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The Effects of the Recession of 2008 on Manufacturing and Logistics Strategies of International Companies

The Case Study of East West Manufacturing

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INTRODUCTION

In early 2009, Frank-Walter Steinmeier, who was Germany's vice chancellor and foreign minister at the time, asserted during an interview with the *Financial Times* that the excessive "turbo-capitalism of the past few years is dead" (Rhodes & Stelter, 2010). In doing so, Steinmeier put in words what many in business were already fearing after the dramatic collapse of Lehman Brothers nearly half a year earlier: the climactic end of an era in business and the beginning of a period of repercussions that would be felt for many years to come. In fact, many simply did not believe that the markets could suffer this ensuing dramatic downturn in such a short period of time; nobody expected that a fast-growing gross domestic product could capsize so quickly, and that production and capacity utilization would be so profoundly affected.

In retrospect, the recession of 2008 has been a game-changing moment for the direction of today's business world. Fast forward to 2012, and it becomes clear that this prognosis is holding true. Indeed, the repercussions of the recession of 2008 are still omnipresent in the working lives of today's executives and managers. Even though it seems that conditions are improving, the problems and weaknesses that the recession has exposed are still overt: global trade imbalances, unstable financial institutions, and over-leveraged consumers.

This entails that today's global markets are characterized primarily through volatility and uncertainty, which inform an environment that is prone to shocks and disruptions. These conditions are especially strenuous for executives and managers when it comes to the strategies they use for their supply chains, which will be the principal foci for this study. Looking at supply chain activities actually provides suitable barometers for addressing the effects of the recession: (1) supply chains have grown more global and interconnected in recent years, so that their exposure to these unforeseeable shocks and disruptions has increased as well, and (2) they correspond with the collective business wisdom of a company, which makes them valuable observation sites for the ways that companies are being tested by today's market conditions. In fact, even with a fixed strategy, lean management, disciplined forecasting, and operations planning, companies

are still exposed to sudden disruptions in the market, which can turn even minor problems in a chain to major issues as they mount up from link to link.

All of this already indicates that due to the fact that changes occurring in the market are very rapid nowadays, they have a dramatic impact over a company's business models and supply chains. The recession has hit the business world with such a force in particular because the supply chains companies have in place do not have the ability to change at the same pace of today's market.

As volatility and uncertainty have been running rampant in the economy and playing cat-and-mouse games with volume, trade patterns, and economies of scale, companies have started to become aware that "the old ways" of doing business may not be feasible anymore. But this does not mean that global supply chain systems are inherently broken. Rather, it is a matter of re-aligning supply chains strategies so that they correspond with the demands of current market environments.

Therefore, in the current recovery period, in which economies are attempting to steady themselves, the question arises for companies how to best respond to these new challenging environments? This notion is clearly anticipated in Steinmeier's attestation: businesses are confronted with the end of an era and, correspondingly, with the emergence of a "new normal". What is this new normal? As an additional underlying belief in Steinmeier's quote, this new normal cannot be the ignorant pursuit of established and traditional supply chain practices but is attended by the importance of establishing a new mindset for competing in today's markets. Managers are now in the position that they have to find ways to adapt to these new circumstances. However, when it comes to finding new methods, managers actually should not assume that these new market environments demand radical changes to the ways they do business. In fact, the purpose of this thesis will be not only to highlight the magnitude and enduring nature of the changes induced by the recession of 2008, but also to investigate to what extent already established business practices are still feasible and valuable for today's markets. In doing so, this thesis will offer insights and practical suggestions for seizing the opportunities that are presenting themselves in the aftermath of the global recession. Ultimately, this thesis advances the claim that despite the new conditions of the market,

a reevaluation of existing theories for supply chain management can go a long way in making a company's supply chain more effective.

Chapter 1 will illustrate that businesses will have to adjust their business models to a number of new guidelines including reduced demand volumes and a new kind of value-conscious consumerism. This chapter will identify the changes that have occurred and what companies can infer with regards to rethinking global supply chain strategies.

Chapter 2 will emphasize that future global supply chains have to be based on flexibility. This means that interconnected networks of suppliers will have to collaborate more closely in order to leverage resources optimally, so that they are more prepared for both inevitable peaks and setbacks. To do this, companies have to reconsider the ways their supply chains operate. Here, manufacturing strategies will serve as a point of departure for illustrating that the new rules of the market require flexible and agile supply chains. By emphasizing that many approaches to manufacturing can still be considered valuable weapons to face the new challenges of the market, this chapter will, among others, stress the value of information and the great improvements of the entire system that are possible when information is shared among all the networks of the supply chain.

