll have customers who don't get their French fries. This situation is called a *stockout*, and it creates two problems:

- » It's a lost sale. (You've lost out on money that you could have earned.)
- » It makes your customers unhappy. (Unhappy customers stop buying from you and also tell their friends about their lousy experience.)



**FIGURE 8-1:** Inventory chart.



TIP

Stockouts are a major challenge that often goes unrecognized. Analyzing the sales that a company makes is easy, but measuring the sales that a company missed because of stockouts is hard.

Every store, factory, or distribution center uses these eight high-level processes for managing their physical inventory:

- » Receiving
- » Put-away
- » Inventory counts
- » Picking
- » Packing
- » Shipping
- » Yard management
- » Over, short, and damaged

These processes are described in the following sections.

## *Receiving*

When products arrive at a facility, someone needs to let them in. The process for accepting inventory when it arrives is called *receiving*. Receiving often involves scheduling appointments for deliveries to occur, along with unloading the goods and performing a quality inspection.

Receiving is often done at a loading dock — a part of the facility that's designed to make loading and unloading freight on trucks or railcars easy. In addition to unloading physical goods, receiving includes doing the paperwork and making computer entries to add the inventory to your records.

In an ideal world, every shipment would arrive at its scheduled appointment time with the right contents and in perfect condition. In

reality, truckload shipments may travel thousands of miles through unpredictable traffic and weather conditions, contents can be loaded incorrectly, and cargo can become damaged.



**TIP** Receiving personnel joke that every day is like Christmas morning because you get to open boxes and might be surprised by what is inside.



**WARNING** Many truck drivers are only paid for the miles they drive, not for the time they spend at a loading dock. That means drivers are in a hurry to hit the road. In the United States, it is common for loading or unloading to take up to two hours. If a driver has to wait longer than that you will be charged a penalty called a *detention fee*.

## *Put-away*

After products have been received and passed a quality inspection, they need to be stored safely so that you can find them when you need them. This process is called *put-away*. To minimize the distances that people will travel, distribution centers are generally laid out so that the products shipped most frequently are closer at hand and those shipped less often are farther away.

The spot where you store a particular product is called a *location*. Because products have different characteristics (dimensions, weights, and so on), dividing your locations to maximize your efficiency is a complex engineering problem. One section of a warehouse might have small locations for light items; another area may have large locations on the floor for heavy items. This type of division is called *slotting*. Distribution centers often have thousands of locations, all controlled by a warehouse management system (see [Chapter 11](#)).



TIP

Some distribution centers have a secure area called a *cage* or a *crib* for storing high value items.

## *Inventory counts*

Inventory is money, so anyone who's looking at your business from a financial perspective wants to make sure that they know how much inventory you have and where it's located. Periodically, you might need to perform physical inventory counts to confirm that your records are accurate.

The traditional approach to conducting inventory counts is to shut down a facility during a slow time of year to count everything, one item at a time. This process is slow, expensive, and (unfortunately) not very accurate. The people who count the inventory may make mistakes along the way, so instead of fixing the inventory records, you may actually create new inaccuracies. Therefore, many companies have switched to cycle counting, in which they divide the facility and count the inventory in each part at different times throughout the year. By the end of the year, the company has done at least one physical inventory count in each section of the facility and corrected any errors that were found. Generally, cycle counting is more efficient and more accurate than traditional physical inventory counting.

Inventory counts can be important for accountants, who want to make sure that the numbers they see on the books line up with what's happening in the store. Inventory counts are also useful for logistics personnel to confirm that inventory isn't being lost, damaged, or stolen. When inventory disappears for unexplained reasons, that disappearance is called *shrinkage*. Shrinkage is a major problem for inventory management, so it's important to measure shrinkage and keep it as low as possible.

## *Picking*



When a customer wants a product that you've been storing in your distribution center, you need to pick that item off the shelf (or off the floor) and get it ready for shipping. Depending on how big your distribution center is, picking can take a while. (Many distribution centers cover more than 1 million square feet.) If two customers order the same product, you want to pick both items at the same time. And if a single customer orders two products, you want to pick both products during the same trip. When you think about how much time it takes to travel between where items are stored and where they're packaged for shipment, you see how important — and inefficient — picking can be.

The good news is that technologies introduced in the past few years make picking more efficient. A warehouse execution system uses sophisticated routing algorithms to translate customer orders into pick paths that minimize time and distance for the people who pick the orders. Pick-to-light systems and other displays give pickers visual cues that help them work faster and more accurately. Pick-to-voice systems have conversations with pickers, telling them where to go and what to pick, and confirming that they've done the work correctly. Picking robots and cobots can work alongside people, or instead of people, to increase picking accuracy and efficiency. Picking is a great example of how people and technology work side by side in a supply chain to improve efficiency. There is a more detailed description of these technologies in [Chapter 11](#) and [Chapter 12](#).

## *Packing*

When you're going to send something to a customer, you need to make sure that it will arrive in good condition. You also want to maximize the density of your shipments. Packaging is the key. Packaging is a form of protection; it's like an insurance policy against all the handling and environmental threats that your product will face from the time it leaves your facility until the time your customer is ready to use it.

Choosing the right packaging for a shipment depends on the products, the shipping method, and the destination. The right packaging method is the one that ensures that your product arrives in good condition for the lowest cost. Customers may be reluctant to purchase products if the

packaging is dirty or damaged, and if the packaging has a lot of empty space then you are paying to transport air.

By far the most common form of packaging is cardboard, also known as corrugated fiberboard or just corrugate. Corrugate is cheap, strong, and light, so it's the perfect material for packaging all kinds of products. Some products can still get damaged if they move around inside a cardboard box, however. One solution is to add filler materials such as packing paper, packing peanuts, or bubble wrap.

If the products you're shipping are sensitive to moisture, you may also need to use an anticorrosion coating, special wrapping, or moisture-absorbing packets. Electronic products are sensitive to static electricity, so these products require special protection against electrostatic discharge.

Every time that you need to touch a product, you add cost to the supply chain. When a product ships from a factory to a retail store, there can be many touches simply because of packaging. A product might be put into a bulk package and then shipped to another facility for custom packaging. Then the custom packaged product might be put in plain cardboard boxes. When the boxes are received by a retailer, the retailer's employees need to undo all that packaging, dispose of the boxes, and then place the products on store shelves in order to sell them to a customer.

To streamline this process, many retail supply chains are adopting *shelf-ready packaging*. A common example of shelf-ready packaging is a colorful printed shipping box. These boxes are more expensive than a plain brown box, but they can be placed directly on store shelves which reduces the number of touches and saves the retailer time.

## ***Shipping***

You have lots of ways to ship a product from one place to another. The mode of transportation you choose determines how you need to prepare the freight for shipment, including getting the paperwork and labeling correct. The paperwork for shipping a domestic package via a parcel

carrier is very different from the paperwork for shipping internationally on a container ship.

Some products, such as alcohol and tobacco, require special licenses or permits. Other products are subject to trade restrictions when they're shipped to another country. For example, when exporting products that could have military uses from the United States, you need to comply with the International Traffic in Arms Regulations (ITAR), which is administered by the Department of State. Also, some products are hazardous and may not be accepted by a particular carrier. Getting all these shipping details right requires communication among the seller, the buyer, and each carrier that handles the freight while it's in transit. In the best cases, mistakes and miscommunications can cause delays that prevent products from reaching customers quickly and safely. In the worst cases, poor management of shipping processes could lead to injuries, lawsuits, fines, and even jail time.

## ***Yard management***

An important, often-overlooked aspect of managing a distribution facility is *yard management*, which is the process of tracking the trailers in your parking lot. It can be easy to forget about inventory when it is hidden inside a trailer. Yard management starts with understanding the two approaches that are used to deliver and pick up your freight:

» **Live load and unload:** A carrier shows up, unloads your freight from its trailer, and then leaves. Another carrier backs up to your loading dock, puts your cargo on its trailer, and carries it away.

The good part of live loading and unloading is that it keeps your freight moving. The bad part is that the truck has to sit and wait while it's being loaded. If your loading dock is slow or busy, the truck may charge you detention fees.

» **Drop and hook:** With drop and hook, when a truck arrives at the destination, it drops off the trailer and leaves. Or, you can pre-load another trailer and have it ready for the truck to hook up and haul away.

Drop and hook is much faster for the truck than live load and unload, and it can be a better choice for making the supply chain run smoothly. But when you're using a drop-and-hook system, you have inventory sitting on trailers in your yard.



**REMEMBER** Managing inventory in the trailer yard is just as important as managing the inventory inside your distribution center.

### *Over, short, and damaged*

When you have lots of inventory, either in a store or in a warehouse, lots of things can go wrong. Shipments may not have the right number of units in them, for example, or they could get damaged.

To deal with these issues, you should have an over, short, and damaged (OS&D) process. A good OS&D process plays two important roles:

- » It allows you to spend the time you need to deal with exceptions without interfering with the normal flow of products and information.
- » It allows you to fix problems efficiently and maintain accurate records of how they've been resolved.

You may discover an OS&D issue when you receive products in a store or distribution center, or when you're selling or shipping a product. Also, while that material is in your facility, it may be dropped or otherwise abused.

## *Establishing Inventory Ordering Policies*

Trying to keep the right amount of inventory on hand is a tricky business. Keep too much inventory, and you're wasting money by tying up working capital. Keep too little inventory, and you'll miss out on

revenue because you won't have anything to sell to your customers. Two of the most important decisions you can make are when to order more inventory and how much to order. The approach you use to make that decision is called *your inventory policy*.

Start with the question of when to order more inventory from your suppliers. You may need to place an order when your current inventory levels drop below a certain level, in which case the current inventory level is the trigger for your inventory policy. Or you may want to order inventory on a set schedule, such as once a week, in which case your inventory policy is built on periodic orders. Triggering orders based on inventory levels is usually more efficient than periodic orders. But suppliers often schedule deliveries periodically because it is more convenient for them. So you need to understand the dynamics of a particular supply chain to make the best decision about which inventory trigger to use.

The next question is how much to order. A mathematically precise approach to calculating your *lot size* is called the economic order quantity (EOQ). The EOQ formula balances the cost of placing an order against the cost of holding inventory. This formula works well on paper but usually needs to be tweaked to work in the real world. You might calculate that your EOQ is 15 widgets but discover that widgets actually come in packages of 20, for example. You also need to consider other factors when deciding how much to order, such as when a big promotion is coming up and whether you expect to have increases or decreases in demand for a product.



TECHNICAL  
STUFF

You can find many articles in business and engineering journals about how to calculate the EOQ, and how to modify the formula based on the unique characteristics of your supply chain.

The items that are managed by an inventory policy are called *stock-keeping units*, or SKUs (rhymes with *cues*). Suppose that your

distribution center handles the same brand of toothpaste in three different sizes. Each size is a separate SKU.

Establishing and implementing inventory policies can become complicated. Imagine what it might be like to optimize the inventory policies for 10,000 SKUs at the same time! For that reason, inventory policies usually are managed automatically by a warehouse management system or a material requirements planning system (see [Chapter 11](#)).



TECHNICAL  
STUFF

One of the important innovations in the Lean Manufacturing philosophy (covered in detail in [Chapter 16](#)) is an approach to inventory ordering called *kanban*. In a kanban system, you pick a lot size for each SKU, and the lot size never changes. When you use all the items in a lot, another full lot is waiting behind it. When you start pulling from that second lot, the system automatically places an order for new lot. A kanban system is an example of a replenishment policy that's triggered at a certain inventory level and has a fixed order quantity (lot size). The kanban system is simple, and it prevents many expensive mistakes (such as overordering and stockouts) that can sometimes occur with more sophisticated inventory policies. Kanban systems help ensure that inventory arrives when it is needed, and not before, so it's a form of just-in-time (JIT) replenishment.

## *Selecting Material Handling Equipment*

Handling the products in a supply chain can be dangerous. Lifting heavy objects and performing repetitive motions can cause serious damage to a person's body. Many tools and technologies are available to help increase the safety and efficiency of moving and storing products. Industrial engineering professor Dr. Michael Kay created a material

handling equipment taxonomy that classifies these tools in five categories:

- » **Transport equipment:** Transport equipment includes anything that's used to move a product from one place to another. Forklifts are common types of transport equipment. Conveyors and cranes are also common, especially in highly automated facilities.
- » **Positioning equipment:** Positioning equipment moves products over small distances, such as within a particular work area. This type of equipment might be used to elevate a product so that the person who's packaging it can stand in a more comfortable position.
- » **Unit load formation equipment:** Individual products are sometimes called *eaches*. When products are bundled together into a single unit, such as when they're placed on a pallet, they're called a *unit load*. Pallets, shrink wrap, and packing straps are common examples of unit load formation equipment.



**REMEMBER** When you're shipping freight, combining smaller units into bigger ones makes it easier to move them efficiently.

- » **Storage equipment:** Storage equipment increases the amount of material you can keep in a particular area: your storage capacity. Real estate is expensive, so businesses often increase the storage capacity in a distribution center by building racks and mezzanines. Adding a rack with three levels could quadruple the amount of material you can store in the same floor space. In order to access the higher levels of the rack, you need transport equipment that can reach it. A mezzanine provides an additional floor for storing materials. Mezzanines are generally used to store small, light items that people walk around to pick.

In automated facilities, the storage equipment may also handle transport, picking, and put-away. These systems are called *automated storage and retrieval systems* (AS/RS). AS/RS systems can work around the clock and tend to be much faster than their



human counterparts. These systems are expensive, however, and have limited flexibility. If your volumes go up significantly in a few years, your AS/RS may become a bottleneck.

- » **Identification and control equipment:** Identification and control equipment helps you keep track of inventory. This area of inventory management has advanced rapidly in the past few years. Bar codes are common, they may require special bar code printers and readers. Other common methods are radio frequency identification (RFID) tags, data matrix codes, and quick response (QR) codes. You can find more information about labeling and tracking inventory in [Chapter 10](#).



**TIP** You can read more about Dr. Kay's material handling equipment taxonomy at [www.mhi.org/cicmhe/resources/taxonomy](http://www.mhi.org/cicmhe/resources/taxonomy).

## PAY ATTENTION TO PALLETS

Pallets have played an important role in the evolution of modern supply chains. Today's pallets trace their origins to a 1939 patent that was awarded to George Raymond, Sr. and Bill House. Many historians claim that the adoption of pallets by the U.S. military during World War II improved their logistics efficiency so much that it was a key factor in the Allies' victory.

After the war, surplus military pallets were sold to civilian supply chains. In Australia, many of the leftover pallets were acquired by a new organization called the Commonwealth Handling Equipment Pool (CHEP). CHEP is now a global company and you can spot their distinctive blue pallets in warehouse stores, stockrooms, and distribution centers.

Experts estimate that there are about two billion wooden pallets in the United States today. There is an entire industry that supports the manufacture, repair, recycling, and distribution of these pallets. Unfortunately, many perfectly good pallets still end up in landfills each year because people throughout the supply chain do not recognize their value.

## *Managing and Filling Orders*



An important part of logistics is understanding how your customers order products or services from you. Some methods include

- » Ordering via your website
- » Calling an account manager
- » Using an inventory system to automatically trigger an electronic order

Many companies use an order management system (see [Chapter 11](#)) to process orders from their customers. Even if you're communicating electronically, it helps to understand the process for preparing a sales order. Each item that a customer orders goes on a separate line of the sales order. Ordering multiples of the same item just changes the quantity shown on that line. But if the customer orders two or more SKUs, each one of these items goes on a separate line. When you're measuring your success rate in filling customer orders, you can use lines (the percentage of lines you were able to ship) or orders (the percentage of complete orders you were able to fill). Because you need to fill every line to fill a complete order, achieving a high fill rate for orders is much more difficult than getting a high fill rate for lines.

In many cases, orders are filled with products that are held in inventory. When not enough products are available to fill an order, that item is backordered. In a backorder situation, you can't send a shipment to your customer until you make more products or get a replenishment from your supplier. Backorders can lead to serious supply chain problems including the Bullwhip Effect. For example, once an item is backordered customers may begin to panic and order more than they need, or place orders for the same product with several suppliers. When that customer finally receives the product they need, they may return any extra products and cancel the remaining orders. Meanwhile, their suppliers have gone from having a backorder to having excess inventory.

Manufacturers, retail distribution centers, and e-commerce fulfillment centers all receive orders from customers, but there are differences in the way that these orders are placed and filled:

- » **Manufacturing and wholesale:** In manufacturing and wholesale supply chains, customer orders often come in the form of purchase orders (POs). A PO is a contract in which a buyer agrees to pay its supplier for delivering a product or service. A PO can be a paper document, or it can be transmitted electronically.
- » **Retail:** For distribution centers that serve retail stores and restaurants, orders can be triggered in a variety of ways. You might receive a PO from a store. But if the store and the distribution center are part of the same company, the ordering process may be informal, or the distribution center may be able to monitor the store's sales and send replenishments automatically. In some cases, the central distribution center may even push new products and promotions out to a store without the store asking for them.
- » **E-commerce:** An interesting supply chain challenge that has emerged in the past few years is managing e-commerce orders. Until recently, distribution centers were designed to efficiently ship unit loads to a limited number of sites, such as retail stores. E-commerce orders, however, are placed online by customers around the world, usually for small quantities of products. In order to manage e-commerce order fulfillment, you need the flexibility to pick, pack, and ship single items to many locations efficiently, which requires a completely different approach to facility layout and slotting.

## **DISTRIBUTION CENTERS VERSUS FULFILLMENT CENTERS**

Traditional distribution centers are often designed around pallets because unit loads are an efficient way to move products. A distribution center might receive a unit load containing 100 widgets and then use a forklift to move that pallet to a storage location on the floor or in a rack. When a customer places an order, the pallet is retrieved by a forklift, loaded onto a truck, and shipped to the customer. This process is simple and efficient: Costs are minimized because the entire pallet of widgets is one line on a customer order and very little handling is required.

But for an e-commerce fulfillment center, a lot more work is involved. Rather than shipping the entire pallet, a fulfillment center ships widgets one at a time to 100 different customers. In other words, there are 100 different customer orders to fill, so workers must make 100 trips to the location where the pallet is stored, picking one widget each

time. Obviously, a lot more labor is required in a fulfillment center than in a traditional distribution center, which makes the fulfillment center much more expensive to operate. It also means that you need to slot your storage locations so that people can reach the products easily. Because you have more people walking around, you need to design traffic patterns in the facility that protect pedestrians from equipment such as forklifts.

E-commerce has become an essential capability for modern supply chains. Many companies have introduced software and robots that automate much of the work of picking, packing, and shipping individual items to customers. Others have outsourced fulfillment to companies like Spreetail ([www.wearespreetail.com](http://www.wearespreetail.com)) that specialize in e-commerce. Finding new ways to improve the efficiency of e-commerce fulfillment is one of the hot topics among supply chain management professionals and technology startups.

## *Maintaining Visibility of Shipments*

One of the most common challenges in any supply chain is knowing what products you have, where they're located, and what condition they're in. It can be especially difficult to pinpoint the location of materials that are being moved on a truck, train, ship, or airplane.

Creating better supply chain visibility usually requires a combination of hardware and software. The hardware includes devices that can transmit their location to the Internet. These devices can be electronic logging devices (ELDs) attached to a vehicle, or they can be trackers attached to a shipment. Visibility software combines information about the products in a supply chain with information about the environment. If delays are expected, this combination of hardware and software alerts you to the problem so that you can respond.

Transportation visibility can be useful for monitoring supply chain performance and identifying improvement opportunities, but it becomes critical when the supply chain is disrupted and you need to respond quickly.

Following are a few companies that provide transportation visibility tools:

» Bloom Global ([www.blumeglobal.com/visibility](http://www.blumeglobal.com/visibility))

- » Everstream Analytics ([www.everstream.ai](http://www.everstream.ai))
- » FourKites ([www.fourkites.com](http://www.fourkites.com))
- » HERE Technologies ([www.here.com](http://www.here.com))
- » Project 44 ([www.project44.com](http://www.project44.com))
- » Tive (<https://tive.co>)
- » Trimble ([www.trimble.com](http://www.trimble.com))

## MANAGING LAST-MILE DELIVERIES

Many retail supply chains deal with the challenge of delivering products to a customer's home. That final leg in the supply chain is called the last mile. Most online retailers use parcel delivery services to handle their last-mile deliveries. Amazon.com has grown so large that it created its own fleet of vans to handle many of its last-mile deliveries. Companies such as Uber Eats, Grubhub, and Instacart are built around innovative solutions for last-mile delivery. Other companies, such as Enroute.ai ([www.enroute.ai](http://www.enroute.ai)), are using machine learning and artificial intelligence to optimize last-mile delivery routes. Today these solutions are focused on reducing the operating costs for delivery vehicles and improving the efficiency of human couriers. In the future, many of these tasks could become automated because last-mile delivery is an attractive target for companies that are developing drones and autonomous vehicles.

## *Leveraging Third-Party Logistics*

Logistics can be complicated and expensive. You probably couldn't find a single company anywhere that handles all the logistics for its own supply chain. Instead, they hire other companies that specialize in different aspects of logistics. Using a third-party logistics (3PL) provider is a strategy that can lower costs and improve service for you and your customers.

Following are some common types of 3PLs:

- » **Asset-based 3PL:** A company that handles trucking
- » **Non-asset-based 3PL:** A company that handles warehousing

- » **Value-added service:** A company that handles kitting, packaging, or returns processing
- » **Freight forwarder:** A company that helps navigate the movement of freight between carriers
- » **Customs brokerage service:** A company that works with government customs officials to move freight across borders
- » **Flexible workforce or workforce augmentation service:** A company that provides temporary workers for warehouses



**TIP** Any company can call itself a 3PL. The term means only that the company can help with some part of your logistics process. Some firms describe themselves as 4PLs or 5PLs. These companies typically are brokers or they provide services such as managing your relationships with 3PLs.



**TIP** Companies that import and export products need to pay close attention to duties, tariffs, and taxes that are charged in each region. Some 3PLs can offer services such as bonded warehouses or free trade zone (FTZ) locations that allow you to reduce, delay, or eliminate these costs.

## *Optimizing Freight Audit and Payment*

Transportation procurement can be a very complicated process, and managing your expenses can be difficult. At a high level, the process involves four steps:

1. You get a rate quote from a carrier. The carrier offers to provide transportation services for a certain price.
2. You hire a carrier to move your shipment. This process is called tendering your shipment to a carrier.
3. You receive an invoice from the carrier. The carrier sends you a bill detailing all the costs and the due date for payment.
4. You pay the bill.

The simplest part of transportation procurement is the rate that you pay for the basic transportation. It's common to pay a per-mile rate for truckload transportation, for example. But other costs, called *assessorial fees*, can be hard to predict. Truck drivers may charge fees for using special equipment, such as tarps, in addition to detention fees if they have to wait a long time to get loaded or unloaded. Some facilities use third-party services called lumpers to unload freight. All of these assessorial fees are added to the invoice that the shipper receives.

Because there are so many variables, errors in freight invoices are common. Before paying freight invoices, shippers often perform a *freight rate audit*. A common approach to auditing is to compare the invoice with the tender and the rate contract — a process called a three-way match. When all three of these documents have the same information, you can be confident that you're paying the correct amount for the services you requested. When the three documents don't match, you need to find out why. Resolving these discrepancies can be time-consuming, involving conversations with your internal teams, transportation providers, and even customers and suppliers.

Several companies specialize in providing freight audit and payment services, using software to streamline the three-way match and send out payments. They can also automate the communications needed to resolve any discrepancies. A freight payment and audit system can save you money by ensuring that you don't pay inaccurate invoices and reducing much of the manual effort required to manage transportation procurement effectively.

Following are some companies that provide freight audit and payment services for various modes of transportation:

- » Cass ([www.cassinfo.com](http://www.cassinfo.com))
- » CT Logistics ([www.ctlogistics.com](http://www.ctlogistics.com))
- » enVista (<https://envistacorp.com>)
- » Ocean Audit (<https://oceanaudit.com>)
- » Intelligent Audit ([www.intelligentaudit.com](http://www.intelligentaudit.com))
- » RateLinx ([www.ratelinx.com](http://www.ratelinx.com))
- » Shipware (<https://shipware.com>)
- » Transportation Insight ([www.transportationinsight.com](http://www.transportationinsight.com))
- » TriumphPay ([www.triumphtpay.com](http://www.triumphtpay.com))
- » US Bank (<https://freight.usbank.com>)



**TIP** U.S. Bank Corporate Payments publishes a free report every quarter that includes a freight rate index and discusses trends in transportation rates and volumes. You can download the report at <https://freight.usbank.com>.

## Chapter 9

# Managing Product Returns and Reverse Supply Chains

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### IN THIS CHAPTER

- » Processing returns efficiently
  - » Remanufacturing and recycling
  - » Avoiding fraudulent returns
  - » Using trade-ins to increase profits
- 

Supply chains don't always flow in one direction, and they don't have to end at your customer. Many supply chains are designed to operate in reverse, with products flowing upstream from a customer back to a supplier. Reverse supply chains don't get as much attention as manufacturing and retail supply chains. But companies can use reverse supply chains as a way of increasing sales, growing market share, and lowering their manufacturing costs. They also play an important role in reducing the environmental effects of a product. In this chapter, I discuss reverse supply chains and explain how managing them effectively can benefit businesses and their customers.

## *Growing Revenue with Easy Returns*

A well-managed reverse supply chain can increase customer loyalty and sales revenue. Some online retailers have built their business strategy on offering their customers free returns. Zappos.com, the online shoe store, is an example. If you order a pair of shoes on the company's website and decide not to keep them, you can send the shoes back at no additional cost. Free returns are a great deal for customers, eliminating the risk of getting stuck with a pair of shoes that don't fit properly or that look



better in a picture than they do in real life. As a result, the free return policy has played a key role in the Zappos.com strategy to grow sales revenue and increase market share.

But the return service isn't actually free. Zappos.com still has to pay for return shipping, of course, and it needs to process the returned shoes to make sure they're in like-new condition. After that, the company needs to get the returned shoes ready for another customer and restock them in inventory.

Think about some of the costs involved in this "free" return transaction:

- » Shipping to customer
- » Return shipping from customer
- » Inventory carrying costs from the time the product is shipped until it's restocked
- » Receiving processing
- » Performing quality inspection
- » Processing customer refunds
- » Repackaging
- » Restocking

All these costs must be absorbed in the price that the company charges for the other shoes that don't get returned. In other words, they're overhead expenses. For the Zappos.com strategy to be successful, the company needs to ensure that its reverse supply chain is extremely efficient.

ReverseLogix ([www.reverselogix.com](http://www.reverselogix.com)), goTRG ([www.gotrg.com](http://www.gotrg.com)), and Returnly (<https://returnly.com>) are examples of businesses that help retailers streamline reverse logistics by making the returns process faster and easier. Because they make it simple for customers to return items and get their money back, those customers end up buying more from the retailers. In other words, by focusing on providing a great returns

process retailers can reduce their reverse logistics cost, improve customer service, and increase sales.

Costco has a very generous return policy. With a few exceptions, customers can return items at any time for a refund. Customers who know about this policy are more likely to purchase from Costco because very little risk is involved. As a result of this returns policy, Costco sells more products and builds stronger customer loyalty than other companies that have more stringent return policies.

Amazon.com and Kohl's have developed an interesting reverse logistics solution that seems to work well for both companies. If an Amazon customer wants to return a product, they can take it to a Kohl's store to have their money refunded immediately. Amazon benefits because the returns process is easy for their customers, and Kohl's benefits because it brings more customers into their store. Even though Amazon and Kohl's compete for customers, they can both benefit from working together to streamline Amazon's reverse logistics.

If your company handles returns from your customers — and almost every company does — you need to think about how returns fit into your overall business strategy. Every dollar that your company can save by reducing overhead expenses is pure profit, so ensuring that you have an efficient process for managing your reverse supply chain and handling returns should be a high priority. The next few sections cover different reverse supply chain scenarios and the issues you should consider in each one.



**TIP** The process of processing and selling used items is sometimes called *recommerce*.



TECHNICAL  
STUFF

Many businesses give their customers permission to return a product by issuing a return material authorization (RMA) — an agreement by the company to accept the product when it's returned. RMA numbers make it easier for the company to track and process returns.

## *Processing Returns of New or Excess Products*

When you're a customer, especially in a retail environment, you usually expect that you can return an unused product for a full refund. Stores may have a liberal refund policy because it encourages customers to buy more and makes them loyal to a brand; a strict refund policy has the opposite effect, making customers reluctant to commit to a purchase.

Retail returns may come from a customer who received an unwanted gift; perhaps they didn't like the color, or the item was the wrong size. These returns increase dramatically around holiday shopping periods. Other return scenarios can occur in both retail and wholesale supply chains, such as when the customer changes their mind or overorders. Overordering occurs when a customer isn't sure how much they'll need, so they buy a bunch and return whatever was left over.

It can be helpful to keep track of why an item was returned. You do this by creating categories that are called reason codes. You might create reason codes for changed mind, gift return, and excess return. When these reason codes are programmed into your returns management system it becomes much easier to process and monitor returns.

Before accepting the return of an unused product, you need to consider issues that can occur with each reason code, including minor wear and tear, tampering, and substitution. Your company should have a plan in place to handle all these situations, and you should provide employees

with instructions about what they need to do in order to process returns correctly.

### ***Minor wear and tear***

Just handling a product sometimes causes scratches or other light. In that case, another customer may not be willing to pay full price for the product. You have a couple of choices. You could clean, polish, and repackage the product so that it looks like new, or you might reduce the price and sell the product at a discount. The key is to decide how much a customer would be willing to pay for the product in its current condition, how much it would cost to repackage the product, and how much more the product would be worth after it has been repackaged. If the increase in value is greater than the cost of repackaging, repackaging is a good investment. Otherwise, you're better off selling the item as-is at a discount.

### ***Damage or tampering***

Some products lose all their value after their packaging is opened. Medicine is a great example. Would you buy a bottle of pills that someone else opened and then returned to the store?

Damage or tampering can occur with any product, including electronics and computers. Before restocking an item and selling it to another customer, you need to have a process that checks for tampering and ensures that the products truly are in working condition with original parts.

### ***Substitution***

Once in a while, a customer returns the wrong product, either by accident or on purpose. A customer who is remodeling their house, for example, might buy similar accessories from several home improvement stores, get the products mixed up, and return one of them to the wrong store. If your store accepts returns, you need to have a process in place to handle such accidental substitutions.

Or you may have a customer who replaces an old fixture with a new one and then tries to return the old one to you in the new packaging. That

kind of substitution — when it’s intentional rather than accidental — can be trickier to handle. For details, see “[Handling Unauthorized Returns and Fraudulent Products](#)” later in this chapter.

## *Processing Returns of Used or Defective Products*

Sometimes, customers return products after using them, either because they don’t want the products anymore or because the products didn’t work as expected. How you handle returns of used and defective products can greatly affect your relationship with customers.

Accepting returns of used products is usually considered to be a courtesy. Retailers sometimes allow customers to return used products as a way to build brand loyalty. In most cases, used products can’t be sold easily, so these returns are commonly resold at a deep discount, without warranty; auctioned off as salvage; or thrown away.

Because they want to build customer loyalty, retailers must handle their salvage or disposal process quickly, recovering as much value as they can without running the risk of compromising their brand by selling substandard used products to other customers.



**TIP** It sometimes costs more to ship and process a return than what the product is worth. In this case, retailers may write-off the loss and ask their customer to keep or donate the product instead of returning it.

## *Handling Unauthorized Returns and Fraudulent Products*

Products are sometimes returned in mysterious ways. Customers may send back products that they never bought from you in the first place, or you may not be able to identify what the product is, where it came from, or where it belongs. This situation requires a delicate balance. You don't want to waste time and money doing an investigation that costs more than the product is worth, but it may be advisable to find out how much the product is worth and how best to recover that value. Odds are that you'll end up throwing away some items that were valuable, but you'll never get back the time and money you spend chasing down the identity of a part that turns out to be worthless.

Unfortunately, reverse supply chains have become targets for criminals. A recent example involved iPhones. Here's how the scam worked: A person bought a counterfeit iPhone and "returned" it to an Apple Store in exchange for an authentic iPhone. Then they sold the authentic replacement online, used part of the money to buy more counterfeit phones, and repeated the process. By the time the culprit was caught, Apple had lost almost \$1 million. That's why your refunds-processing department needs to authenticate the products coming back from your customers.

Fraudulent returns don't necessarily come from criminals, however. Unsuspecting customers sometimes end up purchasing counterfeit products by accident, especially online, and then try to return them to a local store when the products don't work properly. These returns can be useful for helping your business understand the market for counterfeit products.



**TIP** Counterfeiting is a major problem for some businesses; fake products take revenue away, and the counterfeit goods damage your brand. Counterfeit products have a social cost as well, because the profits often go to support organized crime. One way to know whether your products are being counterfeited is to look for fakes among your customer returns.

Obviously, you need to prevent counterfeit products from entering your supply chain as returns. Handling the customers who return fraudulent products can be trickier. You need to decide when to ignore the problem because it appears to be an innocent mistake and when to press charges because it is criminal fraud. Many large companies have brand-protection teams within their legal department — often made up of experienced law enforcement professionals — that investigate these incidents and offer recommendations about how to handle them.

## *Managing Trade-Ins*

Many businesses offer their customers credit for trading in an existing product when they buy a new one. Cars and cellphones are two common examples. You probably see commercials each day in which a car dealer promises to give you “top dollar” for your trade-in. Trade-ins are becoming common for other products, such as appliances, books, and batteries. Amazon.com now encourages customers to trade in or recycle electronic items, and companies like uSell ([www.usell.com](http://www.usell.com)) purchase electronic equipment online. Once, while traveling overseas, I even discovered that I couldn't buy beer at the grocery store unless I had a used bottle to trade in.

Some companies incorporate reverse logistics as part of their sustainability strategy. A good example is Patagonia, which makes outdoor apparel. Patagonia provides customers instructions for repairing their products and also makes it easy for customers to send damaged products in for repair. The company offers credit for returning used products, which are then resold as “Worn Wear” items. By keeping clothing in use for a longer time, the company helps reduce the use of natural resources.

Trade-ins often make sense for products that have a long life. They can be great ways to make more money and to make customers' lives simpler. Trade-in credits reduce the purchase price of your product, so they can increase your sales. If you can sell the traded-in products for a profit, you get to make money on those transactions too. Meanwhile,

your customer gets a shiny new product and doesn't have to worry about disposing of the old one.

For a trade-in program to be effective at increasing sales, it must be easy for customers to use, and customers must feel that they're getting a good deal. For a trade-in program to be profitable, you need to have a process for appraising the value of the trade-in and a channel for reselling the product.

## *Engaging with the Reverse Logistics Community*

Reverse logistics is a relatively new field that is growing quickly. The Reverse Logistics Association ([www.rla.org](http://www.rla.org)) is a U.S. group that brings companies together to conduct research, learn about best practices, and benchmark their results. RLA hosts an annual conference and expo, and offers frequent seminars and webinars. For companies that offer reverse logistics services and technologies, RLA provides a way to connect with new customers. For manufacturers and retailers who are looking for ways to improve their reverse supply chain, RLA helps them find the best solutions.



**TIP** You can find more information about the reverse supply chains and environmental sustainability in [Chapter 19](#).



## Chapter 10

# Enabling Your Supply Chain

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### IN THIS CHAPTER

- » **Aligning business rules and performance goals**
  - » **Tracking and protecting your assets and products**
  - » **Using information technology effectively**
  - » **Building your supply chain team**
  - » **Improving your project management capabilities**
- 

The SCOR Model (see [Chapter 4](#)) helps you analyze the supply chain processes within a business so that you can manage them more effectively. Most of the processes that drive supply chains can be categorized as planning, sourcing, making, delivering, or returning. In this chapter, I discuss another group of critical processes that don't fit neatly into these other SCOR categories: enabling processes. They are called *enabling processes* because they're useful for orchestrating the rest of the processes and making them work together. Examples of enabling processes include your approach to the management of business rules, performance objectives, assets, physical security, information technology, human resources, and project management.

## *Managing Your Business Rules*

Whether you realize it or not, your business is run by a set of rules. You may have rules that define what happens when a shipment is two days late, how much credit to extend to a new customer, and where you store finished goods inventory. Business rules provide consistency in a supply chain and tell your employees how to handle specific situations. Many of these rules may be written in a policy manual, captured in standard operating procedures, or programmed into a computer application. Many

rules are actually documented in memos, or they may only exist in people's heads and get passed around by word of mouth. Although the results of these rules — the outcomes — may be obvious, finding the rules may require some detective work.



**TIP** Conflicts between employees, suppliers, and customers are often an indication of a problem with business rules. The Five Whys technique can be used to identify contradictions or gaps in your rules. Start by asking “Why do we do this?” After you answer that question, ask “Why?” again. Then continue asking “Why?” until you uncover the business rules that caused the conflict.

Business rules often create problems in a supply chain when they fail to address an important factor or when they contradict one another. Here's a good example: Suppose that a company's transportation department develops a routing guide with instructions on shipping material from a supplier to its manufacturing plant. The routing guide provides the following business rule, designed to minimize transportation costs:

For shipments of less than 10,000 pounds, use a less-than-truckload (LTL) carrier, which usually involves a two-day transit time. For shipments greater than 10,000 pounds, use a full-truckload (FTL) carrier, which only has a one-day transit time.

Meanwhile, to improve its supply chain responsiveness, the manufacturing plant implements a different business rule:

Suppliers need to fill all orders within one day.

Each of these rules seems like a good idea, but complying with both is sometimes impossible. Any time a supplier is given an order that weighs less than 10,000 pounds, it needs to choose which of the two business rules to violate. In this case, the customer needs to change one of the existing rules or decide which one takes priority.

# *Managing Supply Chain Performance*

As the saying goes, what gets measured gets done. What really matters is how your whole supply chain performs and how your business is doing. You need to ask yourself what you want to get done (performance goals) and how you can measure it (metrics). Then you can capture metrics and share them with your teams, your customers, and your suppliers. Sharing clearly defined metrics helps to improve supply chain alignment.

## *Setting performance goals*

Almost every performance goal in supply chain management involves trade-offs related to asset utilization — in other words, how efficiently and effectively a company uses its money to create value for its customers and generate profits. You might track the amount of working capital that's tied up in inventory, for example. If the inventory is too low, you could lose sales due to stockouts or waste manufacturing capacity due to shutdowns; if the inventory is too high, you could be tying up working capital unnecessarily. You need to set a performance goal for inventory that addresses these conflicting business priorities. Then you need to define metrics that show whether you achieved these goals and created the desired outcomes.

To identify what your performance goals should be, start with your company's business plan. If the business plan says that your company is trying to grow market share, your supply chain performance goals should focus on availability and customer service. If your business plan is focused on cutting costs, the supply chain goals could target inventory reductions, capacity utilization, and supplier price reductions. Aligning your supply chain performance metrics with the business plan makes it easier to see the value that supply chain management is adding to your company's bottom line.

## *Align your metrics with your customers*

We all have a natural tendency to focus on our own needs and wants, but supply chain management is a team effort. The companies in a supply chain are ultimately working together to provide a product or service to a customer at a price that the customer is willing to pay. By aligning their metrics, supply chain partners can do a better job of managing the flow of money, material, and information from raw materials all the way to their customers.

A simple way to align supply chain metrics is for each company in a supply chain to ask its customers how they measure the performance of their suppliers. When the suppliers have that information, they can adopt those metrics as their own. This practice can lead to a shift from internal metrics to external metrics for each company. Rather than focusing on internal metrics such as capacity utilization, companies may start to look more closely at external metrics, such as on-time delivery.

Just as important as knowing your customers' metrics is understanding precisely what those metrics mean. Some customers measure delivery performance based on when a product is shipped from a supplier, and others measure it based on when the shipment arrives. Some customers include transportation costs and taxes when they compare the cost of one product with the cost of another product, but other customers don't. Understanding what factors are included in a customer's metric reduces confusion and makes it easier to do business together.

### ***Share your metrics with your suppliers***

To meet your needs, your suppliers have to understand how you measure their performance. If you have a scorecard for your suppliers, consider sharing the scores with them. You should also explain what the measurements are based on and why those performance goals are important to you. When you and your suppliers look at the same metrics, it becomes much easier to collaborate on improvements that will benefit all of you.

Suppose that your customers are beginning to make procurement decisions based on the sustainability of the products they buy. To meet your customers' goals, you'll need to have your suppliers report their

sustainability to you. Collaborating with your suppliers on ways to improve sustainability may allow you to come up with solutions that benefit your entire supply chain, such as packaging changes, methods of streamlining transportation, and reductions in inventory.



**TIP** For more detailed information on supply chain metrics, see [Chapter 14](#).

## *Managing Your Assets*

The word *asset* means slightly different things in different contexts. For an accountant, an asset is anything that has value — including money. In this section, assets refer to the property, plants, and equipment that are used to manufacture and distribute products. Supply chains tend to be asset-intensive, with a lot of money tied up in tools and equipment.

Assets fall into two main categories: fixed assets and mobile assets. Fixed assets are sometimes called *fixtures* because they're attached to a building and are difficult to move. Most manufacturing machinery, as well as material handling equipment such as racks and conveyors, are fixed assets. Movable or mobile assets, which can be moved around, include containers, vehicles, and tools.

### **TRACKING MOBILE ASSETS**

To manage the efficiency of mobile assets in supply chains, you need to know where the assets are located. Many companies use tracking technology to improve asset management. Radio-frequency identification (RFID) tags and Global Positioning System (GPS) units, for example, can make it much easier to track mobile assets in real time. As a result, less time is spent looking for these assets, and less money is spent replacing assets that were lost.

One common goal of supply chain managers is to increase asset efficiency, which can be done in two ways:

- » Reduce your assets.
- » Use your assets more.

The efficiency of supply chain assets is measured by your capacity utilization (see [Chapter 7](#)). As your capacity utilization increases, you are using your assets more efficiently.

Movable assets tend to get less attention than fixed assets because they're usually less expensive. But when you use a large number of them in your business, managing moveable assets properly can have a big impact on your profitability. Many manufacturing facilities, for example, move parts around in containers called totes, tubs, or bins. Managing these mobile assets effectively involves making sure that you spend as little money as necessary to buy them, buy no more than you really need, and use the ones you buy as much as possible. Asset management for these containers may also involve cleaning, performing routine maintenance, and disposing of the containers when they're no longer serviceable. If the containers aren't managed efficiently, the company will need to buy more containers, which will reduce the company's profits.

Equipment that can be used for a long time is called capital equipment. Common examples of capital equipment are trucks, trailers, generators, pumps, material-handling equipment, and manufacturing equipment. Capital equipment depreciates, gradually losing its value over time. The amount that you'd get from selling an asset is called the *residual value*. Because of depreciation, the residual value is higher today than it will be tomorrow or the next day. As long as the capital equipment is still usable, it should have some residual value. Eventually, when assets are completely worn out, they lose all their residual value and need to be thrown away. Sometimes, an asset may still have a little bit of value if it can be recycled. This value is called the *scrap* or *salvage value*. Some recyclers will buy old trucks and trailers so that they can melt them down to make more metal, for example. However, there are also times when you may need to pay someone to dispose of completely depreciated assets, particularly if the equipment contains hazardous materials that require special handling.



**TIP** To keep your supply chain costs low, you need to understand the best time to buy and sell your capital assets. Requis (<https://requis.com>) is a software platform that tracks your capital assets and analyzes when to dispose of them so that you minimize the total cost for your supply chain.

## *Labeling Your Products*

Keeping track of products as they flow through your supply chain can be a big challenge. With few exceptions, you need to label each product so that you know what it is. When you think about your labeling processes, you should consider five things:

- » **What will the label be applied to?** In some situations, you need to apply labels directly to a product or package. In other situations, you may want to label a larger unit, such as a case, a pallet, or shipping container. If you know which items are in a shipping container, for example, you don't need to look at the items individually; you can just look at the label for the shipping container.
- » **What information does the label need to contain?** For many products, it's important to track the lot number, the stock-keeping unit (SKU), and the expiration date. The label may also include a serial number, enabling you to look up information about that item in a database. If the product will be sold in a retail supply chain, you may want to include the price on the label, saving retailers time and money because they won't need to affix their own price tags.
- » **Who needs to read the label?** Sometimes, you want it to be easy for a person to read a label without any special equipment; in that case, the text needs to be clear and large enough to read. It also needs to be written in a language that the person reading it will understand. (Remember that many supply chains are global.) In other cases, you want the label to be read by a computer. It's much more efficient for



a computer to read bar codes or quick response (QR) codes than it is for it to read text characters. Finally, you may want to add security features to a label, such as magnetic inks, invisible markings, or proprietary codes that can be read only by using special equipment.

» **How will you apply the label?** Sometimes, you can apply information directly to a product by stamping, printing, or engraving it on the surface. In this case, the label actually becomes part of the product. It's often easier, however, to print information on a label made of paper, plastic, or metal and then attach the label to the product.

» **How durable does the label need to be?** You should think about how the information on a label will be used, and what environments the label will be exposed to, when deciding how durable the label needs to be. Some labels are designed to be temporary, and some need to be permanent. Temporary labels may include information that is irrelevant after the item has been purchased (such as the price and SKU) or instructions for getting a new product set up properly (such as the website to use for registering the product for a manufacturer's warranty). Temporary labels should be durable enough to last until the product has been purchased, and it should be easy for your customer to remove the label without causing damage to the product.

There are other situations in which you want the label to be a permanent feature of the product. On computers, for example, the serial number label can help users troubleshoot problems. On service parts such as oil filters, having the model number printed on the product reduces the chance of a mix-up.

## BAR CODES AND GS-1

Many products benefit from having a bar code as a label. Bar codes use lines to represent numbers, which makes it easier for computers to read the label. If bar codes are to be shared across partners in a supply chain, a central authority must issue the numbers. A Universal Product Code (UPC) is a specific type of bar code that's connected to a global database managed by a not-for-profit association called GS-1. When a company becomes a member of GS-1, it's assigned a unique identification



number. Then the company can create a unique identification number for every SKU that it sells. Combining the company's ID number with the SKU number creates a Global Trade Identification Number (GTIN). Different types of GTINs are used around the world; the version used in the United States has 12 digits, so it's called GTIN-12. UPC and other GTIN codes make it easier for everyone in the supply chain to share information about their products. You can learn more about GS-1 at [www.gs1.org](http://www.gs1.org).



A well-thought-out, well-executed labeling process is easy to take for granted, but when labels lack information, contain errors, or don't hold up to the wear and tear of a supply chain, you can run into some expensive problems. In extreme cases, improper labeling can lead companies to scrap entire production runs of valuable products. More commonly, improper labeling leads to bottlenecks and delays while people try to find the information they need to process a transaction. Think about the last time you were at the grocery store and heard someone announce "Price check on aisle 10!" The cashier had to stop the checkout process because of a question about labeling.

RFID tags are small electronic chips that store identification data (like a serial number) and then communicate wirelessly with devices called RFID readers. RFID tags are common in everyday things like credit

cards, passports, and car keys. They are also used to track products in some supply chains. Retail stores and distribution centers can use RFID to track the location of products and to improve the accuracy of their inventory counts. Some companies are attaching RFID readers to drones, which fly around inside a distribution center or a trailer yard performing fully automated physical inventory counts. The cost for RFID has dropped significantly in the past few years, but they are still much more expensive than printed labels. Many companies that have tried to use RFID tags have discovered that they don't work well in environments where there is a lot of metal (such as warehouse racks) or electronic interference (such as automated factories).

Wiliot ([www.wiliot.com](http://www.wiliot.com)) is a technology start-up that has developed a new kind of tag that communicates using the Bluetooth communications protocol. Since Bluetooth is a common standard that is used by phones and computers the Wiliot tags do not require specialized readers and can be read anywhere in the supply chain.



TECHNICAL  
STUFF

Some electronic tags are *active*; they have a battery and broadcast data whether or not a reader is present. Other tags do not require a battery; these *passive* tags only transmit data when a reader beams energy into them.

## *Preventing Tampering*

Ensuring that a product has not been changed can be important for many reasons. When you buy medicine at a store, for example, you want to know that the bottle hasn't been opened since it left the factory. When a customer returns a computer to a store for a refund, the store wants to know that the customer didn't remove any of the internal components. Companies can use tamper-evident packaging and seals to ensure that products haven't been opened or altered.

High-value consumer goods like cosmetics and electronics are often packaged in clear plastic blister packs. These packages are also called clamshells and they are good example of tamper-evident packaging. When a product is sealed inside a clamshell it easy for a customer to examine the product, but they cannot open or tamper with the product before it has been purchased.

There are two main types of tamper-evident seals: wrappers and labels. A tamper-evident wrapper needs to be broken or removed to access the product inside a package. A tamper-evident label is a sticker that must be broken or removed. The key to making tamper-evident seals effective is to make them delicate enough to break easily and hard for someone else to to copy.

## *Addressing Supply Chain Security Issues*

Supply chains need to address a variety of safety and security issues, including threats such as theft and counterfeiting, as well as special precautions to ensure that delicate or perishable products are kept in the proper condition throughout the supply chain.

### *Ensuring physical security*

Supply chains have a physical presence that's easy to take for granted. People, facilities, computers, and equipment are critical to making supply chains work properly. All these physical things are subject to a variety of threats, which is why you need to think about the physical security of your supply chain. Physical security starts with barriers such as fences, gates, and doors. It can also include security officers, alarms, camera systems, metal detectors, motion sensors, and more.

In distribution centers, for example, physical security includes systems that protect your people. Sadly, in some cases disgruntled workers have become violent with their colleagues or attempted to sabotage a facility. Burglars could break in to steal equipment or inventory. At the same time, plenty of workers have stolen products from the facilities where

they work or run crime rings inside legitimate distribution operations. Nobody wants to think about these situations, but they do happen. You need to protect your supply chain from these risks by having security processes and systems in place.

### ***Protecting supply chain information systems***

As companies rely more heavily on information technology, they become more vulnerable to attacks from computer viruses and hackers. Because customers and suppliers often share access to information systems, they can become targets through which attackers gain access to sensitive information. You need to consider information security processes when you think about managing your entire supply chain.

Some aspects of your information security process are technology-related, such as password policies, encryption methods, and antivirus tools. But many information vulnerabilities rely on exploiting human behavior, such as phishing emails that trick users into exposing their usernames and passwords. In addition to having strong information security processes for your own systems and staff, you should ensure that customers and suppliers who have access to your systems have robust safeguards in place.

### ***Dealing with counterfeiting***

Counterfeit products have been a major problem for supply chains for a long time. Trends such as globalization and e-commerce make it easier for counterfeiters to penetrate legitimate markets and sell their fake goods to unsuspecting customers.

Counterfeit products deprive legitimate companies of revenue, cheat governments out of taxes, and in some cases endanger consumers. Investigating counterfeiting operations and persuading law enforcement agencies to prosecute the perpetrators can be difficult, however. It doesn't help that some customers are willing to purchase fake items for a bargain.

When it comes to high-value products such as pharmaceuticals, customers expect — and need — to receive high-quality, authentic goods. For the companies that make the authentic products and own the

brands, it's critically important that customers recognize the difference between genuine articles and counterfeits.

Fortunately, you can use a variety of technologies to tag authentic products. These technologies include RFID, holograms, proprietary codes, and special inks that have unique textures or react to ultraviolet and infrared light. You may have no way to keep criminals from copying your products, but using anticounterfeiting technologies can make it easier for customers to differentiate between your authentic products and fakes.

Having an anticounterfeiting strategy could protect your company from product liability. If someone gets hurt by a low-quality counterfeit, you want to be able to prove that the product wasn't yours. In a growing number of industries, government regulations require manufacturers and distributors to ensure that the products they sell can be traced to legitimate sources.

## HONEYWELL AEROSPACE PARTS TRACKING

The parts that are used in airplanes have to meet very high quality standards. For safety reasons, it's important that aircraft parts be inspected frequently and repaired properly. Parts are often removed from one airplane, refurbished, and then installed in a different airplane, which makes tracking these parts as they move from one owner to another a complicated process. To solve this problem, Honeywell Aerospace created a division called GoDirect Trade to track aircraft parts by using a blockchain. The blockchain is designed to be a marketplace where companies can buy and sell parts while knowing exactly where each part has been during its lifetime. (See [Chapter 13](#) for more about blockchains.)