Chapter 3 will, then, move to describing a number of logistics strategies that can allow for a comprehensive and efficient approach to supply chain management in general and inventory management in particular, with specific emphasis given to the current problems posed by variability and uncertainty. Especially international companies can profit from a profound assessment of its logistic strategies because they see the challenges of the new market magnified by their global supply chain.

This chapter, then, segues into the case study presented in Chapter 4. The case study of East West Manufacturing not only illustrates the relevant concepts gathered from the analysis, but also critically tests them against the backdrop of a U.S.-based offshore manufacturing and supply chain management company. In the process, all areas of East West's supply chain will be examined also to identify areas where this thesis can offer suggestions for the improvement of the company's supply chain. Furthermore, East

West has been chosen for the case study because it is representative of those companies that, in the past, used to build their business models predominantly on high volumes.

This thesis attempts to show that the strategies that drive the success of a global supply chain in today’s market are actually already existing. The purpose will be to reevaluate them along the lines of their value in today's new market. This work will present valuable strategies for supply chain management and test them through a case study. These strategies for supply chain management will, then, be tested through the case study.

Chapter 1. Rethinking Global Supply Chain Strategies after the Recession of 2008

1.1. Preliminary remarks

In the past it was easy to identify the trends that were dominating the market and the paths that companies were using to manage their supply chains. Now global business players are faced with a different and new set of circumstances and rules. In this new environment, much of the way business used to work is not applicable anymore. Therefore, the approach that worked in the past cannot remain a valid way to describe future paths of the global market. One of the biggest implications of the current recession is that companies can no longer rely on the past as a good predictor for the future.

Nowadays, the key to succeed is to develop the ability to adapt to new situations quickly. Companies must rethink the way they structure their supply chains: the challenges of today's market call for a flexible approach to managing manufacturing and logistics strategies.

For international companies this is even more challenging because the market as well as competition is global and their supply chains are spread out all over the world.

The aim of this chapter is to provide a panoramic view of the new challenges and implications influenced by the current recession and to understand how a reevaluation of the drivers of supply chains can help companies to face the current fast-changing and fast-paced market environment.

1.2. Pre-recession approaches to the management of global supply chains

Looking backward, it is easy to describe the trends that have dominated supply chain management. In the 1980s, the attention of the business world was on just-in-time production and lean management. In the 1990s, and particularly starting around 1993, companies realized that there was a limit to the cost savings they could obtain from manufacturing. Therefore, they began to look for other ways to squeeze costs and improve operations performance at the same time. One way was to re-evaluate the

effectiveness of supply chains. Ultimately, there was a shift in focus to different forms of supply chain collaboration and outsourcing of logistics activities ("Your next supply chain", 2010).

Then, in the last decade, the Internet emerged. There was a lot of hope and excitement that the supply chain management would change with it. Phenomena like e-business gave rise to the belief that the mere use of the Internet for business models would potentially solve many of the problems surrounding supply chains. Companies expected e-business to reduce costs while increasing flexibility and profits. Even though the Internet can have a huge impact on supply chain performance, many times it did not deliver the expected results (Simchi-Levi et al., 2007).

For example, one of the industries that could have taken significant advantage from the Internet was the furniture industry. *Furniture.com*, launched in January 1999, was meant to offer thousands of products from several furniture makers (Simchi-Levi et al., 2007). At the beginning, it had great success: one million visitors per month to its web site and $22 million in sales during the first nine months. However, due to an inefficient delivery process, *Furniture.com* suffered a severe downfall in November of 2000. The company was initially using carriers to ship its products from a central warehouse to customers. Then, in order to reduce transportation costs, it formed an alliance with six distributors. However, this did not solve the problems that the company was facing, including handling of repairs and returns.

Another example of an industry that missed the expectations was online grocery. For instance, *Peapod.com*, founded in 1989 and based in Skokie, Illinois, was considered America's leading online grocer (Simchi-Levi et al., 2007). In 1999, the company had more than 130,000 customers and sales of $73 million. However, the same year, it generated a loss of $29 million. As with *Furniture.com*, *Peapod.com* failed because its business model was flawed by too high delivery costs.

These trends that have dominated supply chain management so far are not valid to describe future paths of the global market anymore. For international companies it is even more difficult to predict the direction of their markets. Six aspects that will become crucial in shaping the marketplace for international companies can be identified. These trends will all affect how companies manage their supply chain ("Your next supply chain", 2010).

- The first trend is *globalization*: this is a core force that affects companies and it is going to produce even stronger effects in the future. Globalization has created an environment that can be considered both beneficial and detrimental. For some, globalization has had the effect of creating new markets, new jobs worldwide, and cheaper products. Others believe that globalization has caused the destruction of traditional ways of conducting business. Talking about the effects of globalization, it becomes clear that there is a trade-off to consider: globalization creates new opportunities for individuals and cheaper products available for customers all over the world but it also expands the company's value chain at the expense of local jobs (Rivoli, 2009).
- The second trend is *the significant increase in logistics costs*. This aspect is directly associated with changes in transportation costs and inventory and it strongly affects companies that have a global supply chain, with suppliers and/or facilities far away from customers. For instance, because of energy prices, transportation costs have increased by more than 50% in the last eight years. As a consequence, inventory increased by more than 60% between 2002 and 2008. This is because companies try to take advantage of economies of scale by shipping larger quantities.
- The third trend is *the increase in the level of risk* that companies are exposed to. This is due to the use of strategies like lean manufacturing, offshoring, and outsourcing. Lean manufacturing, for instance, usually implies low levels of inventory: this makes the supply chain riskier because, in cases of disruption, it cannot meet the demand. The level of risk is also higher with offshoring and outsourcing, since these two strategies imply a more geographically widespread supply chain.
- The fourth trend is *the significant increase in labor cost in developing countries*. In the last eight years, the labor cost in China has increased on average 20% per year. By comparison, in the U.S. it increased 3%. The level of costs, of course, cannot be compared between these two countries but companies that made production or sourcing decisions based on labor cost a few years ago might need to rethink their decisions now.

- The fifth trend is the companies' increased *focus on sustainability*. This is particularly true in Europe, where this phenomenon is also called green supply chain. This trend will lead to an increase in regulations that companies must follow.
- The sixth trend is *the substantial increase in the volatility of commodity prices*, such as oil, steel, or coal. This is going to be a great challenge for most companies, especially for the major international ones. When companies sign contracts for the procurement of any of these commodities, it is not clear whether they should commit themselves for long or short term. It is all a matter of guessing how the market price is going to be. For instance, since the prices of oil were going up at the end of 2007, Northwest Airlines decided to sign a long-term deal to have a guaranteed price per barrel of oil through 2009. This was a bad decision because, after that, oil prices went down and the company was stuck with this long-term contract.

Managing the global supply chain is challenging because international companies have to face the combination of all these forces. They cannot concentrate only on one trend without dealing with all the others.

In addition to these circumstances, the world economy has been receiving heavy blows since 2008 which led to the deepest global financial recession since the 1930s. Major declines occurred in employment, output, and trade. GDP in developed countries tumbled by 4.5% in 2008, while the average real GDP growth rate in emerging economies dropped from 8.8% in 2007 to 0.4% in 2009. The unemployment rate boosted to 9% in OECD economies, and even more dramatically in industrial and developing countries. The fall of aggregate output was surpassed by the world trade volume, which dropped by more than 40% in the second half of 2008 (Alfaro & Chen, 2010).

Consequently, the current financial recession is not just another downturn in the global economy (Lane & Maeland, 2011). According to Tompkins (2011, p. 3), this recession can also be called Great Recession because it is global, worldwide significant, and, thus, concerns everyone.

The financial recession has dramatically amplified the implications of supply chain uncertainty (Malik et al., 2011). In the past, companies used planning tools that

analyzed past data and business trends in order to improve the reliability of forecasts for the future. These forecasts were certainly affected by several unknown elements, but it was not impossible to deal with them. One of the biggest implications of the current recession, however, is that companies can no longer rely on the past as a good predictor for the future.

1.3. The new rules of the game: doing international business after the recession

Today's business climate is characterized by risk, instability, and rapid change. And these conditions are not going to disappear once the effects of the recession will have loosened up. They affect the strength of all planning processes: strategic planning, contingency planning, and financial planning (Tompkins, 2011). Indeed, the outcomes of this crisis have not yet been fully understood.