### *Tackling regulatory compliance*

Every country, state, county, and city where you do business has its own set of laws and regulations, which may change frequently. These rules can have effects up and down your supply chain, so you must maintain regulatory compliance. I don't have space to list all the ways that regulations could affect your supply chain, but here are some examples:

- » In the United States, federal regulations dictate how much time a truck driver can spend behind the wheel before taking a break.
- » Many countries have regulations about what kinds of wood can be used to manufacture pallets.
- » Some countries impose tariffs and quotas on products that are imported from other countries.
- » The United States and the European Union have laws regulating which suppliers can sell tungsten, tantalum, tin, or gold — often called *conflict minerals* — because many of the mines that produce these minerals support criminal, inhumane, and terrorist activities.

Failing to observe these rules and regulations can lead to major disruptions in your supply chain, such as having shipments impounded by customs inspectors. In extreme cases, violations can result in fines and even jail sentences. Ensuring regulatory compliance needs to be a priority for your supply chain.

### ***Addressing unique product requirements***

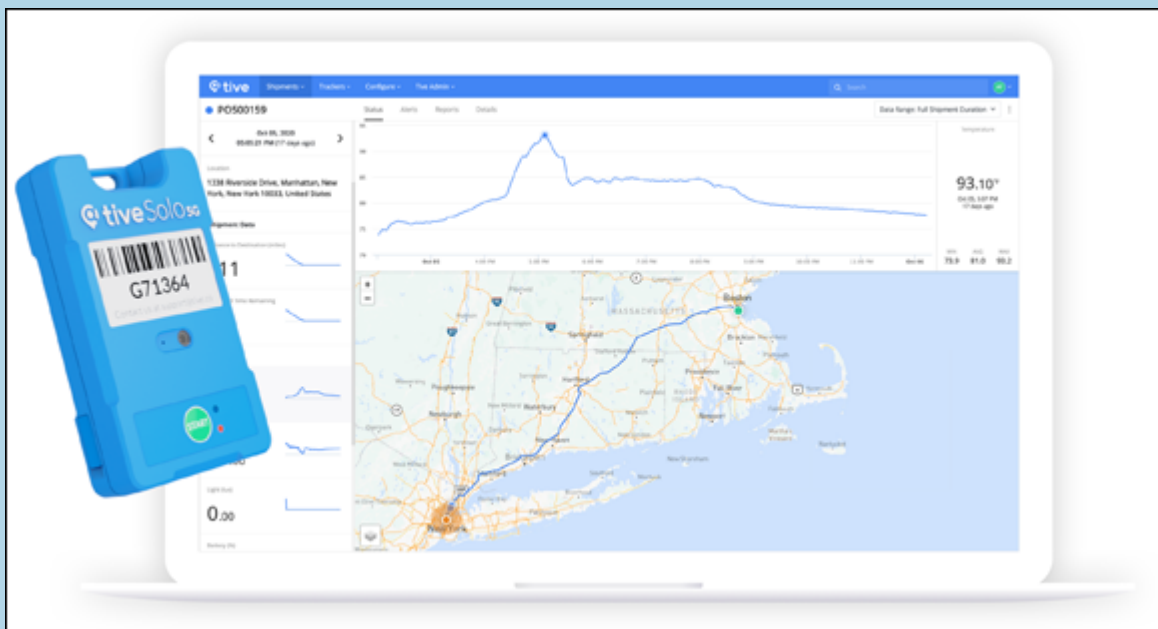
Some products require special considerations at every step in a supply chain. To ensure that these products are handled properly, you may need to provide special signs or labels. You may also need to use special sensors that monitor your products throughout the supply chain. You might place a thermometer inside a refrigerated shipping container so that you can tell whether the contents have gotten too warm during their journey, for example. Following are some examples of products that require special handling:

- » Fresh food needs to be kept cold, which means that temperatures need to be tracked and refrigeration is often needed.
- » Some chemicals need to be kept warm. Bulk rubber, for example, can become unusable if it gets too cold.
- » Products such as batteries, tires, gasoline, and explosives are hazardous materials; they need to be stored and transported in ways that reduce the risk that they could catch fire or hurt someone.

- » Radioactive materials require special supply chains that include regular monitoring and testing for radiation exposure.

## TRACKING SHIPMENTS

Tive sells tracking devices that can be attached to shipments, making it easy to monitor where the shipment is and what condition it's in. The Tive sensor sends its current location to the Internet so that you can view the tracking information from a computer or phone. Knowing where the shipment is makes it easier to predict when it will arrive at its destination. This can also make it easier to find a shipment if it gets lost or is stolen. The Tive device can also send information about its current temperature and the amount of light around it. This feature is especially useful for perishable products like refrigerated food and medicines, which must be kept cold the whole time they're moving through the supply chain.



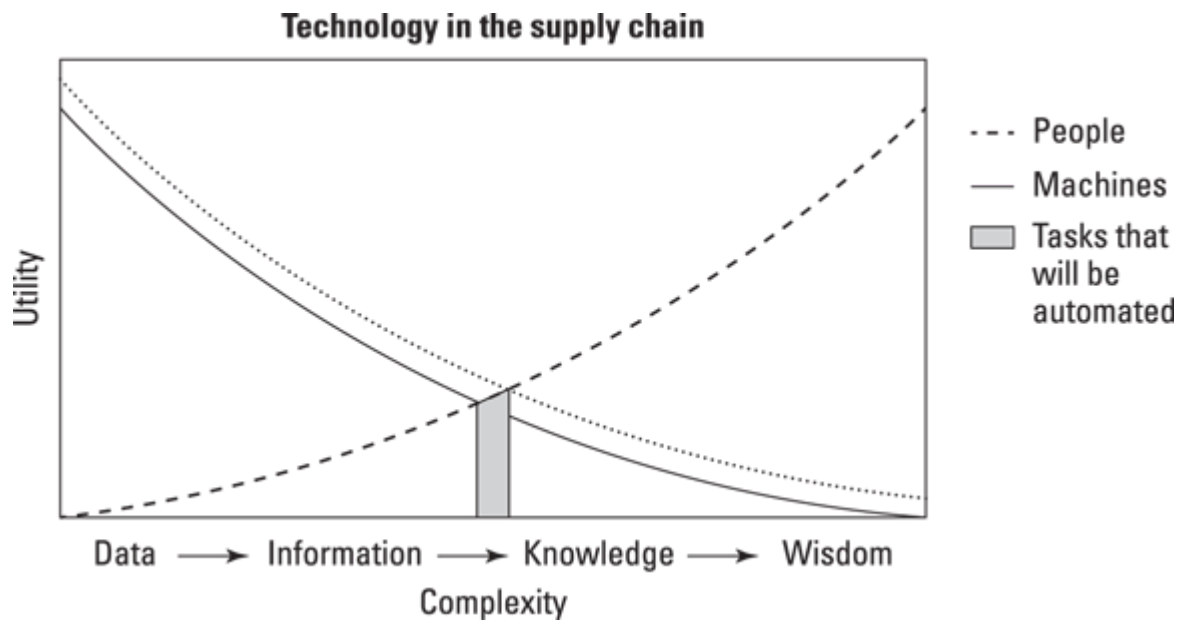
## *Leveraging Information Technology*

Information technology (IT) has a profound effect on just about every business, so staying current with IT capabilities has become an important part of supply chain management. Since the 1970s, the speed of business information processing has been driven by Moore's Law, which says that computers double their processing power about every



two years. Faster processing means that supply chains can use computers to process and share more information more quickly.

[Figure 10-1](#) shows a chart that I call the *information value chain*, which illustrates the relationship between people and IT in the supply chain. Like people, computers are able to process data, make decisions, and take actions. If you plot this relationship on a scale from simple to complex, you progress from data (on the left) to information, knowledge, and (eventually) wisdom (on the right).



**FIGURE 10-1:** The information value chain.

Computers efficiently process huge amounts of data but become less efficient as decisions become more complex. People aren't as efficient at processing simple ideas but are very efficient at dealing with complex decisions that require knowledge and wisdom. Computers can already do many of the same tasks as people, and as the processing power of computers continues to grow, computers are taking on more of these tasks better, faster, and cheaper than their human counterparts. The key to optimizing the role of IT in supply chains is striking the right balance on the information value chain: Use computers to process data and information so that people can focus on tasks that require knowledge and wisdom.



[Chapter 11](#) covers specific types of software that you can use to improve supply chain processes; the information value chain applies to all of them. Your goal is to automate the data and information tasks throughout your supply chain where computers can do this work better, faster, and cheaper than humans can. As technology becomes more powerful, the range of tasks that should be automated grows.

## *Leveraging Human Resources*

A supply chain is made of people, processes, and technologies. Supply chain managers tend to focus on the processes and the technology and often underestimate the importance of the people. A supply chain with great products, perfect processes, and cutting-edge technology can still grind to a halt if you don't have the right people in the right places using the right skills to do their jobs properly.



**REMEMBER** The COVID-19 pandemic taught all of us a lesson about the important role that people play in our supply chains. When retail clerks, warehouse associates, factory workers, and truck drivers were not able to do their jobs, the impacts were significant.

People up and down the supply chain decide who to do business with, which processes and technologies are implemented, and how to resolve problems. Getting the right people on board, giving them the skills they need to be successful, and keeping them around to do their jobs are incredibly important parts of enabling any supply chain.

Most of the human resources problems that supply chain managers need to think about can be broken down into three processes: recruit, develop, and retain. Following are some things you need to consider to ensure that your human resources capabilities support your supply chain:

- » **Recruit:** You need to decide how many people are needed to do the work at each step in your supply chain and what skills they need to have to be qualified for a job. You also need to figure out where you

can find these people, how much will it cost to hire them, and what are the best ways to connect with them and attract them to your company. Partnering with high schools, technical schools, and universities can make it easier to recruit students. Active engagement in the local community and with professional associations can help you recruit experienced talent.

It is sometimes difficult to provide a business case for the cost of recruiting, but looking at the problem differently helps. Rather than ask “How much should we pay for recruiting?” ask “How much will it cost us if this position is unfilled or is filled by someone who doesn’t have the necessary skills and experience to do it well?” The true cost might involve lost sales business opportunities, dissatisfied customers, or overtime and burnout for other employees. Helping decision-makers see the cost of leaving a position open can make it easier to justify the investment required to recruit qualified candidates.

- » **Develop:** There may be a difference between the skills required to get a job and the skills required to perform that job. Even if you require candidates to have an engineering degree before you hire them, for example, you may still need to train them in the characteristics of your product and the tools available in your company. Your development efforts should identify the knowledge, skills, and abilities that each person needs to be successful in their job. Focusing on these aspects can help you and your team members agree on the training that they need and make it easier to demonstrate the tangible benefits of your investment in developing them.



TIP

We all learn in different ways. Rather than developing a one-size-fits-all approach to talent development, it’s usually more effective to provide people options and encourage them to choose the method that works best for them.

- » **Retain:** Your employees ultimately create value for your company, and talent goes where it’s treated best. Part of treating people well is

making sure that they're paid fairly for the work they do. One way to do this is to perform a compensation study that compares the salaries of your employees with those of similar firms. Although pay and benefits are important incentives, they may not be enough to keep your employees happy. Helping people see that their work is important and giving them a voice in how decisions are made can keep them more engaged. Other retention techniques that are popular in some industries include flexible work arrangements, tuition assistance programs, and office perks (such as free snacks). The cost of these initiatives may be offset by a reduction in turnover and improved ability to attract top talent.



**TIP** Treating workers with respect and soliciting input from everyone are key parts of the Lean philosophy (see [Chapter 16](#)).

## LINKING TALENT DEVELOPMENT TO CORPORATE PERFORMANCE

The executives in a global manufacturing company realized that many of their business problems were the result of poor communications between their supply chain managers. The cost of this problem was hard to calculate, but it probably led to millions of dollars' worth of lost profits due to unnecessary inventory and expedited transportation costs. Furthermore, supply chain managers throughout the company were spending time arguing about supply chain terminology rather than aligning their performance goals. To get everyone on the same page, the executives decided that all supply chain managers throughout the company would be required to earn a certification. To pass the certification test, each of these managers would need to study the same material and learn the same method for describing supply chain processes.

The managers all had the same development goal — to complete the certification — but they could choose to meet it in different ways. Many of them chose to take instructor-led classes or online courses; others studied on their own. The company would support them no matter which option they chose, but if they didn't complete the certification within two years, they would no longer be allowed to work as supply chain managers.

Shortly after the managers began to get trained, it was clear to everyone that the nature of their discussions had changed. Once the supply chain managers were speaking the

same language they were able to communicate more effectively about challenges and opportunities.

## *Mastering Project Management*

Businesses change through projects, so project management is an important enabling process in your supply chain. That's also why project management is the final step in the New Supply Chain Agenda (see [Chapter 1](#)). Many companies find it difficult to implement supply chain projects successfully, so there is growing demand for supply chain project managers.

One of the best resources for project management training is the Project Management Institute (PMI), which has created the *Project Management Body of Knowledge* (PMBOK). The PMBOK looks at projects in terms of five main phases, each of which contains specific tasks for which the project manager is accountable.

- » **Initiating:** Broadly outline the goals of the project.
- » **Planning:** Create a detailed plan including a budget and timeline.
- » **Executing:** Complete the activities in the plan.
- » **Monitoring and Controlling:** Track key performance indicators to ensure that goals are met.
- » **Closing:** Complete all the final steps, such as performing a lessons-learned analysis and assigning new roles to team members.

PMI offers several certifications, including Project Management Professional, that are built on the PMBOK. Visit [www.pmi.org](http://www.pmi.org) for more information.



TIP

There is information about several other project management methods in [Chapter 16](#).

Recruiting, developing, and retaining effective supply chain project managers can be challenging for two reasons:

- » You want someone who understands two disciplines — supply chain management and project management.
- » Project management jobs are often temporary; when the project is finished, the project manager is out of a job.

Supply chain professionals may view project management as a stepping-stone to more stable, permanent roles. When they find those new positions, there'll be fewer supply chain project managers for you to hire.

One of the most effective ways to resolve this issue is to create a project management office (PMO). A benefit of a PMO is that it allows project managers to develop and share best practices across all your supply chain projects. If all your supply chain projects are managed through a PMO, it's easier to see and address conflicts between projects, such as when two projects are competing to solve the same problem. Because there are ongoing projects from different areas of the supply chain, the PMO provides a greater level of job security for your project managers, so they're less likely to be concerned about working themselves out of their jobs.



**TIP** Some organizations call their PMO a Project Management Center of Excellence (CoE).

A PMO can also be a great training ground for supply chain professionals. People who are rotated into and out of the PMO can learn about many parts of the business, develop a better understanding of how the parts fit together, and build a large professional network. These are valuable professional skills that are hard to develop when people are stuck in functional and professional silos.

## Part 3

# Using Technology to Manage Supply Chains

## IN THIS PART ...

Look at the different kinds of supply chain software and see how they tie into your processes.

Learn tips and tricks to find the right solutions for your supply chain.

Think about the future of supply chains as automation becomes more common.

Understand how trends like e-commerce, 3D printing, and Big Data are changing the rules for supply chain managers.

Develop metrics for tracking your status and your progress.

Create analytics and control towers to provide deeper insights and better data.

# Chapter 11

## Selecting Supply Chain Software

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### IN THIS CHAPTER

- » Seeing how supply chain software has evolved
  - » Making sense of software abbreviations
  - » Understanding where each type of software fits into your supply chain
  - » Getting advice from the experts
- 

Information technology has become an essential part of supply chain management because virtually every process in a supply chain involves entering, processing, sharing, and retrieving data. Automating the tasks for a process can increase your efficiency, but choosing the best way to automate a task can be complicated. Because there are so many processes in a supply chain, there also are many categories of software that you need to manage. Within each category of software, you'll find several companies that sell software packages with different features, capabilities, and price tags.

For some reason, almost every category of supply chain software is described by a three letter acronym (TLA), and supply chain managers use the TLAs as a sort of shorthand. It would be quite reasonable for supply chain managers to ask their colleagues whether the WMS and the TMS are sharing BI data with the ERP. (You'll read about each of these terms later in this chapter.) Unfortunately, these TLAs can lead to confusion and make supply chain software more difficult to understand than it should be.

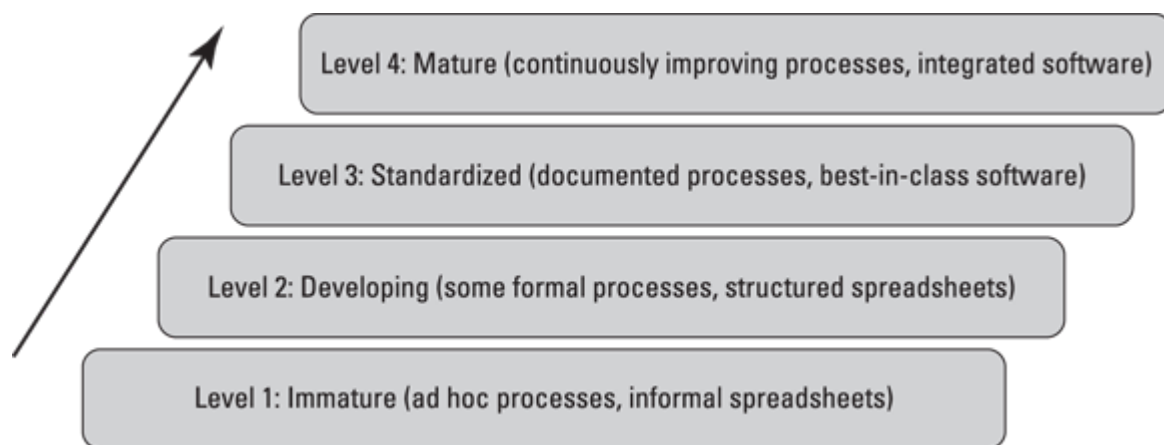


The good news is that if you start by understanding what needs to happen in a supply chain — the processes — it's much easier to understand what the various software tools are intended to do and how they work together. In this chapter, you discover how supply chain processes evolve into software platforms, how these platforms integrate with one another, and how to get help in choosing the right combination of software for your supply chain.

## *Understanding How Processes Evolve*

These days, it's hard to find a supply chain process that isn't tied to a piece of software. You can't place an order, make a phone call, or move a box without logging a transaction in one or more systems. But processes don't become automated instantly; they need to evolve.

An approach that tracks the evolution of a process or the software that supports that process is the capability maturity model (CMM). CMMs usually take four or five steps to describe a journey from immature to mature. [Figure 11-1](#) shows a four-step CMM.



**FIGURE 11-1:** An example capability maturity model.

People naturally want to jump from an immature process to a mature one, but processes and software have to make the journey in gradual

steps. Understanding where you are on a CMM helps you know where you're headed and how to get there.



**TIP** A process should be stable and repeatable before it is automated. Automating an immature process leads to extra work, such as correcting inaccurate data and overriding rules in the system.

Supply chain software is a business investment. You can evaluate an investment in automating a supply chain process by comparing four options:

- » Run the process manually, without software (do nothing).
- » Buy software off the shelf from a vendor (buy).
- » Subscribe to a cloud-based solution (rent).
- » Create a program from scratch (make).

The buy option is straightforward. You talk with a sales representative, negotiating the price, install the software, and train your team.

Instead of buying and installing software on your own computers, you can get a subscription to software that runs in the cloud. You have nothing to install; you just access the software through a web browser or an app and pay for it as you use it. In other words, you rent the software.

Making supply chain software involves writing your own software code. For companies that have unique requirements, writing their own software may be a worthwhile investment. But many companies end up making their own software without realizing it. Here's a common example that I've seen of how companies can accidentally create problems by making their own software:

1. Someone realizes they have a lot of information to track and things are slipping through the cracks, so they create a spreadsheet to organize the data. The spreadsheet is soon a critical part of managing that process.

2. The spreadsheet takes on a life of its own. More fields are added, and it's shared with other people.
3. As the spreadsheet gets bigger and is used more often, people start writing macros and formulas that automate process steps. At this point, the spreadsheet is actually a software application, but no one has noticed.
4. The spreadsheet file gets too big and starts to run slowly. Then, the data gets messed up when someone makes a data-entry mistake. Someone decides to convert it to a simple database.
5. The simple database is too limiting, so it is rewritten in Structured Query Language (SQL). Now the database is really, truly storing critical data and is essential for operating the business, but no documentation or training materials exist. Then the system crashes unexpectedly, and no one knows how to fix it.
6. A vendor shows up with a piece of software that does something very similar to the database, but does it better and with more bells and whistles. The cost of buying (or renting) this software is cheaper than the cost of maintaining your homegrown system. You need to decide whether to discard all your old data and start fresh or spend a bunch of time and money to import your old data into the new system.

The lesson is to be careful about storing important data in spreadsheets. Although using a spreadsheet may be a low-cost option in the short term, it could lead to data loss and an expensive migration in the future. If you see this scenario starting to play out in your supply chain, it's probably a good idea to stop and ask whether a better commercial solution is available. Recognizing that software solutions are available for most supply chain processes and starting with them early in your process maturity can save you time and money.



**REMEMBER** An important rule applies to every supply chain software system: The usefulness of the system depends on the accuracy of the data it has to work with. In other words, garbage in, garbage out. Providing quality data to the system in the first place is very important; so is maintaining the integrity of that data over time.



**TECHNICAL STUFF** You may run across people who make a distinction between information technology (IT) and operational technology (OT) systems. When they talk about OT they are describing systems that manage physical processes. In this book, I refer to all of these systems as IT.

## *Using Transportation Management Systems*

A *transportation management system* (TMS) keeps track of shipments and carriers. It may contain features such as a routing guide that tells you which mode of transportation and which carrier you should use for a shipment. A routing guide may have weight breaks, specifying (for example) that any domestic shipment less than 100 pounds should go by parcel, a shipment between 100 pounds and 10,000 pounds should go by less-than-truckload (LTL) transport, and any shipment over 10,000 pounds should be sent via full-truckload (FTL) transport.

A TMS may help you analyze your freight history, tracking how many loads you ship in each lane. You can use this history as the basis of a freight forecast — an estimate of how much you expect to ship on each lane in the future. The freight forecast helps you collect bids from carriers that are interested in hauling your freight. When the

transportation bidding is complete and the contracts are in place for each lane, this information is loaded into the routing guide of the TMS.

Many TMSs monitor the handoffs as a shipment moves through the supply chain, which can help you — and your customers — keep track of your shipments. When you schedule the shipment for a product, you notify the TMS. (This notification is sometimes called an advance ship notice.) When the carrier comes to pick up the shipment, the TMS is notified, and the status for that product is updated. Each time the carrier hands the product off in the supply chain, your TMS can be notified. (These messages are often called shipment status messages.) After the product is received, the TMS can trigger additional actions, such as invoicing the customer and authorizing payment to the carrier.

Some TMSs can do route planning by analyzing the freight that needs to be shipped. These systems figure out the best combinations of loads to maximize the use of transportation capacity while minimizing costs. They can even make changes to routes as new shipments get entered into the system. This sort of transportation planning and execution is a good example of how technology can solve problems and come up with solutions that even an experienced human would find extremely difficult to create. The systems that perform these advanced functions are also called transportation planning systems, transportation execution systems, or freight routing systems.

Following are some TMS vendors:

- » AscendTMS (<https://ascendtms.com/login>)
- » Blue Yonder (<https://blueyonder.com/solutions>)
- » BluJay ([www.blujaysolutions.com/solutionsxtransportation-gtn/transportation-management](http://www.blujaysolutions.com/solutionsxtransportation-gtn/transportation-management))
- » C.H. Robinson ([www.chrobinson.com/logistics/managed-tms](http://www.chrobinson.com/logistics/managed-tms))
- » Flexport ([www.flexport.com](http://www.flexport.com))
- » Infor ([www.infor.com/solutions/scm](http://www.infor.com/solutions/scm))
- » MercuryGate (<https://mercurygate.com>)

- » Oracle ([www.oracle.com](http://www.oracle.com))
- » SAP ([www.sap.com/products/transportation-logistics.html](http://www.sap.com/products/transportation-logistics.html))
- » TMS First (<http://tmsfirst.com>)
- » Transplace ([www.transplace.com/transportation-management](http://www.transplace.com/transportation-management))

## *Using Electronic Load Boards*

A *load board* is a tool for matching shippers with truckers or third-party logistics providers. Shippers post information on the load board about the freight they want moved. A shipper would post the origin, the destination, the date it wants the shipment picked up, and the type of trailer needed to move the freight. Truckers can view the post on the load board and place bids according to how much they'd charge to move the load. This process is a reverse auction, in which the truckers are bidding against one another and the prices go down with each bid. The shipper usually chooses the trucker who charges the lowest price but might consider other factors, such as its relationship with each trucker or the trucker's reputation.

Load boards used to be managed by people, but these days, electronic load boards are very common. Following are some popular electronic load boards:

- » Amazon Freight (<https://freight.amazon.com/shippers>)
- » Convoy (<https://convoy.com>)
- » DAT ([www.dat.com/load-boards](http://www.dat.com/load-boards))
- » Shipz ([www.shipz.com](http://www.shipz.com))
- » Truckstop.com (<https://truckstop.com>)
- » Uber Freight ([www.uber.com/freight](http://www.uber.com/freight))



TIP

These technologies are evolving quickly, and it's sometimes hard to tell the difference between a TMS and an electronic load board.

## *Using Warehouse Management and Execution Systems*

Keeping track of all the stuff that's stored in a warehouse or distribution center is a big, complicated job. The tool that does that job is called a *warehouse management system* (WMS). Figuring out how to pick each order and combine the individual order lines into shipments is an even bigger job. The system that makes these decisions is called a *warehouse execution system* (WES). Really, though, the line between WMS and WES is blurry and many systems perform both functions.

A WMS is like the system that manages the passenger manifest for an airplane. Each passenger is assigned a seat and given a boarding pass before they get to the airport. In other words, the WMS knows what material is coming in and decides where it will be stored. As passengers board the plane, their boarding passes are scanned. For a WMS, this is the receiving process.

A WES works in reverse. The gate agent might say "Hey, Flight Attendant 3, bring me passenger Cassandra Jones from seat 12B." The flight attendant would find the passenger and then escort that person off the airplane and back to the gate. A WES receives orders for items that need to be shipped to a customer and determines who should pick each of those items from inventory. In other words, the WES decides what has to happen — what warehouse processes to execute — and issues those instructions.

The main functions of a WMS mirror the functions of a warehouse: receiving, put-away, picking, and shipping. The WMS also provides tools for doing inventory counts and making adjustments in inventory

levels. The WMS can also help with more complicated processes, such as combining individual products into kits, called *kitting*. An example of kitting is combining all the parts needed to do an engine tune-up so that a customer can order them all at the same time. The WMS may be able to track the process of breaking bulk shipments into smaller units, a process called *break bulk warehousing*. Break bulk warehousing is common in facilities that handle replenishments to small stores or that do direct-to-customer e-commerce fulfillment.



**TIP** The real differences between a WMS and a WES have more to do with marketing than with technology. The important point is you need software to manage the movement and storage of materials in a warehouse. Call the system something that makes it easy for people to understand what you mean and makes you feel better about the amount of money that it costs.

Following are some WMS and WES vendors:

- » Körber (formerly HighJump) ([www.koerber-supplychain.com](http://www.koerber-supplychain.com))
- » Infor ([www.infor.com/solutions/scm](http://www.infor.com/solutions/scm))
- » Blue Yonder (<https://blueyonder.com/solutions>)
- » Manhattan Associates ([www.manh.com/products/warehouse-management](http://www.manh.com/products/warehouse-management))
- » Oracle ([www.oracle.com](http://www.oracle.com))
- » SAP ([www.sap.com/products/extended-warehouse-management.html](http://www.sap.com/products/extended-warehouse-management.html))
- » Softeon ([www.softeon.com/our-solutions/product-solutions/warehouse-management](http://www.softeon.com/our-solutions/product-solutions/warehouse-management))
- » Tecsys ([www.tecsys.com](http://www.tecsys.com))



## PLANNING SOFTWARE VERSUS EXECUTION SOFTWARE

People sometimes separate supply chain software into two categories: planning software and execution software. Planning software collects data and forecasts the most efficient ways to use supply chain resources. Execution software looks at actual orders and decides how to fill them. In other words, planning software tries to prepare your supply chain based on what the future is expected to look like, and execution software makes decisions about what you need to do today. Managing any supply chain process involves both planning and execution. The term *supply chain execution* is very popular among software companies, but you need to dig deeper to understand which supply chain processes their software is intended to automate.

### *Using Demand Planning Systems*

Determining how much of your stuff customers are likely to buy is one of the biggest challenges in any supply chain. This process is called forecasting or (if you want to sound fancy) demand planning. This guess about the future can be based on many inputs, such as how much you've sold in the past, how strong you think the economy will be in the future, or how effective you expect your marketing to be. You have many ways to forecast demand, but doing so often requires a combination of math and judgment. Preparing these forecasts over and over across a range of products requires a special kind of software called a *demand planning system* (DPS).

A DPS typically provides many methods for forecasting demand and enables you to add information or adjust the forecast. It helps you look at the forecasts at different levels, from the individual stock-keeping unit (SKU) level forecast to your master demand schedule. You can configure the DPS to use different forecasting methods for products based on whether their demand is steady or volatile. If you have products that sell more during the winter and less in the summer, you may need your forecast to account for seasonality.

A DPS commonly interfaces with a customer order history so that it can incorporate information about past sales into the forecast. The DPS may

also tie into a material requirements planning (MRP) system (see the next section) because that system provides a starting point for creating a master production schedule.

Following are some DPS vendors:

- » Alloy (<https://alloy.ai>)
- » Demand Solutions ([www.demandsolutions.com/solutions/demand-optimization](http://www.demandsolutions.com/solutions/demand-optimization))
- » Infor ([www.infor.com/solutions/scm/planning](http://www.infor.com/solutions/scm/planning))
- » John Galt (<https://johngalt.com>)
- » Kinaxis ([www.kinaxis.com/solution/supply-chain-planning-solution/demand-planning](http://www.kinaxis.com/solution/supply-chain-planning-solution/demand-planning))
- » Logility ([www.logility.com/solutions/demand-planning-solution](http://www.logility.com/solutions/demand-planning-solution))
- » Oracle ([www.oracle.com](http://www.oracle.com))
- » SAP ([www.sap.com/products/advanced-planning-optimization.html](http://www.sap.com/products/advanced-planning-optimization.html))
- » ToolsGroup ([www.toolsgroup.com](http://www.toolsgroup.com))

## *Using Material Requirements Planning Systems*

Before you can assemble a product, you need to have all the necessary pieces, parts, or components. Sometimes, the assembly process has multiple steps that need to occur in different places and in a particular sequence. The purpose of a *material requirements planning* (MRP) system is to figure out what parts you need, and when and where you need them, so that you can manufacture your products.

To start with, the MRP system needs to know what you plan to make and when you plan to make it. That is, it begins with your production

forecast, also called the master production schedule. Based on that schedule, the MRP system looks at the bill of materials (BOM) for each product you want to make. This document lists all the components that are needed to make a product. After looking at each BOM, the MRP system checks the inventory level for each component to see whether you will have the parts you need when you need them. If inventory falls short, the MRP system calculates how much you should order and when you should order it so that the material arrives in time for you to make your product.

In some cases, the MRP system goes beyond planning to executing tasks. The system can issue purchase orders for components, for example, and monitor the performance of your manufacturing process to adjust the plan as needed.



**TIP** It is common for large companies to issue a purchase order to a supplier for a large number of items, and then ask the supplier to ship the items in small batches as they are needed. The MRP system can calculate when the items are needed and send a schedule to the supplier to tell them when to ship the items.

Suppose you run a factory that makes two bicycle models: one is red, and the other is blue. The frames for these models are different, but everything else about the bikes is identical, including the wheels, pedals, chains, and other parts. How do you decide how many units of each part you need and when you should order those units from your suppliers to make your bikes?

The simplest approach is to decide how many units of each type of bike you plan to make in a certain period of time, called your *planning horizon*. Suppose that your planning horizon is one year, and you decide to make 100,000 units of each bike model during that time. This figure is your production target: 100,000 of each bike model, or 200,000 bikes total.

During the year, your factory is open for 50 weeks (closing for 2 weeks for maintenance and holidays). To hit your production target, you need to make an average 2,000 units of each type of bike every week, or 4,000 total bikes per week.

The BOM for each bike includes two wheels, a frame, a sprocket, a chain, two pedals, and a set of handlebars. Each component comes from a different supplier, with different lead times and different lot sizes.

You could order all the parts you need at the beginning of the period — enough parts to make 200,000 bikes. But this approach would be a mess for everyone! Your suppliers would be scrambling to fill your order, and you'd need to have all the parts delivered before you could start working. All that inventory would cost you money. You'd need to pay your suppliers for all the parts that they made, and you'd need to store and protect all those parts in a warehouse. Some parts are likely to get lost, damaged, or stolen, resulting in shrinkage costs.

An MRP system tries to improve this situation by comparing the master production schedule with the expected inventory levels and then ordering the parts you need so that they arrive just in time.



TECHNICAL  
STUFF

Some people use the term *manufacturing resource planning* to describe software that performs these tasks. You may even see material requirements planning called MRP and manufacturing resource planning called MRP II. Unless you're truly interested in a career managing supply chain software systems, it's unlikely that you'll ever need to describe the differences between MRP and MRP II.

Following are some MRP vendors:

- » IFS ([www.ifsworld.com/solutions/enterprise-resource-planning](http://www.ifsworld.com/solutions/enterprise-resource-planning))
- » Infor ([www.infor.com/solutions/erp](http://www.infor.com/solutions/erp))

- » Microsoft (<https://dynamics.microsoft.com/business-central>)
- » Oracle (also called JD Edwards)  
([www.jdedwardserp.com/functional-modules/manufacturing](http://www.jdedwardserp.com/functional-modules/manufacturing))
- » SAP ([www.sap.com/products/supply-chain-management/manufacturing.html](http://www.sap.com/products/supply-chain-management/manufacturing.html))

## *Using Manufacturing Execution Systems*

In modern factories, each piece of manufacturing equipment is controlled by a specialized computer called a *programmable logic controller* (PLC). A *manufacturing execution system* (MES) is software that connects to those PLCs and synchronizes the processes in a factory. MESs are also called manufacturing operations management systems, or MOMs. One benefit of an MES is that it can generate reports about how much the factory is producing, and it can change the settings on each machine, which is useful for improving efficiency. An MES can also connect to sensors throughout the factory that monitor environmental conditions, such as temperature and humidity, to help detect problems that could affect the quality of the products that are being manufactured.

There are three main types of MES software. The first type of MES system is similar to a material requirements planning system. The second type is more like an extension to the PLC programming software. The third category of MES systems are designed as a link between the PLCs and enterprise resources planning (ERP) systems. You can read about ERP systems later in this chapter.

Following are some MES vendors:

- » ArcStone ([www.arcstone.co](http://www.arcstone.co))
- » Honeywell ([www.honeywellprocess.com](http://www.honeywellprocess.com))
- » Oracle ([www.oracle.com](http://www.oracle.com))

- » Plex ([www.plex.com/products/manufacturing-execution-system](http://www.plex.com/products/manufacturing-execution-system))
- » Rockwell Automation ([www.rockwellautomation.com](http://www.rockwellautomation.com))
- » SAP ([www.sap.com/products/supply-chain-management/manufacturing.html](http://www.sap.com/products/supply-chain-management/manufacturing.html))

## *Using Distribution Requirements Planning Systems*

Sometimes, businesses need to forecast inventory and plan replenishment orders across several tiers of distribution centers. A master facility might receive FTL shipments from suppliers and break these shipments into pallets that are shipped to local distribution centers. The software system that works through this process is called a *distribution requirements planning* (DRP) system. A DRP system is similar to an MRP system (refer to “[Using Material Requirements Planning Systems](#)” earlier in this chapter). Whereas an MRP system focuses on ensuring that material is available to support a manufacturing process, a DRP system focuses on managing the availability of products in warehouses and distribution centers. The forecasting elements of a DRP system resemble the functions of a DPS system (refer to “[Using Demand Planning Systems](#)” earlier in this chapter), allowing the system to use a variety of inputs to prepare the most accurate forecast.

In addition to forecasting demand at each distribution point, the DRP system has to account for order quantities (called lot sizes). The system also has to factor in order lead times for each product to decide when each order should be placed, thereby minimizing inventory costs and ensuring that inventory stays at the desired level.

Following are some DRP vendors:

- » Infor ([www.infor.com/solutions/scm/planning](http://www.infor.com/solutions/scm/planning))
- » Microsoft ([www.microsoft.com/dynamics365/ax-overview](http://www.microsoft.com/dynamics365/ax-overview))
- » Oracle ([www.oracle.com](http://www.oracle.com))

- » SAP ([www.sap.com/products/extended-warehouse-management.html](http://www.sap.com/products/extended-warehouse-management.html))

## *Using Labor Management Systems*

Supply chains aren't just about things; people are involved too. You have to decide how many people you need on each shift to meet the demands on your warehouse. You also have to track the performance of your workers and identify those who deserve rewards and those who need more training. You perform these tasks with a piece of software called a *labor management system* (LMS).

LMSs can help with scheduling to make sure that you have enough people to do the work on each shift. This system reduces the risk of not getting the work done because you're short-staffed, which can translate into overtime for the next shift. It also reduces the risk of having people sitting idle because there isn't enough work for all the people on a shift. LMSs can track performance in ways that help you understand how efficient your associates are, as well as how and where you can improve efficiency.

In many warehousing and distribution centers, labor expenses are a huge part of operating costs, so having an LMS that does a good job of planning requirements and monitoring performance can have a huge effect on the efficiency of a facility.

Following are some LMS vendors:

- » Blue Yonder (<https://blueyonder.com/solutions>)
- » enVista (<https://envistacorp.com/technology/supply-chain/labor-management-system>)
- » Honeywell (formerly Intelligrated) (<https://sps.honeywell.com>)
- » Körber (formerly HighJump) ([www.koerber-supplychain.com](http://www.koerber-supplychain.com))
- » Manhattan Associates ([www.manh.com/products/manhattan-active-labor-management](http://www.manh.com/products/manhattan-active-labor-management))



» NextView ([www.nextviewsoftware.com/solutions/labor-management-system](http://www.nextviewsoftware.com/solutions/labor-management-system))

## *Using Customer Relationship Management Systems*

Keeping track of your customers is essential for every business, and the software applications that perform this tracking are called *customer relationship management* (CRM) systems. A CRM system can track who your customers are and what they've bought from you in the past. A CRM system can help you understand what deals you have in the pipeline so that you can do a better job of forecasting future sales. It can manage accounts receivable by tracking contracts, payments, and credits for each customer account. It can help you increase revenue by looking for customers who may be interested in new products and services. It can target offers and messages to customers based on their unique characteristics.

A CRM system can also tell you a lot about your sales organization by providing reports on how often sales representatives engage with their accounts, for example. The CRM system can tie into other systems to improve the flow of information along the supply chain. If a CRM system is integrated with a TMS system (refer to "[Using Transportation Management Systems](#)" earlier in this chapter), for example, your customers may be able to track their own shipments.

Fundamentally, a CRM system connects your organization to your customers and ties your customers to you, which makes it a critical link in your supply chain.

Following are some CRM vendors:

» Infor ([www.infor.com/product-summary/cx/infor-crm](http://www.infor.com/product-summary/cx/infor-crm))

» Microsoft (<https://dynamics.microsoft.com>)

» Oracle ([www.oracle.com/cx/what-is-crm](http://www.oracle.com/cx/what-is-crm))



» Salesforce ([www.salesforce.com](http://www.salesforce.com))

» SAP ([www.sap.com/products/crm-commerce.html](http://www.sap.com/products/crm-commerce.html))

## *Using Supplier Relationship Management Systems*

Managing relationships with your suppliers is an important part of supply chain management. The computer program that keeps track of supplier information is called a *supplier relationship management* (SRM) system.

At a minimum, an SRM system tells you who your suppliers are, what products you buy from them, what payment terms you've agreed to, and what contracts you have in place. The system should help you keep track of communications among various members of the supplier's team and the people in your company who interact with them. The system should help you analyze and report on supplier performance as well as tracking supplier qualifications and certifications.

SRM systems are especially useful for making strategic supply chain plans. The system can identify the suppliers and products that are most likely to create bottlenecks if you try to increase your production targets. It can identify the suppliers that are most likely to benefit from additional investments, such as training on new equipment or supplier development. Finally, it can help you spot suppliers that are at risk or should be replaced.

An SRM system plays the critical role of linking your company with your suppliers, which makes it a useful tool for large, complex supply chains.

Following are some SRM vendors:

» Ariba ([www.ariba.com/about](http://www.ariba.com/about))

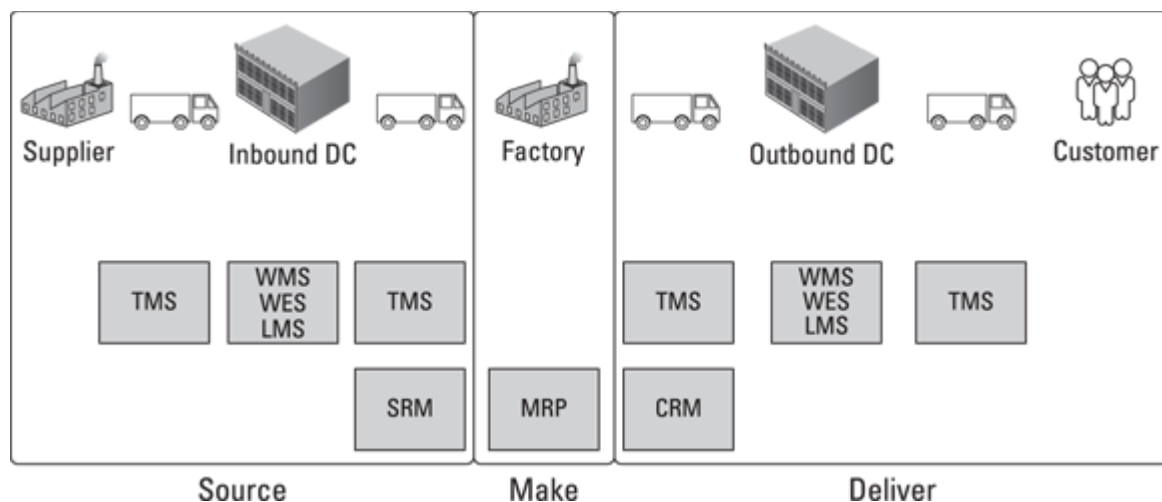
» Coupa ([www.coupa.com/products/supply-chain-design](http://www.coupa.com/products/supply-chain-design))

» Jaggaer ([www.jaggaer.com](http://www.jaggaer.com))

» SAP ([www.sap.com/products/spend-management/supplier-management.html](http://www.sap.com/products/spend-management/supplier-management.html))

## Using Enterprise Resource Planning Systems

Many stand-alone systems support individual supply chain functions, which may lead you to ask, “Why all the different systems?” These systems largely evolved from simple spreadsheets to support individual functions, as shown in [Figure 11-2](#). Now the systems have started to converge into massive, integrated programs called *enterprise resource planning* (ERP) systems. Depending on the brand and the configuration, an ERP system can contain modules that perform all the functions of the systems discussed earlier in this chapter, as well as many more.



**FIGURE 11-2:** Basic ERP system modules.

An ERP system can automate many of the functions and processes in a supply chain, from scheduling production to ordering replenishments to responding to customer orders, and ensure that the information moves smoothly from one step in the process to the next. That’s the good news. The bad news is that ERP systems are extremely complex, and

configuring them often involves massive effort and changes in existing manufacturing processes that can be difficult to implement.

Following are some ERP vendors:

- » Infor ([www.infor.com/solutions/erp](http://www.infor.com/solutions/erp))
- » Microsoft (<https://dynamics.microsoft.com>)
- » Oracle ([www.oracle.com/applications/erp/index.html](http://www.oracle.com/applications/erp/index.html))
- » SAP ([www.sap.com/products/enterprise-management-erp.html](http://www.sap.com/products/enterprise-management-erp.html))

## *Using Supply Chain Modeling Software*

Figuring out what your supply chain looks like can be a huge challenge. With suppliers, customers, distribution centers, and factories spread around the world, it can be difficult to choose the best supply chain configuration.

There are three ways in which companies use supply chain modeling software:

- » **Digital twins:** You create a virtual copy of your supply chain or any of the facilities or processes inside of your supply chain. A digital model that represents an object from the real world is called a *digital twin*.
- » **Simulation:** You create a computer model of the supply chain that you have — or that you want — and then simulate how that supply chain would perform. You simulate what happens as customers buy products so that you see what actions the purchase triggers through the rest of the supply chain. The simulation shows you whether you can meet expected demand, as well as what happens to inventory levels and transportation costs. You can run simulations of different supply chain configurations to determine how each configuration

performs. This process usually is much faster and cheaper than building a real supply chain and waiting to see what happens.

- » **Optimization:** You tell the software what your supply chain needs to do, and the software tells you how to configure your factories and distribution centers. Optimization software eliminates bottlenecks and extra capacity throughout your supply chain. It calculates safety stock levels and reorder points for products in each area of your distribution network.

Most supply chain software — the stuff that goes into an ERP system (refer to “Using Enterprise Resources Planning Systems” earlier in this chapter) — is really just a big database, storing transactions and tracking relationships among different types of data. But supply chain modeling software uses sophisticated math and performs complex calculations to predict the behavior of actual supply chains.

Supply chain modeling can be based on either of two mathematical approaches:

- » **Deterministic:** In this type of model, you’re precise in your guess about how something will work. You might make the deterministic estimate that the demand will be for 500 units, for example.
- » **Stochastic:** In this type of model, you model probabilities. Your stochastic model might estimate demand to be between 400 and 600 units, for example.

The stochastic models are a bit more complicated than deterministic models, but they often do a better job of representing how a supply chain will operate under real-world conditions.

You use supply chain modeling software to save time and money when making improvements in your supply chain. The software helps you achieve a larger goal. The model needs to be only good enough to provide the right answer. When you have confidence in the results of a model, spending more time and money to make the model better may not provide any benefit to your business or to your supply chain.

Following are some vendors of supply chain modeling software:

- » anyLogistix ([www.anylogistix.com](http://www.anylogistix.com))
- » Arena ([www.rockwellautomation.com/products/software/arena-simulation.html](http://www.rockwellautomation.com/products/software/arena-simulation.html))

## BUILDING USEFUL MODELS

I like to share three pearls of wisdom with everyone when they start to learn about supply chain modeling. The first comes from statistician George Box: “All models are wrong, but some are useful.” Whether you’re talking about simulation or optimization, the goal is to understand the problem you’re trying to solve and model the variables that are most likely to help you understand that problem and come up with a good solution.

The second is a quote from French philosopher Voltaire: “Perfect is the enemy of good.” Trying to make a supply chain model too good is a waste of time, because it’s impossible to predict all of the variables perfectly.

The third comes from artificial intelligence expert Tony Grichnik: “A good model has to tell you something that you know in order to give you confidence that it is accurate, and it has to tell you something that you don’t know in order to help you learn something new.” There’s more information about building models for supply chain analytics in [Chapter 15](#).

- » Coupa ([www.coupa.com/products/supply-chain-design](http://www.coupa.com/products/supply-chain-design))
- » Flexsim ([www.flexsim.com/flexsim](http://www.flexsim.com/flexsim))
- » Greenscreens.ai ([www.greenscreens.ai](http://www.greenscreens.ai))
- » Optimal Dynamics ([www.optimaldynamics.com](http://www.optimaldynamics.com))
- » Simio ([www.simio.com/index.php](http://www.simio.com/index.php))
- » simul8 ([www.simul8.com](http://www.simul8.com))
- » TADA ([www.tadanow.com](http://www.tadanow.com))
- » Vensim (<https://vensim.com>)

# *Using Business Intelligence Software*

Understanding what’s happening across a supply chain involves tapping many data sources for analysis and reporting. The software that enables people to perform these tasks is called *business intelligence* (BI) software.

BI software needs to do three things well:

- » **Connect with data.** The software needs to be able to connect with your data, no matter where it’s stored. A BI system may need to talk with your other supply chain systems. Alternatively, you may need to combine the data from all these systems into a single data warehouse or data lake so that your BI system can access that data easily.
- » **Combine and analyze data.** A BI system needs to combine and analyze data from other systems, even though it’s often difficult to link data from different systems. Fortunately, BI systems have sophisticated techniques that make this task relatively easy.
- » **Provide insights.** A BI system needs to provide answers to questions about your supply chain in ways that are easy for people to understand, sometimes illustrating the data in graphs, charts, and pictures.

BI features are sometimes built into other supply chain software, such as ERP systems (refer to “Using Enterprise Resources Planning Systems” earlier in this chapter). Because these systems already contain much of the data that you need, including a BI tool in them makes sense.

BI systems are often used to create dashboards that allow managers to see what’s happening in their business. These dashboards can be automated, which makes it easy to track what’s happening in real time so managers know where to focus their attention right now.

Following are some BI vendors:

- » IBM ([www.ibm.com/analytics/business-intelligence](http://www.ibm.com/analytics/business-intelligence))
- » Microsoft (<https://powerbi.microsoft.com>)
- » Oracle ([www.oracle.com/solutions/business-analytics/business-intelligence/index.html](http://www.oracle.com/solutions/business-analytics/business-intelligence/index.html))
- » Qlik ([www.qlik.com](http://www.qlik.com))
- » SAP ([www.sap.com/products/lumira.html](http://www.sap.com/products/lumira.html))
- » SAS ([www.sas.com/solutions/business-intelligence.html](http://www.sas.com/solutions/business-intelligence.html))
- » Tableau ([www.tableau.com](http://www.tableau.com))

## *Supply Chain Risk Management Software*

Supply Chain Risk Management (SCRM) collects real time information about events happening in the world to notify you of possible disruptions. For example, SCRM software could detect a natural disaster in a certain region, and then notify you about which suppliers are located in that region, and which orders they are currently filling.

Following are some SCRM vendors:

- » Everstream Analytics ([www.everstream.ai](http://www.everstream.ai))
- » Resilinc ([www.resilinc.com](http://www.resilinc.com))
- » RiskMethods ([www.riskmethods.net](http://www.riskmethods.net))

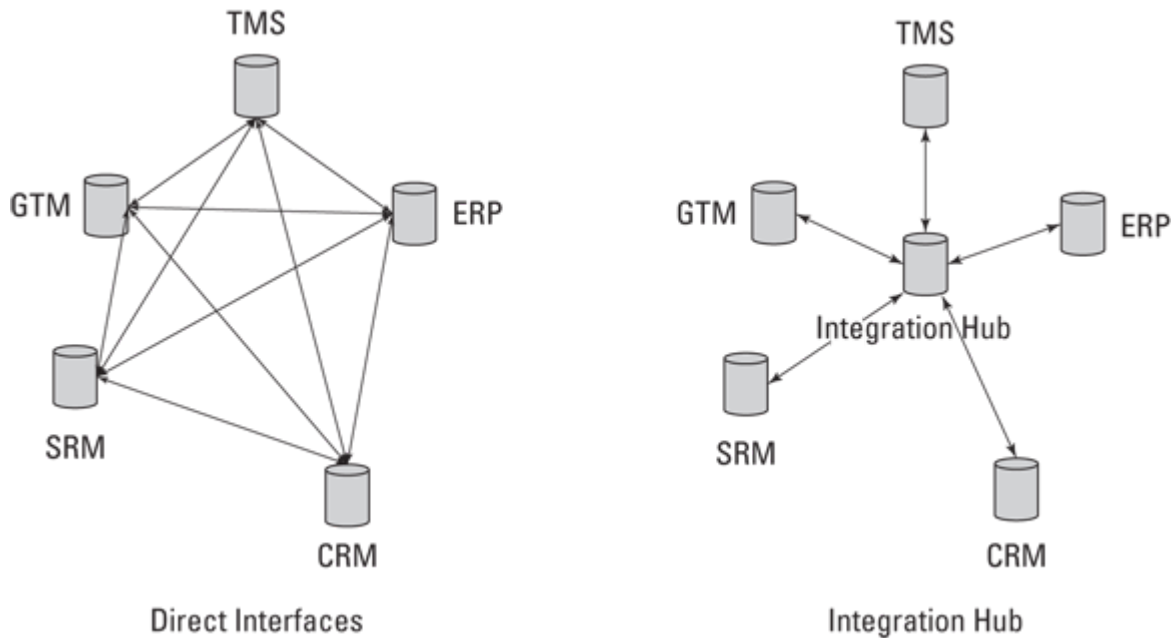
## *Integrating Supply Chain Software*

When you purchase a new software application you need to implement or *deploy* that solution. In other words, you need to configure the new information system to work with your business processes, and you need to upload your own data into the new system. In many cases, you also need the new system to talk with existing, or *legacy*, information

systems throughout your supply chain. For example, a new TMS might need to share information with a legacy ERP system to accurately plan the lead time for orders from your suppliers. Integrating systems so that they can share information is often one of the most difficult parts of implementing a new solution because each system stores different information, calls the same information by different names, and uses different formats to store the data.

Systems are connected by *interfaces*, which are instructions about what information should be shared, what rules govern the sharing of that information, and what format the information needs to be shared in. Many systems today provide a tool called an *Application Programming Interface* (API) that makes it easier to build interfaces to other systems. Even with APIs it can be complex to integrate many different systems with one another because these APIs don't always match up between different software packages. Tools like backboneAI ([www.backbone.ai](http://www.backbone.ai)) can streamline the process of creating interfaces and check for data errors. Or, instead of creating multiple interfaces, it may be easier to implement a data integration hub like Chain.io ([www.chain.io](http://www.chain.io)). Data integration hubs enable you to create one interface for each supply chain information system, and then that system can share information with all of the other systems that are connected to the hub, as illustrated in [Figure 11-3](#).





**FIGURE 11-3:** Direct software interfaces versus a data integration hub.

Some companies implement new software using their own personnel. An advantage to this approach is that your internal employees probably understand your unique business requirements better than anyone else. Some companies put their software vendor in charge of the implementation, which can make sense because they have the best understanding of the software. A third option is to hire an integrator which is a consulting firm that specializes in configuring supply chain software. Integrators typically have lots of experience implementing complex solutions in a variety of different environments. In many cases, supply chain software implementations involve a combination of all three — internal employees, vendor resources, and outside consultants — working together as a cross-functional implementation team.



**TECHNICAL  
STUFF**

For information systems to communicate effectively, they need to share a common language called an *ontology*. David Morrow is a researcher who is working to create a standard ontology for supply chain information systems. You can learn more about this challenge in his paper, “Developing a Basic Formal Supply Chain Ontology

to Improve Communication and Interoperability” at <https://scholar.afit.edu/etd/5062>.

## *Leveraging Software Analysts*

So many categories of supply chain software are available, with so many competing applications in each category, that keeping track of them is a full-time job. Professional software analysts study supply chain software so that they can make recommendations to the rest of us about which tools are the most useful.

Some analysts work for supply chain software vendors. These analysts focus on defining capabilities and demonstrating the benefits of their company's software compared with competitors' software.

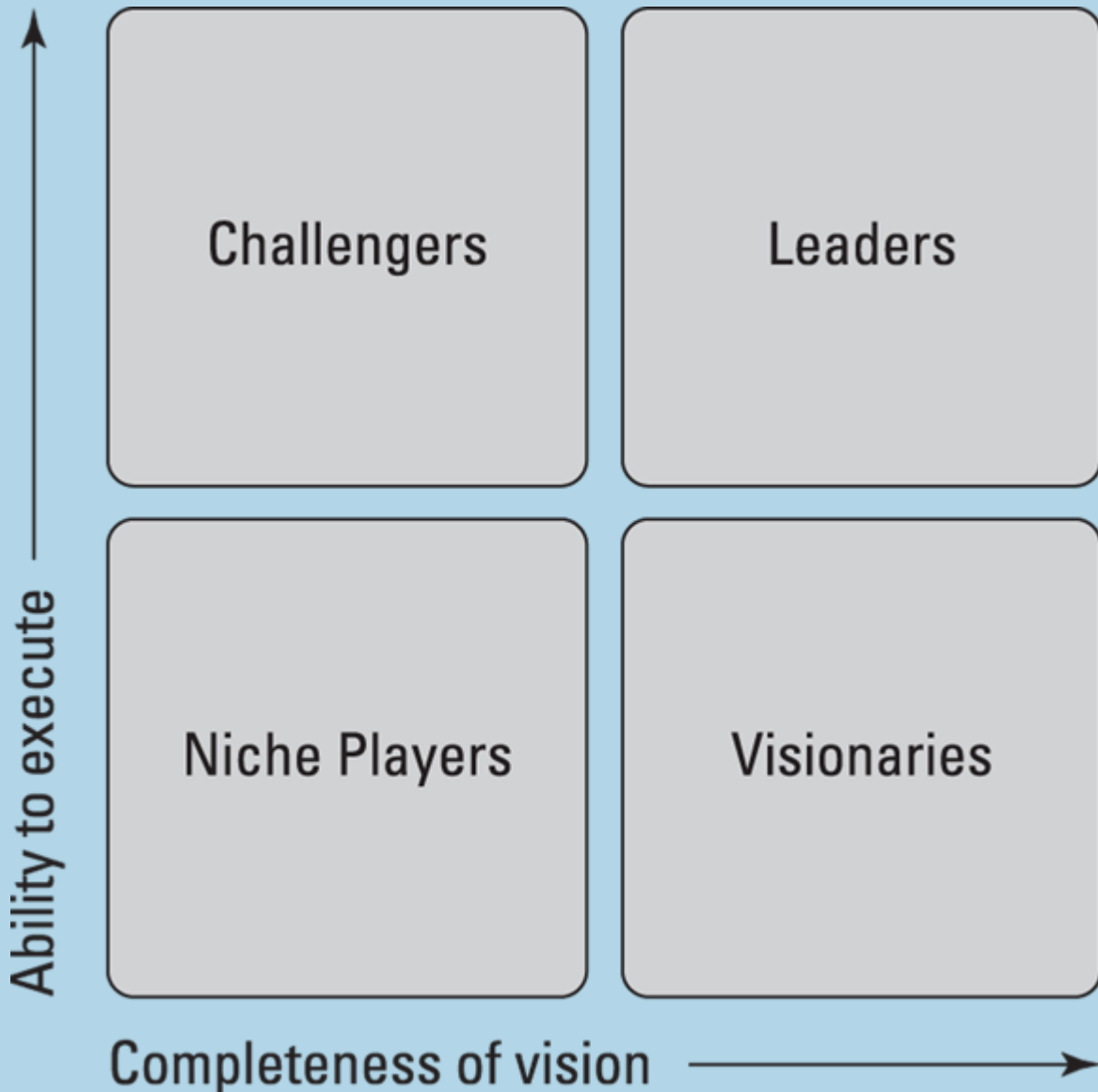
Other analysts are independent, working on their own or with small consulting teams, and they specialize in studying industry trends. Two good examples are Supply Chain Insights (<http://supplychaininsights.com>), led by Lora Cecere, and Adelante SCM (<http://adelantescm.com>), led by Adrian Gonzales. Even though these firms are small, their leaders are well-known, and their opinions are valued by many executives in the supply chain industry.

Some supply chain software analysts work for large companies that publish research reports and support major consulting projects for selecting, installing, and integrating these tools into an existing supply chain. Four of the best-known supply chain analyst firms are Aberdeen ([www.aberdeen.com](http://www.aberdeen.com)), ARC Advisory Group ([www.arcweb.com](http://www.arcweb.com)), Forrester ([www.forrester.com](http://www.forrester.com)), and Gartner ([www.gartner.com/supply-chain](http://www.gartner.com/supply-chain)).

Software analysts often charge thousands of dollars for access to their research, but that's cheap compared with the time and money it could take for you to research software on your own. More important, analysts can help to protect you from the mistake of buying software that isn't a good fit for your business.

# GARTNER'S MAGIC QUADRANT

Analysts often develop models to compare the strengths and weaknesses of various supply chain software vendors. Gartner has popularized a concept called the Magic Quadrant (see the following figure). Each software vendor in a category is rated based on the completeness of their vision and their ability to execute. The leading software providers should have both a complete vision and ability to execute. There's room for niche players who may not rate well on either dimension, and there are spots for contenders and visionaries. Models like the Magic Quadrant make it easier to tell which vendors will be a good fit for your needs.



# *Anticipating the Future of Supply Chain Software*

Technology is evolving from helping people plan tasks to executing those tasks automatically. In that sense, supply chain software is evolving from a *planning* role to an *execution* role.

Referring to any software platform as a supply chain execution solution implies that it somehow addresses all your supply chain needs, which isn't the case — yet. The day may come when all these software platforms are truly integrated, which would eliminate the need for people to be involved in any part of a supply chain. This process is called *digital transformation*, and it is the topic of [Chapter 13](#). As digital transformation takes hold, artificial intelligence may someday lead to autonomous digital supply chains, and at that point, fully automated supply chain execution will become reality.



**TIP** The LogTech Map is a project that organizes supply chain technology companies into a chart that shows how they solve logistics challenges. It is available at [www.refashiond.com/news/2021/11/22/new-logistics-technology-market-map-seeks-to-center-buyers-of-logistics-technology-and-services](http://www.refashiond.com/news/2021/11/22/new-logistics-technology-market-map-seeks-to-center-buyers-of-logistics-technology-and-services).

# Chapter 12

## Integrating Advanced Manufacturing into Your Supply Chain

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### IN THIS CHAPTER

- » Looking at how technology is changing supply chains
  - » Exploring automation of manufacturing and material handling
  - » Preparing for drones and autonomous vehicles
- 

With machines getting smarter, stronger, and faster every day, dealing with the rapid pace of innovation has become an important part of supply chain management. Many of the principles of supply chain management are built on assumptions about the capabilities of manufacturing and distribution processes. How much you can make, how far you can move it, and how much it will cost all depend on what technologies you use. New technologies are changing the way supply chains work, and will require supply chain managers to reevaluate the best ways to plan, source, make, deliver, and return products in the future.

The problem with these new technologies is that it is hard to predict how quickly they will become available and how significantly they will affect a supply chain. In many cases, new technologies provide new ways to perform the same tasks we're already doing, but the technologies enable us to do those things better, faster, and cheaper. In other cases, new technologies disrupt entire industries and could make the tasks we're doing today obsolete.

These new technologies for making products and managing processes are often described as *advanced manufacturing*, but the trend goes

beyond manufacturing to include design and distribution. Really, it would be better to use the term *advanced supply chains*.

In this chapter, you discover many of the important trends and technologies that are likely to change the way that manufacturing and distribution are done in the future. These advanced technologies will lead to changes in the way we design and manage supply chains too.

## *Avoiding Obsolescence*

Advances in technology can quickly make an entire supply chain obsolete. Obsolescence can occur in two ways: products become obsolete, or processes become obsolete.

Examples of products that have been made obsolete by technological innovation are easy to find: the typewriter, the film camera, the videocassette. Companies that made a lot of money manufacturing these products are now extinct. The demand for the products that these companies made went away because customers found that a new type of product worked better.

A good example of a process that became obsolete is the story of the ice industry. Did you know that ice — plain old frozen H<sub>2</sub>O — was the number-two product exported by the United States in 1850? Back then, a huge industry was built around harvesting, transporting, and storing ice. The ice supply chain crisscrossed the globe, and companies in the United States were the leading suppliers. Later in the 1800s, though, after refrigeration technology was developed, it became possible to manufacture ice on demand, anywhere. In other words, the development of refrigeration technology changed the process and made the old supply chains for the ice industry completely obsolete.

The story of the ice trade is an example of how a new technology can disrupt an established process. The key point from the story is that the demand for the product — ice — didn't diminish, and the supply didn't go away. People didn't stop using ice, and refrigeration actually made ice much more widely available. But the long global supply chains for ice that involved transportation and material handling were more

expensive and less reliable than the newly invented refrigerators; therefore, those global supply chains went away as they were replaced by the newer technology and processes.

No matter what business you are in, new technologies are being developed that could disrupt your product or your process. Part of your job as a supply chain manager is to be aware of emerging technologies and try to anticipate the effects they'll have on your business. You may be able to gain a competitive advantage by adopting new technologies early. Or if a new technology will make your business obsolete, you might need to be proactive in developing a plan to remain profitable in a shrinking market.

## *Preparing for Industry 4.0*

You probably learned about the Industrial Revolution in school. Many experts now argue that there have been several industrial revolutions and that we're witnessing another one right now. The First Industrial Revolution occurred in the late 1700s, when we began to use steam power. The Second Industrial Revolution came in the late 1800s, when we began to use electricity and mass production. The Third Industrial Revolution was in the late 1900s, as we developed computers and software for manufacturing. Now we're witnessing the Fourth Industrial Revolution, which involves the convergence of many new technologies, from robotics to communications to artificial intelligence (AI). The result of this revolution will be Industry 4.0, an era in which many of the processes in a supply chain are completely automated.



**TIP**

Some experts talk about Supply Chain 4.0 when describing the way supply chains will operate during the age of Industry 4.0. Some people are already trying to figure out what Industry 5.0 will look like, but most of us are still adjusting to Industry 4.0.

## LAUNCHING INTO INDUSTRY 4.0

Technology has always been at the heart of industry, and a good way to understand how radically information technology is changing supply chains is to look at how other technologies have revolutionized supply chains in the past. Many experts describe the Industrial Revolution in four stages:

- **Industry 1.0:** Harnessing water and steam to power factories and transportation
- **Industry 2.0:** Generating electricity to power industrial processes
- **Industry 3.0:** Automating manufacturing and distribution by using computers
- **Industry 4.0:** Connecting complex supply chain processes by using the Internet and making decisions with AI

During each industrial revolution supply chains have become more automated. We are in Industry 4.0 right now, which is why sensors, Big Data, and IoT are so important for supply chain management.

## *Capitalizing on Advanced Manufacturing*

Several new technological capabilities are changing the way engineers think about designing and manufacturing products. Three technologies that are enabling advanced manufacturing are

- » Automated manufacturing
- » Computer-aided design
- » 3D printing

### *Automated manufacturing*

Automated equipment is a critical part of virtually every supply chain. The work of creating, installing, and maintaining this equipment is often called *industrial automation*. Automation usually starts with machines that are programmed and operated by people, but it can evolve into completely automated manufacturing systems that operate



autonomously. Some machines are even able to detect problems and repair themselves!

Automated processes can be controlled in two ways:

- » **Open loop:** In an *open-loop* system, the automated process operates based on a fixed input. An open-loop process may operate on a set schedule or produce a specific number of widgets, for example.
- » **Closed loop:** In a *closed-loop* system, the automated process receives feedback that it uses to make decisions. This approach is sometimes called “sense and respond.” A closed-loop process might monitor the yield from a process and then adjust the production target to ensure enough usable products are manufactured, for example. (See [Chapter 7](#) for more information about yield.)

A good example of the difference between open-loop and closed-loop control systems is a security light. If a light turns on and off according to a set schedule, the system is an open loop. If the light is triggered by a motion sensor so that it turns on only when something moves nearby, the system is a closed loop. The evolution of closed-loop control systems that can receive inputs and respond appropriately is driving much of the growth of automated manufacturing.

## *Computer-aided design*

Computers are now essential for designing products. In the old days, a draftsman created a blueprint for a product by hand. These days, the process is done via computer-aided design (CAD). Rather than send a physical blueprint to a factory, a designer sends a CAD file directly to a computer-aided manufacturing (CAM) system, which decides how to manufacture or assemble the product from the CAD file. The whole process — from design through manufacturing and assembly — is done with computers, reducing or eliminating the need for printouts and prototypes. When CAD/CAM processes are automated and integrated with one another, they are called *virtual design*, *virtual manufacturing*, or *virtual assembly* processes.

## 3D printing

One exciting development is a group of technologies that are collectively called 3D printing. To see how a supply chain is likely to be affected by 3D printing you first need to understand how 3D printing works.

Many — if not most — products have been made by *subtractive manufacturing*, which means removing extra material until you have the shape you need. (Think of Michelangelo chipping away at marble to create a sculpture.) 3D printing is the opposite process. Instead of removing extra material, 3D printing adds material to make a product. That's why the process is also called *additive manufacturing*.

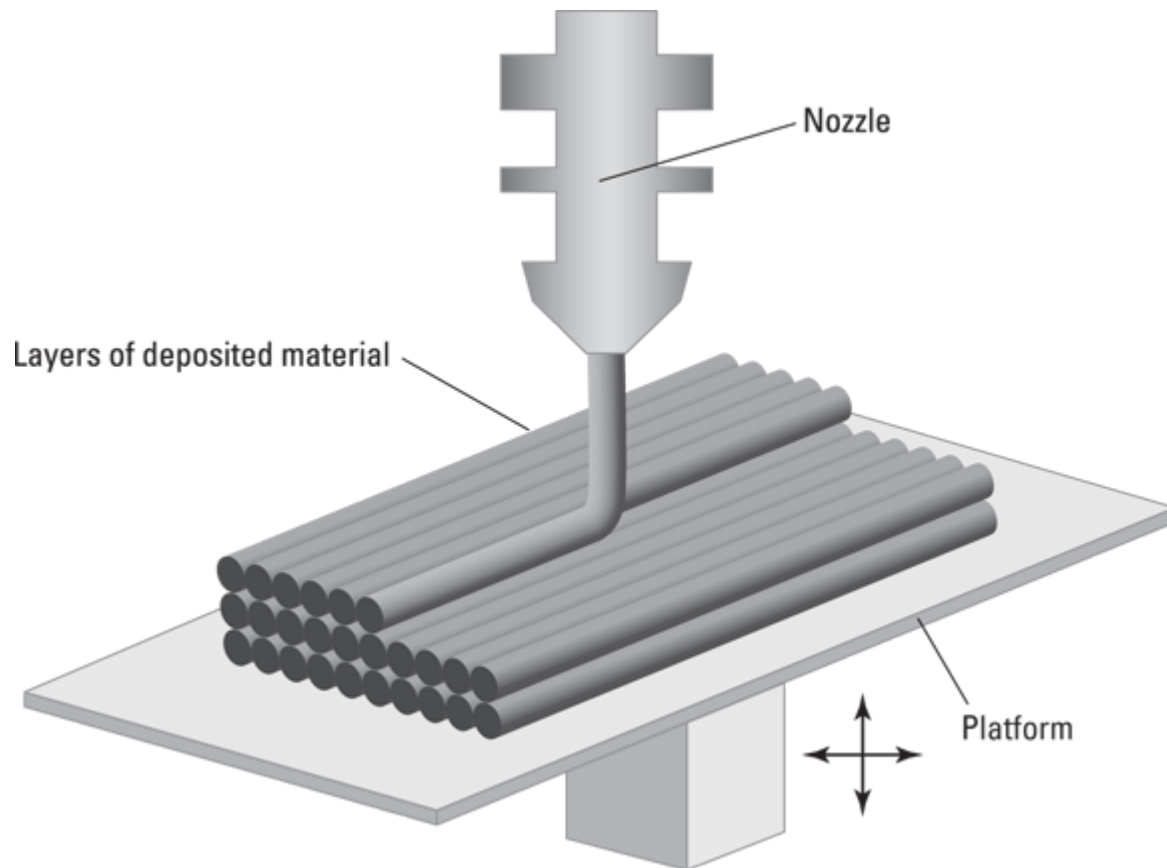
3D printing is a broad term that covers many techniques, most of which use one of three types of material (*feedstock*) to make products: solid materials (usually in spools), powders, or liquids.

By far the most common 3D-printing technology uses spools of plastic as feedstock. These printers deposit small amounts of molten material in layers, gradually building a finished part through a process called *fused deposition modeling* (FDM). FDM is similar to a hot-glue gun or a wire-feed welder. The raw material usually comes on a spool and is fed into a nozzle, where it's melted and squeezed onto a platform. The nozzle is mounted on arms that allow it to move front to back, side to side, and up and down. In other words, the nozzle prints in three dimensions. [Figure 12-1](#) shows an FDM 3D printer.



TECHNICAL  
STUFF

Squeezing a melted material through a small opening is called *extrusion*, which is a common manufacturing method for metals and plastics. FDM printers create extruded products, but because the nozzle moves in three dimensions, FDM is more flexible than traditional extrusion techniques.



**FIGURE 12-1:** FDM 3D printer.

Because of the material limitations of FDM, other 3D-printing technologies may be more useful for your supply chain. You can print with powdered metals through a process called selective laser sintering, for example, and you can print with liquids and then harden them into solid objects through a process called stereolithography.

3D printing has potential benefits for manufacturing supply chains:

- » Manufacturers can print shapes that would be difficult to make with other processes.
- » Waste and energy consumption are often lower.
- » Inventory and transportation costs are lower because products can be printed when and where they're needed. (See the section on postponement in [Chapter 17](#).)

3D printing also has some limitations:

- » Options for the materials used to make a product are limited.
- » The size and quality of a product are limited by the capabilities of the printer.
- » 3D printing tends to be much slower than traditional manufacturing.

3D printing works well with CAD (refer to “[Computer-aided design](#)” earlier in this chapter). When you have a CAD file for the object you want to make, you can send those instructions to a 3D printer just as you’d send a document to a regular printer.

When making a prototype or a small number of items 3D printing has some clear advantages. The cost of 3D printing a single prototype is often much lower than the cost of creating the dies, molds, and tooling required for mass production of parts with traditional manufacturing techniques. And 3D printing can be a better alternative for products that have unpredictable demand, for customers who need products quickly, and for customers who are a long way from the factory or distribution center.

Whether 3D printing makes sense in your supply chain is a question that you’ll probably need to ask and answer over and over. As your business, products, and customers change, you may have to adopt 3D printing. As the technology gets better (which it certainly will), the barriers to using 3D printing will fall.

## **3D PRINTING IN HUMANITARIAN SUPPLY CHAINS**

Humanitarian supply chains may reap great benefits from 3D printing. One example is the use of 3D printing to make plumbing fittings in remote parts of the world. A humanitarian organization might ship all the components needed to install a water well in a remote village, but when workers start to assemble the plumbing, they realize that they’re missing a part that isn’t available locally. The whole project would stall. Rather than shipping the part via a parcel carrier and dealing with logistics and customs issues, the humanitarian organization instead might be able to send a file to a nearby 3D printer.

Another supply chain that could be affected by 3D printing involves replacement parts for industrial equipment such as tractors and electrical generators. This equipment is

expensive, and breakdowns can have life-threatening consequences. As a result, companies spend lots of money on inventory for spare parts just to make sure that they're available. If a company could print those parts, it might be able to eliminate that inventory.

## AUTOMATION LINGO

Several technical terms come up frequently when people talk about automated manufacturing and distribution. Being familiar with the following terms will make it much easier for you to follow the conversation:

- **Neural network:** A neural network is a type of computer program that uses feedback loops to recognize patterns and learn from its own experience. Neural networks are an example of artificial intelligence that enables computers to perform tasks that used to require human intervention. Neural networks play a key role in voice recognition systems such as Apple's Siri.
- **Control limits:** The acceptable upper and lower bounds of a process output are called the *control limits*. You might say that every widget you manufacture needs to weigh 100 pounds, plus or minus 1 pound. In other words, as long as the widget is between 99 pounds and 101 pounds, it's within the control limits.
- **Human-machine interface:** A *human-machine interface* (HMI) is a device that allows machines and humans to exchange information. The display of your computer is an HMI, for example. In advanced manufacturing, HMIs can include displays, touchscreens, voice-recognition systems, keyboards, and joysticks.
- **Interface:** An *interface* is a piece of software that exchanges information between two computer systems.
- **Interlock:** An *interlock* is a device that connects two systems. Interlocks are often used as safety precautions. The access door for an area that has a robotic arm may have an interlock installed so that if someone opens the door, the robot stops moving.
- **Operating parameters:** Automated equipment is generally designed to work under a range of conditions called the operating parameters. If it's too hot or too cold, the temperature could fall outside the operating parameters, and the equipment could malfunction.
- **Programmable logic controller:** A *programmable logic controller* (PLC) is a special kind of computer that controls automated equipment. PLCs are designed to be simple, flexible, and durable.

# *Automated Mobile Robots*

If you've been in a factory or distribution center lately, you've seen how common automated material handling systems are. Long, winding conveyors move and sort packages, and many facilities have tall automated storage and retrieval systems. This equipment can move more material than people can, so it radically increases the capacity of a facility. But the equipment requires a large up-front investment, and after it has been installed, it's difficult to make changes. In other words, the drawbacks are cost and lack of flexibility.

A different type of automated material handling system is starting to become popular in fulfillment centers: autonomous mobile robots. These robots are relatively inexpensive and extremely versatile. You can increase or decrease your picking capacity by adding robots to or removing robots from the network. These robots can work around the clock, seven days per week, so one robot could replace three or four human pickers. In some systems, you can change the layout of your facility simply by programming the robots to move your racks to different locations.

Following are some companies that sell robots to pick inventory in a warehouse and carry it to the area where it will be packed and shipped:

- » 6 River Systems (<https://6river.com>)
- » Bionic Hive ([www.bionichive.com](http://www.bionichive.com))
- » Boston Dynamics ([www.bostondynamics.com](http://www.bostondynamics.com))
- » Dematic ([www.dematic.com](http://www.dematic.com))
- » GreyOrange ([www.greyorange.com](http://www.greyorange.com))
- » Honeywell (<https://sps.honeywell.com>)
- » inVia Robotics ([www.inviarobotics.com](http://www.inviarobotics.com))
- » Locus Robotics (<https://locusrobotics.com>)
- » Opex ([www.opex.com](http://www.opex.com))

- » RightHand Robotics ([www.righthandrobotics.com](http://www.righthandrobotics.com))
- » Swisslog ([www.swisslog.com](http://www.swisslog.com))

As robots become more common, supply chain managers will need to reevaluate how their fulfillment centers are designed and operated. These robots could greatly increase the productivity of human workers but also could eliminate many jobs that are currently done by people.

## *Unmanned and Autonomous Vehicles*

For many years, unmanned vehicles have been important tools in supply chains. Factories use remote control vehicles to move heavy objects; in mines, loaders and other equipment are operated by remote control. The new generation of unmanned vehicles are called *drones*. Drones are different from traditional remote-controlled vehicles because drones are autonomous, capable of traveling from one place to another without getting instructions from a person.

Drones fall into four categories:

- » Unmanned aerial vehicles (UAVs) fly through the air, like airplanes or helicopters.
- » Unmanned ground vehicles (UGVs) travel over land, like cars and trucks.
- » Unmanned surface vehicles (USVs) travel over the water, like ships.
- » Unmanned underwater vehicles (UUVs) travel under the water, like submarines.



**TECHNICAL  
STUFF**

The line between remote-controlled vehicles and autonomous vehicles can be blurry; there is often a person providing instructions at the same time the vehicle is making some of its own decisions. A person may direct the drone to travel to a certain location, but then the drone is able to maintain its position while calculating wind velocity, avoiding hazards, and so on.

It's pretty easy to identify places where drones could make supply chains faster, safer, cheaper, and more reliable. Locomation (<https://locomation.ai>) has developed technology that allows autonomous trucks to follow behind a human driver. Google, Tesla, and Uber have all developed autonomous trucks that could carry freight thousands of miles without a driver. Amazon and Walmart have experimented with autonomous aerial vehicles for delivering packages. Walmart and Sam's Club have experimented with robots that patrol stores and perform inventory counts.

On the one hand, you need to be careful about getting caught up in the hype. For drones to do a lot of things that people are dreaming of, the technology needs to get a lot better. On the other hand, many companies are working hard to make the needed improvements. You should pay attention to how drone technology is advancing so that you can incorporate it into your supply chain when and where doing so makes sense.



**REMEMBER** You also need to consider the risks that autonomous vehicles present. There are reasons to doubt whether drones will be reliable enough to support many supply chains. If a drone makes a mistake, such as delivering products to the wrong location, the consequences could be severe.



Some people are skeptical about the business value of using drones. To provide a business benefit, you need to have a clear understanding of how drones help you deliver a service that will increase revenue, reduce costs, or avoid costs in the future.

There are also questions related to the brand effects of using drones in a supply chain. Using autonomous vehicles could make your brand more valuable (as in “Yeah, that brand is awesome because they have drones”), but it could also cause damage to your brand (as in “Nope, those guys are awful because they employ robots instead of humans”).

## **AERIAL DRONES IN HEALTH CARE**

UPS has created a subsidiary called Flight Forward to develop the business of using aerial drones for last-mile delivery. In 2019, UPS Flight Forward began using drones made by Matternet to carry blood samples from a North Carolina hospital to the nearby testing laboratory. By car, the trip would normally take 30 minutes. But because the drone can fly from point A to point B without stopping for traffic, samples can be delivered in three minutes. In 2020, because of the COVID-19 pandemic, UPS and Matternet began using drones to carry prescriptions from a CVS pharmacy to customers in a Florida retirement community, ensuring that vulnerable customers could receive their needed medicine without leaving their homes.

# Chapter 13

## Managing Digital Transformation in Supply Chains

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### IN THIS CHAPTER

- » Driving toward digitalization
  - » Exploring digital supply chain technologies
  - » Building an omnichannel supply chain
- 

Virtually every supply chain transaction boils down to a three-step process: A customer gives a supplier some money, the supplier gives the customer a product or service, and the customer and supplier exchange some information. That's why it's common to think of a supply chain as three flows: money, material, and information. (See [Chapter 2](#) for a description of this approach.) Advances in information technology are changing all three of these flows and generating new opportunities to create value with radically different solutions.

Your *digital supply chain* consists of all the information about your products, transactions, and locations that is stored or shared electronically. Warehouse management systems, transportation management systems, and all the other systems discussed in [Chapter 11](#) are part of your digital supply chain; each of them helps your business operate more effectively.

During the COVID-19 pandemic, many employees needed to work from home, customers wanted touchless transactions, and facilities were often closed with little warning, so companies had to find innovative ways to keep money, materials, and information flowing. In many cases, companies replaced manual supply chain processes with more

automated, digital solutions such as e-commerce and curbside delivery. Some of these changes were temporary work-arounds, but many of these new solutions are here to stay.

In the past, supply chain technology tended to focus on improving existing processes by automating them. Today three trends are redefining the role of digital tools in supply chain management:

- » The evolution of products from analog to digital to digitalized
- » The convergence of planning, execution, and visibility systems
- » The desire by customers to have products and services customized to their specific needs

As we move through the Fourth Industrial Revolution, technology is changing what is possible, and it is changing our customers' expectations. Responding to these trends will require supply chains to make a lot of changes — what we call a *digital transformation*. In this chapter, you look at each of these trends and why they're making digital supply chains so important. You also find out about the technology, tools, and applications that are making these trends possible.

## *Smart Industry Readiness Index*

A good place to begin your digital transformation is to use the Smart Industry Readiness Index (SIRI), which is curated by the International Centre for Industrial Transformation (INCIT). SIRI is an assessment that evaluates process, technology, and organizational readiness. Many of the tools you need to conduct a SIRI assessment are available for free, but if you need help to complete a formal assessment, you can hire a certified SIRI assessor. [Figure 13-1](#) shows the 16 elements of a company that are examined during a SIRI assessment.

Once you complete the SIRI assessment, you can compare your results to other companies' results and determine where you need to focus your efforts in order to undergo a digital transformation. INCIT recommends a four-phase approach for leading a digital transformation:

- » **Learn:** Learn key concepts and build a common language for alignment.
- » **Evaluate:** Evaluate the state of existing facilities and the company's readiness level for Industry 4.0.
- » **Architect:** Architect a comprehensive transformation strategy and implementation roadmap.
- » **Deliver:** Deliver impact and sustain transformation initiatives.



**TIP** You can learn more about the SIRI assessment process at <https://siri.incit.org>.

**Smart Industry Readiness Index**

Process			Technology			Organisation	
Operations	Supply Chain	Product Lifecycle	Automation	Connectivity	Intelligence	Talent Readiness	Structure and Management
↓	↓	↓	↓	↓	↓	↓	↓
Vertical Integration 1.	Horizontal Integration 2.	Integrated Product Lifecycle 3.	4.	Shopfloor 7.	10.	Workforce Learning and Development 13.	Inter-and Intra-Company Collaboration 15.
			5.	Enterprise 8.	11.		
			6.	Facility 9.	12.	Leadership Competency 14.	Strategy and Governance 16.

SIRI, International Centre for Industrial Transformation.

**FIGURE 13-1:** Smart Industry Readiness Index assessment matrix.

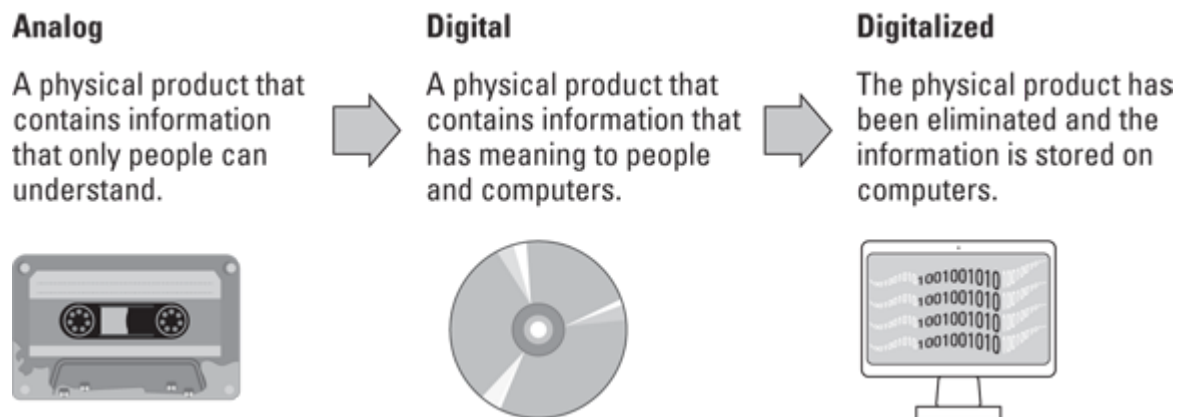
## *Digitalizing Products and Services*

One of the major trends that is occurring around us is digitalization. *Digitalization* is the process through which the physical products and services people buy become dependent on virtual products and services.

As products and services are digitalized, they create new opportunities and challenges for a digital supply chain.

When you store a lot of information about a physical object, you're creating a digital model of that object called a *digital twin*. Digital twins are used to monitor the performance of the machines that operate in a supply chain and they are used to predict how a supply chain will behave. (Refer to the discussion of digital twins in [Chapter 11](#).)

The most extreme examples of digitalization occur when a physical product or service is replaced by an electronic version. Digitalization has been apparent in the supply chains for movies for several years, for example. As [Figure 13-2](#) illustrates, a few years ago most people would buy a movie by purchasing an analog videotape, That was a physical product with a pretty conventional supply chain. A factory would make the videotapes and then ship them to distribution centers; the distribution centers would ship the tapes to retail stores.



**FIGURE 13-2:** Many products are becoming digitalized.

Then movies were converted to a digital format and stored on DVDs. Even though the movies were digital, the DVDs were still physical products, and the supply chains for DVDs were similar to the supply chains for videotapes. Today, movies are becoming digitalized. Instead of buying a DVD, now you download movies from the Internet. The physical supply chain for movies is being replaced by a digital supply chain that allows movie producers to eliminate inventory and

transportation costs, and customers can watch those movies on a TV, a computer, or even a phone.



TECHNICAL  
STUFF

Converting anything from analog to digital involves translating it into a series of zeros and ones that a computer can understand. After a product becomes digital, it can often be digitalized, and at that point it is completely virtual.

Services can also be digitalized. The supply chain for education, for example, is being changed by online learning. In the past, college students had to travel to a university to take classes on complex topics. Today, many of those courses are available anywhere in the world over the Internet. Other service businesses that are being digitalized include travel agencies, taxi dispatch, and even health care. Technology is transforming the way that these services are delivered to customers. In this transformation process, digital supply chains are becoming more essential.

*Augmented reality* (AR) technologies change the way people perceive and interact with the world around them. One example of AR is a computer built into a pair of eyeglasses that adds information to the things you look at in a store or warehouse. For example, imagine if you could look at an item on the store shelf and have the ingredients displayed inside your glasses so that you could read them without touching the item. Or imagine you are in a distribution center and your glasses display instructions for how to safely get to a location without getting run over by a robot.

*Virtual reality* (VR) technologies take this a step further and immerse people into a completely different environment. There are many examples of VR games, for example, where users wear special goggles and headsets to create the illusion that they are inside of the game. There are also VR booths called *simulators*, and VR rooms, called *caves*, where the virtual environment is displayed onto the walls around you. VR in the supply chain is being used to train equipment operators so that

people can get hands-on experience without the risk and expense of operating large expensive machines. In the future, VR could be used to allow people to operate machines from a distance. For example, VR might enable forklift operators to do their jobs from an air-conditioned office while remotely controlling a robotic forklift in a far-off distribution center that is hot and humid.

When you imagine the widespread digitalization of both products and services, it seems like we are basically created a new universe that only exists as data stored on the Internet. This digital universe is called the *metaverse*. Products and services in the metaverse will need to be supported by digital supply chains.



**TIP** Many companies are already taking steps to prepare for the metaverse. For example, the company that runs Facebook has changed its name to Meta.

Digitalization doesn't always eliminate physical products. Smartphones are examples of physical products, with a physical supply chain, that depend on a digital supply chain. For a smartphone to deliver the value that customers expect, the physical supply chain has to deliver the phone, and the digital supply chain has to deliver apps and data.

The good news about digitalization is that customers often get more options for the same products, which means digitalization tends to make supply chains more customer centric. The bad news is that offering both physical and digitalized versions of a product costs businesses money. Because not all customers make the switch from physical to digitalized products at the same time, companies have to carry the cost of making both available.

## *Prioritizing Cybersecurity*

While digital transformation is creating new ways for supply chains to create value, it is also creating new ways for hackers to cause damage. In

the past few years there have been several high-profile examples of cyberattacks that were directly related to supply chains:

- » In 2013, hackers stole information about 40 million credit and debit cards from a U.S. retailer.
- » In 2017, an attack shut down one of the world's largest steamship lines for ten days.
- » In 2022, a ransomware attack shut down the Colonial pipeline, which provides gas, diesel, and jet fuel to the U.S. East Coast.

Because digital transformation is making our supply chains vulnerable to cyberattacks that can be launched by hackers anywhere in the world, there is now a Supply Chain and Cyber Directorate (SCD) within the U.S. National Counterintelligence and Security Center. You can find up-to-date information about the threats SCD is monitoring and the actions the government is taking to address them at

[www.dni.gov/index.php/ncsc-what-we-do/ncsc-supply-chain-threats](http://www.dni.gov/index.php/ncsc-what-we-do/ncsc-supply-chain-threats).



**TIP** You often can't prevent cyberattacks from affecting your suppliers or customers, but here are some of the things you can reduce the vulnerability of the entire supply chain by protecting your own digital infrastructure:

- » Implement security best practices, such as strong passwords that need to be changed frequently, and multi-factor authentication for users.
- » Ensure that software updates are deployed quickly to address vulnerabilities as they are discovered.
- » Deploy security tools such as antivirus software, firewalls, and network monitors.
- » Establish a backup, reaction, and recovery plan.



- » Adopt security principles such as least privilege, where users are granted only the permissions they need, and zero trust, where users are continually authenticated.



**TIP** The National Institute for Standards and Technology (NIST) has published a short guide with tips about supply chain cybersecurity at <https://csrc.nist.gov/CSRC/media/Projects/Supply-Chain-Risk-Management/documents/briefings/Workshop-Brief-on-Cyber-Supply-Chain-Best-Practices.pdf>.

## *Integrating Planning, Execution, and Visibility*

The different categories of supply chain software (see [Chapter 11](#)) generally fill one of three roles:

- » *Planning* software uses forecasts to make decisions about how a supply chain should operate.
- » *Execution* software looks at real-time data about orders, inventory, and capacity and makes decisions that determine how a supply chain will operate.
- » *Visibility* software aggregates real-time data to show supply chain managers what's happening.

Planning, execution, and visibility are all important capabilities for a digital supply chain. Advances in information technology, such as faster processors and cloud computing, are making it possible for the information from all three types of systems to be processed and shared much faster, which may change the way that we think about supply chain management.

In a traditional supply chain, the first step is planning, which is followed by execution, and visibility brings up the rear. You plan what you are going to sell, forecast how much your customers are going to buy, estimate how much inventory you're going to need, and so on. Then you execute by receiving orders, shipping products, and tendering loads. All the while, you try to get visibility so that you can see what has happened.

As digital supply chains mature, the three steps can happen simultaneously. A digital supply chain can have visibility into what customers are buying and how much inventory is available. With this visibility, it can make execution decisions while taking into account the current state of the entire supply chain. As these execution decisions are made, planning systems are able to make real-time adjustments to forecasts, production schedules, and replenishment orders.

The result of integrating planning, execution, and visibility is that digital supply chains are becoming more autonomous and more responsive to customer needs.

## *Creating Customer Centricity*

Henry Ford was famous for saying that customers could buy a Model T car in any color they wanted, as long as it was black. Ford Motor Company built its early success on standardizing processes and products, which drove down the costs for its supply chain and allowed Ford to offer low prices to its customers.

One-size-fits-all supply chains are efficient because they create economies of scale, but many customers would rather have customized, or *bespoke*, products and services that are tailored to their needs. The ability to offer customers bespoke solutions at a reasonable cost can provide a company with a strong competitive advantage and has led to a supply chain strategy called *mass customization*. Companies that operate with a mass customization model wait until a customer places an order and then manufacture a product that meets the customer's exact specifications. Mass customization relies on the make-to-order production system (see [Chapter 5](#)).

Dell Computer used mass customization to gain a competitive advantage in the early days of the PC industry. While other computer companies offered standard models with predefined components, Dell allowed each customer to decide exactly which components they wanted. Because Dell couldn't begin assembling the computer until after an order had been received, the company needed to ensure that all the manufacturing and distribution steps occurred very quickly. Dell's use of a mass customization strategy relied on the ability to capture, store, and share information in its digital supply chain.

Another important aspect of customer-centricity is delivery flexibility. Amazon.com was a pioneer in providing delivery flexibility, but the trend is spreading to other retailers and logistics providers. Customers can choose to have products delivered to their homes or offices, and they can choose to have products delivered quickly or to schedule a delivery time. Many retailers now offer customers the choice of buying products in a store, ordering online and picking the products up in a store, ordering online and having the products shipped to their homes, or ordering in the store and having the products shipped to their homes. Delivery flexibility is possible only if a company has a digital supply chain that can efficiently match customer demand with information about inventory and transportation capacity.

## *Harnessing the Internet of Things, Big Data, and the Cloud*

One of the key drivers of improvements in supply chain visibility is the emergence of the Internet of Things (IoT). Today, there are more than twice as many devices connected to the Internet as there are people in the world, and IoT devices are growing at about 20 percent per year. Connected devices that are used in industrial environments like factories and distribution centers are called the Industrial Internet of Things (IIoT).

A good example of an IoT device that is useful in supply chains are the trackers made by Tive. Each tracker is about the size of a cellphone. The

trackers connect to the Internet wirelessly and transmit information about where they are and what's happening around them. In other words, they provide information that improves supply chain visibility. Some IoT devices also receive instructions over the Internet, make decisions, and take action based on the data that they collect. In other words, IoT devices can be useful for supply chain execution. A truck driver might carry a smartphone that transmits their location to a transportation management system, and then they would receive instructions about where to pick up the next load based on the latest traffic conditions.

The growth of supply chain information systems and the emergence of IoT have contributed to another trend that's important for digital supply chains: Big Data. Big Data is great for supply chains because it can help companies better understand their customers, their products, and their infrastructure. Unfortunately, the growth of Big Data also means that there's really no limit to how much a company can spend on technology. Companies may seem to be on a treadmill, continually buying bigger servers with more storage and upgrading them with newer software. They also need to keep their hardware, software, and data secure, all of which can be major expenses.

Many companies are replacing on-premises supply chain information systems with virtual computers, called *cloud-based servers*, which can be accessed over the Internet. One of the advantages of cloud-based supply chain solutions is that you can share the data in real time with people anywhere in the world.

Other advantages of cloud-based solutions include

- » Scaling processing and storage up or down based on business needs
- » Instant access to software upgrades
- » Reductions in infrastructure and staff
- » Access to applications on any kind of device anywhere in the world

Cloud-based solutions also have disadvantages:

- » You depend on the service provider to keep your business working.

- » Data and applications are on the Internet, where hackers can get them.
- » All users must have access to the Internet.
- » Switching platforms can be difficult.

## *Connecting with Social Media*

Any website or computer application that allows users to generate and share content is a form of social media. Social media is changing the relationships between people up and down the supply chain. When a customer tweets their frustrations about a company or product, that message can reach millions of people, including the news media. Social media is often closely connected with e-commerce. When one customer reviews a product on Amazon, their opinion will influence future customers. Other social media platforms that are having an effect on supply chains include Facebook, LinkedIn, Instagram, TikTok, Wikipedia, and Reddit. Many companies are also using social media tools like Microsoft Teams and Slack for internal and external communications.



**REMEMBER** These are the social media platforms that are popular in the U.S. right now, but the list can change quickly and there are different platforms that are popular in other parts of the world.

Because social media moves so quickly and can spread so far, each company in the supply chain needs to be aware of the effect of social media on its business. In addition to sharing opinions, social media can be used to share information that may not be easy to find in a manual or database. Some companies are using social media to improve communications across their business units and to connect with their customers and suppliers.

One interesting example is how U.K.-based retailer Travis Perkins uses internal social media sites to help its stores communicate with one

another and to collaborate with their distribution centers and supply chain teams. In one case, Travis Perkins found that using social media helped reduce the time needed to make decisions from 37 minutes to just 3 minutes. Social media can also help companies share their knowledge with other companies, and that can make all of our supply chains better. Many supply chain visibility tools can aggregate data that is submitted by suppliers.

Manufacture 2030 (<https://manufacture2030.com>) is a social media platform that helps companies collaborate on ways to reduce waste and improve sustainability.

## *Retooling for Omnichannel*

As a consumer, you may take e-commerce for granted. You go to a website, find a product to buy, enter your credit card number, and the stuff you ordered is on its way. For the company that needs to fill this order, though, your e-commerce order is full of supply chain challenges.

The place that a customer goes to buy a product or service is called a *channel*. Retail stores represent a sales channel for a supply chain. Many people refer to retail stores as a *brick-and-mortar* channel. E-commerce is a different sales channel. Each channel may sell the same products — and might even sell to the same customers — but the supply chains for these channels are different. A retail distribution center may ship out pallets of merchandise on a full-truckload carrier, whereas an e-commerce fulfillment center needs to ship individual items to customers by parcel carrier.

One of the biggest differences between a traditional supply chain and an e-commerce supply chain is how products are delivered from the company to the customer. The final distribution leg, called the *last mile*, is also one of the most expensive steps in any supply chain. In a traditional retail supply chain, customers do a lot of the work; customers pick their own items from the shelf and pay the transportation costs to get products from the store to their homes. In the world of e-commerce, the retailer is responsible for picking items from the shelf and delivering

products to consumers. That means retailers need to pay people to pick, pack, and ship that product; they also need to pay a parcel freight carrier or courier to deliver it off. Dealing with these last mile deliveries adds a significant cost to the retailer's supply chain.

Although many customers enjoy the convenience of online shopping and home delivery, most of them aren't willing to pay extra to have products delivered to them. So retailers are stuck with a big problem: To remain profitable, they have to increase revenue or lower supply chain costs to offset the effect of last-mile logistics.



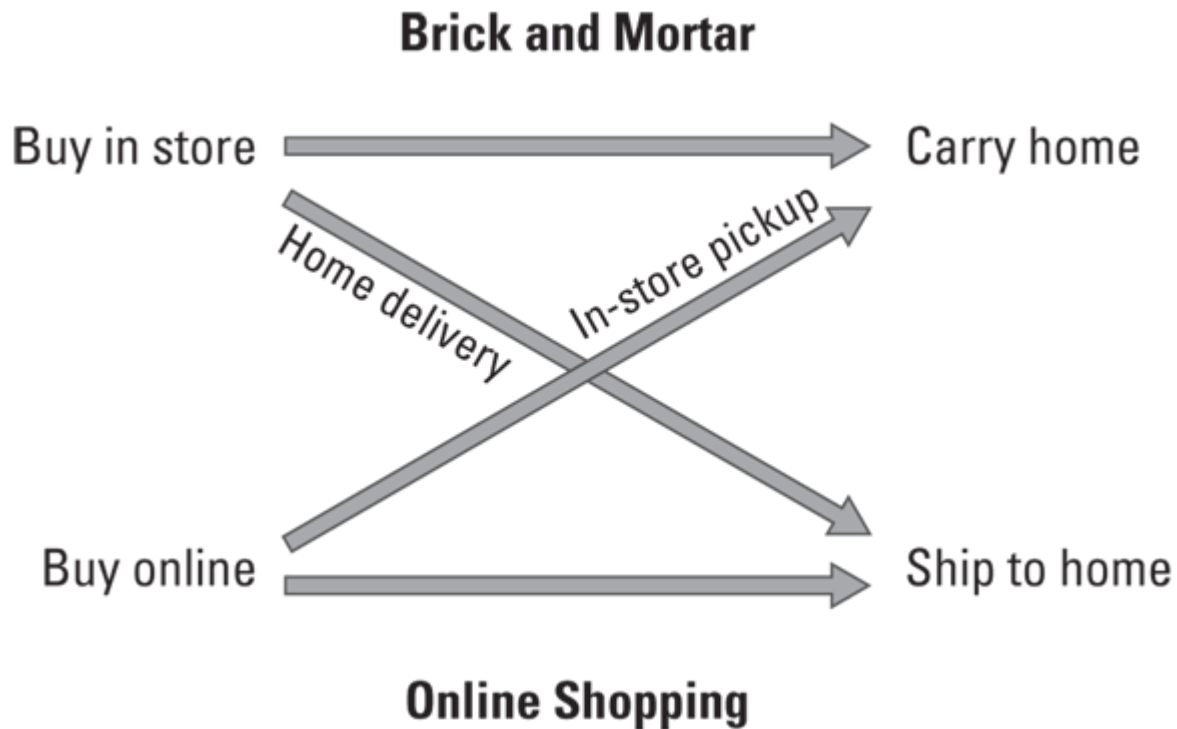
**TIP** Home delivery became a necessity for many businesses during the COVID-19 pandemic. In spite of the difficult challenges that everyone was facing, many businesses that excelled at home delivery were able to grow their revenue and their market share.

To compete in both the brick-and-mortar and the e-commerce marketplaces retail companies are now focused on developing an *omnichannel distribution* model. With an omnichannel supply chain, a customer could buy a product online and return the product to a retail store. A customer could also look at the products in a store but have them shipped directly to their house — an approach called *showrooming*. The opposite of showrooming is *click and collect*, in which a customer buys a product online and picks it up at a store. In other words, an omnichannel model makes it easier for customers to do business with you and makes your supply chain more customer centric.

Omnichannel distribution is a business strategy that's made possible by digital supply chains. [Figure 13-3](#) illustrates a number of different options a retail supply chain might need to support. An omnichannel approach requires you to have lots of flexibility and excellent information sharing across all the customer-facing parts in your supply chain. Your website may need to show whether an item is in stock in each of your retail stores, and your retail stores need to have a process for managing returns from online purchases. This end-to-end integration



is different from the way that many supply chains were engineered, so making the shift often requires the transformation of multiple information systems (see [Chapter 11](#)) into a single digital supply chain.



**FIGURE 13-3:** Retail options for shopping and delivery in an omnichannel supply chain.

## *Employing Artificial Intelligence*

Many of the jobs that are critical to making supply chains work properly involve collecting data and making decisions. Advances in artificial intelligence (AI) are making it possible for computers to do many of these jobs as well, or better than, their human counterparts. In other words, AI is taking jobs that used to be part of the physical supply chain and moving them into the digital supply chain. One of the supply chain challenges that computers can address more effectively than people is analyzing inputs from multiple data sources, such as Big Data.

AI is a general term that actually refers to many different technologies. In some cases, AI is used to basically describe solving hard math problems quickly. In other cases, AI describes a process in which the computer doesn't need to be told exactly how to do something. Instead,



the computer is able to start with a basic set of instructions and some training data. Then, the computer can evaluate the results of its decisions and adapt how it responds over time. This process is called *machine learning*. A computer program that is designed with AI to perform a certain task is called an *intelligent agent*. An example of an intelligent agent that uses machine learning to get better over time is Apple's Siri voice recognition system.

AI has the potential to change the role that people play in supply chains. Intelligent agents are already replacing people in roles like customer service and dispatch. During the COVID-19 pandemic, many companies implemented interactive tools that enabled their customers to perform simple transactions. With the trend toward planning, execution, and visibility systems converging, it's likely that AI will play an important role in managing digital supply chains in the future.