Together with uncertainty, companies also have to deal with increased complexity. This is a trend that has not slowed down with the crisis. Companies, especially the international ones, now have to work harder to meet the increasing requirements of customers. International mobile-phone producers, for instance, introduced 900 more varieties of handsets in 2009 compared to what they had offered in 2000. Other categories of products were or have been affected by this trend as well: beverages, baked goods, and confectionery, for instance, boosted by more than 25% a year between 2004 and 2006. Moreover, the number of SKUs[1] in some large groceries in the U.S., such as Wal-Mart, exceeded 100,000 in 2009 (Malik et al., 2011).

The global financial recession of 2008 has changed the rules of the game. Pre-crisis rules were based on a relatively stable and predictable world that no longer exists (Tompkins, 2011). The crisis has offered companies the opportunity to reflect on the basic rules that run the market. According to Lane and Maeland (2011, p. 29), this crisis will hopefully lead to an actual evolution and not merely to a "huge anti-cyclical

[1] SKU or stock-keeping unit refers to the unique code used to identify a product or item for sale in a store or other kind of business. The use of SKUs enables companies to track their inventory and product availability in warehouses or retail outlets. SKUs are often used to identify different versions of the same item.

spending frenzy with a rejuvenated Keynes". These new rules, thus, require a new approach to managing the supply chain.

1.3.1. The importance of flexibility in global market environments

The key to succeed in the current marketplace is to develop the ability to adapt to new situations quickly (Tompkins, 2011). In this re-defined global environment in constant flux, success will go to the ones who demonstrate to be the most resilient. As Tompkins (2011, p. 3) states, "being adaptive is not about having a great plan, but being able to move and change quickly to stay ahead of the market". And it is impossible to do that if a company does not have a responsive supply chain to rely on.

The approach that needs to be used is to create flexible production and business strategies, which have to be feasible considering the position of the company in its market, its capacity, and its location in the supply chain respectively (Malindžák et al., 2011). Therefore, there is the need to define a flexible as well as adaptive model to face the new fast-changing international environment.

In times of financial and economic crises, companies need to be flexible in terms of business and fairly stable with regards to production (Malindžák et al., 2011). Companies that do not adapt their production models to changes in the marketplace risk losing market share as well as jeopardizing competitiveness. For international companies and their globally spread supply chains, achieving flexibility and keeping stability in the productions at the same time demand hard efforts.

An answer to this unstable international environment is to rethink about the manufacturing and logistics principles that companies uses. This will lead to strategies that are much more flexible because they are based on different models for organization, coordination, flows, production planning, and supply chain (Malindžák et al., 2011). That way, companies can brave themselves for these new challenges in a highly cost-effective way.

As already mentioned, the global financial recession of 2008 has led to massive changes in the international market, which will continue to have strong ramifications for companies all over the world. These changes are directly connected to changes in the demand and to the customer behavior. This is a new system with new challenges that Malindžák and others (2011) describe in the following way:

- reduced volume of orders;
- increased number of small orders;
- more production than demand;
- reduced product prices;
- fall in productivity;
- increased insolvency.

In order to react to these challenges, companies have to prepare themselves to respond quickly. There are specific goals that companies must keep in mind to successfully survive the recession. These are (Malindžák et al., 2011):

- to reduce uncertainty;
- to have a high manufacturing stability;
- to take full advantage of capacity;
- to preserve employment level as well as to keep market share;
- to meet due dates;
- to maintain manufacturing productivity.

The necessity for companies not to waste resources, either time or capital, has become stronger than ever. There are several approaches to manufacturing and logistics strategies that companies can apply to curb the implications of the current global recession and to achieve the goals above.