## *Sharing with Blockchains*

Information sharing in digital supply chains can be difficult because of three problems:

- » **Systems mismatch:** Information is stored in different systems, which makes it hard for the parties in a supply chain to share data efficiently.
- » **Data reliability:** Companies need to have complete confidence that their supply chain information is accurate and that no one can change it without their permission.
- » **Trust in partners:** Companies don't know all the people and companies in their supply chain and are reluctant to share information with strangers.



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Blockchain is a relatively new technology that tries to solve these problems. A *blockchain* is a digital ledger that's copied to

many computers, called *nodes*. The ledger records data in blocks, and these blocks are linked together in the order that they are created. In other words, the data is connected in a chain. To make a change in the database, such as adding information, you need to add a new block of data to the end of the chain. Before you can add the block to the chain, all the nodes need to agree to add that block. This agreement is called *consensus*. After a block is added to the chain, it can never be moved or changed — that is, it's immutable. For that reason, blockchains are often called *immutable distributed ledgers*.

An immutable distributed ledger is useful for supply chains because it enables companies to share information in a way that's nearly impossible to change or hack. As a result, companies can have a high level of trust in the information in the blockchain. With a blockchain, you create rules for what information is shared and who gets to see it. A blockchain provides a common platform that lets many participants in a supply chain track and share information about the transactions that matter to all of them. The Baseline Protocol ([www.baseline-protocol.org](http://www.baseline-protocol.org)) is an open source project that uses blockchains to help companies share information securely and synchronize their supply chain processes. Morpheus Network (<https://morpheus.network>) provides shipment visibility by connecting a blockchain to many information systems from several different companies. Everledger (<https://everledger.io>) and Origin Trail (<https://origintrail.io>) are blockchain platforms that allow companies and consumers to track products as they move through a supply chain and ensure that they are authentic.



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The term “blockchain” has gotten a lot of hype in the past few years. In order to distance themselves from those negative perceptions, some blockchain companies now use the term Distributed Ledger Technology (DLT).

One feature of blockchains that may transform supply chains is the *smart contract*: an agreement between parties to perform some actions. You can digitize a contract and post it to a blockchain. As each party to the contract does the things that it agreed to do, that information is added to the blockchain, and the contract executes automatically.

Suppose you sold a widget to a customer you've never met who lives in another country. You and your customer both need to manage the risk of doing business with a stranger. One way to manage this risk is by using a blockchain in a process that might go something like this:

1. You create a smart contract with the customer and post the contract to a blockchain. You and the customer can both see and agree to the contract.
2. The customer gives their payment to a third party, such as a bank, on condition that the bank will pay you when the product is delivered.
3. You pay a third-party logistics company to deliver the widget and require that company to log the delivery in the blockchain.
4. When the product is delivered, the bank is notified, and you're paid. In other words, the contract is fully executed.

This approach could change the way that many supply chains are managed in the future. It could also create interesting opportunities for entrepreneurs who can take advantage of the ability to transact business quickly and efficiently with strangers, as well as with their traditional supply chain partners.

A digital model of a physical object is called a *digital twin* (see [Chapter 11](#)). When a digital twin is stored on a blockchain it is called a *token*. Tokenizing an asset (storing its digital twin on a blockchain) makes it easy for anyone to identify the asset's owner, and also makes it easy to transfer ownership. For example, you could sell a physical asset and create a permanent record of the transaction by transferring the token to your customer on the blockchain.

Blockchains can make it easier to share data and they also make it easier to control who has access to your data. Regulations such the General

Data Protection Regulation (GDPR) in the European Union are designed to give people control over who is storing data about them and how that data is being used. With blockchain technology, it is possible for people to own their data and adjust their blockchain settings to control who gets to access their data.

## *Digital Supply Networks*

Many consultants describe digital transformation as the process of moving from an analog supply chain to a digital supply network (DSN). A DSN is essentially a supply chain in which all of the suppliers are connected and all of the processes are automated. DSNs function based on programming and sensors, and react to changes using AI. The book, *Digital Supply Networks: Transform Your Supply Chain and Gain Competitive Advantage with Disruptive Technology and Reimagined Processes* by Amit Sinha, Ednilson Bernardes, Rafael Calderon, and Thorsten Wuest (McGraw Hill; 2020), highlights six key capabilities for a DSN:

- » **Digital development:** Designing products using tools like computer aided design, and building prototypes using 3D printing.
- » **Synchronized planning:** Ensuring goals and constraints are shared across business functions, and with supply chain partners.
- » **Intelligent supply:** Automatically ordering only what is needed, from the right suppliers, at the right time.
- » **Smart factory:** Sensors and AI that manage production to optimize yield and capacity utilization while minimizing inventory.
- » **Dynamic fulfillment:** Taking orders and filling them automatically, within the time and cost constraints that your customers expect.
- » **Connected customer:** Continuous engagement with customers, whether that is to encourage them to purchase new products or to receive feedback about past purchases.

In other words, DSNs are basically the supply chains of the future.

# *Preparing for Quantum Computers*

Do you remember (or can you imagine) what the world was like before computers? All the computers we use today are binary computers, which means they perform calculations by using zeros and ones. Computer processors have been getting exponentially faster and smaller for at least 60 years, following a pattern known as Moore's Law.

Today we are pushing the limits of physics and it's getting hard to make binary processors any smaller. In other words, we are reaching the physical limits of Moore's Law. To make faster computers, scientists and engineers are using quantum physics to make a new kind of computer that can do calculations in a totally different way. These *quantum computers* are millions of times faster than our best binary processors. Quantum computers will be useful for solving complex supply chain problems like transportation routing and materials planning, and they'll supercharge cybersecurity and AI.

## Chapter 14

# Adopting Supply Chain Metrics

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### IN THIS CHAPTER

- » Focusing on performance attributes
  - » Identifying metrics and key performance indicators
  - » Measuring operational, financial, and human performance
- 

There's a common saying in supply chain management circles: "What gets measured, gets done." Almost everything about a supply chain can be measured, either directly or indirectly. Metrics give you data and allow you to make decisions based on facts rather than on guesses. But measurement costs money because you need to invest in technology and processes to capture, store and analyze the data.

It pays to be smart about what you measure, how you measure it, and what you do with the information that you collect. In this chapter, you examine different ways to measure the performance of your supply chain and how to select metrics that will help you manage trade-offs and drive improvements.

## *Establishing Process Metrics*

After you define the processes in a supply chain, the next step is deciding how to measure them. Supply chain measurements are usually called *metrics* — reference points that help you monitor whether your people, processes, and technology are performing the way that you want and expect them to. Metrics reduce the subjectivity of a process and bring everyone's focus to the things that really matter.

Metrics fall into two broad categories:

- » **Quantitative:** *Quantitative* metrics are based on an objective number or property, such as the number of units produced or the amount of revenue you've received. Many software systems in a supply chain track quantitative metrics automatically. A warehouse management system tracks the volume of material that is received, for example, and a transportation management system tracks the number of shipments that you tender to carriers. (See [Chapter 11](#).)
- » **Qualitative:** Many important attributes of a supply chain are difficult or impossible to measure quantitatively, but you may be able to measure them qualitatively. A *qualitative* metric is based on someone's judgment or perception and therefore is subjective. Two different people can often perceive the same situation or event in different ways. Customer satisfaction is a good example of a qualitative metric that can be important for supply chains.



**TIP** Some supply chain processes are best measured quantitatively, some qualitatively, and some both quantitatively and qualitatively. The key is to choose metrics that help you understand how well a process is functioning and identify opportunities to add value or decrease waste.

In a fast-food restaurant, the following three metrics could be very useful:

- » **Order-to-delivery cycle time:** How long it takes from the time customers place an order until they receive the food.
- » **Perfect order proficiency:** What percentage of orders are delivered on time and exactly as the customer asked (and paid) for them.
- » **Net promoter score:** What percentage of customers were so pleased that they would recommend the restaurant to someone else.

Notice that order-to-delivery cycle time and perfect order proficiency are quantitative metrics; they're based on objective data. The net promoter

score, however, is a qualitative metric; it measures how people feel and, therefore, is based on subjective data.



**REMEMBER** It's usually best to use a combination of quantitative and qualitative metrics to understand how your supply chain is performing and where you have opportunities for improvement.

## *Understanding Metrics*



**TIP** You can make a qualitative metric look and act like a quantitative metric by using a scoring system or scale. You might rate customer satisfaction on a scale of 1 to 10, for example. Even though you end up with a number, customer satisfaction is still a qualitative metric because it's based on an opinion rather than an objective, independent measurement.

The value of a metric depends on how it's measured. If you have a broken gauge, for example, or if the people counting make a mistake, the metric will be wrong. More specifically, the validity of a metric depends on the accuracy, precision, and reliability of the measurement process. When a metric is accurate, that means it measured what you wanted to measure, and measured it correctly. When a metric is precise, that means it has the right level of exactness or detail. And when a metric is reliable, that means it measures something correctly over and over again.



**TECHNICAL STUFF** Any problem that leads to an incorrect measurement is called a *gauge error* because the process you use to measure is a kind of gauge.



It's hard to argue with objective facts, so quantitative metrics are often perceived as being superior to qualitative ones. In many situations, however, qualitative metrics can be more practical and more useful than quantitative metrics. A great illustration of the role of quantitative and qualitative metrics is the "Goldilocks and the Three Bears" story. When Goldilocks tried the porridge, the first bowl was too hot, the second was too cold, and the third was just right. Those metrics were qualitative metrics. Instead, if Goldilocks had said, "Porridge 1 was 250 degrees, Porridge 2 was 20 degrees, and Porridge 3 was 125 degrees," she would have been using quantitative metrics. In this case, Goldilocks's opinion mattered more than the precise quantitative metric. Why waste time and money with a thermometer when you could just ask Goldilocks whether she liked the porridge?

Metrics can also be classified as internal or external. Internal metrics measure things that are important to your company, but may not be important to people outside of your company. Inventory turns and capacity utilization are internal metrics. External metrics measure things that are important to people outside your company — people such as your customers and suppliers. Some examples of external metrics are perfect order fulfillment (see "[Understanding SCOR Metrics](#)" later in this chapter) and customer satisfaction.

Another way to classify metrics is as leading or lagging metrics. Leading metrics tell you something about the future. For example, today's customer orders are a leading indicator of what tomorrow's deliveries will be. Lagging metrics tell you something about the past. An expense report, for example, can tell you how much money was spent on fuel last month. Lagging metrics for one function or process can be leading indicators for other parts of the supply chain.



TIP

Whenever possible, align your customer-facing metrics with the things that your customers measure. If your customers are measuring your on-time delivery rate, for example, you want to make sure that you're also measuring on-time deliveries and measuring them in exactly the same way as your customers. Otherwise, you'll spend time trying to reconcile the differences in metrics rather than using that time to correct problems in the delivery process.

## *Identifying Performance Attributes*

Before you can define a useful metric, you have to decide what attribute or characteristic of your supply chain you're trying to measure. Choosing which attributes to measure may sound obvious, but it can be quite challenging, especially when you think about how supply chain processes interact and affect one another.

Take the example of a factory that's trying to choose metrics as it implements Lean. From an inventory perspective, the company wants to receive the parts it needs for production no more than one day in advance. If parts are received sooner, the company has more inventory. To measure whether this policy is being followed, it would be natural to measure on-time deliveries. From a transportation perspective, however, the company wants to maximize the amount of freight that's carried on each truck. The company could save money by sending one full truck every other day rather than shipping half-full trucks each day. Tracking this performance characteristic would involve using a transportation capacity utilization as a metric.

Each goal in the example — reducing inventory and reducing transportation cost — is tied to an attribute of the supply chain. It's relatively easy to create a metric for each of these attributes, but the business goals are in conflict. If the transportation planners focus only on the capacity utilization metric and the production planners focus only

on the inventory metric, the supply chain is going to suffer. The two groups need to create a combined metric that allows them to work together toward a common goal. In this case, they could create a metric for the combined cost of inventory and transportation, or they could focus on whichever metric will produce the greatest benefits.



**TIP** If you need to look at several metrics at the same time, you can combine them in a dashboard that provides a more holistic view of how your supply chain is performing. You can find information on creating dashboards in [Chapter 15](#).

## *Understanding SCOR Metrics*

Five attributes of the Supply Chain Operations Reference (SCOR) Model (see [Chapter 4](#)) are important for understanding supply chain performance:

- » **Reliability:** The ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of a process.
- » **Responsiveness:** The speed at which tasks are performed and at which a supply chain provides products to the customer.
- » **Agility:** The ability to respond to external influences and respond to marketplace changes to gain or maintain competitive advantage.
- » **Cost:** The cost of operating the supply chain processes.
- » **Asset management:** The ability to use assets efficiently.

Within these five attributes, the SCOR Model defined ten metrics that can be tracked in every supply chain. Together, these top-level metrics can give you a good sense of how efficiently your supply chain is working. More important, these metrics make it easier to objectively measure the value of any improvements you make in your supply chain and help you measure the costs of a supply chain disruption.

## Reliability

Reliability is measured with a single metric: perfect-order fulfillment (POF). A *perfect order* is one that is ... well, perfect: the right product, delivered to the right place, in the right quantity, in the right condition, for the right cost. In other words, a perfect order is one in which the supply chain worked flawlessly. When your POF is increasing, your supply chain process improvement efforts are working. A drop in your POF metric is a sign that something isn't performing the way it's supposed to.

Although the concept of a POF metric makes loads of sense, it can be challenging to collect and connect the data that needs to be included. The customer order data may be in your customer relationship management system, for example, whereas the delivery information might be in your transportation management system. (See [Chapter 11](#) for more information on these systems.) To calculate an accurate POF score, you need to track orders through each step in your supply chain and through each of your supply chain information systems.

An alternative approach is to multiply the metrics from each step in your supply chain and use the final number as your POF metric. If you had an order fill rate of 98 percent and an on-time delivery rate of 97 percent, for example, you could decide to use the product of these two numbers as your POF metric. In this case, your POF would be  $98\% \times 97\% = 95\%$ .



**TIP** Information from customer complaints and product returns often indicates issues that you need to address to improve your POF metric.

## Responsiveness

Responsiveness is measured by a single metric: order-fulfillment cycle time (OFCT). OFCT is the period between when customers place an order and when they receive a product. In a grocery store, OFCT is zero; customers pay for their products and walk out the door. In the world of

e-commerce, though, OFCT can vary wildly from one company to another. Because a short OFCT can drive more sales, higher customer satisfaction, and greater customer loyalty, this metric can be a leading indicator of revenue for your company.

## *Agility*

Agility is measured with four metrics:

- » **Upside supply chain flexibility:** The number of days it would take to respond to an unexpected 20 percent increase in demand
- » **Upside supply chain adaptability:** The amount of capacity you could add in 30 days
- » **Downside supply chain adaptability:** The amount of a drop in orders you could absorb without significant financial effect
- » **Overall value at risk:** The amount of money you would lose if a major disruption occurred in your supply chain

Agility metrics are often based on estimates rather than hard data, and you should validate them periodically. To measure upside supply chain flexibility and adaptability, for example, you need information about your internal manufacturing and logistics capacity as well as information about each of your suppliers' available capacity. A supplier might tell you that it has plenty of capacity today, but as soon as that company gets a big order from another customer, that capacity will no longer be available. A good practice is to define the data that you need to calculate each of your agility metrics and then have a process for updating those metrics regularly.



**TIP**

One common way to keep supplier capacity data current is to have your buyers collect it during their routine meetings with each supplier's account manager. Another common approach is to send surveys to your suppliers.

## *Cost*

Cost is measured by a single metric: total cost to serve (TCS). TCS brings together all the costs of running a supply chain, including purchasing, logistics, and operations. It can also include essential functions such as sales and customer support. TCS helps you understand how much it costs to operate your entire supply chain and how this cost is changing over time.

The data for your TCS metric is available directly from your accounting system. It's often useful to track TCS in relation to sales to determine whether your costs are increasing or decreasing in proportion to your revenue. Lowering TCS is great, because when TCS is growing more slowly than sales, your company is becoming more profitable. TCS can grow faster than sales when your company is making investments, such as building up inventory to prepare for a holiday sales cycle. TCS can also increase when you are making investments to increase resilience, grow market share, or improve customer service levels.

## *Asset management efficiency*

Asset management efficiency is measured with three metrics:

- » **Cash-to-cash cycle time:** The number of days between when you purchase inventory and when you collect accounts receivable. The longer this cycle is, the more working capital you need to run your business. See [Chapter 17](#) for more information about cash-to-cash cycle time.
- » **Return on supply chain fixed assets:** Return on investment from the assets you used in your supply chain. Return on supply chain fixed assets can help you decide whether the money you've invested in your supply chain infrastructure provides an acceptable financial benefit.
- » **Return on working capital:** Return on working capital shows how efficiently your end-to-end supply chain is running. This metric can help you decide whether the money you've invested in inventory is providing an acceptable financial benefit.

# *Optimizing Operational Metrics*

Each function of a supply chain has unique attributes that are key to understanding performance. By selecting the right metrics, you can make better decisions and manage your supply chain operations more successfully. This section introduces some of the operational metrics that can provide insights into the efficiency and effectiveness of specific supply chain functions. Many of these metrics are useful for measuring cross-functional and interorganizational performance as well.

## *Supplier metrics*

Many supplier attributes are useful to track. Tracking the number of suppliers is a good place to start, because every supplier relationship you need to manage has a cost. The performance of each supplier can be tracked with metrics such as on-time shipping, on-time receipt, and product quality. A common way to measure quality for a supplier is the number of parts per million (PPMs) that have some kind of problem or defect.

## *Procure to pay metrics*

The process of purchasing products from a supplier and then paying for them is called the *procure-to-pay cycle* or P2P. Measuring the time it takes for each order that you place to complete the P2P cycle provides insight into the combined efficiency of your sourcing functions and your suppliers' delivery functions.

## *Purchase price variance*

How do you know whether you are paying too much for the products you buy? One approach is to set a standard cost for a product and then compare that standard cost to the amount you pay when you place an order. The difference between the standard cost and the actual cost is the purchase price variance (PPV). Standard costs can be established based on purchase history, benchmarking, or market research. Companies often use PPV to determine whether they are managing their procurement effectively.



## *Customer service metrics*

The whole point of a supply chain is to deliver value to your customers, so measuring how your supply chain is performing from your customers' point of view is very important. One common customer metric is *order fill rate*, which is the percentage of customer orders that you're able to ship within your desired response window. If you tell customers that you'll ship a product within 48 hours after they place an order, for example, your order fill rate measures the percentage of orders that achieve the goal. Other customer metrics include on-time shipment, on-time delivery, and product returns.

On-time shipment (OTS) and on-time delivery (OTD) are self-explanatory. You can also measure on time in full (OTIF), which indicates whether you got the right amount of product and whether it arrived when it was supposed to.

Measuring product returns can often provide useful insights about customer service and product quality, but this may not be as straightforward as many other metrics. In addition to tracking the number of returns you also need to identify the reason for the returns. If a product is returned because it's defective, you have a quality problem and a dissatisfied customer. But if a product is returned because your customer ordered three units and kept the one they liked best, the return is unrelated to quality.

Another way to measure customer satisfaction is to conduct customer surveys. One of the most popular survey approaches uses a Net Promoter Score (NPS). All NPS questions follow a similar format: "On a scale of 1 to 10, how likely is it that you would recommend our product to one of your friends?" If a customer chooses 9 or 10 — very likely to recommend your product — they are a *promoter* of your product. A customer who chooses 7 or 8 is *neutral* about your product, and a customer who chooses 6 or less is a *detractor*. An NPS can range from –100 to 100, with 100 being the best. The higher your NPS, the more likely it is that your customers are satisfied and will recommend your product. You calculate an NPS by using this formula:



$(\text{Number of 9s and 10s}) / (\text{Total Number of Responses}) - (\text{Number of 6s or less}) / (\text{Total Number of Responses}) = \text{NPS}$



**TIP** If you are interested in learning more about NPS, check out the *Harvard Business Review* article, “The One Number You Need to Grow” at <https://hbr.org/2003/12/the-one-number-you-need-to-grow>.

## ***Capacity, throughput, and yield metrics***

The amount of product you can process is measured as your capacity. Capacity can change over time, so this metric can help you see how your supply chain is evolving. If you’re investing in new equipment or process improvements, you expect to see your capacity increasing. If you’re closing old facilities, you expect to see capacity decreasing.

Whereas capacity measures how much material you could be processing, throughput measures how much you actually are processing. An applesauce factory might have the capacity to process 100 tons of apples per day, but due to a shortage of apples or a low number of orders, the supply chain manager might decide to run at a throughput of only 50 tons per day.

Some of the materials that you process will turn into valuable products, and others will be left over as waste. The amount that becomes a valuable product is called the *yield*. You can measure yield in terms of the amount of product that’s produced or as the percentage of throughput that’s usable. In the case of the applesauce factory, the seeds and skins might need to be discarded. Also, some material is likely to be wasted because of issues with quality. So even though the throughput for the factory is 50 tons per day of apples, the yield might be only 40 tons of applesauce, or 80 percent of the throughput. The higher your yield is, the more efficient your process.

One of the most popular metrics for measuring performance in a factory is overall equipment effectiveness (OEE). The OEE is calculated by

multiplying three metrics: availability, performance, and quality. Availability measures whether the equipment is operating or out of service. Performance measures whether the equipment is running at full speed. And quality measures whether it is producing materials that meet your specifications. When a piece of equipment is always available, running at full capacity, and producing acceptable products, the OEE is 100 percent.



**TIP** Achieving an OEE of 100 percent is not realistic in most factories because manufacturing equipment needs to be taken offline periodically for maintenance and tooling changes between jobs.

## *Formalizing Financial Metrics*

Managing the flow of money in your supply chain is an essential part of running your business. This section explains some critical financial attributes and metrics you can use to measure your financial performance.

### *Financial statements*

Companies track their financial performance using a set of documents called *financial statements*. There are three types of financial statements that are especially important for supply chain management: balance sheets, income statements, and cashflow statements. A *balance sheet* measures how much money a company has and how much money it owes at a point in time. An *income statement* measures how much money the company made or lost over a period of time. A *cash flow* statement shows when money is being spent or received. The information from these three statements can often be used to generate metrics for your supply chain performance.



TIP

The income statement is also called the profit and loss statement, or simply the P&L.

### *Accounts payable metrics*

Accounts payable represents money that your suppliers are lending you. Measuring the amount of money that you owe your suppliers can provide insight into your relationships with those suppliers. If your accounts payables are high, or if your days payable outstanding is high, it may mean that your suppliers aren't getting paid quickly. If you're late paying your bills, you can create cash-flow problems for your suppliers, who might respond by freezing your account or holding shipments. Keeping accounts payable low can reduce many problems and risks that suppliers can pose to your supply chain, but it also increases your working capital requirements.



REMEMBER

To pay your suppliers, you may need to borrow money, which increases the amount of working capital that your supply chain is consuming. You pay interest on this money, so it increases your costs. If you don't pay your suppliers, they'll need to borrow money and increase their working capital. Borrowing will increase their costs, and eventually, they'll need to charge you more to make up the difference.

### *Total spend metrics*

Tracking the amount of money your company spends is important for several reasons. In terms of your supply chain, a metric that shows how the amount you spend is changing can be critical for understanding how your supply chain is performing.

An increase in spending can be good if it's accompanied by an increase in sales. When spending stays steady while sales are dropping, though, you may have a supply chain problem.

You should divide your spend metrics into direct costs (for the parts that go into your products, for example) and indirect costs (for other things you need to run the business, such as cleaning supplies and safety equipment). Generally, direct costs should rise and fall at about the same rate as sales. Reducing indirect costs can be a simple way to reduce expenses and generate significant savings without making any changes to your products.

## *Savings metrics*

Tracking the amount of money you save through supply chain improvement projects demonstrates the value of supply chain management. If you can show that your last project saved \$1 million, it's much easier to ask for the process changes and investments you need to support your next project.

There are three common ways to demonstrate savings from a supply chain improvement:

- » **Cost reduction:** You could show that it used to cost \$100 to make each product, and now it costs only \$95. You're saving \$5 per product, multiplied by the total number of products you make.
- » **Yield improvement:** You could show that your process used to convert 80 percent of your inputs to usable products, and now your improvements have increased that figure to 90 percent. The value of the additional 10 percent yield is your savings.
- » **Cost avoidance:** You could show that if a change hadn't been made, you'd have paid a penalty of \$10,000 per month. By making the change, you avoided that cost and saved your company money.



**TIP** If you're interested in learning more about supply chain finance, two books that I often recommend are *Practical Finance for Operations and Supply Chain Management* by Alejandro Serrano and Spyros D. Lekkakos (The MIT Press; 2020), and *Supply Chain*

*Finance: Risk Management, Resilience and Supplier Management*  
edited by Wendy Tate, Lydia Bals, and Lisa Ellram (Kogan Page;  
2018).

## *Perfecting People Metrics*

You have several ways to measure important issues relating to the people who are such a critical part of your supply chain:

- » **Engagement:** How satisfied people are with their jobs
- » **Productivity and efficiency:** How productive and efficient people are in their roles
- » **Turnover:** How often people leave their jobs
- » **Safety:** How often people are hurt while doing their jobs

These metrics can indicate whether you're effectively balancing the needs of your business and the expectations of your employees.

### *Engagement metrics*

Employee engagement measures how satisfied, or engaged, people are with their jobs. Employee engagement is usually measured qualitatively through anonymous surveys. You could ask employees whether they feel that their work is valuable and whether they look forward to coming to their jobs in the morning, for example. There are also quantitative metrics that can provide insights into engagement, such as the number of complaints that employees file against their supervisors. The tangible benefits of maintaining high engagement are that it can help increase productivity and reduce turnover. Engaged employees also do a better job of caring for customers and suppliers.



**TIP** If you're going to measure employee engagement, you need to be transparent about the results and to take action on them. Otherwise, people will feel that their input isn't valued, and their level of engagement will decline.

## *Productivity and efficiency metrics*

The productivity and efficiency of many employees can be measured directly. Here are some examples:

- » For customer service representatives, productivity can be measured by the number of calls they answer or the number of issues they resolve.
- » For buyers in your purchasing department, productivity can be measured by the number of suppliers they manage or the value of the materials they purchase.
- » For manufacturing technicians, productivity can be measured by the number of products they make during a shift.
- » For associates in a distribution center, productivity can be measured by the number of order lines picked or put away per hour, as well as order picking accuracy.



**TIP** Many productivity metrics can be tracked automatically in computer systems such as a warehouse management system or labor management system (see [Chapter 11](#)). These systems can track the tasks that are assigned to each worker and measure how long it takes for each task to be completed.

## *Turnover metrics*

Measuring the number of employees you lose — your employee turnover — can provide great insights into how your employees feel

about your company. People leave jobs voluntarily for many reasons. They may not like their boss, they may not like the work environment, or they may be able to make more money someplace else, for example. People also leave jobs involuntarily for many reasons.

Losing and replacing employees is expensive. There are costs associated with separation, because you often need to fill out paperwork and pay for things like accumulated time off. There are also costs for recruiting and training replacements. Last but not least, there's a cost for the work that doesn't get done while a position is vacant or work that gets done poorly because the people who have to do the work haven't been trained properly.

When turnover is high, you spend more money on recruiting and training. You may also find that high turnover creates challenges for your customers and suppliers because they aren't able to build long-term relationships with contacts in your company.

When turnover metrics are low, it is a good indication that your people are being treated and managed well. As a result, you're avoiding turnover costs and probably building stronger relationships throughout your supply chain.

## THE GREAT RESIGNATION

The COVID-19 pandemic led to a series of complex challenges when it came to managing the people who are critical for supply chains. First, offices and facilities were shut down. Many office employees started working from home, while front-line workers had to deal with issues ranging from illness to irate customers. As the pandemic receded, many employees started to look for better jobs. This led to an episode called "The Great Resignation" when companies faced high employee turnover rates and struggled to find qualified replacements. The Great Resignation is an example of why tracking people metrics is important for supply chain managers.



**TIP** If you're interested in learning more about the relationship between human resources and supply chain management, I

recommend reading *Talent on Demand: Managing Talent in an Age of Uncertainty* (Harvard Business Review Press;2008)

## *Safety metrics*

Safety metrics may be the most important metrics in your entire supply chain. Making sure that everyone has a chance to go home healthy at the end of the day is one of the basic responsibilities of a business. The most common safety metrics are lagging indicators, which measure problems after they occur. Examples of lagging safety metrics include the following:

- » **Lost-time incident rate:** How often someone gets injured badly enough that they have to leave work
- » **Days without injury:** How many days it has been since the last time someone was injured at work
- » **Cost of claims:** The amount of money spent as a result of an injury

There is a growing trend toward using safety metrics that are leading indicators so that you can taking proactive steps to avoid injuries before they occur. Examples of safety metrics that are leading indicators include

- » **Audits and inspections completed on time:** Whether you're looking for issues that could be unsafe
- » **Number of audits with compliance issues:** Whether your audits are finding issues that need to be corrected
- » **Corrective and preventive action items overdue:** Whether you're addressing issues that could cause injuries in a timely fashion

## *Solidifying Sustainability Metrics*

Sustainability, in a broad sense, means doing things in a way that can go on for a long time. In business, the idea of sustainability is to achieve balance among the needs of a company, the people connected to the company, and the environment around the company. But when people



talk about sustainability metrics, they're usually talking about environmental metrics.

Environmental sustainability metrics fall into two categories:

- » **Consumption:** Things that a company consumes. Companies use energy and raw materials in their manufacturing and distribution processes, for example.
- » **Waste:** Things that a company emits, throws away, or gets rid of in some fashion.

## *Consumption metrics*

It helps to break consumption metrics into renewable and nonrenewable resources. *Renewable resources* are materials and energy sources that can be easily regenerated by the environment. Any product that comes from a plant (such as wood or ethanol) is a renewable material. Wind and solar power are examples of renewable energy sources.

*Nonrenewable resources* are materials that cannot be easily regenerated by the environment. Metals, minerals, coal, and petroleum are nonrenewable resources.

There are three common ways to gather consumption metrics:

- » **Collect data during a process.** You could place a gauge in your manufacturing facility to measure the amount of water you're using.
- » **Estimate based on other metrics.** If you hired a truck to deliver freight to a customer 1,000 miles away, you can estimate how much fuel the truck consumed.
- » **Ask your suppliers.** Many companies ask their suppliers to provide sustainability reports indicating the resources that were required to produce their products.

## *Waste metrics*

Waste metrics include things like the carbon your supply chain emits and the amount of material you send to landfills. Most of the carbon that's being emitted into the atmosphere comes from burning fossil fuels to

create energy. Much of this fuel is used to power ships, trucks, and trains. In other words, supply chains have a huge effect on the amount of carbon that's emitted. As a result, companies are beginning to focus on carbon emissions. Even if your company isn't concerned about the amount of carbon it emits, there's a good chance that its customers are, and so is the government. Minimizing your carbon footprint is a good idea in principle, and it may also be a requirement for some businesses.

Another important waste metric is the amount of material sent to landfills. Many companies have undertaken initiatives to eliminate landfill waste, which requires them to redesign many of their supply chain processes, such as switching to reusable or recyclable packaging materials. These initiatives may require some investment, but they can generate savings by reducing the cost of waste disposal; they may also build brand value and increase customer loyalty.

There are three common ways to gather waste metrics:

- » **Collect data during a process.** You can measure the amount of scrap that's left over after a production run or how frequently your trash containers need to be emptied.
- » **Estimate based on other metrics.** If you know that it takes about 2 gallons of water to make a widget, you can estimate the total amount of water used based on the number of widgets you make.
- » **Ask your suppliers.** You can ask your suppliers to provide data that they collect during their processes, such as asking your waste management supplier to track the number of tons of garbage it collected from your facility.



**TIP** There's more information about supply chain sustainability in [Chapter 19](#).

# Chapter 15

## Building Supply Chain Analytics

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### IN THIS CHAPTER

- » Understanding the value of analytics
  - » Planning analytics projects
  - » Improving visibility with scorecards, dashboards, and control towers
  - » Integrating analytics with scenario planning
- 

The rapid advances in information and communications technologies over the past 50 years have led to an explosion of data — with a few keystrokes you can learn everything from how much stuff your customers are buying to what the weather will be like in Kokomo, Indiana, next week. Analytics is the key to making this data useful for your supply chain.

*Supply chain analytics* is the process of structuring and filtering data in ways that allow you to make better decisions and take action to improve your supply chain. Analytics helps you understand the past so that you can predict more accurately what will happen in the future. In other words, analytics can help you can make better decisions, with more confidence. Analytics is also leading to the automation of many manual processes.

In this chapter, you examine the technology trends that are making huge amounts of data available, some of the challenges that often arise when working with this data, and some specific ways that you can use analytics to manage your supply chain more effectively.

# Examining the Four Levels of Analytics

There are four levels of analytics, each building on the levels before. The higher you move through these levels, the more value can create for your supply chain.

- » **Level 1: Descriptive analytics.** Descriptive analytics involves structuring and filtering historical data to identify patterns and trends. Six Sigma uses a lot of descriptive analytics.
- » **Level 2: Predictive analytics.** Predictive analytics uses historical statistics to estimate future probabilities. In other words, predictive analytics uses what has happened in the past to make forecasts about the future. Predictive analytics are used heavily in demand planning.
- » **Level 3: Prescriptive analytics.** Prescriptive analytics compares forecasts with real-time data, and then uses artificial intelligence (AI) to provide people with recommendations and instructions about what they should do. Prescriptive analytics tools are sometimes called *recommendation engines*.



TIP

Greenscreens (<https://greenscreens.ai>) is an example of prescriptive analytics tool that helps many freight brokers and their customers determine how much a shipment should cost.

- » **Level 4: Advanced analytics.** Advanced analytics involves automating process and taking humans out of the loop. Autonomous vehicles that make routing decisions and respond to traffic conditions are an example of advanced analytics.



TIP

Optimal Dynamics ([www.optimaldynamics.com](http://www.optimaldynamics.com)) is an example of a company that uses AI to automate supply chain

processes such as load planning and routing for their customers.

## *The Rise of Big Data, Sensors, and the Internet of Things*

Data is everywhere in a supply chain. Data tells you, for example, who your customers are, when your product needs to be delivered, and which carrier is transporting the shipment. The number of new transactions that occur and the amounts of data that we create each day are pretty amazing.

The rapid rate at which new data is being created has led to a trend called Big Data, which requires supply chain information systems to store larger amounts of data. To keep up with all that data, you need larger hard drives and faster computers, which often leads to the adoption of cloud-based supply chain information systems. (Read more about Big Data and the cloud in [Chapter 13](#).)

Traditional supply chain data was structured to fit neatly into database tables, making it easy for computers to process. A challenge with Big Data is that much of the data is unstructured. Unstructured data includes things like social media posts, audio recordings of conversations, and digital videos and photos. A social media post about an accident on the freeway, for example, could alert you to a supply chain disruption such as a shipping container falling off a trailer. A picture of the shipping container could provide useful insights about whether the contents of the container are salvageable. Both the post and the photograph are examples of the kinds of unstructured data that make managing Big Data a challenge.

One other factor that is feeding the growth of Big Data is the explosion of sensors. A *sensor* is a device that monitors and reports on something that is happening in the world around it. Sensors provide visibility, allowing you to “see” a supply chain even when you aren’t there. Each time one of those sensors takes a measurement, a new piece of data is

added to the growing pile of Big Data. Following are some examples of sensors:

- » Optical sensors monitor changes in light.
- » Thermal sensors track changes in temperature.
- » Programmable sensors detect a change and trigger an action or event. Activating an optical sensor in a smoke detector, for example, triggers the smoke alarm.

Many sensors are connected directly to the Internet. In fact, all kinds of devices are being connected — cars, refrigerators, thermostats, and so on — which has led to another trend called the Internet of Things (IoT). IoT is a way of describing that the Internet is now being shared by computers, as well as sensors and other devices. Any device that can automatically exchange information over the Internet is an IoT device. Devices that are used in factories and distribution centers are called Industrial Internet of Things (IIoT) devices.

It's not hard to imagine a future in which every part of a supply chain will be connected to the Internet. These supply chains will be IoT-enabled. Some people envision that virtually every machine will be an IoT device. In other words, they expect an Internet of Everything. Tapping into Big Data can lead to a better understanding of your supply chain. It can give you an advantage over your competitors because it can help you find opportunities that they can't see. On the other hand, if you don't figure out how to use Big Data, you and your supply chain may get left behind.

## *Building Your Analytics Toolkit*

There are lots of different problem-solving techniques and software tools that can be useful for doing supply chain analytics. Professor Sime Curkovic of Western Michigan University recommends this list of skills for students who are preparing for a career in supply chain analytics:

- » **Microsoft Excel:** Excel spreadsheets are powerful and flexible tools for data analytics. Some of the basic Excel features including graphing and formulas. Some of the advanced features that are particularly useful for analytics are Power Query, Power Pivot, and Macros.
- » **Data visualization:** Converting data into charts, graphs, and pictures can make it much easier to explain complex insights. Software packages such as Tableau, Power BI, and Python with Seaborn, Matplotlib, and Plotly can create powerful visualizations.
- » **Data mining, machine learning, and data science skills:** This includes using Python and Jupyter notebook with data analytics and statistical libraries such as Pandas and NumPy.

## *Outline of an Analytics Plan*

Analytics is a lot like science because it focuses on discovering new insights. If analytics is to have value to your business, you need to trust the results and be able to take action on the things you find out. Follow these steps to make sure that your supply chain analytics leads to useful insights:

1. **Define your theory of the problem or opportunity.**
2. **Acquire relevant data.**
3. **Clean, structure, and filter the data.**
4. **Query the data and test your theory.**
5. **Look for patterns.**

The steps don't always go in this order, so use this list as a general guide while staying focused on the goal of finding ways to make better decisions and improve your supply chain.

### *Define your theory of the problem or opportunity*

Analytics projects focus on using data to answer a question about your supply chain. You could use analytics to understand things like how

much it costs to deliver your product to customers in Maine, how much your freight rates should change when fuel prices decrease, and what are the main causes of lead time variability for your inbound material.

A good way to start an analytics project is to write down how the process you're going to study works. Next, consider your vision of the ideal future state. Finally, identify the gaps between the two, and write a hypothesis stating how to bridge those gaps.

Suppose that you're interested in reducing lead time variability in your supply chain. You could start your analytics project by writing down your understanding of how the current ordering process works. You describe the event that triggers an order, list the steps involved in filling that order, and include estimates of how long each step should take in an ideal world and the amount of variability you expect to occur along the way. Your starting hypothesis could look like this:

1. Purchase order issued to supplier.
2. Purchase order received by supplier (1 day).
3. Processing time at supplier (3 days +/- 1 day).
4. Transportation lead time (7 days +/- 3 days).
5. Receiving inspection (1 day).
6. Placed in inventory (1 day +/- 1 day).
7. Total expected lead time = 13 days +/- 5 days.

When your hypothesis is clear, your focus shifts to accumulating evidence to show whether this description of the process is accurate and achievable. In other words, you try to prove or disprove your hypothesis.

This approach is an easy starting point for defining the scope of your analytics project and identifying the data that you'll need to acquire. Keep in mind that your initial hypothesis may be wrong. As you gain insights throughout your analytics project, be prepared to refine your hypothesis.

### *Acquire relevant data*



Analytics is about structuring and filtering data, but figuring out how to get the data you need is often a challenge. For supply chain analytics, you're likely to discover that your data is spread across several information systems. To study lead time variability, you might need data from purchasing systems, transportation systems, and warehousing systems. You may also need public data from the Internet, and proprietary data from your customers or suppliers. If you're looking at transportation variability, for example, you may need to include weather data and the holiday calendar for your supplier's location.

In some cases, you may not be able to get all the data that you want, but you might be able to find data that would work as a substitute or proxy. Suppose you need to know how many associates are employed in a facility but are unable to get access to human resources data because of privacy rules. In that case, you might try to get financial data and use the amount of money spent on labor as a proxy for the head-count data.



**WARNING** When you acquire data from your own information systems or from your partners and suppliers, you need to make sure that you comply with government regulations (such as privacy laws) and with your contractual obligations (such as nondisclosure agreements). Also pay close attention to information security, including viruses. You don't want your supply chain analytics data to get into the hands of a competitor or a malicious hacker.

### ***Clean, structure, and filter the data***

When collecting data for an analytics project, you can expect issues with the data, such as the following:

- » Some records will have incomplete data, or the data in those records is wrong. A database of customers may be missing some phone numbers, or some of the phone numbers could be out of date.
- » When you are pulling together data from different systems, you need to find ways to link the data. You might have information about a

customer's address in your transportation management system and information about that customer's order history in your customer relationship management system. To analyze both shipments and orders, you need to find ways to link these data sources such as using a customer identification number.

- » Some records will be unnecessary. You need to filter them out and structure the remaining data in a usable format.

To get around these issues, you need to clean, structure, and filter the data, which can be a laborious process. Business intelligence systems (see [Chapter 11](#)) can do much of this work automatically. These systems look for patterns in data and can automatically suggest ways to structure and filter the data.

### *Query the data and test your theory*

A query is a small computer program that retrieves information from a database. You can think of queries as being questions that are translated into computer language. Once you identify the business question that you want to ask, you need to translate it into a database query so the computer can understand the question and return an answer.

When you're doing supply chain analytics, the goal of a query is generally to accumulate evidence that supports or refutes your hypothesis. In the lead-time example earlier in this section, you might start by focusing on products coming from Supplier A. Then you would run a query that asks for all the purchase orders you issued to that supplier in the past year. You would run another query that asks for all of the shipments received from Supplier A in the same year. You can combine the results of these two queries to estimate the total average lead time and test whether your hypothesis seems reasonable.

### *Look for patterns*

As you run queries and manipulate the data, look for patterns that explain how your supply chain behaves. Patterns in the data help you translate analytics into insights that can improve supply chain decisions. Here are some examples of the kinds of patterns that might become

evident when you analyze supply chain data for a company that makes winter apparel:

- » Demand goes up when the weather gets cold.
- » Shipments cost more when the loads are tendered with short lead times.
- » Suppliers in one region have a lower quality level than suppliers in another region.

Each of these insights could influence decisions about sourcing, making, and delivering the company's products.

It's common to start an analytics project with a hypothesis, use that hypothesis to build a query, and then try to find correlations. But unexpected patterns and correlations may lead you to new theories and deeper insights. When you analyze the data for the apparel manufacturer, for example, you may find a spike in sales in late March, and you wonder why. Analytics often provides clues that help you investigate what's happening in your supply chain, and you can build on that knowledge to make improvements.

## *Correlation, Causation, and Interpolation*

Three words — correlation, causation, and interpolation — are key to almost everything that happens in analytics. If you understand what they mean and how to use them, the rest of analytics is a breeze.

Correlation and causation are closely related. *Correlation* means that two variables are connected in some way. *Causation* means that one variable causes another to occur. The fact that two variables are correlated doesn't mean that one causes the other to occur. The correlation could be a coincidence, or some other factor may cause both variables to change. Sales of ice cream and sunblock lotion may be

closely correlated, for example, but one doesn't cause the other. Both are affected by the season and weather.

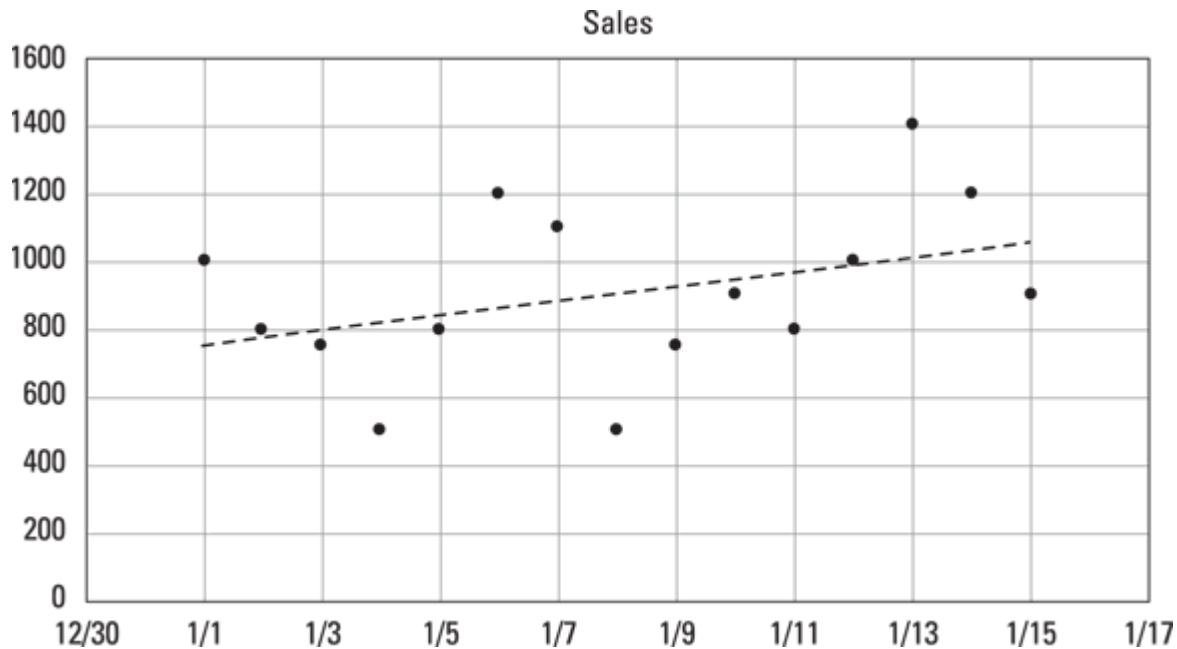
Generally, the business questions that you ask should be based on trying to understand causation (such as “Does increasing the amount we spend on marketing lead to an increase in sales?”). You try to answer these questions by looking for correlations. The data can't tell you for certain that advertising was the only reason for the increase in sales, but it can show whether sales tend to go up when you advertise more.

Each piece of data that you collect from your supply chain can be plotted as a point on a graph. The amount of product that you sold on a particular day could be a point on a graph. When you plot several pieces of data, such as sales on different days, you end up with multiple points on the graph. To do analysis and look for trends in data, however, you may need to see the data as a line. That is, you collected point data, but you need to convert this data to continuous data to do some kinds of analysis. Many times, you can create a line that does a good job of averaging or approximating the point data. The process of converting point data to a line is called *linear interpolation*.

[Figure 15-1](#) shows how linear interpolation turns points into a line that reveals a trend. In this example, the upward trend would be hard to see with just the raw data points, but it's clear when you look at the trend of the line.



**TIP** Interpolation is commonly used in forecasting. You can create a line based on the data points from the past and then extend that line into the future to create a forecast. Spreadsheet applications such as Microsoft Excel can do interpolations automatically. In Excel, you can add interpolations to a chart by using the trend-line feature. If you want to calculate an interpolation within a cell on an Excel spreadsheet, you can use the FORECAST function.



**FIGURE 15-1:** Linear interpolation of data points.

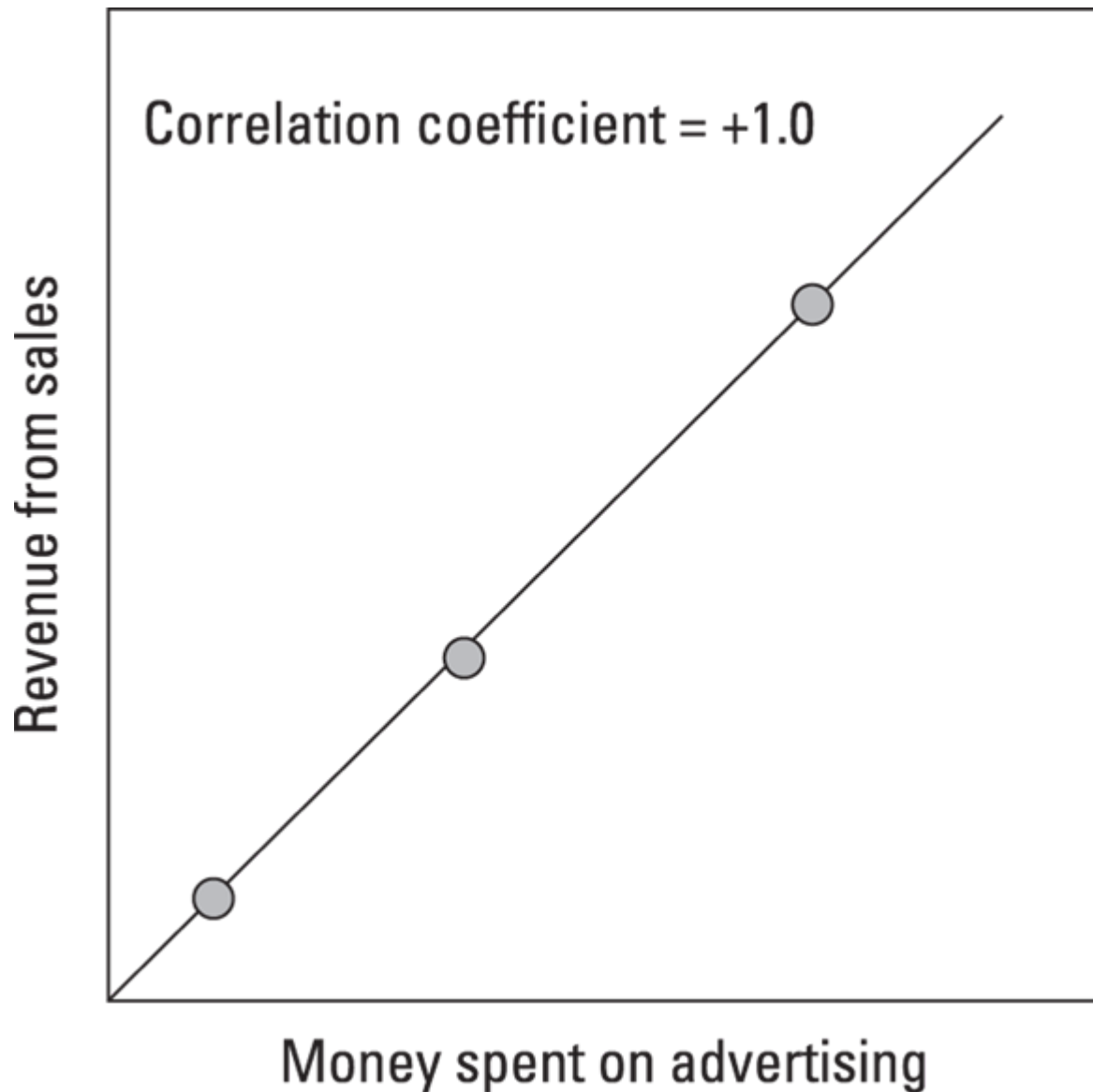


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Another way to analyze data is a mathematical process called nonlinear interpolation. Excel's data visualization tool includes several trend-line options that perform nonlinear interpolation.

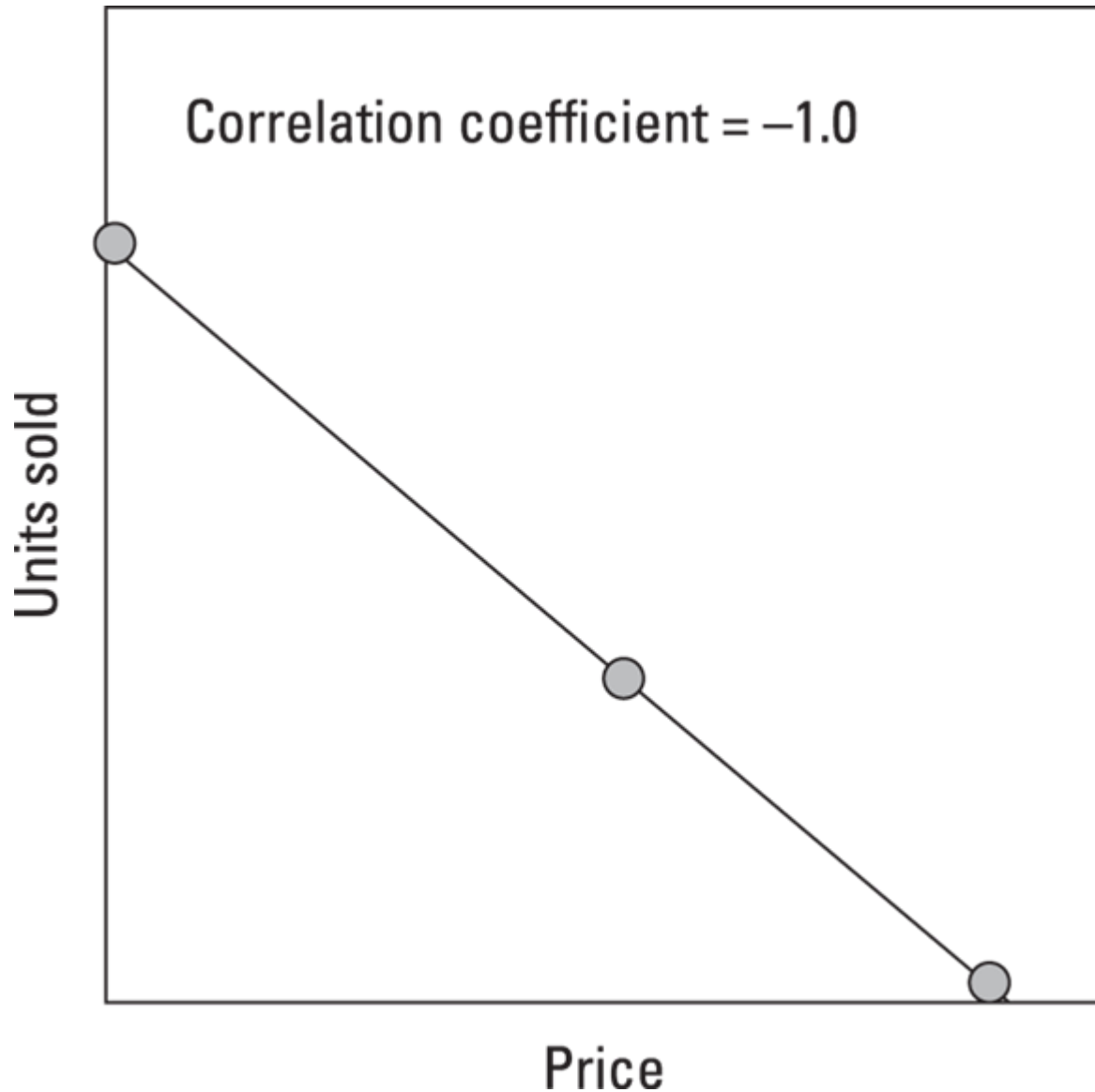
Correlations are easy to see on a graph, but they can be calculated mathematically as well. Correlations can be positive, negative, or zero.

When two things are perfectly and positively correlated, their correlation coefficient is +1.0. [Figure 15-2](#) shows two variables that have a positive correlation. In this example, increasing the amount of money spent on advertising coincides, or correlates, with an increase in revenue.



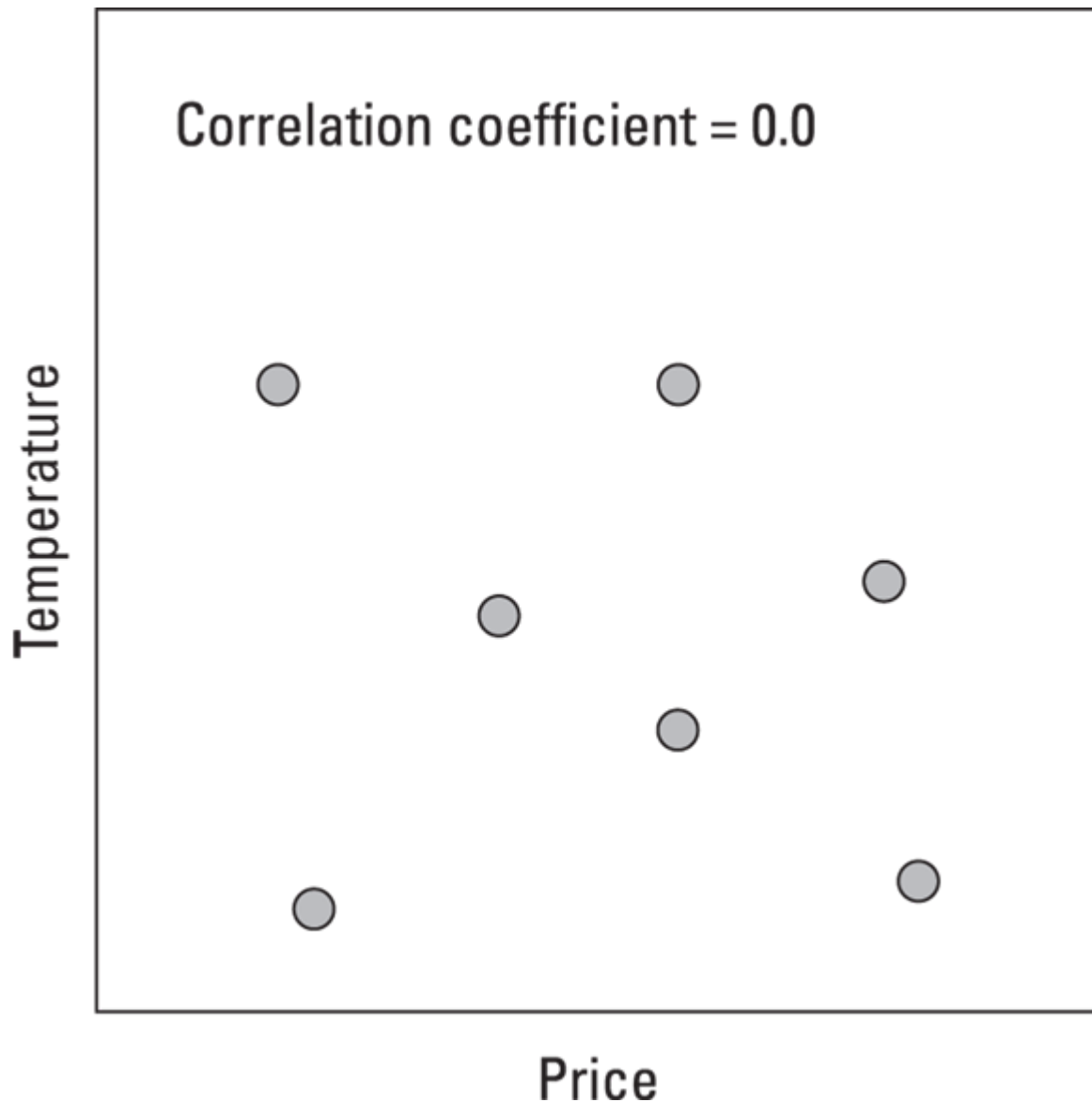
**FIGURE 15-2:** Variables that have a positive correlation.

When one thing goes up while another thing goes down, their correlation coefficient is  $-1.0$ . [Figure 15-3](#) shows an example of negative correlation in which increasing the price correlates to a decrease in the number of units sold.



**FIGURE 15-3:** Variables that have a negative correlation.

If no correlation exists between two things — they're totally independent — their correlation is 0. [Figure 15-4](#) shows two variables that appear to have a correlation of 0. When the correlation between two variables is very low or close to 0, those variables are unrelated.



**FIGURE 15-4:** Variables that are random and not correlated.

In real-world analytics problems, you rarely find correlations that are exactly 1.0, 0.0, or  $-1.0$ . As a result, it isn't always easy to tell whether the data supports your hypothesis. Deciding whether a correlation is significant depends on the question you're asking, the data you're using, and how you ask the question. You also have to consider confidence (how important it is to be right). There's a big difference between needing to be 80 percent confident and 99 percent confident. Many times, the best approach is to ask an analyst or a statistician what they think the level of significance should be.





TIP

Seeing that two things are correlated is a useful insight that can help you identify ways to improve your supply chain, even if you can't claim a high degree of confidence or prove that one caused the other.

## *Simulation and Optimization*

Computer modeling has become essential for planning supply chains and predicting how they will perform. Models are generally designed to achieve one of three things:

- » Digital twins are used to monitor the performance of a supply chain, or some its parts.
- » Simulation models show how a supply chain will behave under a certain set of conditions.
- » Optimization models show how to change the performance of a supply chain to achieve a particular goal.

One reason we use models is that it's better to use data than intuition to make supply chain decisions. Supply chain models, however, are only as good as the assumptions on which they are based and on the data they are given. A good model tries to simplify a problem by capturing the key elements of a supply chain while stripping away the things that aren't relevant.

Those decisions will help to ensure that your model is appropriate for the problems you're trying to solve without being unnecessarily complex. A model doesn't have to be an exact copy of the real thing to be useful, and a model that works well in one situation may not be adequate in another.

### **BUILDING A MODEL**

Building supply chain models can be time-consuming and expensive, and it may make sense to hire a consultant to do this work for you. Whether you build a model yourself

or hire someone to help you, here are some things to consider:

- What questions you're trying to answer
- What factors will influence the decision or outcome
- How stable those factors are (whether they're likely to change over time)
- What other questions you could answer with this model
- How you'll maintain this model

## *Simulation*

One reason to build a model is to see how the elements of a supply chain interact over time. A model that shows how supply chains behave is called a *simulation*. Simulation models can illustrate complex dynamics such as swings in inventory that are caused by the Bullwhip Effect (see [Chapter 2](#)), in which demand signals become distorted as they move upstream in a supply chain. Understanding these dynamics allows you to make supply chain improvements by identifying issues such as bottlenecks and constraints, unused capacity, and unexpected events and relationships.

## *Optimization*

Although simulations can demonstrate supply chain behaviors, they are not always actionable. Supply chain managers often want to know how to make improvements, such as where to locate a distribution center to minimize shipping times, how much inventory is needed to meet the service-level target, and which transportation modes minimize costs. An optimization model would provide this answer. Optimization models try different combinations of variables to find the ones that work best.

## *Scenario Planning*

Supply chain analytics uses data to answer business questions. Scenario planning complements analytics by identifying which questions are most important to answer. Combining scenario planning with analytics allows you to do long-range planning and make strategic decisions for your supply chain.

Scenario planning is based on the idea that the future is uncertain. In a supply chain, for example, it's hard to predict commodity prices, customer demand, technology adoption rates, and many other variables. But you can often identify a manageable set of variables that are most likely to shape the future. When you look at these variables and the ways things could go, you can describe a small number of possible outcomes, called *scenarios*, that represent the most likely versions of the future.

When you understand the potential scenarios that you need to prepare for, then you can focus on what you'd need to do in each scenario. The decisions you need to make and things you could do fall into four categories:

- » **No-brainers:** Some decisions benefit your supply chain in every scenario, involving investments that everyone should agree to make.
- » **No-gainers:** Other decisions don't provide value in any of the scenarios, so there's no point in bothering with them.
- » **No-regrets:** Some options help in one scenario but don't hurt you in the others. In other words, they may turn out to be good investments, or they may be unnecessary but harmless.
- » **Contingent:** Some options help you in one scenario but hurt you in another. You need to know what the future is going to look like — which scenario will emerge — before you can make the right investment.

Identifying the no-brainers, the no-gainers, and the no-regrets options can speed the process of building a strategic plan for your supply chain. The contingent options require constant focus. Deciding whether to move forward with a contingent option depends on how things change over time, so you should have a process for monitoring and a plan for making the decision. You might choose a metric and then set a threshold for contingent options.

Here's a scenario involving advertising and e-commerce fulfillment that illustrates how contingent decisions can work. Suppose that you're a candy manufacturer that has just begun to sell your products online.

Right now, you sell only 100 candy bars per month through your online store. At this low volume, it's more cost-effective to outsource your e-commerce fulfillment to a third-party logistics provider than to do this work yourself. At a higher sales volume, however, you could do this fulfillment work profitably, so when your e-commerce sales reach 1,000 candy bars per day, you want to bring fulfillment back in-house.

To boost your sales, you're preparing to invest in advertising, but you don't know how effective the advertising will be. What should you do about your e-commerce fulfillment?

## THE MIT SCENARIO PLANNING TOOLKIT

The Center for Transportation and Logistics at the Massachusetts Institute of Technology (MIT) has been a pioneer in using scenario planning for supply chains. The center has worked with companies and governments to create scenarios and run strategic planning workshops. They even created a scenario planning tool kit that you can use free of charge. Visit <https://ctl.mit.edu/scenario-planning-toolkit> to get it. The primary audience is transportation planners, but the scenarios are useful for anyone who's involved in long-range planning for supply chains.

The tool kit includes four scenarios that describe what the world might look like in 2037. None of these scenarios is likely to come to pass, but each one is based on data and analytics. Comparing these scenarios shows how hard it is to predict what the world will be like in a few years.

If you want to try scenario planning, you can use the scenarios that MIT has provided or create your own scenarios based on the factors that are most relevant to your business. You can also pick up a copy of *Strategic Planning for Dynamic Supply Chains: Preparing for Uncertainty Using Scenarios* by Shardul S. Phadnis, Yossi Sheffi, and Chris Caplice (Macmillan; 2022). Thinking about the challenges and choices that you would face in different scenarios is a good way to ensure that your supply chain is prepared for the future.

In this case, you're likely to find that people on your team have different opinions about what you should do. Some will be optimistic about the advertising and will want to bring fulfillment in-house immediately; others may be pessimistic about the advertising and suggest that you wait to insource fulfillment. In reality, this decision is contingent; the best option depends on how effective the advertising turns out to be. So

a logical approach is to set a target, collect data, and make your decision based on the result.

Making guesses about what is going to happen in the future is an important part of supply chain management. One benefit of scenario planning is that it helps people with different perspectives and motivations see the things that they agree and disagree on. Where there is disagreement, scenario planning lets you create a process for gathering additional facts and data so that everyone can get on the same page.

## *Scorecards, Dashboards, and Control Towers*

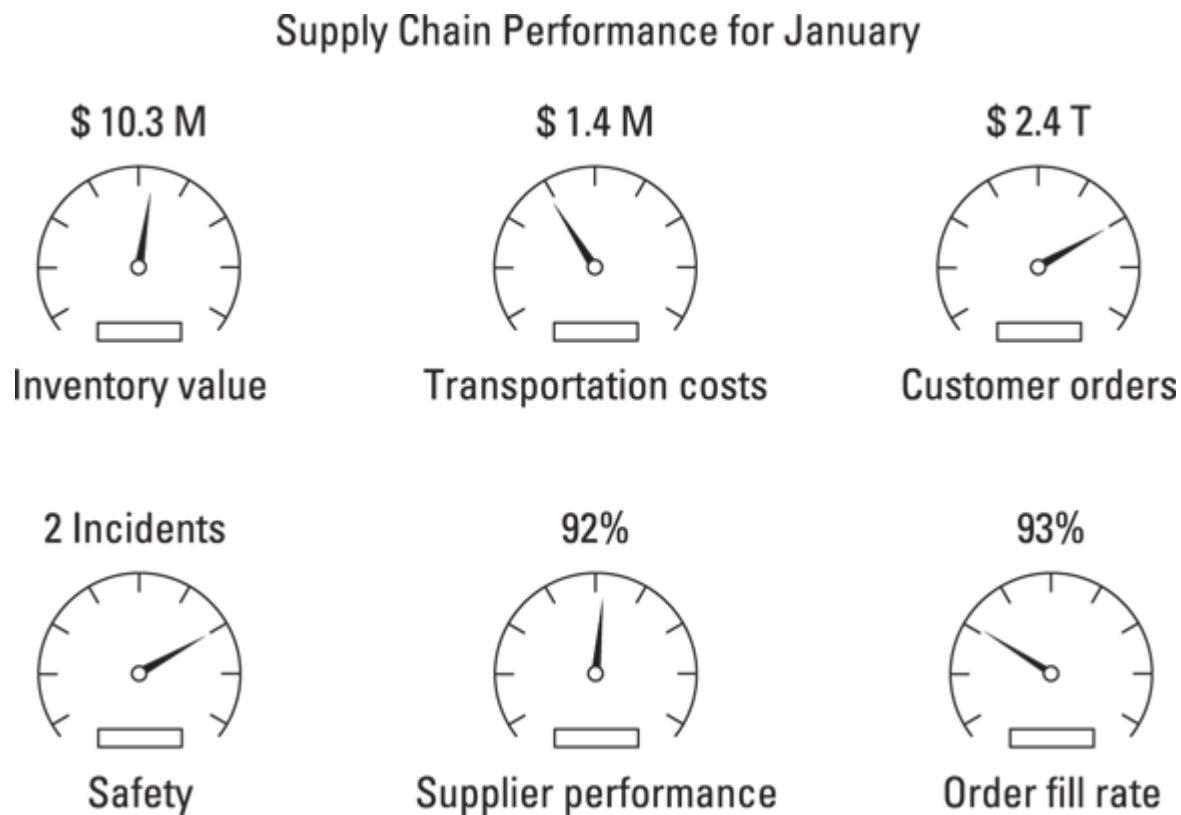
When you play a game, you keep track of how each player is doing using a scorecard. In supply chains, it's common to have scorecards that track the performance of facilities or suppliers. Because scorecards provide a snapshot of what was happening at a particular time they can be useful for understanding what has happened in the past, but they may not be able to tell you what is happening right now or what will happen in the future.

That is where dashboards come in. Dashboards contain live data rather than just a snapshot.

When you drive a car, your primary source of feedback is the dashboard. The dashboard provides dynamic, real-time data about the car's performance, including its speed, the amount of gas in the tank, and the status of the turn signals. The dashboard also can alert you when something is wrong, such as when it flashes the check-engine light. Supply chain dashboards are reports that show the current status of key performance indicators. (See [Chapter 14](#) for more information about supply chain metrics.) Ideally, a dashboard is updated automatically based on live data.

Scorecards and dashboards often use colors and images to show trends and irregularities in data. [Figure 15-5](#) shows a supply chain dashboard

that includes graphics. Notice that the gauges help to show if the KPIs are higher or lower than expected.



**FIGURE 15-5:** Sample supply chain dashboard.



**TIP** Supply chain scorecards and dashboards often use red, yellow, and green to indicate whether a metric is good or bad. But a portion of our population is color-blind, which means that these colored indicators are invisible to many people. If you use colors in your scorecards and dashboards, remember to also include features that people with color blindness can interpret easily.

Spreadsheets are the most common tool for creating supply chain scorecards and dashboards. Business intelligence software can make it easier to access data across multiple information systems and present that data in scorecards and dashboards that are attractive and easy to read. (See [Chapter 11](#).)

Scorecards and dashboards provide a snapshot of key data that gives you insights into what's happening in a supply chain. At times, though, you need to dig even deeper. For example, you may need to access additional data to investigate why a process appears to be out of control.

In such cases, you need a supply chain control tower (see [Chapter 17](#)). Some control towers use business intelligence software to provide real-time, flexible access to data so that you can ask complex questions and address business issues. ([Chapter 11](#) lists some business intelligence software vendors.) There are also several companies that sell supply chain control tower software, including:

- » IBM ([www.ibm.com](http://www.ibm.com))
- » Kinaxis ([www.kinaxis.com](http://www.kinaxis.com))
- » o9 Solutions (<https://o9solutions.com>)
- » SAP (<https://sap.com>)
- » TADA ([www.tadanow.com](http://www.tadanow.com))
- » Unity SCM ([www.unityscm.com](http://www.unityscm.com))

Control towers are useful for performing strategic management, such as viewing long-term trends, and managing supply chain disruptions. When a major problem occurs in your supply chain, having easy access to the right information helps you make good decisions and manage trade-offs quickly.



**TIP** Over time, the reports that are developed in a control tower can lead to new KPIs, which can then be added to supply chain scorecards and dashboards.



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Supply chain information systems tend to be broken into silos: one system for transportation, another system for manufacturing, and a different system for procurement. This is called an *application-centric* model. You may hear experts talk about a data-centric or data mesh approach, which attempts to connect the silos by having these systems share information with each other.

## CATERPILLAR'S ASSURANCE OF SUPPLY CENTER

A good example of a supply chain control tower is the Assurance of Supply Center (ASC) created by Caterpillar, Inc.

Caterpillar was struggling to manage its inbound supply chain, which included more than 640,000 stock-keeping units from 7,000 suppliers, which were being shipped to 127 facilities. The company's purchasing division built a supply chain control tower by integrating data from many sources, including purchasing, transportation, and manufacturing systems.

The control tower could then generate scorecards for each supplier and each facility. It also provided visibility to complex supply chain relationships, such as which plants were receiving parts from each supplier. Having this data available made it much easier for supply chain managers to minimize the impact of supply chain disruptions when a supplier experienced a disaster or when a port was shut down. For more information, see the "Caterpillar 3000K" video at <https://youtu.be/JeS5SPyvHmA>.

## *Interpreting Analytics Results*

The goal of analytics is to learn things about your supply chain, but the answers are not always obvious. For example, a problem that is often discussed in the United States is the chronic shortage of truck drivers. Some researchers have used data to argue that the solution to the problem is to relax regulations and train more truck drivers. But other researchers have pointed out that there are lots of licensed truck drivers who choose to work in other industries. These researchers argue that the



answer is to treat drivers better and pay higher wages. Both groups are performing analytics using the same data but they are coming up with conflicting conclusions.

Another challenge analytics professionals often encounter is selecting a useful solution rather than an optimal solution. In some cases, an answer that is likely to be correct, or close to being correct, can be found fairly easily, while finding an answer that is perfect requires a much larger investment of time and money. Choosing the good-enough solution is called *satisficing*, and is often the best choice for the business.

## *Finding Useful Analytics Data*

Finding useful data for performing analytics can be a challenge. You may need to use both internal data from your company or supply chain, and external data from outside sources. If you are working in a company you first need to find out where the data is stored, then you need to get access to it, and then you need query the databases to get the information you need. This could involve building relationships with, and getting approval from, people in many different functions in order to learn about what information systems they use, and how they use them.

There is also a lot data available from public and private sources on the Internet. Some examples of data sources that could be useful for your supply chain analytics projects include:

- » Bureau of Labor Statistics ([www.bls.gov](http://www.bls.gov))
- » CIA World Factbook ([www.cia.gov/the-world-factbook](http://www.cia.gov/the-world-factbook))
- » Council of Supply Chain Management Professionals Logistics Managers Index ([www.the-lmi.com](http://www.the-lmi.com))
- » DAT ([www.dat.com](http://www.dat.com))
- » Federal Reserve Board ([www.federalreserve.gov](http://www.federalreserve.gov))
- » FlightAware (<https://flightaware.com>)
- » FreightWaves SONAR (<https://sonar.freightwaves.com>)

- » Institute for Supply Management ([www.ismworld.org/supply-management-news-and-reports/reports](http://www.ismworld.org/supply-management-news-and-reports/reports))
- » Marine Traffic ([www.marinetraffic.com](http://www.marinetraffic.com))
- » Project44 (<https://supplychaininsights.project44.com/#/overtheroad>)
- » Telegraph (<https://telegraph.io>)
- » World Bank (<https://data.worldbank.org>)



**TIP** Professor Jason Miller from Michigan State University is an expert at using analytics to explain supply chain trends. You can follow his updates on LinkedIn at [www.linkedin.com/in/jason-miller-32110325](http://www.linkedin.com/in/jason-miller-32110325).

## Part 4

# Driving Value with Supply Chain Management

## IN THIS PART ...

Explore strategies for translating supply chain knowledge into business results.

Understand how to optimize your supply chain to create the most value for you and your customers.

Identify, prioritize, and manage the risks to your supply chain.

Discover the environmental, social, and governance issues that pertain to the global supply chain and the role supply chains play in enabling sustainable development around the world.

# Chapter 16

## Improving Your Supply Chain Processes

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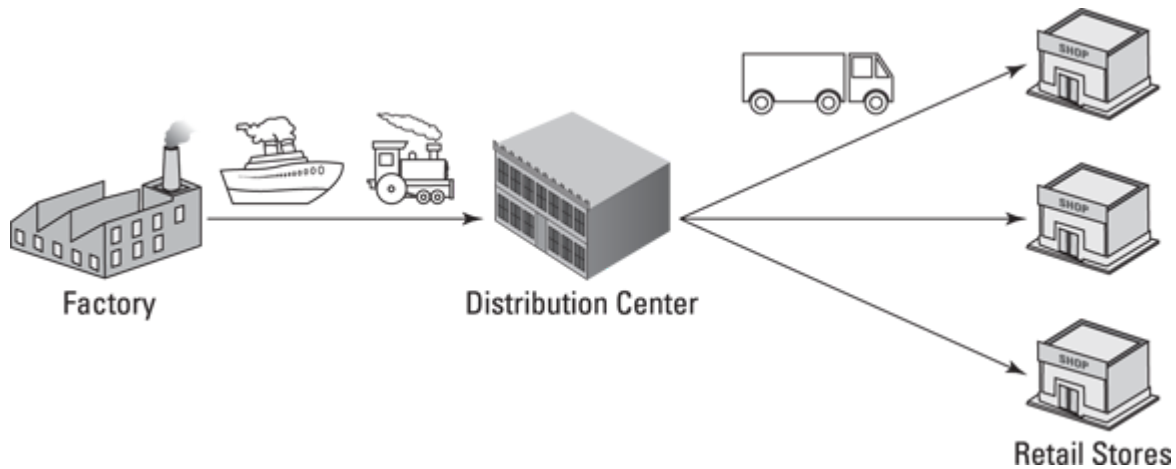
### IN THIS CHAPTER

- » Mapping your supply network
  - » Driving process improvements
  - » Managing supply chain projects
- 

Depending on the product or service that you're selling, you probably have many alternatives to choose among when designing your supply chain. You may have choices of how and where to buy your materials or make your products. Perhaps you can even choose different ways to deliver your products to your customers. In this chapter, I discuss the techniques to optimize your supply chain to ensure that you're creating the most value, in the most sustainable way, for you and your customers. I also talk about how to implement improvements to your supply chain through cross-functional projects.

### *Designing Your Network*

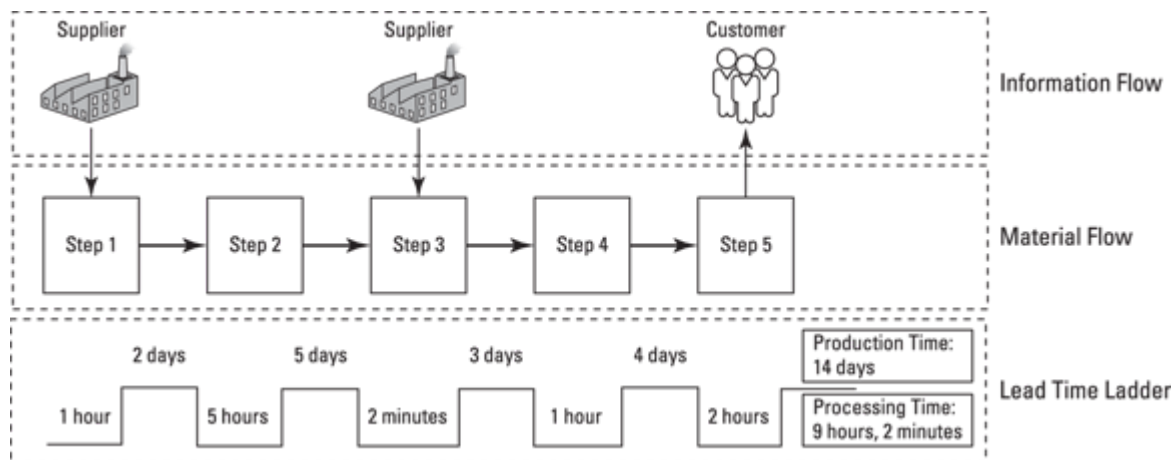
It's often useful to think about your supply chain as a network. Networks are made up of nodes and links. As [Figure 16-1](#) shows, every stop that a product makes between raw materials and a customer is a *node* of the network. A factory is a node; so are a warehouse, a distribution center, and a retail store. Nodes are connected by links. Generally speaking, *links* are forms of transportation, such as a ship, a railroad, a truck, or a drone. Products move through a supply chain, flowing through links and stopping at nodes.



**FIGURE 16-1:** Nodes and links in a supply chain.

Your goal for any supply chain is to deliver maximum value at the lowest cost. One way to achieve this goal is to change the nodes and the links. Perhaps you can lower the costs of your raw materials by sourcing them from a different supplier, which means you'd be changing one of your nodes. Changing a node also means changing the links that connect that node to the rest of your supply chain.

Making changes in the links and nodes is called *network optimization*. One approach to begin network optimization is called *value-stream mapping* (VSM). [Figure 16-2](#) shows a simple example of a VSM. The more of your supply chain that you're trying to optimize, the larger — and more complex — your VSM becomes.



**FIGURE 16-2:** Example VSM.

VSM is an important part of a Lean professional’s tool kit, as you see in the next section, but network optimization can be done on a larger scale with sophisticated mathematical analysis. Several supply chain software platforms are available to help with analyzing supply chain flows, starting with spreadsheets and moving up to complex supply chain modeling tools. In addition to factoring in the costs for buying materials and transporting them between nodes, network optimization can also factor in variables such as supplier performance and the effects of tariffs and taxes.

## *Improving and Innovating Processes*

Supply chains are made up of people, processes, and technologies. All three components need to improve over time for a supply chain to remain competitive. People get better through education, training, and experience. Technology gets better through improvements in hardware and software. Processes get better through innovation and ... well, process improvement.

Three approaches to process improvement are particularly useful in supply chain management: Lean, Theory of Constraints, and Six Sigma. These approaches share a goal — process improvement — but achieve it by focusing on different aspects of a process. [Table 16-1](#) highlights the primary focus of each method.

**TABLE 16-1 Three Approaches to Process Improvement**

<i>Method</i>	<i>Focus</i>
Lean	Reducing waste
Six Sigma	Reducing variability
Theory of Constraints	Relieving bottlenecks

### *Lean*

*Lean* is an approach to supply chain management that originated with Toyota, which is why you may hear it referred to as the Toyota Production System. The idea behind Lean is that you use the least amount of time, effort, and resources by maintaining smooth and balanced flow in a supply chain. The best way to accomplish this goal is to have logical, disciplined processes and excellent communications.



**TIP** TPS originated in the manufacturing world, so it is often called Lean Manufacturing, but the principles have gradually been adopted in retail, distribution, and even service-based organizations. These days, you can find Lean initiatives in virtually every industry.

Many people make the mistake of thinking about Lean as a training program or a set of tools that a company can buy. But Lean is really a philosophy — a different way of looking at how businesses create value. For Lean to work properly, everyone in the company needs to be working together to eliminate three things that cause inefficiency:

- » **Muda:** Waste
- » **Mura:** Unevenness or variability in operations
- » **Muri:** Overburdening of people and equipment



**REMEMBER** Because Lean was formalized by Toyota in Japan, many of the principles are still described using Japanese words.

When someone identifies a need to innovate or improve a process, the key stakeholders are brought together for a *kaizen* event. (*Kaizen* is pronounced to rhyme with “Hi Ben.”) During a *kaizen*, the stakeholders form a team and look at how the process is working, come up with ideas for how to make it better, and then implement changes. That sounds simple, and it should be. But business cultures often make it hard for



people to speak up or be heard, so a formal approach like Lean helps get everyone involved.



**TIP** A core value of Lean is that people must be treated with respect because all the workers have ideas to contribute that could benefit the company.

Under the Lean approach, companies should continually drive eight kinds of muda out of their processes and supply chains:

- » **Transportation:** Any time you ship something from one place to another, you're consuming time and money. The less you need to ship a product, the better.
- » **Inventory:** Any time you have products sitting around in inventory, you're wasting money by tying up space and working capital.
- » **Motion:** Any time you move something when it isn't necessary, or when it isn't somehow making your product more valuable to a customer, you're wasting time and money.
- » **Waiting:** Any time you have to wait for one thing to happen before you can do something else, you're wasting time and money.
- » **Overproduction:** Any time you make too much of a product, or make a product before you can sell it or use it, you're wasting time and money.
- » **Overprocessing:** Any time you do something that doesn't add value — that a customer won't pay for — you're wasting time and money.
- » **Defects:** Any time you make a product that you can't use or sell (including scrap and rework), you're wasting time and money.
- » **Untapped skills and employee creativity:** Any time you fail to engage and inspire your employees to offer ideas, implement improvements, or identify waste, you're wasting an asset that you're already paying for: their brains.



TIP

An easy way to remember the eight wastes is to use the acronym TIM WOODS. (The S at the end comes from *skills* in the last item.)



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Toyota originally identified the first seven kinds of muda, but as Lean has been adopted in other companies, most of the experts have come to agree that untapped human skills and creativity is so important that it needs to be included as an eighth form of waste.

Lean emphasizes the use of a structured approach to solving problems by identifying the root cause rather than the symptoms of a problem. One of the simplest tools for finding the root cause of a problem is the Five Whys technique. First, identify the problem, then ask, “Why does that happen?” Once you have answered that question, ask “Why?” again. In most cases, by asking “Why?” five times you can trace a problem back to its root cause.

Lean practitioners also emphasize the value of clarity rather than complexity when analyzing a problem. For example, many Lean techniques involve explaining a complicated issue using only a single sheet of A3 paper (A3 is the metric equivalent of an 8.5 x 11-inch sheet of paper).

## *Six Sigma*

Six Sigma is a process improvement method that’s built on statistics. The basic idea is that variation is bad. When you’re running a manufacturing process or a supply chain, you need consistency and predictability. If you don’t have consistency, some percentage of the things that you make probably isn’t useful for your customers. If you do have consistency — that is, if you have a process under control — there’s a much better chance that the products you make are useful. Consistent processes lead to a high quality level for products.



TECHNICAL  
STUFF

Statisticians describe the variation of a process in terms of the amount of deviation from an average value. The symbol used to represent deviation in a mathematical equation is the Greek letter sigma ( $\sigma$ ). Any set of data about a process has some deviation, and the less deviation you have, the more stable your process is. So the statistical basis for Six Sigma is to reduce process variability so much that defects occur only at the sixth sigma ( $6\sigma$ ), or just 3.4 defects out of 1 million events.

I don't want to get too deep into the math here; you can find plenty of other books that do. The important thing to understand about Six Sigma is that the goal is to have a very small number of defects — that is, improved quality — as a result of decreased process variation. You get there by measuring processes and using mathematical tools to improve consistency.



TIP

There's so much overlap between Lean and Six Sigma that some people combine them into a single discipline called Lean Six Sigma.

You follow five steps to apply Six Sigma as a process improvement methodology. These steps create the acronym DMAIC (pronounced “duh-may-ick”).

- » Define
- » Measure
- » Analyze
- » Improve
- » Control

### *Step 1: Define*

The first step is to clearly define the process that you're trying to improve and why you want to improve it. During this phase, you need to build a business case for why the project is important and what resources you need to complete it. An important part of building the business case is to get feedback from the people who deal with the outputs of a process: the customers. This feedback is called *voice of the customer (VOC)*. The overview of the project, including the VOC, should be summarized in a Six Sigma project charter.



**TIP** Writing a project charter can be harder than people expect. Don't get hung up trying to make the charter perfect. Instead, create a rough draft that explains what you are trying to do. That will make it easier to clarify your thinking and to get input from other people. The charter is your starting point, so it's okay to make changes and improve it as the project moves forward.

### ***Step 2: Measure***

The second step is measuring the process that you're trying to improve. Because Six Sigma is a mathematical approach, you need to collect data so that you can measure how the process is working and calculate the amount of variation. Taking good measurements is critical so that you can calculate benefits during the next steps in a project. If your measurements aren't accurate, your improvement efforts are probably going to be misguided.

### ***Step 3: Analyze***

After you collect data about the process, you analyze the data. In the world of Six Sigma, this analysis often requires a solid understanding of statistics and the use of statistical analysis software such as Minitab or SPSS. Generally speaking, the data helps you identify variations in a process and shows how those variations affect the quality of your products. Once you have evidence to show what things are causing the variability — the root causes — you can look for ways to improve the process.

### *Step 4: Improve*

The next step is putting the knowledge you gained from data analysis into action by making changes to improve the process. These changes can happen all at once, or they can be introduced over time. Commonly, this phase includes some pilot studies to provide confirmation that the changes provide the expected benefits before you implement them throughout a process. If you decide that several improvements need to be brought online over time, you can sequence them in a *multigenerational project plan (MGPP)*. An MGPP is like a road map that shows the order in which you will implement improvements.

### *Step 5: Control*

The funny thing about improving a process is that sometimes, when you stop paying attention to it, the process goes right back to working the way it did before you improved it. In Six Sigma, the final step is establishing a system to ensure that the improvements you made become permanent. Control often involves ongoing measurements and reporting to show that the improvements remain in place and continue to provide consistency over time.



TECHNICAL  
STUFF

Another Six Sigma approach called DMEDI (Define, Measure, Explore, Develop, Implement) is used to design new processes.

## **SIX SIGMA TRAINING AND CERTIFICATION**

Lots of programs are available to educate people about Six Sigma, and many of them will grant you a certificate when you're done. There are four levels of Six Sigma certification:

- Yellow Belts understand the basic concepts and terminology of Six Sigma and can contribute as a member of a process improvement project.
- Green Belts have a solid understanding of Six Sigma and can lead process improvement projects on their own.

- Black Belts have mastered Six Sigma and can teach other people how to manage process improvement projects.
- Master Black Belts have a high level of mastery and can train and supervise Black Belts.

Check out [Chapter 21](#) for a list of organizations that offer Six Sigma training.

## *Theory of Constraints*

The Theory of Constraints (TOC) is one of the simplest, yet most powerful supply chain concepts. The basic idea is that every process is limited by some kind of *constraint*. (Think of the saying “A chain is only as strong as its weakest link.”) TOC is about tuning an entire supply chain to run at the same pace as the slowest step in the process.

There are many examples of how constraints control the processes around us. In the world of auto racing, there are times when you need to limit the speed at which cars travel around the track, so you send out a pace car that no one is allowed to pass. When you’re draining a bathtub, the rate at which water flows out is constrained by the size of your drain. In every case, the most restrictive step in a process is the one that constrains the entire system. TOC helps you focus improvement efforts on the constraints because that is where you can have the greatest effect on the supply chain.

After you find the constraint, you have two choices:

- » Slow all the other steps so that they run at the same speed as the constraining step. This option prevents the buildup of inventory between the steps in your process.
- » Improve the constraint so that the entire system moves faster. As you continue to improve the constraint (perhaps by using Lean and Six Sigma), eventually, the constraint is no longer the slowest step in your process. At that point, some other step becomes the constraint that’s limiting your process, and the cycle starts again.

Suppose that you have a supply chain that involves several steps. Your customers, at the end of the supply chain, want to buy 1,000 widgets

each month. But you can deliver only 750. How do you increase the capacity of your supply chain to sell your customers the products they want?

Because of TOC, you know that the entire process is limited by a single constraint — in this case, the slowest step in the process. Instead of trying to fix everything, you start by finding out which step is slowing the system.

After you find the constraint, you might slow all the other steps so that the entire system is running at the same speed — in this case, tuning each step to produce only 750 widgets per month. That way, you won't have inventory building up between the steps of your process. But you still won't be meeting your customer's needs.

If you can improve the constraint you would allow the entire supply chain to move faster. As you continue to make improvements, eventually the constraint will no longer limit your process. At that point, some other step has become the constraint, and you need to shift your focus to the new constraint.



TECHNICAL  
STUFF

TOC was made popular in a novel called *The Goal* by Eliyahu M. Goldratt (North River Press; 2014). Herbie was one of the characters in the book, and his name has since been adopted in TOC to describe the constraining step in any process. Although looking for a constraint may sound obvious, the problem is that constraints are often hard to find. When a constraint is at the beginning of a process (like a pace car) or at the end of a process (like a bath drain) then the process is probably stable. When a constraint occurs in the middle of a process, the constraint can cause chaos. For example, a machine in the middle of an assembly line that breaks down might be a Herbie. But until you look at it from the perspective of TOC, people might not see how the starts and stops of that machine actually cause inefficiencies throughout the whole supply chain and lower the company's overall efficiency.



# *Introducing New Products*

Any time a company launches a new product, it is creating a new supply chain. The product team will need to answer questions such as, “Where will our customers be located, where will manufacturing be done, and what materials will the product be made from?”

As products move through the development process from concepts to prototypes to market-ready, the supply chain needs to be put in place. Many companies formalize their development steps with a New Product Introduction (NPI) process. NPI ensures that the right stakeholders are involved at the right time, and helps to avoid expensive mistakes, miscommunications, and rework.

Each step in an NPI process is called a *stage gate*. A product cannot move forward in the development process without passing through each stage gate. And each stage gate requires the approval of several different functions. For example, a prototype might need to be approved by the transportation expert prior to it moving on in the development process. The transportation expert might offer recommendations for changes to the design that would make the product easier to ship, or that could allow it to be moved using different modes of transportation.

In some cases, product designs are strategically linked to supply chain capabilities or limitations. This approach is called *design for supply chain*.

# *Structuring Supply Chain Projects*

Projects are the way that companies make changes. Because supply chains need to adapt to changes all the time, project management is an important part of supply chain management. Supply chain projects tend to be cross-functional. You may need to have logisticians and operations managers, human resources professionals, information technology experts, and accountants working together, which can create challenges in terms of communication and workload. So you need to look at the unique characteristics of supply chain projects and how they can create



management challenges, and then you need to have a set of principles that help you lead cross-functional projects and navigate these challenges effectively.

### ***Managing cross-functional project teams***

Supply chains connect companies and cut across the silos within a company. As a result, supply chain projects commonly involve team members from many functions. A supply chain project team might include people from business development, customer service, shipping, receiving, manufacturing, information technology, accounting, and human resources. Each of these groups could have different goals and priorities for the same project. Bringing people with diverse skill sets together as a project team can be a great way to stimulate innovation and accelerate change. Managing cross-functional supply chain projects is a great way to develop a broad network and a deep understanding of the complexity of supply chains. Three of the most common challenges for cross-functional project managers are authority and influence, communication, and prioritization.

#### ***Authority and influence***

*Authority* means that you have the ability to hire, fire, reward, and correct someone. Often, key team members report to managers in another division in the company and are only loaned to the project. This is an example of a matrix organization. In matrix organizations, it can be difficult for the project manager to address performance issues directly because they do not have the authority to do so. If the project manager doesn't have the authority to manage the team members, they will need to rely on influence to motivate team members and keep everyone pulling in the same direction.

#### ***Communication***

Experts in any field have their own tools, rules, and language. In supply chain management, the same word can mean something different depending on the context. Transportation companies (such as steamship lines and trucking companies) refer to their customer as the *shipper*, whereas their customers often use the term *shipper* to describe the

transportation company. The project manager needs to watch for jargon and act as a translator so that they can avoid miscommunications between the team members.

### ***Prioritization***

When someone is asked to work on a project, it is often in addition to their existing workload. It's common for team members to be working on several projects at the same time. You must make sure that your project gets enough support to keep moving forward. By anticipating potential problems, you can make formal and informal arrangements to resolve them. You might make an agreement with the team member's boss to ensure that your project has priority, for example. Or perhaps the team member's boss may commit a certain number of hours each week to your project.

### ***Creating cross-functional project plans***

One of the best ways to deal with the challenge of leading a cross-functional project is to have a solid project plan. Building the plan gives everyone a chance to provide input and catch interdependencies. The training department, for example, may not be able to start training employees in a new process until the necessary equipment has been delivered and installed. An integrated, cross-functional project plan makes it easy to see these connections and provides a clearer picture of the time required to complete a project.

You can use many approaches to build an integrated project plan, but the following system works best for me:

- 1. Bring representatives from all the necessary functions together for a planning meeting.**

Representatives may include people from logistics, operations, information technology, human resources, and accounting.

- 2. Ask the team to come up with a list of deliverables.**

*Deliverables* are clearly defined results that the project must produce.



TIP

To check your deliverables, use the Done/Not Done test. You should be able to ask whether a deliverable is done or not. The answer shouldn't be "Almost," "Mostly," or "It's 64.67 percent done." The answer should be "Yes, it's done" or "No, it's not done."

### 3. Ask the team to create ten tasks for each deliverable.

You might ask the team members, "If you were to summarize what it takes to complete this deliverable in 10 steps, what would those steps be?" Each step is a task. A structured list of tasks, like the one in [Figure 16-3](#), is called a *work breakdown structure* (WBS).



TIP

I prefer deliverables and tasks that start with verbs, because that makes it easier to tell what needs to be done. "Design receiving process" is more descriptive than simply "Receiving process," for example.

ID	Name	Accountable Owner
1	Select location for distribution center	Sue
1.1	Complete network design study	Bob
1.2	Select three regions for potential site studies	Jim
1.3	Complete site studies	Dean
1.4	Submit site studies to VP for review	Sue
1.5	Schedule visits	Dean
1.6	Conduct negotiations with developers	Jill
1.7	Select final site	Sue
1.8	Sign contract	Sue
2	Select real estate broker	Dean
2.1	Acquire list of licensed brokers	Jim
2.2	Interview reference clients	Dean
2.3	Interview broker candidates	Dean

Deliverable →

Tasks {

**FIGURE 16-3:** Sample work breakdown structure.

### 4. Ask the team to decide which tasks have to be completed before another task can begin.

Relationships among tasks are called *dependencies*. The task that needs to happen first is called a *predecessor*. The task that has to wait is called a *successor*. For simple projects, you can track dependencies manually. For more complex projects, the dependencies need to be tracked using project management software. [Figure 16-4](#) shows a network diagram that illustrates the predecessor and successor relationships between tasks.



TIP

Using project management software to track tasks and dependencies can help you avoid mistakes and save a lot of time.

### 5. Evaluate the timeline, and crash the plan.

Dependencies often mean that it takes longer to complete a project than anyone expected or considered to be reasonable. When that happens, you need to look for ways to shorten the timeline. This process is called *crashing* or *compressing* the project plan.

Start by looking at the tasks that are driving your schedule — the ones that are taking the longest time to complete. The longest series of tasks is called the *critical path*. The only way to shorten a project is to change the tasks on the critical path. Perhaps some tasks don't need to occur in sequence (in series). Instead, those tasks could run at the same time (in parallel), or they could be independent of one another. Continue analyzing the tasks on the critical path until you have a timeline that seems reasonable both to the team and to your sponsor.

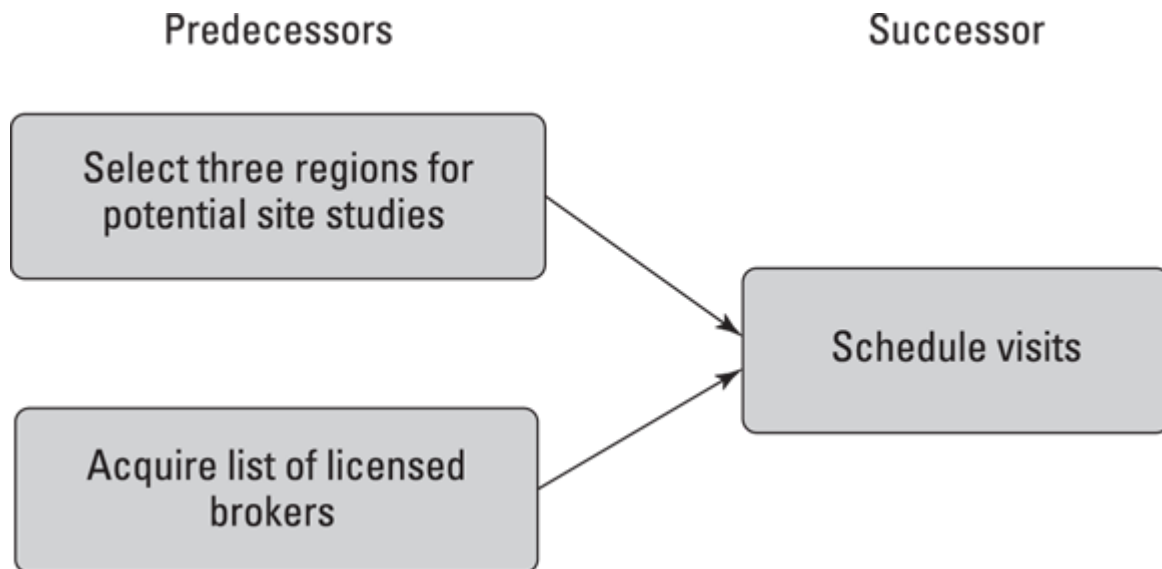


**REMEMBER** Project tasks that happen in sequential order are *serial*. Tasks that can be done at the same time are running in *parallel*.



TIP

Creating a list of project deliverables and tasks is relatively easy and can be done with a word processing or spreadsheet program, but calculating project timelines and the critical path is cumbersome work. Project management software does this work automatically, which saves a lot of time when you're crashing or revising a project plan.



**FIGURE 16-4:** Sample network diagram.

## *Creating a RACI matrix*

When lots of people are working on a project, they often have different opinions about their roles and responsibilities. The project manager needs to clarify what everyone is doing to make sure every task will be completed. It's much easier to set these expectations up front than to resolve misunderstandings later on.

For any task in a project, a team member can have one of four roles:

- » **Responsible:** A team member is responsible for helping to complete a task. If the task requires someone to do any work or make a decision, that person is responsible for working on that task until it's complete.

- » **Accountable:** The accountable team member is the one person who is ultimately on the hook for getting the task done. The accountable owner may need to make the decisions and do the work. Or they may need to prod and poke their team members to do the work. When it comes time to ask “Is this task complete?” the accountable owner is the person whose career and credibility are on the line. There should be one, and only one, accountable owner for each task.
- » **Consult:** A consult team member should be asked to provide input for a task, but they aren’t the one doing the task or making decisions.
- » **Inform:** An inform team member needs to be notified that a task is occurring or that it has been completed.

Assigning people to these four roles makes it easier to set expectations and communicate exactly what each team member has to do for your project to be successful. You can document the roles with a RACI matrix (Responsible – Accountable – Consult – Inform, pronounced *ray-see*).

Using a RACI matrix like the one in [Figure 16-5](#), you list all the tasks in your project and define the role for each of your team members for each task. If there is disagreement about someone’s role on a task, you have a chance to resolve it on paper before it creates a problem for your project. Read horizontally, a RACI matrix makes it very easy for the project manager to know who needs to be involved for each task to get done. Read vertically, a RACI matrix shows each person’s role throughout the project.

Task	Sue	Bob	Jim	Dean	Jill
Complete network design study	I	A	R	R	
Select three regions for potential site studies	I	C	A	R	
Complete site studies		R	R	A	
Submit site studies to VP for review	A	R	R	R	I
Schedule visits	C	C	C	A	C
Conduct negotiations with developers	C			R	A
Select final site	A	R	R	R	R
Sign contract	A	I	I	I	I

**FIGURE 16-5:** Sample RACI matrix.



TIP

It can be hard to convince team members that only one person should be accountable for a task. I've found, however, that when more than one person is accountable, it's more difficult to manage the project. If two people insist that they're both accountable for the same task, consider breaking it into two separate tasks and making each person accountable for one of these two tasks.

## *Designing project scorecards*

Tracking the progress of a project is the key to figuring out what's working, what's not working, and how to keep a project on track. One of the most effective ways to track a project is to use a scorecard and update it on a regular basis. For most projects, I recommend doing weekly updates at the same time every week; for slower-moving projects, monthly or quarterly updates are fine. In some cases, such as when there is an emergency, things change so fast that you need daily or even hourly updates.

The project scorecard should make it easy for anyone to tell at a glance how a project is doing — whether it's ahead of schedule and under budget or behind schedule and over budget; whether things are going as planned, or whether unplanned risks are putting the project in jeopardy. Following are the items I often include in a scorecard and plan to update every week:

- » **Status of major deliverables:** Which deliverables have been completed and whether they were on time, early, or late
- » **Recent accomplishments:** New things that have been completed since the last time the scorecard was updated
- » **Upcoming tasks:** Things that the team will be working on between now and when the scorecard is updated in the future
- » **Risks and concerns:** Unexpected challenges and issues that are causing problems or that could interfere with the project

Having this information at your fingertips makes it much easier to manage well, reward people for their accomplishments, and help them deal with challenges. If you understand what is happening, what should be happening, and what might happen, you can make decisions faster. Other pieces of information can also add value to a scorecard, such as budget performance, quality ratings, and employee engagement. To build a good scorecard, understand what information you need to track to keep everyone on the same page and ensure the success of your cross-functional supply chain projects.

[Figure 16-6](#) shows an example scorecard that makes it easy to communicate four essential pieces of information about the status of a project.