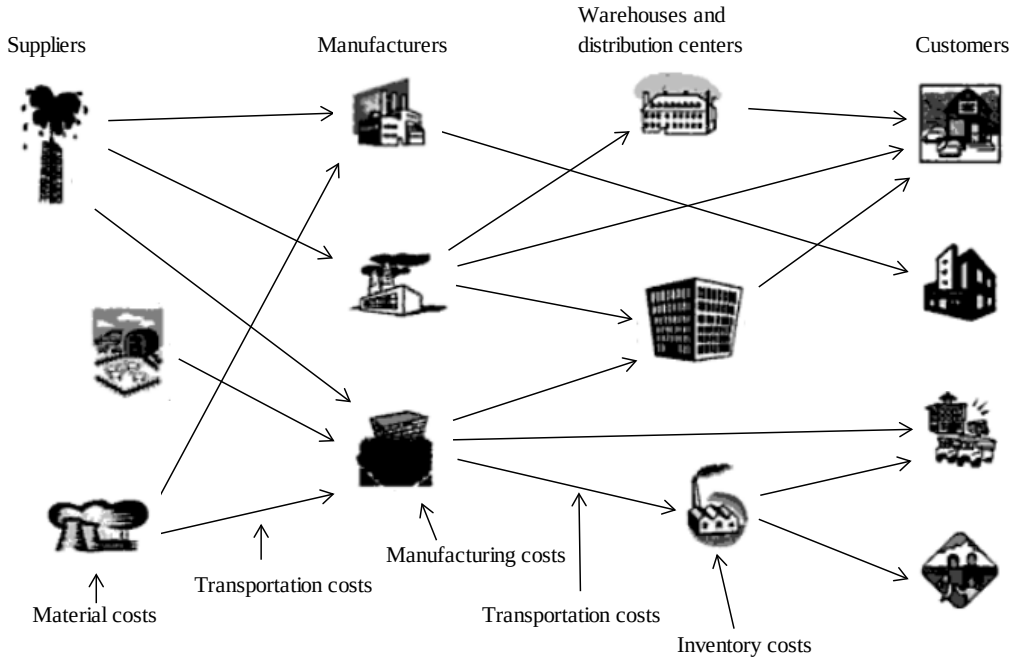
The aim of this thesis is to introduce them and to carefully analyze how companies, especially international ones, can implement them in their supply chain. The criteria for the analysis will be defined in accordance with the demands of international markets. Before doing that, it is important to illustrate how proper supply chain management can help companies to improve their performance.

1.4. What supply chain management really means for international companies

According to Simchi-Levi and others (2007, p. 1), supply chain management refers to “a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide

costs while satisfying service level[1] requirements". Figure 1.1 illustrates the supply chain management network which connects suppliers, manufacturing centers, warehouses, distribution centers, and customers.

Figure 1.1. The supply chain network



Source: Simchi-Levi et al. (2007), p.2

With regards to international companies, some further considerations need to be made before talking about their supply chains ("Global Supply Chain Management", n.d.). Due to increased globalization and the phenomenon of offshore sourcing, the aim of global supply chains is to reduce risks concerning production and to decrease overall procurement costs. Global supply chains differ from their traditional counterparts in the sense that integrated processes within the former involve one or more entities that operate in different countries.

The global profile of these supply chains brings additional difficulties that need to be addressed appropriately. First of all, the overall costs have to be mentioned. The costs of traditional supply chains are typically lower than of global supply chains. In fact, companies that implement a global supply chain have to deal with costs of tariffs, taxes, and other expenses encountered when doing business overseas. Another factor to

[1] Service level is the measure of the performance of a system. It is used in supply chain management especially as a measurement criterion of the performance for inventory policies.

consider is the exchange rate; this can significantly affect the convenience of having any kind of relationship - suppliers, production, or customers - with another country.

Lead time is one of the main factors that distinguishes traditional supply chain from global ones. Because of long distances, the lead times of global supply chains are significantly longer. Suppliers and/or production locations are likely to be far away from customers and, thus, global supply chains need to plan their activities appropriately. Furthermore, factors that relate to distance affect global supply chains. If a company has its production sites in areas, which are frequently hit by bad weather conditions, it is significantly impacted by potentially delayed production and shipping times. International companies with global supply chains have also to take into consideration regulations in different countries, which can require modifications in the production cycle. These are all issues that show that managing a global supply chain is more challenging than managing a traditional one.

A number of decisions need to be made when managing a global supply chain. First of all, companies must decide which activities to perform domestically and which to outsource or offshore. Even though it would be desirable to keep some steps of the supply chain closer to the company’s headquarters, other countries may be more convenient or technologically more advanced. For instance, India is becoming a high-tech center for outsourcing activities such as software development or services such as technical support. These developing centers for business attract a large variety of companies because service can be offered at very low rates compared to advanced business countries in the Western hemisphere.

Moreover, companies that want to establish global supply chains have to set aside resources to be able to select suppliers appropriately. Choosing an appropriate set of suppliers within a company's national environment can certainly be strenuous; but confronting this step in the planning process of a global supply chain can be even more troublesome. It is no surprise, then, that this step is one of the most, if not the most crucial step in setting up a global supply chain. That is why a company will be well advised to commission surveys to scout available suppliers in a sophisticated way in order to avoid the pitfalls of focusing too naively on low price suppliers without taking into consideration other cost-related elements such as infrastructure or tax rates. Furthermore, it is generally advisable to keep the number of suppliers low to make

supply chain management easier. Yet, this number needs to be large enough to confront the possible scenario of bottlenecks in delivery resulting from problems that individual suppliers might face at any given time.