Project Scorecard for the Week of January 21

Status of major deliverables	Upcoming tasks
Recent accomplishments	Risks and concerns

**FIGURE 16-6:** Sample project scorecard.

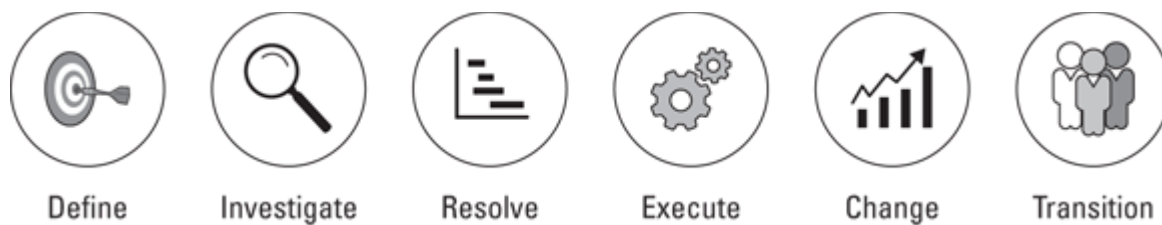
### *Using the DIRECT framework*

Over the years, I've developed an approach to leading cross-functional teams called the DIRECT project leadership framework. The idea for this approach came from the realization that every movie — no matter how great the actors are — needs a director who can keep everyone working on the right things at the right time, and a cross-functional project in a company is no different.



The DIRECT framework is built around the six things that a leader needs to focus on to help their team complete a project successfully (see [Figure 16-7](#)):

- » Define the objective.
- » Investigate the options.
- » Resolve to a course of action.
- » Execute the plan.
- » Change the system.
- » Transition the people.



**FIGURE 16-7:** The six responsibilities of a leader in the DIRECT framework.

### ***Define the objective***

Every project should start with a charter that clearly describes the scope, schedule, and budget of the project; identifies the project sponsor; and explains why the project is important. The charter helps ensure everyone has similar expectations and can prevent *scope creep* (new work added to the project later).

### ***Investigate the options***

Before implementing a solution, it's usually a good idea to consider other ways to accomplish your goal. Investigating your options early reduces the risk that you'll suffer buyer's remorse and ensures that you take into account the many points of view that can affect decisions in the supply chain.

### ***Resolve to a course of action***

Once the options are understood, the team needs to make a decision to move forward. Supply chain projects can suffer from analysis paralysis

if teams get bogged down trying to collect data rather than making decisions and taking action. On the other hand, teams can also fail if they get busy working too soon — before they properly understand all the interdependencies and risks.



**TIP** Resolving to a course of action is a leadership art that involves probing and listening to ensure that you truly understand the priorities and concerns of your stakeholders, as well as helping them accept the need to compromise. Building a project plan that shows the dependencies among all their tasks is a good way to capture these issues and build consensus.

### *Execute the plan*

When the plan is in place, the team needs to focus on executing it. Moving projects forward, keeping them on schedule, and keeping them on budget require special skills. Surprises will always occur, and surprises take time and money to address, but the credibility of the team and the value of the project depend on getting the work done on time. Executing the plan takes focus, a sense of urgency, and good communication among team members.

### *Change the system*

Projects are about changing the way that the supply chain — the system — works. You must understand how a system works, the current state, before you change it. That understanding comes from the work that your team does to define and investigate the project. You also need to know how you expect the system to perform when the change is complete — the future state — which comes from the work the team does to resolve and execute. The change from the current state to the future state doesn't happen instantly or by magic. The implementation of the change needs to be planned, too. If you're starting a new distribution center on Monday, for example, consider whether you should shut down the old one the Friday before or run both centers in parallel for six months to make sure that the new one is working properly. You should also plan for

the issues that are likely to come up during the change, such as shipments that get misrouted or equipment that doesn't work as expected.

### *Transition the people*

You need to think about the people who are part of your supply chain and how your changes will affect the routines of your customers, your employees, and your other stakeholders. Any time something changes, people need to process and accept that change. If your project is going to affect someone, you need to help them prepare for the change.

Organizational behavior expert William Bridges called this process *transitioning*. Whereas the change is about the system, the transition is about the people. Managing the transition is just as important as managing the change.



**TIP** You can learn more about using the DIRECT framework from one of my LinkedIn Learning courses called “Leading Projects.” Find it by logging in to LinkedIn, selecting Learning from the Work drop-down menu, and typing **Leading Projects** in the Search box.

### *Adopting Agile project methods*

The traditional approach to project management is often called a waterfall approach, because each task rolls down into the next. This is a good approach if you know what you need to accomplish and can break it down into small steps. In other words, waterfall projects work well when there is a clear beginning and ending and well-defined requirements. But what if you aren't sure what your finished product will look like? That is a common problem for software development, and it is why agile project management has become common in technology companies.

*Agile* is a general name for a group of project management methods that use an iterative approach to deliver projects or products in small usable pieces. Agile projects break work into short windows called *scrums* or *sprints*. A sprint usually lasts for two weeks or less, and during that time

the team needs to develop, test, and deploy a complete product or feature. There is a product owner who is responsible for creating user stories that describe how a new product or feature would be used. These user stories are prioritized, and the team develops a plan to complete the features that will be most valuable to their users. The team starts each day with a short scrum meeting to discuss their progress and identify issues. As the scrum moves forward, the team's progress is tracked on a visual display called a task board or a kanban board. Once a sprint is complete, the process starts over.



**TIP** Agile is a global movement that was started by group of programmers who felt that bureaucracy was preventing them from doing their jobs well. You can learn more about these rebellious pioneers and read their Agile Manifesto at <https://agilemanifesto.org>.

## Chapter 17

# Optimizing Your Supply Chain

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### IN THIS CHAPTER

- » Minimizing inventory by improving information flow
  - » Reducing complexity by eliminating unprofitable products
  - » Trimming costs and working capital requirements
  - » Paying for innovation and improvement with quick wins
- 

Supply chain management becomes most valuable when you are able to improve service levels to your customers and increase the profitability of your company. By making strategic choices about how to optimize your supply chain, you can drive significant improvements such as increasing product availability for your customers, reducing working capital requirements, and increasing the flexibility of your business. But you probably can't do all of them, and you certainly can't do them all at the same time. In this chapter, you look at several strategies that can help you provide significant benefits for your business by using supply chain management tools and techniques.

## *Improving Transparency and Visibility*

Effective supply chain managers catch problems when they're small, before they affect the company or its customers. Because supply chains cross so many functions and so many companies, it can be hard to get complete and accurate data. Even if you can get the data, you may not be able to analyze it fast enough to make accurate decisions. A good example is the challenge that companies face when a natural disaster occurs, such as a hurricane. To understand how their supply chain might

be affected, they need information from customers, suppliers, and logistics providers. To improve your ability to manage a supply chain, you need to have *visibility* — current and accurate data about what’s happening in as close to real time as possible.

When you share supply chain visibility with people outside of your company, you are providing *supply chain transparency*. Customers, suppliers, regulators, and nongovernmental organizations are placing a greater emphasis on supply chain transparency for two main reasons: supply chain resilience (See [Chapter 18](#)) and supply chain sustainability (see [Chapter 19](#)). Visibility and transparency are closely linked: In order to have visibility to your supply chain, you need your customers and suppliers to be transparent about their supply chains, but they can’t be transparent unless they have visibility into their own supply chains.

One way to increase visibility is to build a *supply chain control tower* — a hub that pulls updates from each of your supply chain information systems. (See [Chapter 11](#) for a closer look at the different types of supply chain information systems and control tower software vendors.) A control tower can also pull in data from systems run by your customers and suppliers, as well as third-party sources such as news and weather reports. A supply chain control tower can be useful for responding to a disruption, such as a hurricane, or for identifying and fixing problems as they arise throughout your supply chain. In other words, it can increase your supply chain’s responsiveness. But a control tower can also be useful for tracking how well your entire supply chain is working and whether process improvement efforts are benefiting your key metrics, such as order fulfillment cycle time and total cost to serve.

It’s sometimes best to have a control tower located in a control room with powerful computers, skilled analysts, and a backup power supply. But many companies are also creating virtual supply chain control towers that consolidate supply chain information and make it available to managers throughout a company via the Internet. There are many benefits to a virtual supply chain control tower, including the ability to give everyone in the company access to the same information at the same time.

# *Deploying Demand Shaping*

In many ways, supply chain management is really about balancing supply and demand. Companies do their best to control supply — to make sure they have the right product in the right place at the right time. But companies can do a lot of things to control demand, too. As your ability to make and deliver products changes — perhaps as a result of seasonality or the availability of materials — you can employ tactics to change the demand for your product. Following are some methods that can influence demand:

- » Use promotions such as price discounts to increase demand.
- » Use price increases to reduce demand.
- » Offer to substitute one product for a different one.
- » Limit sales, set quotas, and allocate products to certain customers.
- » Provide incentives for customers to order products at different times or to accept different delivery dates.

Airlines often use a demand-shaping technique called *dynamic pricing* when selling tickets. If they have unsold seats on a flight from Chicago to Los Angeles, for example, they lower the price to increase demand. As those seats get sold, they increase prices, which decreases demand. They might also offer a substitute for a direct flight from Chicago to Los Angeles, such as taking two flights with a connection in Phoenix. One result of demand shaping in this case is that everyone on the airplane could end up paying a different price for their seat. The airline's goals are to sell all of its capacity while maximizing profits, and demand shaping helps it achieve both goals simultaneously.

Demand shaping gives you more control of the delicate balance between supply and demand. Generating value from demand shaping requires cross-functional communication and alignment throughout the supply chain. If a promotion increases the demand for a product too much, you might need to pay more to expedite a replenishment order, and you might even run out of inventory, which would disappoint your



customers. Excessive demand shaping can also contribute to the Bullwhip Effect.

## *Performing Postponement*

If your product requires any kind of customization for your customers, you should look for a way to postpone that customization for as long as possible. This technique is called *postponement* or *delayed differentiation*. By postponing the customization, you preserve the flexibility to change the characteristics of the finished product or even to sell it to a different customer. You also delay the cost of those customization steps, which means that you're keeping inventory at a lower value for a longer time and that reduces your inventory costs.

The value of your total inventory is the sum of the values of all the individual products that you are storing. Every time you touch or change a product, you add value. As you do any kind of work on a product, you're investing money in it. Polishing, painting, and assembling parts increase their value, for example, and therefore increase the total value of your inventory. Because postponement focuses on keeping products in the lowest-value state for as long as possible, it can reduce your inventory cost even though it doesn't affect inventory levels or turns.

One great example of postponement occurred in Benetton's supply chain for sweaters. The company made the same sweater, using the same materials, in several colors. Originally, the supply chain was designed so that the wool would be dyed before it was knitted into sweaters. The company tried to guess how many sweaters it should make in each color. The guesses were often wrong, however, so the company would run out of sweaters of a popular color and be overstocked in sweaters of less popular colors. Then the company changed its supply chain to incorporate postponement: knitting the sweaters first and dyeing them later. That small change made it much easier for the company to provide sweaters in the colors that customers wanted. The company could keep undyed sweaters in inventory and dye them based on which colors their customers were buying.



Here's another good example of postponement. Hewlett-Packard makes inkjet printers for customers all over the world, but different countries have different electrical power systems, so the printers have to be customized with the right kind of plugs and power supplies. Rather than adding power supplies during manufacturing, the company implemented postponement and added the power supply to printers just before final packaging. This change gave the company more flexibility to decide where to sell each printer it manufactured.

## *Reviewing Sourcing Regions*

When companies look for suppliers, they don't always do a good job of making apples-to-apples comparisons. Companies sometimes get quotes from suppliers located in other countries, thinking that global sourcing will provide huge savings. In many cases, this strategy works well. But in some situations, global sourcing creates big problems and can even end up costing extra. Following are some of the often-overlooked challenges in global sourcing:

- » Long shipping distances result in higher transportation costs; greater lead-time variability; more risks; and larger, less-frequent shipments.
- » Long lead times reduce supply chain flexibility.
- » Differences in time zones and languages can make it more difficult to resolve problems and collaborate effectively.

As a result of these types of challenges, many supply chains now focus on creating shorter supply chains through local or regional sourcing. This focus might involve changing from an overseas supplier to a domestic supplier, which is called *reshoring*.

Nearshoring involves moving suppliers from a country that is far away to a country that is closer. Following the supply chain disruptions in the last few years, many U.S. companies are adopting near shoring by moving their suppliers from China to Mexico.

Friendshoring is a new trend that has emerged as a result of trade disputes, territorial disputes, and wars around the world. Friendshoring involves sourcing from countries that have political and military alliances, in order to decrease the risk of future supply chain disruptions.

## *Reducing Stock-Keeping Units*

One thing that makes supply chain management challenging is the fact that every version of each product you sell has to be managed separately as a unique stock-keeping unit (SKU, pronounced “skew”). Even if you make only a single product, you usually have multiple SKUs. For example, even if you make a single product like bottled water you could easily have several SKUs:

- » 12-ounce bottles sold in a 4-pack
- » 12-ounce bottles sold in a 20-pack
- » 16-ounce bottles sold in a 4-pack
- » 16-ounce bottles sold in a 10-pack

At first glance these products all seem to be the same, but each SKU has a slightly different supply chain. You need to have a separate sales forecast for each SKU, as well as a production schedule, inventory policy, and distribution plan. You may buy 12-ounce bottles from one supplier and 16-ounce bottles from another. You may have one customer that wants only 4-packs and another that wants only 10-packs. All the additional work and inventory created by each SKU adds costs to your supply chain.

Companies often try to keep their product image fresh by introducing new variations on a product or different packaging options. Although this marketing strategy can be effective in increasing revenue, it also leads to an expensive proliferation of SKUs. Adding SKUs can increase revenue, but it often reduces profits because of the additional cost.

A common way to balance the revenue that each SKU generates with the cost of maintaining it is to use ABC analysis. First, group your SKUs

into segments based on total sales. Assign these segments names such as A, B, C, and D. In this case, segment A is your biggest sellers, and segment D is your slowest movers. Because SKUs in the D category cost you money to maintain and they don't generate a lot of revenue, you may want to discontinue those items. Here's an ABC analysis of the bottled-water example:

- » Segment A: \$500,000 total sales (16-ounce bottles sold in a 4-pack)
- » Segment B: \$150,000 total sales (12-ounce bottles sold in a 4-pack)
- » Segment C: \$100,000 total sales (16-ounce bottles sold in a 10-pack)
- » Segment D: \$25,000 total sales (12-ounce bottles sold in a 20-pack)

Segment D contributes very little to total sales and probably should be eliminated. The customers who are buying this SKU may even be willing to substitute one of the other SKUs instead. So ideally, by eliminating your slow-moving SKU, you can reduce costs and increase the sales of another SKU at the same time.



**TIP** An alternative way to do ABC analysis is to segment by profits rather than by revenue. Using the profit approach, you may find that some of your low-volume products are actually very profitable.

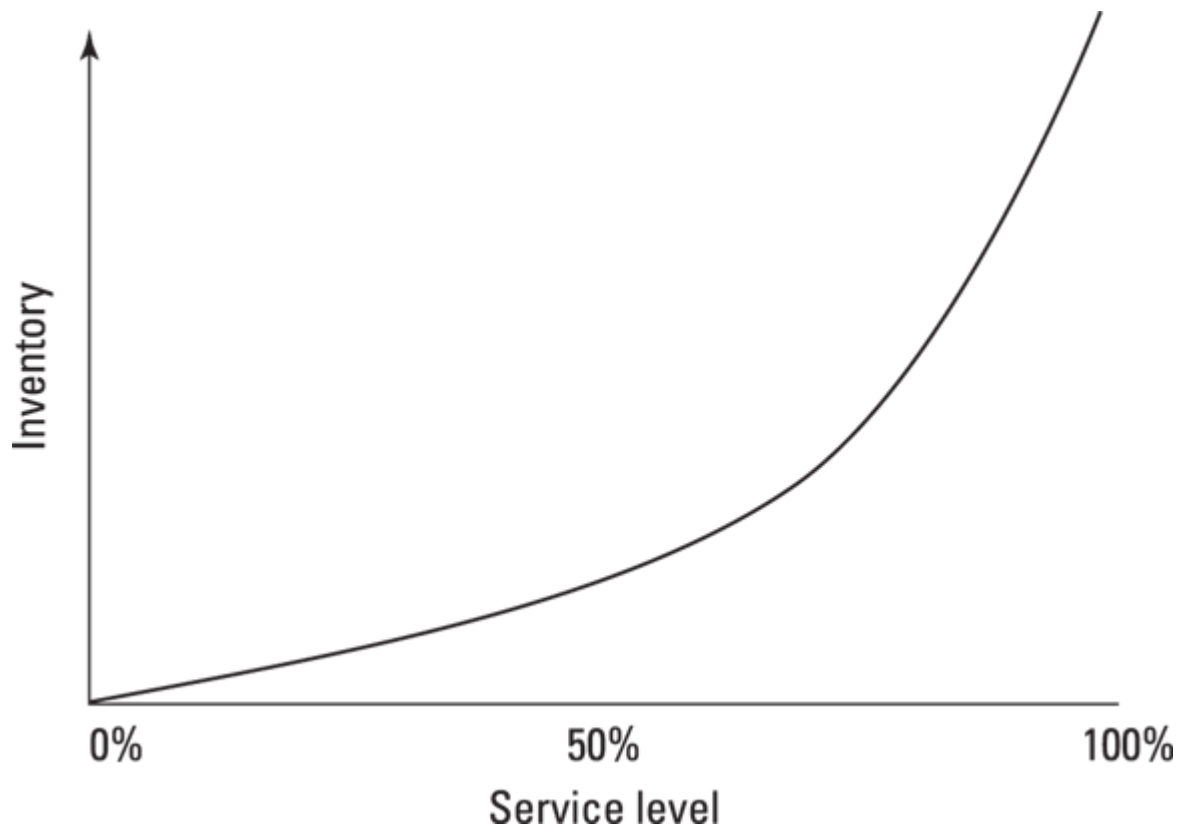
## *Optimizing Inventory*

Inventory is a major expense for most manufacturing, wholesale, and retail companies. But without inventory, making and selling products is hard. Keeping the right amount of inventory in stock is one of the primary goals for many supply chain managers.

One way to optimize your investment in inventory is to decide how often you're willing to tell customers that you've run out of the product that they want to buy. Here's why. Inventory management (see [Chapter 9](#)) is a great place to use statistics and probability. You can look back at your

statistical performance (how much you've sold in the past) and generate forward-looking probabilities (how much you expect to sell in the future). Mathematical models and computer simulations can analyze your sales patterns and tell you how often you're likely to have a stockout based on how much inventory you keep on hand and when you receive replenishments. If you want to fill eight of every ten orders you get, you'd set an 80 percent service level target. If you want to be able to fill nine of every ten orders, you'd be shooting for a 90 percent service level.

The difference between an 80 percent service level and a 90 percent service level sounds small, but it requires an exponential increase in inventory. Each improvement in service level requires a larger investment in inventory than the last one (see [Figure 17-1](#)). To optimize the amount of inventory you carry, you need to choose a service level target, which means deciding how often you're willing to run out of inventory.



**FIGURE 17-1:** Relationship between service level and inventory.



**TIP**

The increase in demand from the COVID-19 pandemic led to stockouts of many products, such as toilet paper and hand sanitizer. The same thing often happens when a hurricane is approaching. When people are afraid that they may not be able to go to the store, they buy more. If the stores are not prepared for this increase in demand, they will probably experience stockouts.

Deciding how often it's appropriate to be out of inventory is difficult, because no one ever wants to lose out on a sale as a result of not having inventory in stock. But the math is clear: The only way to ensure that you never run out is to have an infinite amount of inventory. That's impossible, of course. So you should think instead about how to handle occasional stockouts to minimize the effect on your customers. Perhaps you can substitute a different product or fill an order from a different location. Also look for ways to increase the velocity of your supply chain so that stockouts can be eliminated quickly through replenishment.



**REMEMBER**

Companies often need to decide whether to reduce inventory levels in order to save money or boost inventory levels to improve customer service.

You may discover that it makes sense to have different service level targets for different products or channels. You may decide that you want to have a service level of 80 percent for widgets in your retail stores, for example, and a service level of 98 percent for purchases made through your website. That way, you reduce the amount of inventory in your stores but ensure that customers can almost always get your products by going online.



**TIP** ABC analysis can provide a basis for setting service level targets. You might establish a policy stating that you have a 98 percent service level for your A items, a 95 percent service level for your B items, and a 90 percent service level for your C items.

One of the main risks from a stockout is that customers will be disappointed if they can't buy the product they want when they want it and could end up buying from your competitors. When you look at optimizing your inventory, don't look just at how much money you can save. Also think about how having a high level of product availability can help you grow revenue, increase market share, and build customer loyalty.



**TIP** Interest rates have a significant impact on the cost of inventory and they can change frequently. If a company borrows money to purchase inventory, then the interest rate on the loan is part of the carrying cost for the inventory. If interest rates go up, carrying the same amount of inventory becomes more expensive.

Warehousing space is another important factor for inventory optimization. In some places around the world it is hard to find building space or associates to work in warehouses. A good example is the Inland Empire in southern California which is close to the ports of Los Angeles and Long Beach. So many companies have built distribution facilities there that today it can be difficult for new companies to find space or hire employees.

## *Incorporating Vendor-Managed Inventory*

Sometimes, the best way to manage inventory is to let your vendors do it for you. Allowing your vendors to check your inventory levels, place replenishment orders, and keep you from running out of the products you need can save you time and money. This practice has become common among companies that supply packaging materials and chemicals, as well as that who sell sodas and snacks to convenience stores. Using a vendor-managed inventory (VMI) strategy is great for suppliers because it gives them the power to order their products for you. VMI can be good for customers too because it reduces the cost and effort required to manage their inventory.

A similar approach that goes a step further is consignment inventory. In consignment inventory, vendors keep their inventory in your facility. As soon as you pull the inventory, it becomes yours; then the vendors charge you for it. Consignment inventory is becoming popular for safety equipment in factories, where employees can purchase items such as safety goggles and gloves from vending machines.

Many companies are experimenting with innovative ways to use VMI and consignment inventory to make their supply chains more efficient. Automotive manufacturers often require suppliers to provide their parts under a VMI arrangement. Also, some electronics manufacturers ask their component suppliers to maintain consignment inventory in the manufacturer's facility so that they can access it immediately rather than needing to order it and wait for delivery.

But VMI and consignment inventory have their drawbacks. Both methods require a huge amount of trust between the parties, and nothing is really free. In VMI, your suppliers absorb the cost of managing your inventory, which could push their profits lower or push the cost of your materials higher. In consignment inventory, suppliers keep the inventory on their books until you pull it and they can charge you, which could also reduce their profits or increase your prices.

VMI and consignment inventory strategies can solve problems and reduce costs throughout your supply chain. They both rely on trust and transparency, so you need to look at these option closely to make sure

that you aren't giving up too much control of your supply chain and increasing your total costs in the long run.

## *Adjusting Payment Terms*

In supply chains, timing is everything, especially when it comes to the payment terms that you offer to customers and negotiate with your suppliers. Two dates are particularly important in the financial cycle of any product:

- » The date when you spend the money to buy the components
- » The date when you collect payment for your product or service from a customer

The time between these dates is called the *cash-to-cash cycle time*. The shorter your cash-to-cash cycle time is, the less working capital you need and the more efficient your supply chain is.

The dates on which you pay suppliers, and get paid by customers, are determined by the payment terms that you agree to. Cash-to-cash cycle time is calculated as receivable days plus inventory days minus payable days. The following examples show how payment terms affect the amount of working capital that you need to run your business:

- » You extend 30 days of credit to your customers (your receivables). Your suppliers give you 30 days of credit (your payables). You maintain enough inventory to cover 15 days of demand. Your cash-to-cash cycle time is  $30 + 15 - 30 = 15$  days. Because your payable days and your receivable days are the same, you need only enough working capital to pay for your average inventory level.
- » You extend 30 days of credit to your customers, but your suppliers require you to pay for products immediately when you place an order. You also need to keep 15 days of inventory on hand. Your cash-to-cash cycle time is  $30 + 15 - 0 = 45$  days. In this case, you need enough working capital to cover your average inventory plus working capital to cover your sales for 30 days.



» You require customers to pay you when you take their orders, but your suppliers give you 30 days to pay them for the products you buy. You don't maintain any inventory, because you wait to buy materials until you receive an order from your customer. So your cash-to-cash cycle time is  $0 + 0 - 30 = -30$ . In this case, your cash-to-cash cycle time is negative. You don't need any working capital because you're getting paid before you have to give any money to your suppliers. In fact, if you get really good at this process, you can stockpile cash from your customers in the bank and earn interest on it for 30 days before paying your suppliers.

Payment terms and inventory requirements vary from one supply chain relationship to the next, which will affect your cash-to-cash cycle time. Suppliers may extend longer payment terms in exchange for charging a higher price for their products. Customers may be willing to pay more quickly in exchange for a discount on the price you charge them. Cash-to-cash cycle time is a useful metric for understanding how quickly you can turn products into revenue. Although reducing your working capital requirement is useful for reducing costs, remember that the most important goal for your supply chain is to usually to maximize profit.

## *Using Supply Chain Finance*

Managing cash flow can be a challenge for any business. If you run out of money, you go bankrupt, and it's game over.

When a big company places an order with a smaller company, the smaller company often has to make a relatively major investment in equipment, labor, and raw materials, which can create cash-flow challenges. After the small company fills the order, months may pass before the big customer pays for the work. In the meantime, the small company may have trouble paying its own bills if it doesn't have adequate cash reserves.

Supply chain finance strategies give small companies options for managing their cash flow based on orders that they receive. Following are four common supply chain finance strategies:

- » A bank extends credit to a small company while the company is waiting to get paid by its customers. This strategy is often called *invoice financing*. Invoice financing is pretty common, but it's expensive because the bank may see the small company as being a high credit risk and will charge a high rate of interest.
- » A small company sells the right to collect payment from the big company to a third party for a percentage of the order's actual value. This process is called *purchase-order factoring* or *invoice factoring*. The small company can use the money it receives immediately to fill the big company's order. But when the big company finally pays the invoice, the check goes to the third party rather than to the small company.
- » A big company cuts out the middleman and extends short-term credit directly to its suppliers. This strategy benefits the big company, because it probably can borrow money more cheaply than its smaller suppliers can. If their suppliers borrowed the money from a bank, they'd likely pay higher interest rates and pass those costs along to the big company. So by lending suppliers money at favorable rates, the big company keeps its own supply costs down.
- » A bank works with a big company to lend money to the company's suppliers. Because the big company is acting as a cosigner on loans to its suppliers, the bank is willing to lend the money at a lower rate than it would otherwise offer.

## *Controlling the Bullwhip Effect*

The business roller coaster known as the Bullwhip Effect is one of the most common problems for supply chains. Here's how it works:

1. A big customer order makes you think that demand for your widgets is rising, so you increase production and stock up on inventory to meet the demand.  
Lo and behold, demand drops. But you need cash to pay your expenses.

2. You stop production and sell off your inventory at fire-sale prices.
3. When you're out of inventory, you get a bunch of new orders.

The cycle repeats.

But this effect isn't happening just to your company; it's also happening to your customers and suppliers. The Bullwhip Effect occurs in all kinds of supply chains and can have devastating effects. Variations in demand get amplified as they move up a supply chain. A small variation in demand for a retailer gets more extreme for the wholesaler and even more extreme for the factory.



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The Bullwhip Effect has been studied since the 1960s. One of the best articles is “The Bullwhip Effect in Supply Chains”

(<https://sloanreview.mit.edu/article/the-bullwhip-effect-in-supply-chains>).



TIP

An easy way to experience the Bullwhip Effect is to play the Beer Game (see [Chapter 21](#)).

The following sections describe three things that you can do to reduce or even eliminate the Bullwhip Effect in your supply chain.

### ***Sharing information with your partners***

Many of the behaviors that lead to the Bullwhip Effect are actually rational responses to uncertainty and come from a desire to avoid stockouts. If you provide everyone in the supply chain accurate data about demand, inventory, and lead times, people are less likely to make panic decisions that lead to erratic swings in inventory. If suppliers can see actual demand downstream in the supply chain, they're less likely to overreact to small variations. And if customers see the upstream

inventory levels, they're less likely to overorder when there are disruptions.

### ***Reducing and aligning lot sizes***

Differences in the amount of product that gets ordered at each step of a supply chain can contribute to the Bullwhip Effect. Consider a carton of eggs that you buy from a local store. You probably use only one or two eggs per day, but you need to buy them in a lot size of 12, so you end up buying one carton per week. Then you decide to make egg salad to take to a family reunion, so you buy a couple of cartons of eggs for that event. That one-time increase in demand gets amplified because of the lot size. The store sees a spike in demand, and may overreact by ordering an extra case of eggs from their supplier. The demand signal becomes more distorted the farther it gets passed up the supply chain.

By making batches or lot sizes smaller and ordering more frequently, you can reduce the amplification of the Bullwhip Effect. The ideal situation is one in which the lot size is the same throughout the supply chain, from the customer to the beginning of the supply chain. In many cases, however, establishing uniform lot sizes is difficult because sending smaller batches more often leads to higher costs for transportation and material handling. Nonetheless, focusing on making lot sizes smaller and uniform can go a long way toward reducing the Bullwhip Effect.

### ***Managing promotions***

Promotions and incentives can increase sales, but they can also create huge variations in demand and initiate a Bullwhip Effect in the entire supply chain. It's hard to predict how effective promotions will be. A promotion that does well could lead to stockouts for your product, thereby triggering unrealistic forecasts and overordering, which in turn leads to excess inventory and the need for additional promotion.

Many companies have tried to reduce or eliminating promotions. For example, Walmart focuses on an Everyday Low Price (ELP) strategy that reduces the need for promotional pricing. But in many industries promotions are a critical tool for marketing and sales. From the

standpoint of supply chain management, they add a layer of complexity that we need to address. If your company uses promotions, or if your customers do, factor the Bullwhip Effect into your supply chain planning and inventory management to ensure that you can meet the demand that promotions create without getting stuck with too much extra inventory when the promotions are over.

The opposite of a promotion is allocation. *Allocation* means that you limit the amount of product that customers can buy or that you prioritize which customers receive products. The goal of allocation is to reduce demand to the same level as your available supply. Ironically, when a product is scarce, people want it even more. This is called Fear Of Missing Out, or FOMO. In extreme cases, FOMO can cause customers to place orders that are larger than they need because they expect to be allocated only a fraction of what they order. As a result, allocation can amplify the Bullwhip Effect rather than reducing it.

## TOILET-PAPER SHORTAGES

The COVID-19 pandemic provided a great example of the Bullwhip Effect in the supply chain for toilet paper. Under normal conditions, the toilet paper supply chain is extremely stable and efficient. But as people prepared to be quarantined in their homes, they began to stock up on basic supplies, including toilet paper. Enough people did this that the increased demand caused stockouts in retail stores, which caused other people to be afraid that they might not be able to buy toilet paper in the future. Customers kept buying toilet paper faster than the stores could restock the shelves. But the amount of toilet paper that people were using never changed, so within a few months, people had lots of toilet paper at home, and the toilet paper sales in stores dropped to below normal levels. Stores that had been stocked out now had extra inventory, and no place to store it. Often, the best way to deal with the Bullwhip Effect is to wait for it to pass. But Costco implemented two simple policies that seemed to help that retailer resolve the toilet paper shortages faster than many of their competitors:

- Limiting the amount of toilet paper that each customer could buy
- Notifying customers that the company would not accept toilet paper returns in the future

*Starting with Small Improvements*

Cost is often an obstacle to implementing supply chain improvements. Even supply chain projects that are expected to save money in the future generally require an up-front investment and involve some risk.

To overcome this challenge, start with small projects that are likely to provide tangible savings. As you demonstrate that small supply chain improvements can increase revenue and lower costs, you should have an easier time justifying investment in larger projects. You can even use the value created by smaller projects to fund future improvements.



**TIP** The savings that are easiest to get are often called quick wins or low-hanging fruit.

Suppose that your company hasn't been doing a good job of managing transportation costs. You could launch a project to rebid your freight lanes and track the savings to demonstrate how much value you created for the company. That technique wouldn't cost very much, but it would generate savings right away. Then you could ask to use part of those savings to invest in a transportation management system that will improve your transportation routing, increase the speed of your supply chain, and save even more money. This strategy of using the savings from one project to fund the next project is a great way to build momentum for supply chain improvements and to demonstrate the benefits that effective supply chain management can deliver to the business.

## *Creating Sandboxes*

It can be hard for businesses to make investments in supply chain initiatives when they don't have data and experience to guarantee a positive return on those investments. In many cases, supply chain projects suffer analysis paralysis, which occurs when a desire for more information prevents leaders from making a clear decision.

Supply chain innovations can be risky. Until you try something new, you have no way of knowing whether it's going to save as much money as your team expects or as a vendor promised.

A good way to minimize risk in innovation and to get past analysis paralysis is to create sandboxes. *Sandboxes* are small experiments that allow you to try new processes and technologies on a small scale to collect data about how they perform. This data makes it easier to decide whether, when, and how those processes and technologies should be scaled up and deployed across the rest of your supply chain. You might select a small number of stores or distribution centers as a sandbox and allow them to implement new supply chain processes and technologies on a trial basis, or you might choose a new product as the sandbox to test a new inventory planning system.



**TIP** You may want your experimental projects to be high-profile because they show that your company is innovative, which may encourage other employees to look for ways to improve your supply chain. In other cases, you may want to keep experiments low-key until you know how well they're going to work. Secret projects (sometimes called skunkworks) may be the better choice if a project has a high probability of failure or involves patents or trade secrets.

## *Investing in Innovation*

Professor Richard Wilding of Cranfield University says, "Innovation is about taking ideas that are new to you and creating social, economic, and environmental impact." Supply chains are an excellent target for innovation and entrepreneurship. There are endless possibilities for creating valuable new businesses based on changing consumer behaviors and new technology developments. Amazon is a great example of a company that took a simple idea and revolutionized global supply



chains. The company started in 1994 as an online bookstore; today, it's one of the most valuable companies in the world.

A useful way to describe what a company does — or will do — is to define a unique value proposition (UVP). The UVP should explain what the company does, why that is valuable to their customers, and why they are better at it than their competitors. Amazon's UVP is to offer low price, fast delivery, and a wide selection of products. The UVP for General Motors is to offer quality, safety, performance, and newness.



**TIP** You can define the UVP for a company by filling in the blanks in this sentence: We provide (description of products or services) to (types of customers), which solves their need for (the problem that your products and services solve).

Some entrepreneurs start companies by using their own money, a process called *bootstrapping*. But starting a new business can be expensive, so entrepreneurs often look for investors who are willing to take a chance on their idea. Early in the life of a startup, an entrepreneur might look for angel investors to provide a small amount of seed capital to get the company started. As the company grows, they can look for venture capitalists (VCs) to provide larger investments. VCs can invest on their own, or they can pool their money to create VC funds.

To persuade a VC to invest, entrepreneurs need to explain their idea succinctly. The description should be able to grab the attention of an investor in a short conversation that occurs while you are sharing an elevator ride. For that reason, this short description is often called an *elevator pitch*. Entrepreneurs might also create a short set of slides called a *pitch deck* that describes an idea and why it's likely to have a big impact.



**TIP** It's often hard for entrepreneurs to convert their idea into a solid plan for a profitable business. An excellent tool to clarify your



business model is the *Business Model Canvas* (BMC). A BMC is a template where you fill in the blanks to describe your customers, your suppliers, your UVP, and more. You can read more about this approach in an HBR article written by Stanford University professor Steve Blank at <https://hbr.org/2013/05/why-the-lean-start-up-changes-everything>.

Investors may also want to see a basic example of how an entrepreneur's solution works. This is called a *minimum viable product* (MVP). The MVP doesn't need to be fancy; it just needs to be good enough to show that an idea is feasible.

Great ideas can blossom into great companies. So when you have a clever idea for making a better supply chain, think seriously about how you could implement it. Your idea might be the seed that grows into the next Amazon.

Several websites track investments in startups. Search the following websites to learn about innovative new supply chain companies and see who has invested in them:

- » CrunchBase ([www.crunchbase.com](http://www.crunchbase.com))
- » PitchBook ([www.pitchbook.com](http://www.pitchbook.com))

There are also a growing number of angel investment and VC firms that focus on supply chain startups, including:

- » Cambridge Capital (<https://cambridgecapital.com>)
- » Plug And Play Supply Chain ([www.plugandplaytechcenter.com/supply-chain](http://www.plugandplaytechcenter.com/supply-chain))
- » REFASHIOND Ventures ([www.refashiond.com](http://www.refashiond.com))
- » Supply Chain Ventures (<https://supplychainventure.com>)
- » ZEEBOX ([www.ze-box.io](http://www.ze-box.io))

# Chapter 18

## Improving Supply Chain Resilience

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### IN THIS CHAPTER

- » Identifying risks to your supply chain
  - » Prioritizing risks based on severity
  - » Planning for and responding to supply chain risks
- 

You may have heard the saying “The best-laid plans of mice and men often go awry.” You can build a great plan for how you want your supply chain to work, but you also need to prepare for the inevitable surprises. In this chapter, I explain processes that you can use to guide your strategy and deal with these problems so that your supply chain will be more resilient. I include tools and techniques that you can use to identify, prioritize, and manage supply chain risks.

You’ll never be able to eliminate all the uncertainties facing your supply chain, but risk management can give you more control and better options when unexpected events occur.

## *Challenging Assumptions about the Future*

Supply chain plans are built on assumptions about what will happen in the future, and these assumptions are usually based on past experience. If the transit time between one of your suppliers and one of your factories has always been 15 days in the past, you would assume that the transit time will be 15 days for future orders too. This 15-day transit time will be used to determine when to send an order to that supplier so that it

will arrive at your factory on time. But past performance is not a guarantee of future results.

Although we have to make assumptions in order to plan how a supply chain should perform, we need to deal with reality when it comes to managing day-to-day operations. Think about the potential effects that any of the following events could have on your supply chain:

- » A shipping container with raw materials needed for your product gets stuck in a port for 30 days.
- » One of your factories is closed because of an epidemic.
- » A key supplier files for bankruptcy protection.
- » A major customer unexpectedly cancels a huge order for your products.
- » A new customer unexpectedly places a huge order for your products.

Each situation represents a scenario that supply chains around the world face every day. In order to prepare for your supply chain to respond to these risks you need to start with a few basic principles:

- » **Risk = uncertainty.** Every plan you make is based on assumptions about how the future is going to play out. You need to analyze your supply chain and plan the way you want things to work, but you also need to be flexible enough — in your planning and in your thinking — to adapt to what happens around you. Risk management is fundamentally about reducing uncertainty as much as you can and then adapting and responding to the uncertainty that remains.
- » **Statistics ≠ probabilities.** This principle can save you from a lot of trouble. Analysts commonly look at how often something has happened in the past (statistics) and use that data to predict how often the thing is likely to happen again (probabilities). This approach can be useful in some cases, but it can also lead to poor decision-making in supply chains.

For example, statistics would say that a disease epidemic is unlikely, so worrying about that situation in advance might not seem

worthwhile. But the probability that a particular disease will start to spread may be 100 percent if you know that people are coming into direct contact with it. The problem with ignoring this risk is that you really don't have enough information about the disease and the people who are coming into contact with it to know the true probability of an outbreak. In other words, relying on general statistics about how epidemics emerge can lead you to underestimate the risk that a particular disease poses to your supply chain.

- » **Flexibility = insurance.** In many cases, the best way to manage a supply chain risk is to have a backup plan, or Plan B. If your risk is that a supplier could go bankrupt, your Plan B could be to have at least two suppliers. If your risk is that a cargo vessel could be delayed, your Plan B could be to keep extra inventory on hand.

In many cases, the flexibility needed to protect your supply chain from a risk comes with a cost, so it may be tempting to eliminate this flexibility to save money. The challenge is estimating how valuable that flexibility could be in the event of a supply chain disruption and then deciding whether it's worth the cost. In other words, think of the cost of supply chain flexibility as though it were the premium on an insurance policy. In some cases the premium is too expensive, and you're better off dealing with the consequences if you have a problem. In many cases, however, the cost of a Plan B that gives you more flexibility is cheap compared with the cost of a supply chain disruption.



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The Supply Chain Risk Leadership Council offers a free handbook called “Supply Chain Risk Management: A Compilation of Best Practices” that includes a scary list of all the things that can go wrong in a supply chain. You can download this handbook at [www.scrlc.com](http://www.scrlc.com).

# *Understanding the Stages of Supply Chain Disruption*

Understanding how a disruption is likely to unfold can help you to prepare a strategy to avoid many of the negative impacts, including the Bullwhip Effect discussed earlier in [Chapters 2](#) and [17](#). Supply chain risk management expert Gary S. Lynch developed a framework to describe what he expects to happen when there is a significant supply chain disruption:

- » **Stage 1: Disruption.** The uncertainty around both supply and demand causes concern. Everyone in the supply chain starts looking for information and updates. This creates an environment in which inaccurate information or misinformation can spread quickly, potentially leading to panic. Leaders step forward to assure everyone that the situation is under control.
- » **Stage 2: Comfort.** Because it appears that the leaders are aware of the situation, people throughout the supply chain relax and shift their focus elsewhere. Meanwhile, inventories are being depleted at some points in the supply chain faster than they can be replenished.
- » **Stage 3: Tipping point.** A stockout occurs at some point in the supply chain and that brings the disruption back into the spotlight. Many people in the supply chain now feel that they have been caught off guard and respond by overbuying the products that appear to be in short supply. This leads to behaviors such as hoarding, panic buying, speculating, hedging, and price gouging.
- » **Stage 4: Inflation and the Bullwhip Effect.** The price for the disrupted products increases, which stimulates manufacturers and distributors to place larger orders and schedule production increases.
- » **Stage 5: Panic supplying.** Governments step in and attempt to improve the situation. Meanwhile, supply chains begin adapting to the disruption by substituting products or reallocating capacity. New producers enter the market, and innovative new products are

introduced. The shortages also create an opportunity for counterfeit or grey market products to be sold.

- » **Stage 6: Oversupply.** Supply chains become clogged up because there is too much inventory while demand starts to slow down. Companies offer discounts and promotions in an attempt to increase demand. It often takes years for this excess inventory to be sold or scrapped, during which time it consumes space in a warehouse and adds to the overhead cost of the supply chain.



**TIP** You can learn more about Gary S. Lynch's approach to supply chain risk management in his book, *Single Point of Failure: The Ten Essential Laws of Supply Chain Risk Management* (Wiley; 2009).

## *Building Supply Chain Resilience*

You may find people using the words *risk*, *threat*, and *disruption* interchangeably, but in the context of supply chain management, each of them means something slightly different. A *risk* is an event that may or may not occur, such as a hurricane. Risk is just another word for *uncertainty*. A *threat* is the impact the risk would have on your supply chain; in the case of a hurricane, one threat could be that your factory would be flooded. A *disruption* is how the threat would affect your business and that of your supply chain partners. If a hurricane flooded your factory, your supply chain would be disrupted because you couldn't manufacture products.

Strictly speaking, risks can be either bad or good. There is a risk that you could lose a customer, but there is also a risk that you might receive a big order. Good risks, such as big orders, are called *upside risks* because they are related to growing your business; bad risks are called *downside risks*. Either type of risk can lead to supply chain disruptions. A rapid increase in customer orders can trigger a buildup of inventory and

overwhelm a distribution center, for example. The result would be a disruption in the ability of the distribution center to process shipments efficiently. The disruption caused by an upside risk can be just as expensive as the disruption from a downside risk, especially when it triggers the Bullwhip Effect (see [Chapter 2](#)). Even so, it's typical for supply chain risk management processes to focus mostly on the downside risks.

A supply chain's vulnerability to disruptions can have serious consequences for all the businesses involved. Reducing this vulnerability requires collaboration among the firms in a supply chain so that they can help one another deal with threats as they emerge. The goal, of course, is to engineer and manage your supply chain so that it can function during and after a disruption — in other words, you want your supply chain to be resilient.



**TIP** Professor Richard Wilding has created a LinkedIn Learning course called “Building Resilient Supply Chains for Effective Risk Management.” It is available at [www.linkedin.com/learning/building-resilient-supply-chains-for-effective-risk-management](http://www.linkedin.com/learning/building-resilient-supply-chains-for-effective-risk-management).

You can think about supply chain resilience in terms of a shipment of bananas bound from South America to a grocery store in the United States. A lot of uncertainty is involved in that supply chain, from weather to commodity prices to the reliability of the cargo ship. From these risks and others, you see that the supply chain has many threats — many things that could go wrong. If a threat occurs, it can cause a disruption. If the ship breaks down, for example, it could delay the delivery of bananas and disrupt the store's supply chain. But if the grocery store has flexibility in the form of extra inventory or another source of supply, it can continue selling bananas to its customers in spite of the supply chain disruption, so its supply chain is resilient.





**REMEMBER** Supply chain risk management is very similar to business continuity management. Business continuity plans often focus on making a particular facility or company more resilient; supply chain risk management looks more broadly at how all the companies working together contribute to the resilience of a supply chain.

It is common for people to think about resilience on a scale with fragile on one side, and resilient on the other side. Author Nassim Nicholas Taleb argues that there is another step which he calls anti-fragile. While a resilient supply chain can continue to function in spite of a disruption, an anti-fragile supply chain performs even better when there is a disruption.

Some people argue that the world around us has become harder to predict. The term VUCA — short for Volatile, Uncertain, Chaotic, and Ambiguous — is often used to describe this situation. In many ways, the current focus on resilience in supply chains is a response to the VUCA environment that we have all experienced over the past few years.

## **LA/LB PORT CONGESTION**

Southern California is a critical link that connects the U.S. supply chain to Asia. Because they have deep water and are on the Pacific Ocean, the ports of Los Angeles (LA) and Long Beach (LB) handle roughly 40 percent of all of the shipping containers that are imported into the country. From LA/LB, containers are loaded onto trucks and trains and distributed to all 50 states. Once the cargo from Asia has been unloaded, some containers are loaded with grain and other U.S. exports, and others are sent back to Asia empty.

In 2021, as supply chains were recovering from shutdowns and delays caused by the COVID-19 pandemic, the volume of containers flowing into the LA/LB ports exceeded the ports' capacity. There were many factors that contributed to this problem, including chassis shortages, a global imbalance of shipping containers, and the Bullwhip Effect.

Cargo ships were forced to drop anchor and wait for weeks before they could be unloaded. Meanwhile, shippers scrambled to expedite shipments and consumers began to panic. Some large retailers such as Walmart, Target, and Home Depot began to charter their own vessels and schedule them to unload at smaller, less congested ports. The issue became so severe that the city, state, and federal governments all got involved.



Some of these responses probably helped, and others may have made it worse. In the end, the problems were resolved by closely managing the capacity constraints in the port while allowing container volumes to stabilize.

## *Mapping Your Supply Chain*

Before you can truly understand the risks to your supply chain, you need to have a solid understanding of what your supply chain looks like. In other words, you need to create a supply chain map. Your supply chain map should include the locations of your facilities, which could include retail spaces, offices, factories, and distribution centers. Your supply chain map should also include the locations of your customers' and suppliers' facilities. Ideally, your map will include several tiers of suppliers so that you can better understand where you have concentrations of risk. As you build this map, you will begin to identify infrastructure that is required to support your supply chain, such as highways, railroads, ports, and airports. This map could be created in a geographic information system (GIS) such as ArcGIS ([www.arcgis.com](http://www.arcgis.com)) or with specialized supply chain risk management software (discussed earlier in [Chapter 11](#)). [Figure 18-1](#) is a three-dimensional map of a supply chain with several tiers that was generated by Everstream Analytics ([www.everstream.ai](http://www.everstream.ai)).



Everstream Analytics.

**FIGURE 18-1:** Three-dimensional supply chain map from Everstream Analytics.

## Identifying Risks

You probably have a good idea of some of the things that could go wrong with your supply chain. To really understand the scope of risks, however, you need to get input from other people who manage the different parts of your supply chain. Following are some of the groups you should include in your process to identify supply chain risks:

- » Transportation
- » Distribution/warehousing
- » Purchasing

- » Information technology
- » Accounting and finance
- » Legal
- » Sales and marketing
- » Key customers
- » Key suppliers

It might be easiest for you to reach out to each of these groups separately, but you could also invite all of them to join a supply chain risk management committee. However you choose to engage this team, use their input to make a list of the risks that could affect your supply chain. To encourage effective brainstorming you may need to give people some ideas to prompt their thinking. Here are some risk categories that you can ask your team members to think about:

- » Accidents
- » Crime, terrorism, and war
- » Financial problems
- » Government regulations and politics
- » Management problems
- » Manufacturing problems
- » Market trends
- » Natural disasters and epidemics
- » Supplier problems
- » Surge in customer demand
- » Technology trends
- » Transportation and distribution problems
- » Counterfeit products
- » Workforce and training issues

Getting people to think about these risks in concrete terms and write them down can be an eye-opening experience. The odds that any one of these risks will materialize may be low, but the odds that at least one of them will materialize is high. It's a good bet that something will surprise you, but you have no way to know which thing it will be.

## *Classifying Risks*

After you have identified your supply chain risks, you need to decide which risks are most important. You may be most concerned about the risk of a fire at your supplier's distribution center, for example, or the risk of a disease outbreak that would shut down travel between countries.

One approach is to classify risks according to their scope. Classifying risks according to their scope is useful when you want to decide how to mitigate them. Risks fall into three general scope categories:

- » **Global:** Risks that affect everybody in the world. Managing global risks is the responsibility of senior management, but your risk management planning should ensure that your leaders are aware of how global risks could affect your supply chain.
- » **Systemic:** Risks that affect more than one facility or company. These risks could disrupt the entire supply chain, not just its parts. Many times, people don't realize how severe a systemic risk can be because they think about it in terms of how it affects them locally rather than how it affects the rest of the supply chain. The responsibility for managing systemic risks is often shared among leaders in several companies, so these companies need to collaborate to manage the risks effectively.
- » **Local:** Risks that affect the people in a particular company or facility. Local risks are the responsibility of facility and operations managers and are often addressed in a business continuity plan. Your supply chain risk management process can be useful in ensuring that

each of these separate plans is complete and properly aligned with the rest of the supply chain.

## THE \$400 MILLION LIGHTNING STRIKE

A good example of a systemic risk comes from a book called the *Resilient Enterprise* (The MIT Press, 2007), by Yossi Sheffi at MIT. According to the book, two cellphone companies bought processor chips from the same manufacturing plant in New Mexico. One day, the manufacturing plant was struck by lightning, which started a small fire in the facility. One of the phone companies realized how serious this problem was and immediately started sourcing chips from other suppliers. The other phone company assumed that the chip facility would be repaired quickly, so it waited. When the repairs took longer than expected, the phone company that chose to wait wasn't able to get the parts it needed and had to shut down its entire supply chain. The lightning strike ended up costing the unprepared customer \$400 million in lost revenue.

## *Scoring Risks*

After you identify and classify your risks, the next step is scoring them. Risk scores help you prioritize which risks you need to be most concerned about.

You score risks based on how likely they are to occur (probability) and how severe their effects would be (impact). Then you multiply these scores to get an overall risk score.

There are many scoring systems for probability and impact ratings, but here's an example to get you started. On a scale of 1 to 10, assign a value to the likelihood that a risk will occur:

- » **10:** Will occur; 100 percent probability
- » **5:** May occur; 50 percent chance
- » **1:** Very unlikely to occur; 10 percent chance or less

Next, use a scale of 1 to 10 to estimate the impact of a risk on your supply chain:

- » **10:** Would stop the supply chain or cost someone their job

- » **5:** Would be a major problem taking days to fix but wouldn't stop the supply chain from operating
- » **1:** Would create a minor problem that can be handled in the normal course of business

Use a scale of 1 to 100 to categorize the risk score after you multiply the probability value by the impact value:

- » **100:** Critical. This risk needs to be resolved immediately.
- » **50:** Major. This risk needs to be monitored closely and mitigated effectively.
- » **25:** Moderate. The company should have a mitigation plan in place for this risk.



**REMEMBER** A risk can never have a zero score for either probability or impact. If the score is zero in either category, it isn't a risk.

The document that you use to track and score risks is called a risk register. [Table 18-1](#) shows a typical risk register.