With this, logistical considerations come into play. Companies, that have chosen to manufacture overseas, not only need to decide the number of factories but also where to place them. In order to find strategically suitable locations for factories it helps to consult the location and density of suppliers in certain areas that are part of the global supply chain. In fact, such an approach tends to benefit not only the supplier-manufacturer relationship but also allows for a much deeper level of collaboration. Especially this aspect is important to bring up since global supply chains, by their very nature, already entail the necessity to establish dedicated communication networks to foster coordination.

When managing the global supply chain, there are three main issues that must be considered (Simchi et al., 2007):

1. Strategies focused on global supply chain cannot be decided in isolation. In fact, they are directly affected by the development chain, which refers to the set of activities involving new product introductions. Moreover, global supply chain strategies must be aligned with a company's competitive strategy and goals (Chopra & Meindl, 2001).
2. The challenge of designing and managing the global supply chain is related to finding the right balance between total system-wide cost minimization and system-wide service level safeguard. The process of managing the supply chain within a global vision is also known as global optimization.
3. Cross-national supply chain management always involves dealing with uncertainty and risk. Especially in a time of crisis, this issue is even more present. Therefore, the global supply chain needs to be managed so that uncertainty and risk can be minimized.

All of these issues need to be considered when designing an effective supply chain strategy to meet the current challenges in international marketplaces.

1.4.1. Achieving the strategic fit

The competitive strategy of a company attempts to define customer needs and wants and to satisfy these with its products and services (Chopra & Meindl, 2001). In order to be successful, the supply chain strategy must fit the competitive strategy. Strategic fit means that both strategies have the same goals (Chopra & Meindl, 2001). This refers to the fact that a company must constantly monitor customer priorities, which the competitive strategy is assigned to satisfy, and support this strategy with an effective supply chain simultaneously.

All functions of a company's supply chain contribute to its success or failure. These functions operate in a system and they are not isolated (Simchi et al., 2007). Therefore, the failure of a single function can lead to the failure of the entire system.

Many times companies fail because they either lack strategic fit or their systems do not have the capability to support themselves. In order to achieve strategic fit, managers have to work on aligning all functional strategies with a global competitive strategy. If management is not committed to do it, many conflicts between different functional goals can arise, which will lead to conflicts during execution since different processes and resources are structured to support different functional goals (Chopra & Meindl, 2001). For instance, if marketing advertises the ability of the company to provide a large variety of products and, at the same time, distribution applies a less expensive transportation strategy by delaying orders to group several orders together and get better transportation economies, this system will not succeed and, therefore, it will not achieve strategic fit.

To explain the importance of achieving strategic fit, it is good to use a practical example (Chopra & Meindl, 2001). Dell Computer is able to offer a large variety of products at a reasonable price by allowing its customers to select among a wide range of possible configurations. Usually, a PC manufacturer has several options for its supply chain. On one extreme, it can focus on an efficient supply chain by producing low-cost PCs and by limiting variety and, thus, taking advantage of economies of scales. On the other extreme, a PC manufacturer can have a highly responsive supply chain by offering a large variety of products. Of course, in the second case costs will be higher than in the first one. Dell is able to apply a strategy that takes advantage of both efficiency and responsiveness. In fact, Dell Computer found a great strategic fit between its

competitive strategy and its supply chain strategy. Its products are designed to be easily customizable: it uses many common components in its products and it designs common platforms which are shared across several different products. In this way, Dell is able to take advantage of economies of scale throughout the entire supply chain. Moreover, these features allow Dell to assemble customized PCs quickly and, thus, be more responsive to customer demand. Dell Computer has clearly achieved strategic fit by structuring its functions and, more in general, its supply chain in such a way to support its competitive strategy.

But how can a company achieve the strategic fit? There are three basic steps to follow (Chopra & Meindl, 2001): understand the customer, understand the supply chain, and achieve the strategic fit.

Step 1. Understand the customer.