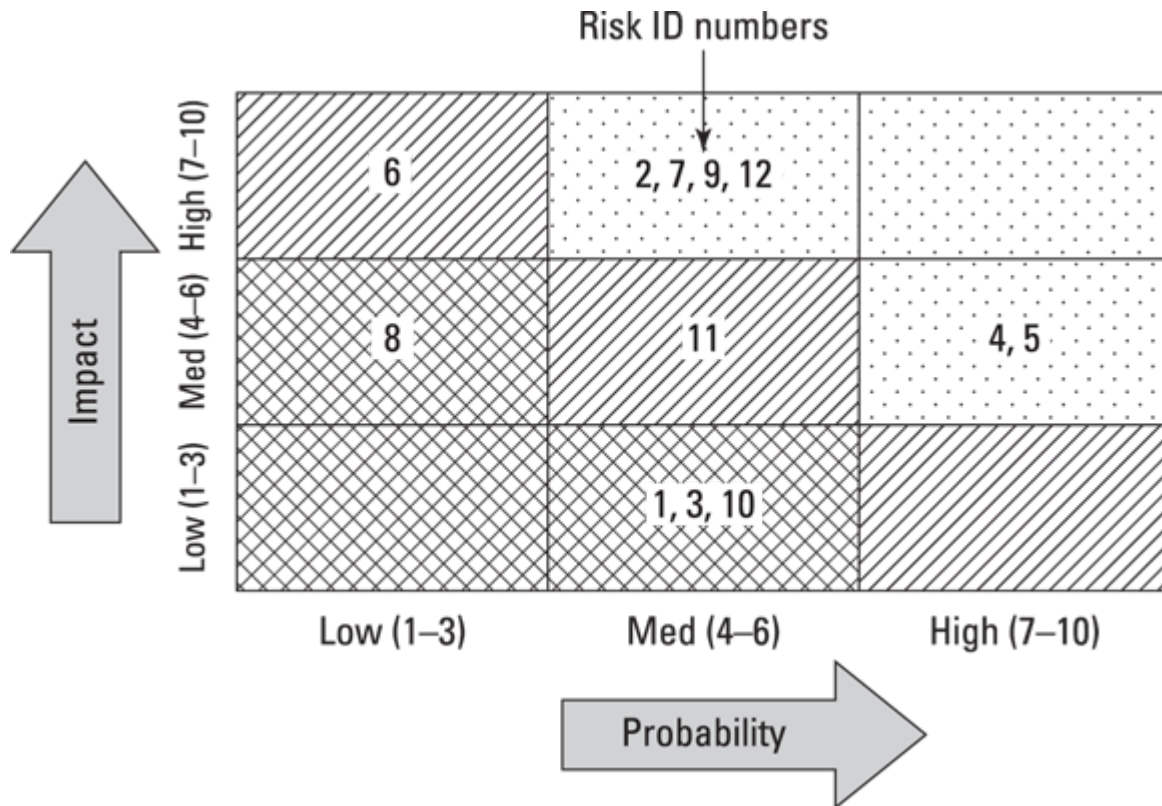
**TABLE 18-1 Risk Register**

<i>Risk</i>	<i>Probability</i>	<i>Effect</i>	<i>Risk Score</i>
Port strike	9	9	81
Supplier fire	3	9	27
Forklift breakdown	6	1	6
Comet strike	1	10	10
Canceled customer order	8	6	48

If you create your risk register in a spreadsheet program, such as Microsoft Excel, you can sort your risks according to the risk scores.

You can also create reports and graphs so that you can communicate the status of your risks more clearly.

A common way to visualize risks is to use a risk plot or a heat map. [Figure 18-2](#) shows an example heat map for supply chain risks.



**FIGURE 18-2:** Supply chain risk heat map.



**WARNING** Risk scoring is handy but not perfect. Just because a risk gets a low score doesn't mean that you should ignore it, especially if the potential impact is severe. Any risk that has the potential for someone to get hurt needs to be addressed, even if the probability (and the risk score) are low.



TIP

A risk that has a low probability of occurring but would have a severe impact is often called a *Black Swan* event. This name comes from a book called *The Black Swan*, by Nassim Nicholas Taleb. Many people use the COVID-19 pandemic as an example of a Black Swan that disrupted global supply chains.



REMEMBER

Risk scoring is like taking a snapshot of risks as they are today. You should keep your risk register up to date as circumstances change, watch for new risks to appear, and monitor changes in the scores of existing risks.

## *Managing Risks*

To make a difference in your supply chain, you need to decide what to do about each risk. The action you decide to take is called the *risk treatment*. You only have four choices for risk treatment:

- » Accept the risk.
- » Transfer the risk.
- » Avoid the risk.
- » Mitigate the risk.

### *Accepting the risk*

Even though you know that a risk exists, you don't always have a good way to resolve it. The risk may be relatively small, or it could be so enormous that it's impossible to avoid. In those cases, you may decide that you'll accept the consequences if the risk materializes. Following are some examples of risks that you may decide to accept:

- » A forklift runs out of fuel in a distribution center.



- » A supply chain manager breaks their leg while skiing.
- » A giant comet collides with Earth.

Could these things happen? Yes. Do you need to devote effort to preparing a special plan for them? Probably not.

## *Transferring the risk*

Sometimes, you can make someone else deal with a risk for you. In fact, that is exactly what insurance companies do. You pay an insurance company for a policy, and it accepts responsibility to pay for the damages if something goes wrong. You can buy insurance to cover many of the risks that can come up in a supply chain, such as theft, fires, and accidents.



**TIP** Shipping cargo involves huge risks that many people do not understand until they have experienced a problem. For example, you could be liable for damage that a truck driver does while hauling your load, or you could be required to pay a general average claim if there is an accident at sea. Companies like LoadSure ([www.loadsure.net](http://www.loadsure.net)) and OTONOMI ([www.otonomi.ai](http://www.otonomi.ai)) specialize in providing cargo insurance policies that allow you to transfer these risks.

In another scenario, you can write contracts with your customers and suppliers that transfer risk to them. You could make your suppliers deliver their products to your facility; if a shipment were to be stolen during transit, your supplier would be responsible. Suppliers often charge more for their products in exchange for assuming additional risk.

## *Avoiding the risk*

In some cases, the best way to deal with a risk is to make it go away. If you're concerned that a certain supplier won't be able to meet your requirements, you can switch to a different supplier. If you're afraid that a certain port may have a labor strike, you can ship your freight through

a different port. Avoiding a risk can be the cheapest and easiest way to help everyone in the supply chain sleep better.

## *Mitigating the risk*

If you can't accept, transfer, or avoid the risk, the only option left is to do something about it — that is, mitigate the risk. The goal of mitigating a risk is to reduce the probability, the impact, or both. In other words, you're trying to lower the risk score. How much you need to lower the score depends on how much the risk could cost you and how much money you can afford to invest in mitigation. Generally, you should mitigate a risk to the point that you're willing to accept it.

If one of your risks is that a customer will cancel a big order, for example, you can mitigate that risk by establishing a good relationship with your customer, offering them incentives, and including penalties for cancellations in your contract. You may not be able to eliminate the risk, but you can probably bring it down to an acceptable level and then focus your energy and resources on other parts of the business.



**TIP** Commercial agreements are often used to mitigate risks. If your risk register identifies the financial stability of a supplier as a major concern, you might include a statement in the terms of your commercial agreement that suppliers need to provide periodic financial updates. Or you could subscribe to a financial ratings service like RapidRatings ([www.rapidratings.com](http://www.rapidratings.com)) that monitors this data for you.

The risk register shown in [Table 18-2](#) includes a column for actions. Adding an Action column helps you track how you plan to manage each risk.

**TABLE 18-2 Risk Register with Actions**

<i>Risk</i>	<i>Probability</i>	<i>Effect</i>	<i>Risk Score</i>	<i>Action</i>
Port strike	9	9	81	Avoid

<i>Risk</i>	<i>Probability</i>	<i>Effect</i>	<i>Risk Score</i>	<i>Action</i>
Supplier fire	3	9	27	Transfer
Forklift breakdown	6	1	6	Accept
Comet strike	1	10	10	Accept
Canceled customer order	8	6	48	Mitigate
Port strike	9	9	81	Avoid



TIP

When you choose to mitigate a risk, you should also decide how it will be mitigated and who will be accountable for that work. You may need to create a project to mitigate a risk (see [Chapter 16](#)).



TECHNICAL  
STUFF

The International Organization for Standardization (ISO) has created a global standard to help companies implement risk management processes. You can purchase a copy of the ISO 31000 standard at [www.iso.org](http://www.iso.org).

## *Getting Ahead of Disruptions*

The sooner you know about a problem, the more options you have to deal with it. A self-healing supply chain is one in which problems can be identified and resolved quickly, before they cause a major disruption. For example, supply chain risk management software and supply chain control towers (see [Chapter 17](#)) can provide alerts about potential disruptions so that you can respond quickly. For example, Resilinc's Supplier PO Delivery Delay Prediction Engine ([www.resilinc.com](http://www.resilinc.com)) uses artificial intelligence to match purchase orders (POs) to suppliers; if there is an earthquake near a supplier's facility, you can receive an alert about which POs are most likely to be affected. This gives you a chance to heal your supply chain before it is even broken.



TIP

The Supply Chain Risk Management Consortium at Lehigh University is a group of companies that share best practices and tools. For example, they developed a Supply Chain Risk and Resiliency 90-Day Action Plan and a Readiness Assessment. You can learn more about the SCRMC and access their tools at [www.thescrmconsortium.com](http://www.thescrmconsortium.com).

## *Applying Gartner's Strategies for Supply Chain Resilience*

Analysts at Gartner have studied the impact of supply disruptions on large companies and they recommend six specific strategies for increasing supply chain resilience:

- » **Inventory and capacity buffers.** Ensuring that each link in your supply chain is flexible enough to handle an increase in demand or an interruption in supply.
- » **Manufacturing network diversification.** Having multiple factories in different locations that can make the same, or similar, products provides greater flexibility.
- » **Multisourcing.** Working with multiple suppliers for every product and service that you purchase means that you have options in case one supplier is disrupted.
- » **Nearshoring.** Shorter supply chains tend to be exposed to fewer risks. The further away your suppliers are, the longer it takes to transport your cargo, and the more things can go wrong in the process.
- » **Platform, product, or plant harmonization (also known as “standardization”).** The simpler a supply chain is, the fewer things there are to go wrong. Standardizing on common software platforms, reducing the number of SKUs, and formalizing business rules are all examples of increasing supply chain standardization.

- » **Ecosystem partnerships (also known as “strong relationships with flexible suppliers”).** Creating trusted relationships throughout several tiers in a supply chain allows all of the companies to collaborate in response to a disruption.



**TIP** You can download a free whitepaper that describes these strategies in more detail at

[www.gartner.com/smarterwithgartner/6-strategies-for-a-more-resilient-supply-chain](http://www.gartner.com/smarterwithgartner/6-strategies-for-a-more-resilient-supply-chain).

## *Handling a Crisis*

The goal of risk management is to prepare for surprises as best you can. But when risks materialize, you also need to be ready to handle a crisis. Every crisis is different, so it’s important to be flexible. A few principles can help you manage a crisis in a way that minimizes long-term damage and accelerates your ability to get back to normal operations:

- » **People come first.** Always think about the effects that a decision could have on your employees, your customers, and your community.
- » **Find the bottom fast.** Some leaders try to downplay the effects of a crisis because they don’t want to create a panic. But this response can be seen as a cover-up and cause people to distrust their leaders. When more bad news comes out, people can feel hopeless and defeated. Instead, it’s usually better to assume the worst from the beginning of a crisis, and get everyone focused on how to make things better.
- » **Communication and collaboration are essential.** It’s important to know about the challenges facing your customers and suppliers so that you can change your plans, if necessary. It’s also important to share your own challenges with these supply chain partners so that

they can be prepared too. During a crisis, you should implement a communication strategy, such as daily meetings, to keep your most important partners up to date. The meetings could include representatives from different functions within your company, as well as representatives from your customers, suppliers, and even government agencies.

- » **Prioritize, plan, and execute.** When a crisis hits, lots of issues may need to be addressed. You need to be able to focus on the most important ones first, and you need to put plans in place quickly. The DIRECT framework (see [Chapter 16](#)) can be very useful for this purpose.
- » **Learn from your experiences.** In the words of folk singer Gamble Rogers, “Experience is what you get when you didn’t get what you really wanted.” During a crisis, you often learn a lot about gaps in your planning and execution. When the crisis is over, you can use these lessons to make your supply chain more resilient.



**TIP** Project management expert Sam Yankelevitch created a LinkedIn Learning course called “Project Management Foundations: Lessons Learned” that explains how to capture the lessons that a team has learned from a project or a crisis. It is available at [www.linkedin.com/learning/project-management-foundations-lessons-learned](http://www.linkedin.com/learning/project-management-foundations-lessons-learned).

# Chapter 19

## Boosting Supply Chain Sustainability

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### IN THIS CHAPTER

- » Selecting sustainability goals
  - » Examining sustainability strategies
  - » Setting sustainability metrics
- 

Over the past several years, companies, consumers, and governments have become more concerned about where products come from and what happens to products after they have been sold to a customer. This means supply chain managers need to think about product life cycles. Supply chains begin with raw materials from the Earth and end with used products that are returned to the Earth — ideally, in a way that doesn't harm the planet.

Supply chains can improve our quality of life in the short term, but they can also do significant long-term damage. In this chapter, I describe environmental, social, and governance (ESG) issues that pertain to the global supply chain and the role that supply chains can play in enabling sustainable development around the world.

For supply chain professionals, it is often useful to look at ESG in terms of inputs (the things we consume to create value) and outputs (the things that we create, including any waste that is left over). Applying metrics to our inputs and outputs makes it easier to understand the true impacts of our supply chain and to identify opportunities to become more sustainable.

# *Understanding Environmental, Social, and Governance Goals*

Many of the inputs to the products and services we depend on may come from places we've never heard of and are made by people we don't know. Brian Laung Aoaeh, cofounder of a not-for-profit group called the Worldwide Supply Chain Federation often says, "The world is a supply chain."

Every human being who has ever lived has depended on the Earth's climate and its resources for survival. The Earth's environment doesn't stop at the borders of any country, so many environmental initiatives are being driven by the United Nations (U.N.). The U.N. Intergovernmental Panel on Climate Change (IPCC) is responsible for assessing the science related to climate change ([www.ipcc.ch/about](http://www.ipcc.ch/about)). In 2015, the U.N. member states agreed that all countries should work toward maximizing the benefits of development while reducing the damage that development can cause to people and the environment. They formalized this global strategy for transforming the world in a set of 17 sustainable development goals (SDGs):

1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequality



11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace and justice strong institutions
17. Partnerships to achieve these goals

You can find more information about the SDGs at [www.un.org/sustainabledevelopment](http://www.un.org/sustainabledevelopment).

The U.N. Global Compact (UNGC) is a program that encourages private companies to work together to achieve the SDGs. Thousands of companies have signed on to the UNCG and made sustainable development a part of their business strategy. Many companies issue sustainability reports that document their efforts and the progress. You can learn more about the UNGC and see a list of the current participants at [www.unglobalcompact.org](http://www.unglobalcompact.org).

A number of nongovernmental organizations (NGOs) advocate for the environment, for animals, and for people around the world who are affected by development. Some of the well-known NGOs include:

- » Carbon Trust ([www.carbontrust.com](http://www.carbontrust.com))
- » Natural Resources Defense Council ([www.nrdc.org](http://www.nrdc.org))
- » World Wildlife Fund ([www.worldwildlife.org](http://www.worldwildlife.org))

## ***Making Measurable Improvements***

Companies participate in sustainability initiatives for many different reasons. Some sustainability initiatives are tied to corporate social responsibility (CSR), meaning companies want to behave ethically simply because they believe it is the right thing to do. Sustainability efforts can also be related to consumer preferences or investor activism.

In many cases, the driving force behind sustainability is government regulation. Companies that do business in many states and in many countries often need to implement company-wide sustainability practices to address these regulations. In the United States, the national standards for environmental sustainability are enforced by the Environmental Protection Agency (EPA). Additionally, each state has its own rules. California has experienced severe problems from air pollution and water shortages, and tends to be an early adopter of stricter environmental regulations.

Some sustainability goals focus on reducing the inputs — the consumption of energy and materials. These goals may require the redesign of products or processes. Or they may require you to change the materials you use or change the way you source them. For example, it's often possible to meet consumption goals by switching from nonrenewable to renewable resources.

Other sustainability goals focus on outputs, including waste and emissions. For example, many of the products we use daily are made from plastics, and these plastics are made from petroleum. One of the things that makes plastics so useful is that they last a long time, but that also means it is hard to dispose of them safely. Some byproducts of oil refining are harmful to humans, animals, and plants. Many of these chemicals are known to cause cancer. Plastic waste has caused a serious problem by polluting the ocean and poisoning sea life. Plastic items may break down into small pieces called microplastics that pollute the soil and water and could contaminate the entire food chain. Because they are so small, microplastics are difficult to detect and to remove. Many scientists are afraid that microplastic pollution is already harming human health. As a result, there are a growing number of regulations and voluntary initiatives aiming to reduce the amount of plastics we produce.



**TIP**

Million Marker is a company that provides testing to evaluate how exposure to pollutants like microplastics may be affecting your

metabolism. You can learn more about Million Marker at [www.millionmarker.com](http://www.millionmarker.com).

Water is an especially important resource for many supply chains. Measuring water consumption is important in places where it is scarce. But water pollution is a serious concern, as well. When water becomes salty or polluted, it's no longer usable for some purposes, including for many manufacturing applications. Minimizing the amount of water you use and limiting the amount of pollution you create can make your supply chain more sustainable.

## *Reducing Greenhouse Gases*

The earth is similar to a greenhouse, and the atmosphere acts as a shield between our planet and the sun. For example, the atmosphere controls how much of the sun's rays (solar energy) reach the surface of the earth, and whether heat from the earth is released into outer space or reflected back toward the earth. Many products and processes that we use in supply chains release gases into the atmosphere, and some of these gases can change the chemistry of the atmosphere, which then impacts the climate.

Gases that cause the atmosphere to capture more heat are called *greenhouse gases* (GHGs). Carbon dioxide (CO<sub>2</sub>) is a GHG, and human development since the first industrial revolution has led to a significant increase in the amount of CO<sub>2</sub> in the earth's atmosphere. Increasing the amount of CO<sub>2</sub> has led to an increase in average temperatures for the whole planet. This is often called global warming, and it can lead to extreme changes in climate such as droughts and severe storms, which then affect water supplies, wildlife habitats, and food production.

The amount of CO<sub>2</sub> that something emits is called its carbon footprint. There are many natural events that release CO<sub>2</sub> into the atmosphere; humans and animals exhale CO<sub>2</sub>, for example, and volcanos can release large amounts of CO<sub>2</sub> when they erupt. But scientists are particularly concerned about the increase in CO<sub>2</sub> that is linked to human activities

such as large-scale agricultural production, clearing trees, and burning fossil fuels.

The 2015 Paris Agreement (sometimes called the Paris Accord) is an international treaty in which most of the nations in the world committed to a plan for reducing climate change. Specifically, each country agreed to limit their GHG emissions with the goal of slowing, and eventually stopping, global warming. The Paris Agreement is administered by United Nations Framework Convention on Climate Change. You can learn more about it at <https://unfccc.int>.

The GHG Protocol is an environmental accounting framework that many companies and governments use to measure the amount of CO<sub>2</sub> and other gases that their supply chains emit into the atmosphere. It was developed jointly by the World Resources Institute and the World Business Council for Sustainable Development. The GHG Protocol divides emissions into three categories, called scopes:

- » Scope 1 emissions are produced as part of your company's internal processes.
- » Scope 2 emissions are produced by your company's tier 1 suppliers, such as the firms that provide you with electricity.
- » Scope 3 emissions are produced by all of the other companies in your supply chain.

Measuring Scope 1 emissions is the first step for every company that wants to reduce its GHG emissions. In order for a company to accurately measure its Scope 2 and Scope 3 emissions, it needs to work with suppliers who are willing and able to share this information. In many supply chains, tracking and reporting on GHGs is becoming a necessary requirement. Following are some websites that can help you calculate the emissions for your company:

- » GHG Calculation tools (<https://ghgprotocol.org/calculation-tools>)

- » GHG Protocol Corporate Accounting and Reporting Standard (<https://ghgprotocol.org/corporate-standard>)

## *Reducing Manufacturing Waste*

When most people think about manufacturing processes, they focus on how to convert a set of inputs to a set of outputs. The intended outputs, of course, are the products that you can sell to a customer.

Manufacturing processes also have outputs that aren't useful and end up being discarded. Anything that's left over at some point in the manufacturing process is *waste*. Here are three reasons why you should always be looking for ways to reduce the amount of manufacturing waste in your supply chain:

- » You had to pay for the materials that you're throwing away.
- » You may need to pay someone to dispose of the waste.
- » Anything that's left over has to go somewhere. If it goes into the air, the water, or the soil, it can be bad for the environment.

Reducing waste can have a positive effect both on the planet and on your company's profits, because it's often the fastest, most effective way to make huge sustainability improvements. In many cases, it's as easy as looking at the waste from a manufacturing process and asking "How could I produce the same results for my customer while eliminating this stuff from the process?"

Reducing, reusing, and recycling can cut waste, save money, and minimize your impacts on the environment. That's why many companies have begun to change their management systems to look beyond just financial metrics. The most common approach, called *the triple bottom line*, measures the performance of a company based on social effects, financial performance, and environmental sustainability. This approach is also called the three Ps (people, profit, and planet).

Some supply chains are actually able recover and recycle used products and turn them into new products. Supply chains that circle back on

themselves in this way are called *closed-loop supply chains*.

## RECYCLING EV BATTERIES

Redwood Materials is an example of a company that is building a closed-loop supply chain. Electric vehicle (EV) batteries are made of expensive materials like lithium but are designed so that more than 90 percent of the components can be recycled. When one of these batteries reaches the end of its life, Redwood Materials recovers these materials.

This closed-loop supply chain reduces the amount of material that ends up in a landfill, and it also has another effect: It dramatically reduces the cost of raw materials for the next battery. This approach benefits consumers, manufacturers, and the environment. It's a win-win-win situation!

*Remanufacturing* is a closed-loop strategy where parts are designed in such a way that they can be rebuilt and reused over and over. A used part that's being returned for remanufacturing is called a *core*.

Remanufacturing is a common strategy for the parts used in cars, airplanes, and heavy equipment; remanufacturing these parts typically costs much less than making new parts from scratch. Remanufacturing has a triple benefit for supply chains because it lowers costs, reduces the resources needed to make a new product, and reduces the amount of used and scrap material sent to landfills.



**WARNING** In managing a closed-loop supply chain, inspecting incoming components is critical. Poor-quality cores can result in poor-quality remanufactured parts.

It is not always practical to recycle materials in a closed loop, but it may be possible to use them for some other purpose. Upcycling and downcycling are strategies that take used materials and reuse them in a different way. When materials are *upcycled*, they are used to make products that have a greater value. An example of upcycling is when weathered wood from an old pallet is used to make an expensive piece of furniture. Materials can also *downcycled* where they are used to make

something of lower value. An example of downcycling is when construction debris is used under the foundation of a new building.

## *Adopting Renewable Materials*

Innovative new materials and processes could help to improve supply chain sustainability. While there are many examples of this trend, leather and cotton are two materials that are experiencing transformational innovations today.

### *Leather*

Leather is a common material used for clothing, fashion items, furniture, and automobile interiors. Because leather comes from animals that eat plants and exhale CO<sub>2</sub>, it has a relatively high carbon footprint. Many people and governments are also concerned about the treatment of animals that are raised to produce the leather, and the pollution that sometimes results from processing leather. There are a number of plastic products, such as vinyl, that can be used as substitutes for leather, but these materials are made of petroleum. So while they may address issues related to animal cruelty, these substitutes increase carbon emissions and pollution.

Natural Fiber Welding (NFW) has developed a replacement for leather that is made entirely from plants. This material can be recycled and used as an input for making new products, but it is also biodegradable so it can be composted and will break down naturally into the soil. You can learn more about Natural Fiber Welding at

[www.naturalfiberwelding.com](http://www.naturalfiberwelding.com).

### *Cotton*

Cotton is a natural material that is common in textiles and clothing, but the supply chain for cotton textiles has significant environmental impacts. Cotton fibers may be transported around the world for cleaning and processing, transported again to be converted into fabric, transported again to factories where it is made into clothing, and transported again to stores or customers.



Simplifyber has developed a new technique for making clothing in molds which eliminates many of these environmental harmful steps. Simplifyber's approach is similar to 3D printing because you can use mass customization to tailor each product to a customer's unique needs, and you can manufacture the products on-demand in a location that is close to your customers.

## *Adopting Renewable Energy*

Today, supply chains depend on nonrenewable carbon-based energy sources including coal, gasoline, diesel, natural gas, and jet fuel. These fuels have a high energy density, meaning that they store a lot of energy in a small volume. But there are two major problems with these fossil fuels: They are nonrenewable, and they release pollution into the environment.

One solution to these problems is to use alternative fuels like ethanol, a kind of alcohol fuel that is made from plants. Ethanol is made from renewable materials, and it releases fewer GHGs than fossil fuels. Most gasoline now sold in the United States contains at least 10 percent ethanol, and airlines are testing new kinds of jet fuel that are made from soybeans, corn, and sugar.

Another solution is to change to even cleaner renewable energy sources. Renewable energy is often used to generate electricity which can either be consumed immediately or stored in a battery. Some common examples of renewable energy sources include:

- » Wind turbines
- » Solar panels
- » Geothermal
- » Hydroelectric plants

Each of these renewable energy sources has strengths and weaknesses. Solar panels only generate electricity during the day time, wind turbines only work when it is windy, and hydroelectric plants only work when



there is water flowing through them. It is also important to note that these energy generation tools, and the batteries that they charge, depend on materials that are mined from the earth and processed in factories.

## *Nuclear power*

Nuclear power is an extremely flexible energy source. Nuclear reactors use a small amount of radioactive fuel to produce steam which generates a huge amount of electricity. This fuel is made from uranium, a mineral that needs to be mined, so it is definitely not a sustainable material. However, the amount of uranium needed to operate a nuclear power plant is tiny compared to the amount of coal or natural gas that would be needed to generate the same amount of electricity. Nuclear reactors require a huge amount of water in order to function, which has impacts on the environment. Spent nuclear fuel is radioactive, and this nuclear waste needs to be stored in special facilities to prevent radiation from contaminating the water, soil, and air. While accidents involving nuclear plants or waste are rare their effects are severe.

## *Hydrogen*

Hydrogen is the most abundant element in the universe, and it can also be used as a source of electricity. Hydrogen fuel cells combine hydrogen with oxygen to produce an electrical current, and the only emission is water. Fuel cells are small and light enough that they can be used to power cars and semitrucks. Nikola Corporation (<https://nikolamotor.com>) is one company that is focused on building hydrogen powered trucks. In order to use hydrogen fuel cells on a large scale, however, we need to create a distribution infrastructure for hydrogen like we have done for gasoline and diesel. A second challenge is that the most common source for hydrogen is natural gas, so using hydrogen as a fuel source doesn't necessarily eliminate the consumption of fossil fuels.

## *Electric vehicles*

Using electric vehicles (EVs) in the supply chain could significantly reduce our overall emissions of GHGs. Several companies, including Tesla (<https://www.tesla.com/semi>), have developed EV semitrucks

for long trips. There is also a strong movement toward introducing EVs for last mile deliveries. Amazon has committed to buying EVs from Rivian Motors (<https://rivian.com>), the U.S. Post Office is buying EVs from Oshkosh (<https://oshkoshdefense.com>), FedEx is buying EVs from Brightdrop ([www.gobrightdrop.com](http://www.gobrightdrop.com)), UPS is buying EVs from Arrival (<https://arrival.com>), and Walmart is buying EVs from Canoo ([www.canoo.com](http://www.canoo.com)).

There are also companies developing electric helicopters, called eVTOLs, and electric airplanes. Airbus has already developed an unmanned solar-powered airplane called Zephyr that can stay airborne for weeks at a time ([www.airbus.com/en/innovation/zero-emission/solar-flight](http://www.airbus.com/en/innovation/zero-emission/solar-flight)).

## *Addressing Social Impacts*

CSR also includes understanding how your supply chain affects people. Throughout the world there are many cases of human rights violations such as child labor, forced labor, and discrimination.

These human rights issues often intersect with supply chains, and can be the target of government regulations. For example, the United States has restricted imports of goods that are manufactured in Xinjiang, China, where many people are subjected to forced labor. Germany recently enacted a law called the Supply Chain Due Diligence Act that makes companies responsible for environmental damage and human rights violations that occur in their supply chains.



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You can learn more about the import restrictions on products made in Xinjiang from this briefing by the U.S. Department of State at [www.state.gov/xinjiang-supply-chain-business-advisory](http://www.state.gov/xinjiang-supply-chain-business-advisory).

You can learn more about the details of the German Supply Chain Due Diligence Act from this summary published by the U.S. Library of Congress: [www.loc.gov/item/global-legal-monitor/2021-08-17/germany-new-law-obligates-companies-to-establish-due-diligence-procedures-in-global-supply-chains-to-safeguard-human-rights-and-the-environment](http://www.loc.gov/item/global-legal-monitor/2021-08-17/germany-new-law-obligates-companies-to-establish-due-diligence-procedures-in-global-supply-chains-to-safeguard-human-rights-and-the-environment).

Seafarers are another group of supply chains workers who are frequently overlooked. A ship's crew often includes people from around the world who work seven days per week and spend months at a time away from home. They routinely deal with risks such as accidents, fires, and bad weather. During the pandemic many seafarers were not allowed to leave their ships for over a year. The minimum wage for seafarers is approximately \$675 per month.

CSR issues are not always clear cut. For example, some people argue that supporting military supply chains is equivalent to profiting from violence, and that defense contractors are not socially responsible. Others argue that the defense industry is essential for protecting people, and is socially responsible.

## *Creating Circular Supply Chains*

You can think of supply chain sustainability as a journey from linear supply chains to circular supply chains. A linear supply chain has three steps: take, make, and waste. We extract materials from the earth, convert them into products, and then dispose of those products. Circular supply chains are different because there is no waste. To quote researcher Deborah Dull from Zero100, "In a circular supply chain, everything is inventory."

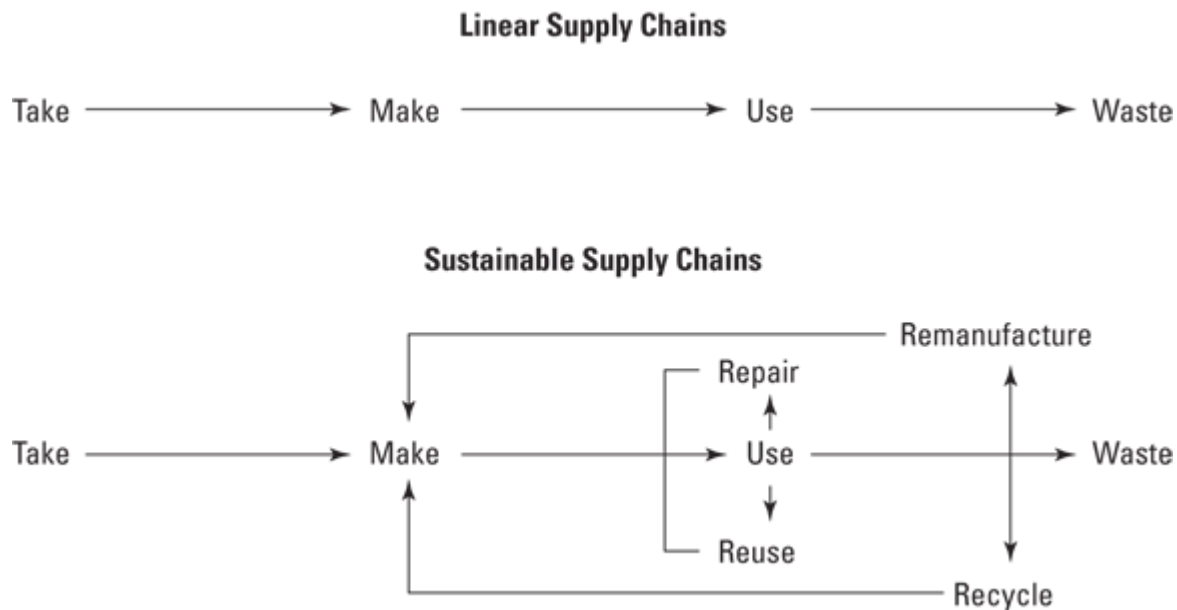
Professor Rüdiger Hahn created a four-step model that describes his view of circularity in supply chains. Each step in this model is a technique for converting waste into a valuable asset:

- » **Reuse.** For lightly used products, the best option is often to simply reuse them. For consumer products, reuse can be facilitated by

consumer-to-consumer (C2C) business models. Ebay, Craigslist, and Poshmark are examples of C2C marketplaces that allow consumers to sell used products to one another.

- » **Repair or refurbish the product.** Used and damaged products can often be fixed when the spare parts, tools, and technical knowledge are available.
- » **Remanufacture or repurpose the parts.** Some products are designed so that they can be used more than once. For example, many of the parts on a Caterpillar bulldozer are designed so that they can be remanufactured, and many HP ink cartridges are designed to be refilled.
- » **Recycle or recover the materials.** When a product can't be used again or repaired, then the last option is to recover the materials and use them as an input for making a new product.

[Figure 19-1](#) illustrates how these techniques can be incorporated into a linear supply chain in order to make it more sustainable.



**FIGURE 19-1:** Circular supply chain model (based on the work of Rüdiger Hahn).

## *Adopting Sustainability Software*

Several software tools are available to help with your sustainability efforts. Three common tools are:

- » Klima (<https://klima.com>)
- » Plan A (<https://plana.earth>)
- » Planetly ([www.planetly.com](http://www.planetly.com))

Each of these tools can calculate carbon footprint, recommend changes that can reduce your environmental impact, and provide options for offsetting your carbon emissions.



**TIP**

The Association for Supply Chain Management (ASCM) offers the ASCM Enterprise Certification for Sustainability. This program enables supply chains to track key ESG metrics for ethical, economic, and ecological practices. ASCM recommends getting started by comparing your current business practices to the ASCM Enterprise Certification for Sustainability standards using the free Enterprise Supply Chain Maturity Assessment. For more information, visit [www.ascm.org/corporate-transformation/enterprise](http://www.ascm.org/corporate-transformation/enterprise).

## Part 5

# **Building Your Supply Chain Management Career**

## IN THIS PART ...

Explore the broad range of career opportunities throughout the supply chain.

Translate your skills and interests into a plan for your career.

Look at traditional options for supply chain education, such as universities.

Investigate emerging and nontraditional education options, such as online courses, degrees, and certificate programs.

## Chapter 20

# Selecting a Supply Chain Career

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### IN THIS CHAPTER

- » Researching supply chain jobs
  - » Understanding government job categories
  - » Exploring career options
- 

Supply chain management can be an extremely rewarding career. Supply chain professionals can work in virtually any sector of the economy; they can be located almost anywhere; and they often collaborate with colleagues, customers, and suppliers around the world. Supply chain professionals may sit at a desk, work in a factory, or travel and live on the road. Supply chain careers are often good options for young people who are starting their professional journey, for military veterans as they transition into the civilian workforce, and for anyone who wants to play a critical role in business. In this chapter, I give you an overview of jobs in the supply chain so that you can decide on a career path that makes sense for you.

## *Doing Your Homework*

People are the most important part of any supply chain. Lots of jobs contribute to the smooth flow of money, material, and information, and any of these jobs — or a combination of them — can become a career. Finding the right job involves being honest with yourself about what you like and what you're good at, as well as gathering objective information about what jobs are available.



Unfortunately, figuring out how to get started with a career in supply chain management can be hard. Even people who already have supply chain jobs often struggle to find the information they need to understand their options and plan their next steps. Finding the right career in the supply chain industry (or any industry, for that matter) starts with lining up three criteria:

- » The things you're good at doing
- » The things you're qualified to do
- » The things someone will pay you to do

Because all three of these criteria can change over time, you should continually reevaluate your options. [Figure 20-1](#) shows how you can use these criteria to choose a career that makes sense for you today and in the future.



**FIGURE 20-1:** Career alignment diagram.

## *Examining Supply Chain Career Categories*

Supply chain careers and job titles can be confusing, because supply chain management is a relatively new field. (Remember, the term *supply chain* has been around only since the 1980s.) Many supply chain jobs are evolving so quickly that the government agencies that track employment data have a hard time keeping up. Staying up to date with new job titles is a little bit easier for companies because they can change job titles fairly easily, without a lot of red tape.

When a new job is created, each company tries to come up with an appropriate title. The result is that different companies may call the same job by different names, and because so many job titles are used for the same job, matching job titles with employment categories can be difficult. Drones are rapidly making their way into the supply chain scene, for example, so demand for drone operators is growing. Being a drone operator requires training and licensure, but this job has many titles, such as unmanned aircraft system operator, unmanned vehicle pilot, and commercial drone pilot. So even if you know what kind of job you are looking for, you may still end up researching several job titles.



**TIP** Here's the disclaimer that we are required to include: The U.S. Department of Labor collects employment statistics for jobs based on classification codes. These statistics are published on a national website called O\*NET. Many researchers, educational institutions, and government agencies structure their programs around these classifications, so the classifications are useful. This chapter includes information from O\*NET OnLine ([www.onetonline.org](http://www.onetonline.org)) by the U.S. Department of Labor's Employment and Training Administration (USDOL/ETA). O\*NET® is a trademark of USDOL/ETA. Used under the CC BY 4.0 license. I have modified all or some of this information. USDOL/ETA has not approved, endorsed, or tested these modifications.

To make sense of information about supply chain careers — even from official government sources — you need to understand supply chain processes. A good way to start is to drill down into a category that seems interesting and find out more about what's involved with the specific jobs in that category. By connecting that information with your knowledge of supply chain processes you can tailor your job search (and your résumé) based on the keywords for each job.

The challenge in finding information about supply chain jobs on O\*NET is that the jobs may be classified in ways that don't make much sense when you think about them in terms of supply chain management.

O\*NET uses different codes for transportation managers, logistics managers, and logisticians, for example, but in industry, these titles are often used interchangeably.

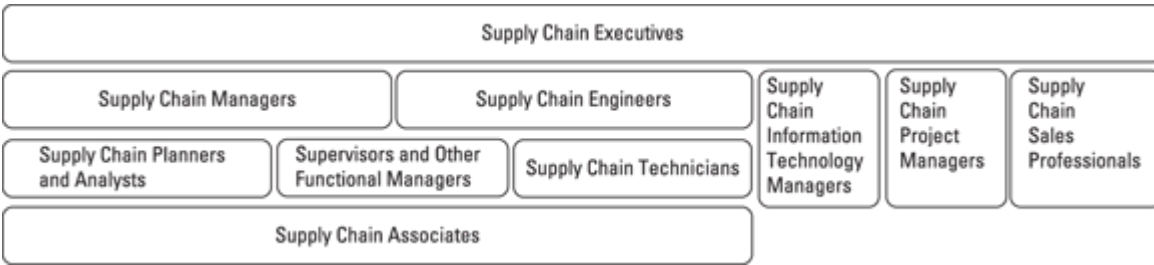
Ten job types cover most of the roles that do the planning, sourcing, making, delivering, returning, and enabling in a supply chain:

- » Associates
- » Technicians
- » Planners and analysts
- » Engineers
- » Supervisors
- » Managers
- » Sales representatives
- » Information technology managers
- » Project managers
- » Executives

Three other important job types might also be interesting, depending on your goals:

- » Journalists
- » Educators
- » Humanitarian supply chain professionals

You can think of these job types in terms of [Figure 20-2](#). In general, the higher you go on this chart, the more money you'll be paid but the fewer job openings you're likely to find.



**FIGURE 20-2:** Supply chain careers framework.

The rest of this chapter describes these job types. As you read about the jobs, you see why some positions are considered to be supply chain jobs even though that fact isn't always clear from the job titles.



**TIP** The use of the words *logistics*, *purchasing*, or *operations* is a clear sign of a supply chain job.

## *Associates*

Supply chain associate jobs usually don't require in-depth education and training, but you may have to get a license to operate specific kinds of equipment or take training on the information systems related to the job in a particular company. These jobs are often hourly, and many are seasonal.

The work of supply chain associates has a huge effect on the flow of the entire supply chain. Not much happens without the help of buyers, truck drivers, warehouse workers, and equipment operators. These roles can be great places to learn the ropes and get firsthand experience with many practical challenges that affect supply chain performance. Here are some jobs that are considered to be supply chain associate positions:

- » **Procurement clerks:** Buy stuff from suppliers, and make sure that all the paperwork is in order. Common job titles for procurement clerks include buyer, procurement assistant, procurement officer, procurement specialist, procurement technician, purchasing assistant, purchasing associate, purchasing clerk, purchasing specialist, and warehouse clerk. (O\*NET code 43-3061.00)

- » **Stock clerks:** Handle the shipping and receiving of inventory in a factory or distribution center. Common job titles for stock clerks include bay stocker, material handler, receiver, receiving lead, stock clerk, stocker, stockroom clerk, warehouse clerk, warehouse representative, and warehouse worker. (O\*NET code 43-5081.03)
- » **Weighers, measurers, checkers, and samplers:** Collect data and metrics throughout the supply chain. Common job titles for these roles include cycle counter, inventory specialist, lab technician, material control manager, quality assurance lab technician, quality control lab technician, quality control operator, quality control technician, scale operator, and supply clerk. (O\*NET code 43-5111.00)
- » **Laborers and freight, stock, and material movers:** Move products or packages from one place to another manually (without a forklift). Common job titles for these roles include dock worker, laborer, line tender, loader, material handler, merchandise pickup/receiving associate, receiver, receiving associate, shipping and receiving materials handler, and warehouse worker. (O\*NET code 53-7062.00)
- » **Machine feeders and offbearers:** Support the machines in a supply chain by loading products on them and unloading products from them. Job titles for these roles include feeder, line operator, lug loader, machine feeder, offbearer, sawmill worker, and tube puller. (O\*NET code 53-7063.00)
- » **Packers and packagers:** Put products in the proper packaging to ensure that the products are protected. Job titles for these roles include bagger, inspector packer, mini shifter, pack-out operator, packager, packer, picker and packer, sacker, selector packer, and shipping clerk. (O\*NET code 53-7064.00)
- » **Industrial truck and tractor operators:** Move materials around a distribution center or storage yard, using a fork truck. Common job titles for these roles include checker loader, forklift technician, fork truck driver, forklift driver, forklift operator, lift truck operator, shag truck driver, spotter driver, tow motor operator, and truck driver. (O\*NET code 53-7051.00)

- » **Light truck or delivery services drivers:** Drive small delivery trucks to pick up parts from suppliers or drop off packages to customers. Common job titles for these roles include bulk delivery driver, delivery driver, driver, driver/merchandiser, package car driver, package delivery driver, route driver, route supervisor, service provider, and truck driver. (O\*NET code 53-3033.00)
- » **Heavy and tractor-trailer truck drivers:** Drive big rigs — the semis that move freight across the country. Common job titles for these roles include delivery driver, driver, line haul driver, log truck driver, over-the-road driver, production truck driver, road driver, semi-truck driver, tractor-trailer operator, and truck driver. (O\*NET code 53-3032.00)



**TIP** Many supply chain associates were designated as essential workers during the COVID-19 pandemic.

## *Technicians*

Supply chain technicians operate, maintain, install, and upgrade the automation technologies that have become critical to most supply chains. These jobs generally require specialized technical training in areas such as electronics, machining, computer programming, and welding. As automation and drones become more critical for supply chains, the need for technicians who can support these new tools is likely to increase. Following are some job titles that fall into the supply chain technician category:

- » **Electromechanical technicians:** Operate, test, maintain, or calibrate unmanned, automated, servomechanical, or electromechanical equipment. These technicians may operate unmanned submarines, aircraft, or other equipment at work sites. Even though it isn't obvious from the name, this job category includes drone operators. Electromechanical technicians may assist engineers in testing and designing robotics equipment. Job titles for this category include

electromechanic, electromechanical technician, electronic technician, engineering technician, laboratory technician, maintenance technician, mechanical technician, product test specialist, test technician, and tester. (O\*NET code 17-3024.00)

- » **Robotics technicians:** Build, install, test, or maintain robotic equipment or related automated production systems. Job titles for this category include automation technician, electrical and instrumentation technician, electronics technician, field service technician, instrument specialist, and instrumentation technician. (O\*NET code 17-3024.01)
- » **Industrial engineering technologists:** Assist industrial engineers in such activities as quality control, inventory control, and material flow methods. These workers may conduct statistical studies or analyze production costs. Job titles in this category include associate product integrity engineer, head of operation and logistics, liaison engineer, manager, asset management, materials planner/production planner, planner/scheduler, production control supervisor, quality management coordinator, quality tech, and senior quality methods specialist. (O\*NET code 17-3029.05)
- » **Industrial machinery mechanics:** Repair, install, adjust, or maintain industrial production and processing machinery or refinery and pipeline distribution systems. Job titles in this category include fixer, industrial machinery mechanic, industrial mechanic, loom fixer, machine adjuster, maintenance mechanic, maintenance technician, master mechanic, mechanic, and overhauler. (O\*NET code 49-9041.00)
- » **Conveyor operators and tenders:** Control or tend conveyors or conveyor systems that move materials or products to and from stockpiles, processing stations, departments, or vehicles. These workers may control the speed and routing of materials or products. Job titles in this category include assembly line tender, bander, cartoner operator, chain puller, chipper operator, debarker operator, packing line operator, press operator, process line operator, and process operator. (O\*NET code 53-7011.00)



- » **Bus and truck mechanics and diesel engine specialists:** Diagnose, adjust, repair, or overhaul buses and trucks, or maintain and repair any type of diesel engines. These workers include mechanics working primarily with automobile or marine diesel engines. Job titles in this category include bus mechanic, diesel mechanic, diesel technician, fleet mechanic, general repair mechanic, mechanic, service technician, trailer mechanic, transit mechanic, and truck mechanic. (O\*NET code 49-3031.00)
- » **Manufacturing engineering technologists:** Develop tools, implement designs, or integrate machinery, equipment, or computer technologies to ensure effective manufacturing processes. Job titles in this category include business process analyst, manufacturing coordinator, manufacturing technology analyst, product manager, and scientist. (O\*NET code 17-3029.06)

### *Planners and analysts*

Planning and analyzing the flow of money, material, and information is an essential part of making any supply chain work. The planners and analysts who do this work typically combine their knowledge of the business with technology savvy and expertise in supply chain information systems. Some of these jobs require an associate's or bachelor's degree, but it's often possible to acquire the skills for these jobs through work experience and/or professional certification programs. Following are some positions that fall into this category:

- » **Logistics analysts:** Analyze product delivery or supply chain processes to identify or recommend changes. These workers may manage route activity, performing tasks such as invoicing, electronic billing, and shipment tracing. Job titles in this category include global logistics analyst, logistics analyst, and supply chain analyst. (O\*NET code 13-1081.02)
- » **Management analysts:** Conduct organizational studies and evaluations, design systems and procedures, conduct work simplification and measurement studies, and prepare operations and procedures manuals to help management operate more efficiently.

Job titles in this category include administrative analyst, business analyst, employment programs analyst, leadership development manager, management analyst, management consultant, organizational development consultant, principal consultant, program management analyst, and quality control analyst. (O\*NET code 13-1111.00)

- » **Operations research analysts:** Formulate and apply mathematical modeling and other optimizing methods to develop and interpret information that helps management with decision-making, policy formulation, and other functions. These workers may collect and analyze data, as well as develop decision-support software, services, or products. They may also develop plans to optimize the time and cost for a logistics network. Job titles in this category include analytical strategist, business analytics director, business insight and analytics manager, decision analyst, operations research analyst, operations research group manager, operations research manager, and scientist. (O\*NET code 15-2031.00)
- » **Production, planning, and expediting clerks:** Coordinate and expedite the flow of work and materials within or between departments of an establishment according to a production schedule. Duties include reviewing and distributing production, work, and shipment schedules; conferring with department supervisors to determine progress of work and completion dates; and compiling reports on progress of work, inventory levels, costs, and production problems. Job titles in this category include master scheduler, material coordinator, materials planner, planner, production assistant, production clerk, production controller, production planner, production scheduler, and scheduler. (O\*NET code 43-5061.00)
- » **Cargo and freight agents:** Expedite and route incoming and outgoing cargo and freight shipments in airline, train, and trucking terminals and on shipping docks. These workers take orders from customers and arrange pickup of freight and cargo for delivery to the loading platform. They also prepare and examine bills of lading to determine shipping charges and tariffs. Job titles in this category include cargo agent, documentation clerk, drop shipment clerk,

freight broker, intermodal dispatcher, international coordinator, load planner, logistics coordinator, logistics service representative, expeditor, and operations manager. (O\*NET code 43-5011.00)

## *Engineers*

Supply chains are complex systems, and designing them often requires high-level math and engineering. Most of the following roles for supply chain engineers require a university degree in engineering:

- » **Industrial engineers:** Design, develop, test, and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination. Job titles in this category include engineer, engineering manager, industrial engineer, manufacturing specialist, operations engineer, plant engineer, process engineer, production engineer, supply chain engineer, and tool engineer. (O\*NET code 17-2112.00)
- » **Logistics engineers:** Design or analyze operational solutions for projects such as transportation optimization, network modeling, process and methods analysis, cost containment, capacity enhancement, routing and shipment optimization, and information management. Job titles in this category include logistics engineer, reliability engineer, and systems engineer. (O\*NET code 13-1081.01)
- » **Manufacturing engineers:** Design, integrate, and/or improve manufacturing systems or related processes. These workers may work with commercial or industrial designers to refine product designs in a way that increases productivity and decreases costs. Job titles in this category include advanced manufacturing engineer, advanced manufacturing vice president, facility engineer, manufacturing director, manufacturing engineer, manufacturing engineering director, manufacturing engineering manager, plant engineer, process engineer, and process improvement engineer. (O\*NET code 17-2199.04)

- » **Robotics engineers:** Research, design, develop, or test robotic applications. Job titles in this category include associate professor of automation, automation engineer, engineer, and plant floor automation manager. (O\*NET code 17-2199.08)

## *Supervisors*

Supervisory jobs are common in the supply chain and are frequent stops for supply chain professionals as their careers develop. Supply chain engineers and managers often serve as first-line supervisors early in their careers so that they get practical experience in the daily operations of a supply chain. A supply chain professional could also be a great candidate for a role such as loss prevention manager, for example, because these professionals understand how supply chains function. Following are some jobs that fall into this category:

- » **First-line supervisors of production and operating workers:** Directly supervise and coordinate the activities of production and operating workers such as inspectors, precision workers, machine setters and operators, assemblers, fabricators, and plant and system operators. Job titles in this category include assembly supervisor, department manager, manufacturing supervisor, molding supervisor, production manager, production supervisor, quality assurance supervisor, shift supervisor, supervisor, and team leader. (O\*NET code 51-1011.00)
- » **Dispatchers:** Schedule and dispatch workers, work crews, equipment, or service vehicles for conveyance of materials, freight, or passengers, or for normal installation, service, or emergency repairs rendered outside the place of business. Duties may include using a radio, telephone, or computer to transmit assignments, as well as compiling statistics and reports on work progress. Job titles in this category include aircraft dispatcher, city dispatcher, dispatch manager, dispatcher, operations dispatcher, rail operations controller, train dispatcher, and truck dispatcher. (O\*NET code 43-5032.00)
- » **Loss prevention managers:** Plan and direct policies, procedures, or systems to prevent the loss of assets. These workers try to protect the

supply chain from theft by determining risk exposure or potential liability and then developing risk control measures. Job titles in this category include loss prevention manager, logistics loss prevention manager, loss prevention operations manager, manager of loss prevention operations, and market asset and protection manager. (O\*NET code 11-9199.08)

## *Managers*

Supply chain managers are business leaders who make decisions about how a supply chain will operate. They may have end-to-end responsibility for purchasing, logistics, and operations, or their scope of duties may be narrower. These roles generally require a bachelor's degree, and for many of them, a master's degree is beneficial. Following are some examples of supply chain manager positions:

- » **Supply chain managers:** Direct or coordinate production, purchasing, warehousing, distribution, or financial forecasting services and activities to limit costs and improve accuracy, customer service, or safety. These workers analyze procedures and identify opportunities for streamlining activities to meet product distribution needs, as well as direct the movement, storage, or processing of inventory. (In other words, they focus on process improvement.) Job titles in this category include global supply chain director, supply chain director, supply chain manager, and supply chain vice president. (O\*NET code 11-9199.04)
- » **Transportation managers:** Plan, direct, or coordinate the transportation operations within an organization or the activities of organizations that provide transportation services. Job titles in this category include director of operations, fleet manager, freight coordinator, global transportation manager, traffic manager, train operations manager, trainmaster, transportation director, transportation manager, and transportation supervisor. (O\*NET code 11-3071.01)
- » **Storage and distribution managers:** Plan, direct, or coordinate the storage or distribution operations within an organization or the

activities of organizations that store or distribute materials or products. Job titles in this category include cold-storage supervisor, customer service manager, distribution center manager, distribution manager, distribution operation manager, load-out supervisor, shipping manager, shipping supervisor, stores supervisor, and warehouse manager. (O\*NET code 11-3071.02)

- » **Logistics managers:** Plan, direct, or coordinate purchasing, warehousing, distribution, forecasting, customer service, or planning services. These workers manage logistics personnel and logistics systems, as well as direct daily operations. Job titles in this category include global logistics manager, integrated logistics programs director, logistics manager, logistics solution manager, and supply chain logistics manager. (O\*NET code 11-3071.03)
- » **Logisticians:** Analyze and coordinate the logistical functions of a firm or organization. These workers are responsible for the entire life cycle of a product, including acquisition, distribution, internal allocation, delivery, and final disposal of resources. Job titles in this category include client services administrator, logistician, logistics director, logistics team lead, logistics vice president, operations vice president, production planner, program manager, supervisory supply management specialist, and supportability engineer. (O\*NET code 13-1081.00)
- » **Purchasing managers:** Plan, direct, or coordinate the activities of buyers, purchasing officers, and related workers involved in purchasing materials, products, and services. Job titles in this category include commodity manager, director of materials, director of purchasing, director of strategic sourcing, materials manager, procurement manager, procurement officer, purchasing director, purchasing manager, purchasing supervisor, wholesale or retail trade merchandising manager, and procurement manager. (O\*NET code 11-3061.00)
- » **General and operations managers:** Plan, direct, or coordinate the operations of public or private-sector organizations. Duties and responsibilities include formulating policies, managing daily

operations, and planning the use of materials and human resources. Job titles in this category include business manager, facility manager, general manager, operations director, operations manager, plant manager, plant superintendent, production manager, and store manager. (O\*NET code 11-1021.00)

## *Sales representatives*

For businesses that sell supply chain products and services, revenue is driven by salespeople. To sell this stuff, you need to understand the business. Supply chain software companies, for example, need sales representatives who understand how their product can solve problems for their customers, which means that their salespeople need to understand both the technology and the customers' businesses. Education and training requirements for supply chain sales professionals vary widely, but sales jobs are available in virtually every company that provides supply chain solutions.

The general description of sales representatives (O\*NET code 41-4012.00) is those who sell goods for wholesalers or manufacturers to businesses or groups of people. The work requires substantial knowledge of the items being sold. Job titles in this category include account executive, account manager, outside sales representative, sales consultant, sales director, sales representative, and salesperson.

## *Product managers*

It is becoming common for businesses to think of everything they sell as a product. This includes physical products, of course, but it also includes virtual products like software and services like e-commerce fulfillment. Along with this trend a new job role has emerged for product managers — the people who are responsible for the guiding each product through its lifecycle from development to obsolescence. Product managers balance the expectations of customers against the needs of the business and capabilities of technology. This often includes anticipating supply chain challenges and opportunities, and incorporating that knowledge into product decisions. In small companies like startups that have very few products, the product manager may be part of the executive team. In



larger organizations with many products, there may be product managers scattered throughout each division.

Some product manager positions include marketing managers (O\*NET code 11-2021.00), sales engineers, (O\*NET code 41-9031.00), and industrial production managers (O\*NET code 11-3051.00).

### *Customer success managers*

In business-to-business relationships, suppliers are often expected to understand the unique needs of each of their customers. That is the job of a customer success manager (CSM) which is a hybrid between technical sales, customer service, and project management. CSMs act as an advocate for their customers to ensure that sales and implementation activities are synchronized and make sure that customer issues are addressed appropriately. CSMs are responsible for the customer experience (CX) and can improve customer retention by helping customers maximize the value they receive from the products and services customers purchase. CSMs can also help product managers prioritize new products and features based on CX feedback and their knowledge of customer needs.

### *Project managers*

Supply chains are in a continuous state of change, which means that lots of projects need to be managed. When several projects need to be managed together they are often called a program. Managing projects and programs well requires two different skill sets: knowledge of how supply chains work and expertise in project management. Combining these two professions is a bridge too far for the government classification system, so you'll have a tough time finding official guidance about how many jobs in this category are available. But you can do an Internet search to find these jobs around the world.

Job titles include project manager, program manager, project specialist, project leader, program administrator, project management office manager, center of excellence leader, and black belt.

### *Information technology managers*



Supply chains have become heavily dependent on information systems, which are in a constant state of change. Consequently, professionals who have both the IT savvy and the supply chain knowledge to manage these systems successfully are in high demand. A career as a supply chain IT professional often requires both a college degree and professional certifications. IT professionals may need certifications for the hardware or software they maintain or the programming languages that they use. They may also need to be certified in project management or in a software development framework such as Scrum. Supply chain IT positions include the following:

- » **IT project managers:** Plan, initiate, and manage IT projects. These workers lead and guide the work of technical staff, and serve as liaisons between the business and technical aspects of projects. They also plan project stages; assess business implications for each stage; and monitor progress to ensure that deadlines, standards, and cost targets are met. Job titles in this category include IT manager, IT project manager, program manager, project manager, team coach, project leader, team leader, technical project lead, project management office (PMO) leader, and transition manager. (O\*NET code 15-1199.09)
- » **Software developers:** Research, design, develop, and test operating-system software, compilers, and network distribution software for industrial, business, and general computing applications. These workers set operational specifications and formulate and analyze software requirements; they may design embedded systems software. They also apply principles and techniques of computer science, engineering, and mathematical analysis. Job titles in this category include developer, infrastructure engineer, network engineer, publishing systems analyst, senior software engineer, software architect, software developer, software engineer, systems coordinator, and systems engineer. (O\*NET code 15-1133.00)
- » **Computer and information systems managers:** Plan, direct, or coordinate activities in such fields as electronic data processing, information systems, systems analysis, and computer programming.

Job titles in this category include application development director, computing services director, data processing manager, information systems director, information systems manager, information systems supervisor, information technology director, IT manager, management information systems director, and technical services manager. (O\*NET code 11-3021.00)

## *Executives*

More roles are available all the time for supply chain executives. Many companies now have a chief supply chain officer (CSCO) who oversees the entire supply chain and reports directly to the CEO. Many CSCOs have even been promoted to CEO. Supply chain executive jobs usually require a bachelor's degree, and a large percentage of executive positions require a master's degree. In O\*NET, all the chief executive jobs are lumped into a single job category with the code 11-1011.00.

Chief executives determine and formulate policies and provide overall direction of companies or private and public-sector organizations within guidelines set up by a board of directors or similar governing body. These workers plan, direct, or coordinate operational activities at the highest level of management with the help of subordinate executives and staff managers. Job titles in this category include chief executive officer, chief operating officer, chief supply chain officer, chief procurement officer, chief purchasing officer, chief logistics officer, executive director, executive vice president, operations vice president, president, and vice president.

## *Journalists*

The community of supply chain journalists is small, but these people play a critical role in the industry. Understanding what's happening and explaining it to others takes work and practice. Trade magazines, blogs, podcasts, business news services, and online platforms need accurate, insightful, well-written content.

If you want to know how supply chains are changing, and you like to write, a job as a supply chain journalist could be an excellent fit for you.

Job titles in this category include contributor, editor, managing editor, editorial director, publisher, author, and technical writer.



**TIP** No matter what your area of expertise is, writing books and submitting articles for trade journals, blogs and magazines is a great way to build your professional brand and grow your network. Building relationships with writers and editors also increases the likelihood that they'll reach out to you for interviews or story ideas.

## ***Educators***

Where do people learn the tools, rules, and language required to do supply chain jobs? From teachers, of course. If you have a strong background in supply chain, and you like sharing your knowledge and experience with others, you might consider a career as a supply chain educator. Following are a few jobs in this category:

- » **Vocational education teachers:** Teach or instruct vocational or occupational subjects at the postsecondary level (but at less than baccalaureate level) to students who have graduated from or left high school. These workers include correspondence-school, industrial, and commercial instructors, as well as adult-education teachers and instructors who prepare people to operate industrial, transportation, and communications equipment. Jobs may be in public or private schools or in organizations engaged in a primary business other than education. Job titles in this category include mentor, coach, instructor, professor, adjunct professor, and teacher. (O\*NET code 25-1194.00)
- » **Career/technical education teachers:** Teach occupational, career and technical, or vocational subjects at the secondary-school level in public or private schools. Job titles in this category include business education teacher, instructor, marketing education teacher, and technology education teacher. (O\*NET code 25-2032.00)

» **Business teachers:** Teach courses in business administration and management, such as accounting, finance, human resources, labor and industrial relations, marketing, and operations research. These workers includes teachers who are primarily engaged in teaching and those who do a combination of teaching and research. Job titles in this category include associate professor, business administration professor, business instructor, business office technology instructor, business professor, faculty member, instructor, management professor, marketing professor, and professor. (O\*NET code 25-1011.00)

### *Humanitarian supply chain professionals*

When a major crisis occurs — such as hurricane, a flood, earthquake, tornado, drought, or war — it disrupts supply chains for essential items such as food, water, and clothing. A growing community of volunteers and full-time professionals specializes in humanitarian supply chain management; these people create temporary supply chains to receive and deliver relief supplies while permanent supply chains are being repaired. A humanitarian supply chain team might set up a temporary distribution center in a vacant warehouse near a community that was flooded and use this facility to receive the donations that are shipped in from out-of-state charities. Because they streamline the flow of relief supplies to victims of a disaster, humanitarian supply chain professionals play a critical role in the recovery.

The job titles for humanitarian supply chain professionals can come from any of the categories in this chapter, but the employers are usually not-for-profit organizations (such as the American Red Cross or Direct Relief) or government agencies (such as the Federal Emergency Management Agency). Also, a not-for-profit organization called American Logistics Aid Network ([www.alanaid.org](http://www.alanaid.org)) specializes in addressing the supply chain needs of communities that have been impacted by disasters.

# Chapter 21

## Pursuing Supply Chain Education

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### IN THIS CHAPTER

- » Choosing the right certifications
  - » Selecting college and university degrees
  - » Examining online education options
  - » Learning with supply chain management games
- 

To advance through your career as a supply chain professional, you'll probably need a combination of degrees and certifications, along with a regular dose of online learning and continuing education. In this chapter, I provide information about the most popular supply chain certifications from professional societies, including ASCM, ISM, CSCMP, and PMI. I also talk about degrees and other credentials that you can earn from traditional community colleges and universities. Finally, you are introduced to online learning options that are now available and games that can be useful teaching tools.

## *Earning Certificates and Certifications*

Credentials such as a professional certificate or a certification can tell your boss, your colleagues, and recruiters that you are knowledgeable about a subject. Many universities, community colleges, professional societies, and online training providers offer certifications in supply chain management. *Supply Chain Management Review* has published a list of these programs at

[www.scmr.com/article/executive\\_education\\_2018\\_list\\_of\\_professional\\_supply\\_chain\\_education](http://www.scmr.com/article/executive_education_2018_list_of_professional_supply_chain_education).

This section focuses on the supply chain credentials that are the most widely recognized in industry.

## ***Association for Supply Chain Management***

The Association for Supply Chain Management (ASCM) is one of the oldest, best-known providers of supply chain certification programs. Originally the American Production and Inventory Control Society (APICS), it rebranded to become ASCM in 2018. You can find more information about ASCM certifications at [www.ascm.org](http://www.ascm.org).

### ***Certified in Planning and Inventory Management (CPIM)***

The CPIM is designed for supply chain planners and analysts. To earn your CPIM designation, you must pass two exams. Candidates must pass [Part 1](#) and [Part 2](#) exams within three years to become certified. You receive your score as soon as you complete the exam.

There are no prerequisites for CPIM. You can prepare for the exam by studying on your own, by taking classes, or by using online study tools. The cost for certification bundle, which includes study materials and two exam vouchers, is \$2,059. You get a discount on the materials by joining ASCM (\$99) and adding on the certification upgrade (\$100). Then you can purchase the CPIM bundle for \$1,860. In other words, the discount basically offsets the cost of your ASCM membership.



**TIP** ASCM members get access to the exam content manuals for each certification, which include sample test questions. For more information, check out [www.ascm.org/learning-development/certifications-credentials](http://www.ascm.org/learning-development/certifications-credentials).

### ***Certified in Logistics, Transportation and Distribution (CLTD)***

The CLTD is designed for logistics and transportation professionals. There is only one exam that you take at an approved testing center. It's a

computer-based exam with 150 questions, and you have three-and-a-half hours to complete it. You'll receive your score as soon as you complete the test.

To be eligible for the CLTD exam, you need to have three years of related experience, a bachelor's degree, or another supply chain certification from ASCM or the Institute for Supply Management. To document that you have met one of these requirements, you need to complete the Certification Eligibility application (<https://www.ascm.org/learning-development/certifications-credentials>) before you'll be allowed to register for the exam.

The cost for the CLTD learning bundle, which includes an exam voucher, is \$1,969. You get a discount on the materials by joining ASCM (\$99) and adding on the certification upgrade (\$100). Then you can purchase the CLTD bundle for \$1,770. In other words, the discount basically offsets the cost of your ASCM membership.



**REMEMBER** Complete the certification eligibility application at least two weeks before you plan to register for the exam.



**TIP** ASCM exams are administered by Pearson Vue, which has testing centers around the world. They also offer online testing. You can find test-taking details at <https://home.pearsonvue.com/apics>.

### ***Certified Supply Chain Professional (CSCP)***

The CSCP is designed for experienced supply chain professionals. There is only one exam that you take at an approved testing center. It's a computer-based exam with 150 questions, and you have three-and-a-half hours to complete it. You'll receive your score immediately.

To be eligible for the CSCP exam, you need to have three years of related experience, a bachelor's degree, or another supply chain



certification from ASCM or the Institute for Supply Management. To document that you have met one of these requirements you need to complete the Certification Eligibility application

([www.ascm.org/learning-development/certifications-credentials](http://www.ascm.org/learning-development/certifications-credentials)) before you'll be allowed to register for the exam.

The cost for the CSCP learning bundle, which includes an exam voucher, is \$2,169. You get a discount on the materials by joining ASCM (\$99) and adding on the certification upgrade (\$100). Then you can purchase the CSCP bundle for \$1,970. In other words, the discount basically offsets the cost of your ASCM membership.



**TIP** Some universities offer college credits for ASCM certifications. For more information, check with the National College Credit Recommendation Service ([www.nationalccrs.org](http://www.nationalccrs.org)).



**WARNING** You can sometimes find used copies of ASCM study materials online, but they may be illegal copies. Buying or selling these materials could be a violation of the ASCM ethics rules and can lead to having your certification permanently revoked.



**TIP** A free ASCM Supply Chain Dictionary app includes study tools to help you prepare for exams. You can download the app onto your mobile device from the App Store or Google Play.

## ***Council of Supply Chain Management Professionals***

The Council of Supply Chain Management Professionals (CSCMP) has changed its name a few times, which sometimes causes confusion. You may run across references that were published under an old name, such



as the National Council of Physical Distribution Management or Council of Logistics Management. You can find information about how to get CSCMP credentials at [www.cscmp.org](http://www.cscmp.org).

CSCMP's SCPro certification is designed for logistics and supply chain management professionals. There are three levels to the SCPro certification:

- » **Cornerstones of Supply Chain Management (Level 1):** To earn this certification, you take a 160-question multiple-choice online exam about the material in the eight pillars of supply chain management. You are given four-and-a-half hours to finish the test. The cost of the exam for CSCMP members is \$650. It costs \$299 to join CSCMP.
- » **Analysis and Application of Supply Chain Challenges (Level 2):** Level 1 certification is required. The certification process for Level 2 involves reading case studies and answering questions about them in a four-hour exam. The cost of the exam is \$1,095 for CSCMP members.
- » **Initiation of Supply Chain Transformation (Level 3):** Level 2 certification is required. The certification process for Level 3 involves developing a plan to implement a supply chain transformation in a real organization. The goal is to demonstrate that you know the concepts and can apply them in a real-world situation. Contact CSCMP for more information about the cost of completing SCPro Level 3 ([scpro@cscmp.org](mailto:scpro@cscmp.org) or 630-574-0985).

## *Institute for Supply Management*

You may be familiar with the Institute for Supply Management (ISM) because business reporters often cover data that it releases. This information tracks how much money companies are spending on purchasing and is considered to be one of the most reliable barometers of the U.S. economy.

ISM has two certifications: one that covers supply chain management with a focus on procurement and a second that focuses on supplier

diversity. You can get details about the ISM certifications at <https://ismworld.org>.

### ***Certified Professional in Supply Management (CPSM)***

The CPSM certification, for people who develop and execute purchasing strategy for organizations, groups supply chain content into three exams:

- » Supply Management Core
- » Supply Management Integration
- » Leadership and Transformation in Supply Management

It costs \$240 to join ISM and \$295 to take each exam. The first two exams have 165 questions each, and you are given two-and-three-quarters hours to complete each one. The third exam has 180 questions, and you have three hours to complete it. You also need to meet education and experience requirements: three years of experience along with a bachelor's degree, or five years of experience if you don't have a degree.

After you have passed all three CPSM exams, you need to submit an application to ISM that includes your score reports, a letter from your employer verifying your experience, and a copy of your university diploma or transcript. You also need to pay an application fee of \$125.



**TIP** ISM exams are administered by Pearson Vue, which has testing centers around the world as well as online testing options. You can find more information about testing at <https://home.pearsonvue.com/ism>.

### ***Certified Professional in Supplier Diversity (CPSD)***

The CPSD certification is for people who manage supplier diversity initiatives. To earn the CPSD, you need to meet education and experience requirements and pass two exams:

- » Supply Management Core

## » Essentials in Supplier Diversity Exam

The first exam has 165 questions that you need complete in two-and-three-quarters hours. The second exam has 120 questions, and you need to complete it in two hours. The cost of each exam is \$295 for ISM members. You also need to meet education and experience requirements: three years of experience along with a bachelor's degree, or five years of experience if you don't have a degree.

After you have passed both CPSD exams, you need to submit an application to ISM that includes your score reports, a letter from your employer verifying your experience, and a copy of your university diploma or transcript. You also need to pay an application fee of \$125.



**TIP** Because the Supply Management Core exam is required for both the CPSM and CPSD certifications, many people get both certifications.

## *American Society for Quality (ASQ)*

The American Society for Quality (ASQ) offers several certifications for process improvement and quality management. Two popular certifications for supply chain professionals are the Certified Six Sigma Black Belt (CSSBB), which costs \$438 for members, and the Certified Supplier Quality Professional (CSQP), which costs \$398 for members. The cost to join ASQ is \$169.



**TIP** You can learn more about all of the ASQ certifications at <https://asq.org/cert/catalog>.

## *Institute of Industrial & Systems Engineers (IISE)*

The Institute of Industrial & Systems Engineers (IISE) offers a range of certifications covering Lean and Six Sigma. They offer in-person and online courses. The Lean Six Sigma Black Belt course costs \$4,195 for IISE members, and this includes the cost of the exam. You can learn more about IISE training and certifications at <https://iise.org/trainingcenter>. The cost to join IISE is \$169.

### ***The International Society of Logistics (SOLE)***

The International Society of Logistics (SOLE) certifies logistics professionals. SOLE members tend to be affiliated with the defense and aerospace industries, but the certification materials are relevant for any supply chain. The cost to join is \$140.

SOLE offers three credentials. You can get details at [www.sole.org](http://www.sole.org).

### ***Demonstrated Logistician (DL)***

The Demonstrated Logistician program is like an apprenticeship that has three levels:

- » Demonstrated Logistician
- » Demonstrated Senior Logistician
- » Demonstrated Master Logistician

The cost to apply for each level of the DL program is \$50. You also need to complete the education and on-the-job training requirements for each level.

### ***Certified Master Logistician (CML)***

The Certified Master Logistician certification is designed for professionals who have eight or more years of education and experience. The cost of the CML exam is \$140. The exam is offered twice per year, in May and November.

### ***Certified Professional Logistician (CPL)***

The Certified Professional Logistician certification is designed for professionals who have nine or more years of education and experience.

The fee for the CPL exam is \$225. The exam is offered twice per year, in May and November.



**TIP** SOLE certifications are common among logistics professionals who have served in the military.

## *Project Management Institute*

The Project Management Institute (PMI) is an association for project managers. It maintains a document called the Project Management Body of Knowledge (PMBOK) that serves as a framework for projects. Many supply chain management jobs include project management responsibilities, so it is common for employers to seek out experienced supply chain candidates who also have PMI credentials. You can find the complete list of PMI certifications at <https://www.pmi.org>. The organization's most popular certification is Project Management Professional (PMP).

The PMP certification demonstrates your understanding of project management tools and methods. To earn the PMP designation, you need to meet minimum requirements for education and experience. If you have a bachelor's degree, you need 4,500 hours of experience as a project manager and 35 hours of project management education. If you have a high school diploma or an associate's degree, the required amount of project management experience increases to 7,500 hours.

After you meet the experience and education requirements, you need to take the PMP exam. You get a \$150 discount on the exam if you are a member of PMI; membership is \$129. The 200-question test costs \$405, and you are allowed two hours to complete it. If you want all the details about the PMP certification process, you can download the free PMP Handbook at

[www.pmi.org/-/media/pmi/documents/public/pdf/certifications/project-management-professional-handbook.pdf?la=en](http://www.pmi.org/-/media/pmi/documents/public/pdf/certifications/project-management-professional-handbook.pdf?la=en).



**TIP** I teach several online courses at LinkedIn Learning that are approved by PMI to meet their education requirements. You can find them at <https://linkedin-learning.pxf.io/PgL7e>.

### ***The Futurist Institute***

The Futurist Institute (FI) provides training and certification focused on long-term forecasting. These qualifications can be useful for supply chain executives and innovators who are responsible for developing and executing long-range supply chain strategies. You can find more details about the FI certifications at [www.futuristinstitute.org](http://www.futuristinstitute.org).

### ***Council of Logistics Engineers Professionals (CLEP)***

The Council of Logistics Engineers Professionals (CLEP) is focused on the defense industry, and is aligned with U.S. military's Defense Acquisition University. You can find more details about CLEP and their certifications at <https://logisticsengineers.org>.

### ***Demand Driven Institute (DDI)***

The Demand Driven Institute (DDI) provides training and certification based on the principles of Demand Driven Material Requirements Planning (DDMRP). You can find more details about DDI certifications at [www.demanddriveninstitute.com](http://www.demanddriveninstitute.com).

### ***Reverse Logistics Association (RLA)***

The Reverse Logistics Associations (RLA) is a community of professionals who focus on returns management. RLA does not offer certifications, but it does offer training and networking opportunities for members. The cost to join RLA is \$499 per year. You can find more details about RLA at <https://rla.org>.

### ***Sourcing Industry Group (SIG)***

The Sourcing Industry Group (SIG) is a community for sourcing professionals. SIG offers networking events, education, and certification programs. SIG breaks its members into two categories: Buy side members manage sourcing, meaning that they buy things, and sell side members offer products and services to the buy side members. If you are interested in learning more about SIG, check out <https://sig.org>.

## ***Warehouse Education and Research Council (WERC)***

The Warehouse Education and Research Council (WERC) is a community of professionals and companies the focus on warehouses and distribution centers. Work does not offer certifications for individuals, but WERC events provide a good opportunity for learning and networking. Most WERC members pay \$275 per year to join. You can find more details about WERC at <https://werc.org>.

## ***International certifications***

Certifications are available in many countries, and supply chain professionals who work outside the United States may want to explore these programs.

### ***African Centre for Supply Chain (ASCS)***

ACSC is research-based organization focused on African supply chains. There are four ASCS membership levels:

- » Student
- » Associate
- » Full Member
- » Corporate Member

ASCS offers two credentials:

- » Graduate Certificate in Logistics and Supply Chain Management
- » Certified Import Compliance Manager



TIP

You can get more information about ASCS at

<https://supplychain-africa.org>.

### ***Chartered Institute for Logistics and Transport (CILT)***

CILT is the UK association for logistics and operations professionals. It costs £158 to join. As you achieve more education and progress in your career, you can advance your status within CILT. The four grades of membership are

- » Affiliate
- » Member
- » Chartered Member
- » Chartered Fellow



TIP

You can get more information about CILT credentials at

<https://ciltuk.org.uk>.

### ***Chartered Institute for Procurement and Supply (CIPS)***

CIPS is the UK association for procurement professionals, offering certificates and diplomas. It costs £262 to become a member. When you start a career in operational procurement roles, you can get these certificates:

- » Certificate in Procurement and Supply Operations
- » Advanced Certificate in Procurement and Supply Operations

When you get advanced education or move into management roles, you can pursue these diplomas:

- » Diploma in Procurement and Supply



- » Advanced Diploma in Procurement and Supply
- » Professional Diploma in Procurement and Supply

You can find more details about CIPS credentials at

<https://www.cips.org>.

### ***Canada's Logistics Association (CITT)***

CITT started out as the Canadian Institute of Traffic and Transport, but has rebranded as CITT — Canada's Logistics Association. CITT offers training and certification, as well as networking events and conferences. The cost for practitioners to join CITT is \$450 per year, and the cost for vendors to join is \$550. You can find more details about CITT at

[www.citt.ca](http://www.citt.ca).

### ***International Supply Chain Education Alliance (ISCEA)***

The International Supply Chain Education Alliance (ISCEA) provides training and certification for global supply chain professionals at various points in their careers, along with specialized credentials for industries such as energy and health care. You can find more details about ISCEA certifications at [www.iscea.org](http://www.iscea.org).

### ***SAPICS***

SAPICS is the professional body for supply chain management in South Africa. SAPICS hosts educational conferences and offers training for many international certification programs. The cost to join SAPICS is R975. You can learn more about SAPICS at [www.sapics.org](http://www.sapics.org).

### ***Supply Chain and Logistics Association of Australia (SCLAA)***

The Supply Chain and Logistics Association of Australia (SCLAA) offers education and networking events for supply chain professionals across Australia. There are different membership levels, starting at AU\$165 per year. You can learn more about SCLAA at

[www.sclaa.com.au](http://www.sclaa.com.au).

### ***Supply Chain Canada***

Supply Chain Canada is the Canadian association for supply chain professionals, offering the Supply Chain Management Professional

(SCMP) certification. You have several pathways to earning the SCMP, including academic courses and military service. Membership in Supply Chain Canada is \$400 per year. You can find more details about the SCMP certification at <https://www.supplychaincanada.com>.

## *Earning Degrees and Diplomas*

The best way to prepare for many supply chain management jobs is to get a formal degree or diploma. Deciding on the right school and the right course of study depends on what you want to do when you finish your education.

Many supply chain jobs require business, engineering, and technology skills. When you look at degree options, think about how each one can help you develop in all three areas. If you plan to become a supply chain analyst, for example, you'll probably benefit most from a business degree, but your classes should give you the opportunity to see how logistics networks are engineered and expose you to technologies that drive the data you'll be analyzing.

### *Undergraduate degrees*

Many community colleges offer supply chain management courses and allow you to earn an associate's degree in about two years. With this kind of degree, you would be qualified for an entry-level job as a supply chain analyst or technician.

For more senior jobs, such as supply chain manager, you probably need a four-year degree in supply chain management. Undergraduate programs in supply chain management have become popular in the past few years and are offered in business schools at public and private universities around the United States.



**TIP**

If you're interested in jobs involving supply chain technology or engineering, look at degrees in those areas. A degree in industrial engineering, industrial distribution, or industrial technology could

be a good choice. Some universities offer certificates to students who take a certain number of supply chain classes as part of their engineering or technology degree. At Bradley University, where I teach, students can earn a Bachelor of Science in Industrial Engineering degree with a concentration in Global Supply Chain Management

([www.bradley.edu/academic/departments/mtg/major/gscm](http://www.bradley.edu/academic/departments/mtg/major/gscm)).

## *Graduate degrees*

As you move further up the management ladder, you'll probably want to earn a master's degree. You may not need a master's degree in supply chain management, but a graduate degree can help you make more money and reduce the risk of being unemployed. A 2021 salary survey conducted by CSCMP and DC Velocity found that professionals with a master's degree earned roughly \$30,000 more per year than their peers who did not have a master's degree, and it has been shown that professionals with a master's degree have a lower average unemployment rate. If your undergraduate degree is in a field other than supply chain management, you should definitely consider a earning master's degree with a supply chain focus. Some schools offer master's degrees in supply chain management, and others offer Master of Business Administration (MBA) degrees with a concentration in supply chain management.

Currently, only four universities in the United States offer graduate degrees in supply chain engineering: Massachusetts Institute of Technology (MIT), Georgia Institute of Technology, North Carolina State University, and New Jersey Institute of Technology. Many offer graduate programs in industrial engineering and industrial technology that include courses that are relevant for supply chain careers. Some universities combine supply chain engineering with supply chain management.

To become a university professor, you often need to earn a terminal degree, such as a Doctor of Philosophy (PhD) or Doctor of Business Administration (DBA). Doctoral programs involve a combination of courses, research, and academic writing. Most of them require you to

spend some time on the university campus, but there are a handful of online and hybrid programs. A doctoral program is a major commitment, usually taking between three and seven years to complete.

## *Exploring Online Education Options*

Online supply chain education programs range from free videos to paid subscription programs to full-blown graduate courses. These programs are making supply chain education cheaper and easier to access for people around the world.

### *Traditional online programs*

Many universities offer online versions of their courses and even online degrees. In most cases, the curriculum is identical to that of a traditional degree program, but the way in which the online material is delivered can vary among schools and even among professors. Some online courses use videoconferences that offer live interaction with the professor and other students; others use video recordings of a lecture; still others ask students to read course materials, write their homework, and interact via email.

### *MITx MicroMasters in Supply Chain Management*

MIT has pioneered a new program called MITx MicroMasters in Supply Chain Management. This program consists of five online courses, which anyone can take for free. If you pay a fee of \$1,694, however, MIT validates your identity and allows you to take exams at the end. If you complete all five courses and pass the exams, you receive a MicroMasters credential in Supply Chain Management. Later, if you're accepted at MIT as a graduate student, you get credit for your MicroMasters courses.

The five courses are

- » Supply Chain Analytics
- » Supply Chain Fundamentals
- » Supply Chain Design

- » Supply Chain Dynamics
- » Supply Chain Technology and Systems

Many universities around the world now have pathways that grant credit for completing the MITx Micromasters certificate. You can find more information about this program and find a list of these pathway universities at <https://micromasters.mit.edu/scm>.

### ***Arizona State University Online MS-SCM***

Arizona State University offers an online Master of Science in Supply Chain Management that builds on the MITx MicroMasters credential. To be eligible for the MS-SCM, you must have a bachelor's degree, and you must have completed the MITx MicroMasters program. After you've been accepted to the program and passed ten online graduate courses, you earn a master's degree from ASU. The MS-SCM program costs about \$18,000. You can find out more at

<https://wpcarey.asu.edu/masters-programs/online-supply-chain-management>.

### ***Online and hybrid masters programs***

The number of online and hybrid masters programs for supply chain management has exploded in the past few years. This list below is not complete, but it will give you a starting point for researching online masters programs:

- » Auburn University (<https://harbert.auburn.edu/degrees-programs/graduate/ms-supply-chain-online/index.html>)
- » Boston University (<https://bumetprograms.bu.edu/scm>)
- » Florida Tech  
(<https://explore.floridatechonline.com/lp/masters-scm>)
- » Georgetown University  
(<https://scs.georgetown.edu/programs/503/online/online-masters-in-supply-chain-management>)

- » Michigan State University  
(<https://explore.michiganstateuniversityonline.com/lp/ms-scm>)
- » Pennsylvania State University  
(<https://www.worldcampus.psu.edu/degrees-and-certificates/supply-chain-management-masters/overview>)
- » University of Arkansas (<https://walton.uark.edu/graduate-programs/supply-chain-masters-degree/>)
- » University of Colorado Boulder ([www.colorado.edu/business/ms-programs/masters-program-supply-chain-management](http://www.colorado.edu/business/ms-programs/masters-program-supply-chain-management))
- » University of Maryland  
([www.rhsmith.umd.edu/programs/business-masters/academics/supply-chain-management](http://www.rhsmith.umd.edu/programs/business-masters/academics/supply-chain-management))
- » University of Oklahoma  
(<https://price.ou.edu/supplychainmanagement>)
- » University of South Carolina  
(<https://online.usc.edu/programs/global-supply-chain-management-gscm>)
- » University of Tennessee Knoxville  
(<https://info.supplychainmanagement.utk.edu/online-masters-supply-chain>)

## ***Coursera***

Coursera is a website that allows many universities to share their courses online. The site currently offers supply chain management courses from a few schools, including Rutgers University.

The costs vary (from \$15 to \$25,000), depending on how you use the website. You pay a subscription fee every month to access the library.

To search the library and find out how much a given course of study costs, visit <https://www.coursera.org>.

## *LinkedIn Learning*

LinkedIn Learning (formerly Lynda.com) is an online library of more than 15,000 courses taught by university professors and industry experts. Several good courses on supply chain management are available, as well as courses on useful topics such as project management, Lean, and Six Sigma. When you complete a course on LinkedIn Learning, you can have that information added to your LinkedIn profile.

You can buy LinkedIn Learning courses one at a time, or you can access the entire LinkedIn Learning library by getting a LinkedIn Premium subscription for \$29.99 per month. LinkedIn Learning is also available through many corporate training departments, as well as libraries and universities. The following link takes you to the “Become a Supply Chain Manager” learning path, and includes an offer to sign up for a free trial: <https://linkedin-learning.pxf.io/dBA5y>.



**TIP** If you're active-duty military, a military veteran, or a military spouse, you can request a one-year free subscription to LinkedIn Premium. For details, visit

<https://linkedinforgood.linkedin.com/programs/veterans>.

## *Udemy*

Udemy is an e-learning platform where instructors can post courses on virtually any topic. There are lots of supply chain courses on Udemy, and many of them have free previews. However, in order to complete a course and get a certificate you will often need to pay between \$10 and \$100. You can check out all of the current supply chain courses at [www.udemy.com/courses/search/?src=ukw&q=supply+chain](http://www.udemy.com/courses/search/?src=ukw&q=supply+chain).

## *YouTube*

You can find a lot of great supply chain management content on YouTube; you just have to look among the millions of funny cat videos to find it. Videos from universities and associations explain supply chain management in many ways and in many languages. You can also find



corporate videos that provide examples of supply chains in action. To find these videos, visit [www.youtube.com](http://www.youtube.com), and search for *supply chain*.



**TIP** You might like this MIT video that uses a lemonade stand to illustrate the challenges of managing a supply chain:  
[www.youtube.com/watch?v=gBRrG0-SA1I](http://www.youtube.com/watch?v=gBRrG0-SA1I). (They gave me a small part as Susie's dad.)

## *Playing Supply Chain Games*

Supply chains often behave in unpredictable ways, and it can be difficult to explain why. Rather than using traditional teaching methods, such as books and lectures, it is easier (and more fun!) to demonstrate these behaviors by playing simulation games. Two games in particular are highly effective teaching tools for supply chain management: The Beer Game and The Fresh Connection. There's also a video game called The Rise of Industry that illustrates some important supply chain concepts.

### *The Beer Game*

One of the first people to teach and research supply chain management was an MIT professor and electrical engineer named Jay Forrester. Forrester noticed that when businesses exchange money, material, and information, they behave a lot like electrical circuits. He developed a technique for modeling businesses that was similar to the way he'd been taught to analyze circuits, and he called this new approach *system dynamics*.

To explain how system dynamics works, he created The Beer Game. Players are divided into four teams: customer, retailer, distributor, and brewery. In this simulated beer supply chain, you see how small variations in demand can quickly create inventory stockpiles and stockouts. The game is used in university classes and executive education programs around the world.



You can order the game from the System Dynamics Society ([www.systemdynamics.org/products/the-beer-game](http://www.systemdynamics.org/products/the-beer-game)) for \$125. Several online versions of the game are also available, and some are free. Playing The Beer Game is an effective way to teach people about system dynamics and introduce them to the unpredictability of supply chains.



**TIP** If you want to see The Beer Game in action, check out this old video of MIT Professor John Sterman on YouTube:  
[www.youtube.com/watch?v=vQQUxgLfY-g](http://www.youtube.com/watch?v=vQQUxgLfY-g).

## *Inchainge*

Inchainge has created four online simulation games that are seriously awesome tools for teaching people about complex supply chain management challenges:

- » The Fresh Connection focuses on supply chain operations.
- » The Cool Connection focuses on supply chain finance.
- » The Blue Connection focuses on circular business models.
- » The Triple Connection focuses on supply chain sustainability.

In addition to teaching supply chain concepts, these games also require participants to collaborate as part of team, and to compete against other teams.



**TIP** For more information about Inchainge's games, visit  
<https://inchainge.com>.

## *Following Supply Chain Media*

An active community of journalists, analysts, and influencers contributes knowledge to supply chains through online news media. Following are some media sites that cover supply chain issues:

- » Air Cargo News ([www.aircargonews.net](http://www.aircargonews.net))
- » Business Insider ([www.businessinsider.com](http://www.businessinsider.com))
- » DC Velocity ([www.dcvelocity.com](http://www.dcvelocity.com))
- » Freightwaves ([www.freightwaves.com](http://www.freightwaves.com))
- » gCaptain (<https://gcaptain.com>)
- » Inbound Logistics ([www.inboundlogistics.com](http://www.inboundlogistics.com))
- » Journal of Commerce ([www.joc.com](http://www.joc.com))
- » Let's Talk Supply Chain ([www.letstalksupplychain.com](http://www.letstalksupplychain.com))
- » Modern Materials Handling ([www.mmh.com](http://www.mmh.com))
- » Supply & Demand Chain Executive ([www.sdexec.com](http://www.sdexec.com))
- » Supply Chain Africa (<https://supplychainafrica.org>)
- » Supply Chain Digital (<https://supplychaindigital.com>)
- » Supply Chain Dive ([www.supplychaindive.com](http://www.supplychaindive.com))
- » Supply Chain Management Review ([www.scmr.com](http://www.scmr.com))
- » Supply Chain Now (<https://supplychainnowradio.com>)
- » The Loadstar (<https://theloadstar.com>)
- » Trains ([www.trains.com](http://www.trains.com))
- » Transport Topics ([www.ttnews.com](http://www.ttnews.com))
- » Wall Street Journal Logistics Report  
([www.wsj.com/news/logistics-report](http://www.wsj.com/news/logistics-report))

You can also find interesting conversations about supply chain management on social media sites such as LinkedIn and Twitter.



TIP

You can follow me on LinkedIn at

[www.linkedin.com/in/danielstanton](http://www.linkedin.com/in/danielstanton) and on Twitter at

[https://twitter.com/Mr\\_Supply\\_Chain](https://twitter.com/Mr_Supply_Chain). You can also subscribe

my free newsletter at <http://supplychained.com>.

## RESOURCES FOR VETERANS

In the United States, lots of special programs help military veterans transition into civilian careers. Here are some free programs that veterans should explore:

- LinkedIn Social Impact (<https://socialimpact.linkedin.com/programs/veterans>)
- Troops2Logistics (<https://troops2logistics.org>)
- V.A. Vocational Rehabilitation ([www.benefits.va.gov/vocrehab](http://www.benefits.va.gov/vocrehab))
- Vets2Industry (<https://vets2industry.com>)

## *Teaching Kids About Supply Chain Management*

The sooner that kids can start learning about supply chains, the better prepared they will be to understand the world around them. One of my favorite games is to point to something and ask my kids, “Where did that come from?” It’s amazing how quickly something as simple as a pizza can turn into a lesson about supply chains! There are lots of resources that can be useful for parents and teachers. Some examples of supply chain books for children include:

» *Fifo Saves the Day: A Supply Chain & Logistics Adventure for Kids*  
by Megan Preston Meyer

» *Supply Chain Jane Leads the Way* by Megan Preston Meyer

- » *The Big Ship and the Little Digger* by Ryan Peterson
- » *The Goal: A Business Graphic Novel* by Eliyahu M. Goldratt, illustrated by Dean Motter

Some games that are appropriate for kids include:

- » Cashflow is a board game where you keep score using an income statement and balance sheet. The goal is to generate cashflow by managing your assets and liabilities. Cashflow costs \$79 and is available at [www.richdad.com/products/cashflow-the-board-game](http://www.richdad.com/products/cashflow-the-board-game).
- » Supply Chain Bingo is travel game that teaches young kids about the different kinds of trucks and trailers that keep our supply chains working. A set with three bingo cards costs \$22 and can be ordered at [www.supplychainbingo.com](http://www.supplychainbingo.com).

Junior Achievement ([www.jaworldwide.org](http://www.jaworldwide.org)) is a non-profit association that teaches kids about business, economics, and entrepreneurship. JA offers activities that can be incorporated into the classroom, as well as after school programs.

## **Part 6**

# The Part of Tens

## **IN THIS PART ...**

Discover ten important questions that you should ask about your own supply chain.

## Chapter 22

# Ten Questions to Ask about Your Supply Chain

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### IN THIS CHAPTER

- » Identifying key customers and what they value
  - » Aligning your supply chain with customers and suppliers
  - » Creating new value with your supply chain
  - » Envisioning the future of your supply chain
- 

One of the most exciting and challenging aspects of supply chain management is how quickly things change. New customers, new suppliers, and new technologies are added to supply chains every day. To meet their goals of delivering value to customers while maximizing profits, supply chain managers always need to look for ways to improve. In this chapter, I provide ten questions that you should ask to make sure that your supply chain is meeting your customers' needs, giving your company a competitive advantage, and keeping pace with technology trends.

## *Who Are Your Key Customers?*

One big challenge for supply chain managers is that they're often disconnected from the company's customers. Sales and marketing departments make deals and entice customers to buy; then it's up to the supply chain folks to make the products and deliver them on time. Supply chain managers may be given a set of production targets, but they often have no idea who their customers are.

Although all your customers are important, your key customers are the ones who are most important to your supply chain. Key customers buy



in large quantities, are expected to buy more in the future, or are influential in your industry. As a supply chain manager, you should know who these key customers are and what makes them important to your business so that you can focus your improvement efforts on meeting their needs profitably.



**TIP** Two common ways for supply chain managers to collaborate directly with key customers are through routine meetings and process improvement projects (see [Chapter 16](#)).

## *What Do Your Customers Value?*

Your supply chain creates value by addressing your customers' needs. You have many ways to gather data about the things that your key customers expect and are willing to pay for, including

- » Analyzing industry trends
- » Conducting surveys
- » Interviewing customers
- » Attending conferences
- » Sponsoring focus groups

As you gain new insights about what your customers value, use this information to choose the metrics for your supply chain (see [Chapter 14](#)). Ensuring that your supply chain is performing in terms of metrics that matter to your key customers helps you capture new customers, sell more to your existing customers, and introduce new products and services that address unmet needs.

## *How Could Your Supply Chain Create More Value?*

Companies can become comfortable — even complacent — about the relationships they have with their customers. This attitude is dangerous, of course, because what customers want and how much they are willing to pay will change over time.

There is often pressure to lower your prices to make your products more competitive. You should always be looking for ways to improve supply chain efficiency, because this can allow you to lower prices without sacrificing profits. But you should also be looking for opportunities to increase revenue by reaching new customers or making your product or service more valuable to your current customers. Selling products online can be a good way to connect with new customers, for example, and fulfilling online sales profitably often involves making significant changes in a supply chain.

## *How Do You Define Supply Chain Management?*

Many people use the term *supply chain management* when they're really talking about the procurement, logistics, or operations functions. To be effective in improving your company's supply chain, you need to have a broader perspective. A project that reduces procurement costs can end up increasing costs for logistics and operations, for example. As a supply chain manager, you should look across all three of these functions and identify the best end-to-end solution. You should also look beyond your own company and understand the effects that a change could have on your suppliers and your customers.

Driving down costs and improving performance in a supply chain require alignment across functions and between companies, so everyone needs to think about how their decisions affect the rest of the supply chain. Supply chain management should be viewed as the process of synchronizing the activities within your company and aligning them with your customers and suppliers.

# *What Information Do You Share with Suppliers?*

Your suppliers need to get certain information from you to maximize their value in your supply chain. Many companies put in effort to position themselves as strategic partners with their customers but then maintain a guarded, arms-length relationship with their own suppliers. It's also important to make sure that you're sharing information in a useful way. If the data you share is hard to interpret or changes too frequently, confusion may result. Here are two tips for sharing information successfully with your suppliers:

- » **Share all the information you can.** Decide what information to share with suppliers and what information to hold back. Some business information certainly needs to be protected, but not all of it requires the security of state secrets. In fact, you're probably better off sharing every piece of information that could be useful for a supplier unless you can identify a genuine risk from disclosing it.
- » **Ask suppliers what they want.** Talk with your suppliers to find out what information they want from you and how (and whether) they're able to get it. In many supply chains, one company assumes that another company is getting the information that it needs, but that assumption may be incorrect. The information could be hard to find or interpret, or it could be going to the wrong person in the company. The easiest way to identify and resolve gaps is to have a conversation with the supplier.

Sharing information with suppliers can help both your company and the supplier create more value.



**TIP** Many retailers have begun sharing sales and inventory information with their suppliers to reduce the Bullwhip Effect (see

Chapter 2). When suppliers have access to information about supply and demand in retail stores, they can do a better job of planning for future needs.

## *How Do You Compare with Competitors?*

You can find out a lot about how well your own supply chain is doing by benchmarking against other companies, including your competitors. You can do benchmarking informally by researching public information about your competitors. You also can do formal benchmarking by sharing data between companies or working with a research firm that collects data from many companies and provides them all benchmarking reports. One advantage of participating in a multicompany benchmarking study is that the study can allow participants to see how they're performing relative to other companies without having to reveal their identities.



**WARNING** Although sharing nonfinancial data with other companies for benchmarking studies is usually perfectly legal, it's illegal to share some information that could stifle competition. You probably can share information about your inventory turns, for example, but you probably can't share information about your prices. Before sharing any information with someone who works for one of your competitors, make sure that you understand what you can and can't discuss.

## *What Changes Could Increase Revenue?*

You have three ways to increase revenue, and each depends on effective supply chain management:

- » Raise prices.
- » Sell more stuff to current customers.
- » Attract new customers.

To raise prices, you need to be providing more value than your competitors. As long as you can deliver the product your customers want, when they want it, and where they want it better than your competitors do, you can charge more money.

If you're looking for ways to increase revenue by selling more stuff to current customers and attracting new customers, here are some specific goals that supply chain management can pursue:

- » Distribute your products through new channels.
- » Improve customer experience and increase brand loyalty.
- » Adapt your product, package, and processes to the needs of new customers.

Think about ways to increase revenue for your company and then get your supply chain team on board with those initiatives.

## *What Changes Could Lower Costs?*

Supply chain management decisions drive most of the costs for every company, so be on the lookout for opportunities to reduce the amount of money that you spend. Following are some supply chain savings to look for:

- » **Increase transportation capacity utilization.** By squeezing more valuable products into every shipment, you make better use of the money that you spend on transportation and lower your overall costs.

- » **Increase supply chain velocity.** By increasing the rate at which products move through your supply chain, you increase your return on investment. Inventory velocity can be measured with inventory turns. Shipment velocity can be measured with order lead times or transportation lead times. End-to-end supply chain velocity — how long it takes for a product to get to your customer — can provide important insights about where your products get stuck along the way.
- » **Reduce order variability.** Variability in order patterns is a well-known driver of costs in supply chains. Variability causes companies to build up inventory, which is expensive. Inventory swings amplify as they move up the supply chain, causing the Bullwhip Effect (see [Chapter 2](#)). Finding ways to make smaller orders more frequently and reduce variability can translate into significant savings by reducing both inventory and the chance of lost sales from stockouts.

Efforts that you make in each of these areas have direct and indirect benefits. The direct benefit is money added to your bottom line. The indirect benefits are reductions in waste and better utilization of capacity throughout the supply chain.



**REMEMBER** Often, 80 percent of a company's expenses are tied directly to supply chain decisions. Every dollar saved in the supply chain becomes profit for your company.

## *What Is Happening Around You?*

Supply chain technology is evolving quickly, and no supply chain manager can afford to ignore it. To stay competitive, keep your finger on the pulse of supply chain technology. Here are a few good ways to stay informed:

- » Read supply chain magazines and blogs.

- » Attend supply chain conferences and trade shows.
- » Subscribe to reports by supply chain consultants and analysts.
- » Stay active in a professional association.
- » Maintain communications with technology vendors.

You may not need to learn the ins and outs of every new technology that comes down the pike, but you need to have a sense of how new technologies can help you deliver more value to your customers, either by increasing revenue or reducing costs.

## *What Opportunities Are We Missing?*

You may have heard the saying “A leader needs to have a microscope in one eye and a telescope in the other.” Using your telescope to look at the future of supply chain management can make the field fun and exciting or terrifying and risky. Opportunities to transform supply chains with technology are all around us, and by recognizing those opportunities early, you can get a competitive advantage. Try to imagine ways that each step in your supply chain could be done differently with technology, and look for opportunities to create value in new ways.

In many cases, the technology doesn't change what is happening, but it does change how it happens. In other cases, new technologies could make an existing supply chain obsolete. The only way to measure risks and identify opportunities that come from technological innovation is to stay in touch with trends. Understand the value your supply chain provides to your customers and what additional needs aren't being met; then keep an eye out for new technologies that could help you meet those needs.

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## ***About the Author***

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You can follow him on LinkedIn

([www.linkedin.com/in/danielstanton](http://www.linkedin.com/in/danielstanton)) for fresh insights about supply chain management, project leadership, and the latest projects he is working on.

# *Dedication*

This book is dedicated to Ruth, my amazing wife and my partner in everything that matters. And to our daughters, our parents, and our families.

To my friend Ed Bond, who founded the Supply Chain Institute at Bradley University.

And to all the supply chain professionals who make our world better, safer, and more sustainable through the work you do every day, we all say, “thank you!” #AlwaysBeLearning

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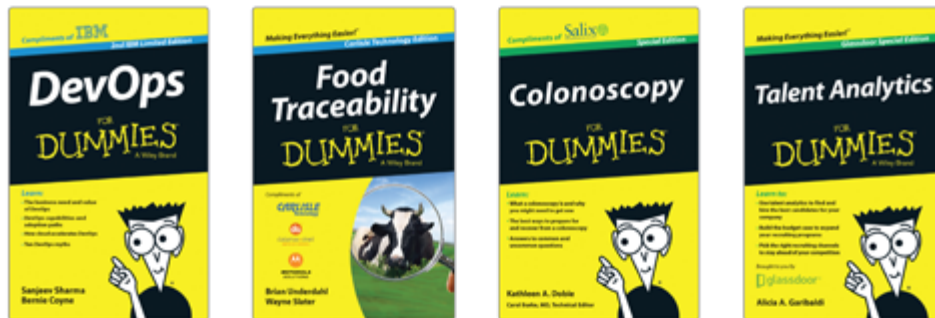
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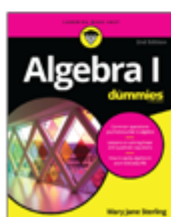
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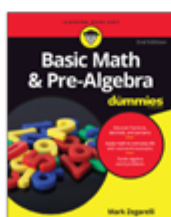
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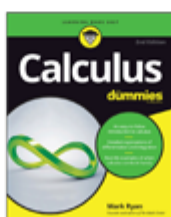
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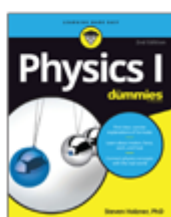
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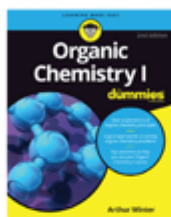
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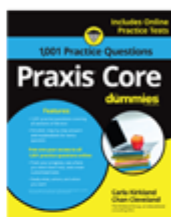
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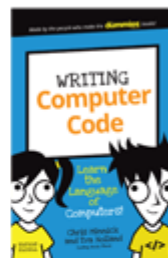
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