In order to understand the customer, a company has to identify wants and needs of the customer segment that it hopes to satisfy. There are several attributes that help to distinguish customer demand from different segments (Chopra & Meindl, 2001):

- *Quality of the product needed*. For instance, an order released for an emergency of material needed to repair a production line will probably be small, while an order for material needed for a new production line will mostly be large.
- *Response time tolerated by customers*. For an emergency order, the response time is likely to be short, whereas it will probably be longer for a regular order.
- *Variety of products*. Especially for emergency orders, customers might be willing to pay a high premium if all the products needed are available from a single supplier.
- *Service level*. Obviously, when a customer places an emergency order, it expects a high level of service and of availability of products. With regular orders, though, customer could accept a longer lead time.
- *Product price*. The customer who places an emergency order is usually less sensitive to price than a customer with a regular order.
- *Desired rate of innovation*. Customers of exclusive or technological cutting-edge products expect a faster rate of innovation in products compared to

customers of stores like, for example, Wal-Mart, that are less sensitive to product innovation.

Although there are several attributes that distinguish customer demand, it is additionally useful to identify one key measure to capture the difference of all these attributes. Even though customer attributes should be viewed separately, each of them can also be translated into a metric called implied demand uncertainty (Chopra & Meindl, 2001). In contrast to demand uncertainty, which is the uncertainty of customer demand for a specific product, implied demand uncertainty refers to "the resulting uncertainty for the supply chain given the portion of the demand that the supply chain must handle and the attributes the customer desires" (Chopra & Meindl, 2001, p.30). For instance, a company facing only emergency orders for a specific product will have a higher implied demand uncertainty than a company that has to deal with a longer lead time for the same product. An example of the need for distinction between demand uncertainty and implied demand uncertainty is the impact of service level. As a supply chain increases its service level, it must be able to satisfy a higher percentage of actual demand. At the same time, this means that the supply chain has to be prepared to handle unusual surges in demand. Therefore, a higher service level leads to an increase in implied demand uncertainty, even though the demand uncertainty related to the product does not change.

Step 2. Understand the supply chain.

After understanding the customer and the characteristics of the demand, it is important to detect how to create a supply chain strategy which can best meet the specific type of demand (Chopra & Meindl, 2001). There are several different kinds of supply chains that a company can decide to implement. They can be placed on a spectrum according to their characteristics. When describing the different kinds of supply chains it is important to underline the trade-off between responsiveness and efficiency.

Supply chain responsiveness refers to the ability of the supply chain to:

- respond to different ranges of product quantities requested;
- offer a large variety of products;
- meet short lead times;

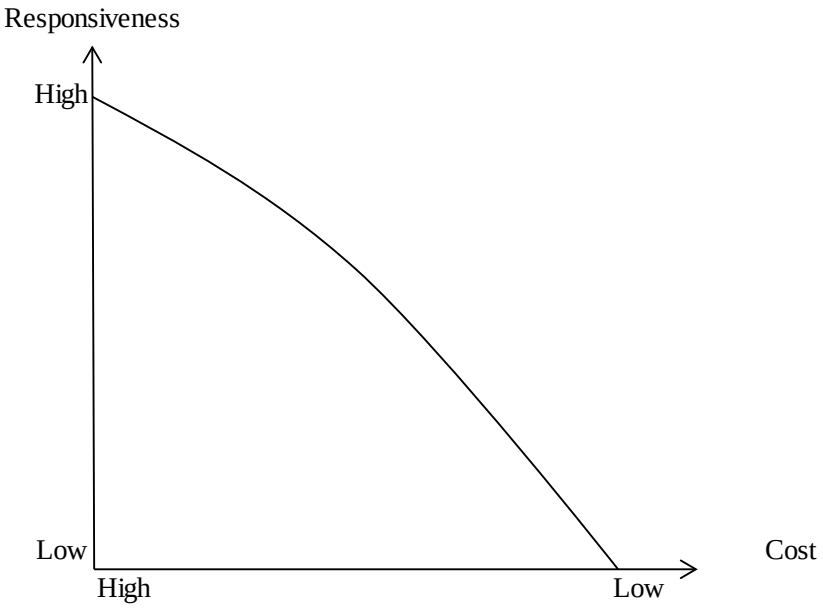
- have a high rate of product innovation;
- satisfy a very high service level.

However, having a highly responsive supply chain has its costs. For instance, being able to offer a large variety of products increases costs, because more capacity is required, and it lowers efficiency.

According to Beamon (1999), supply chain efficiency refers to the measurement of how well the resources are utilized within the supply chain.

Figure 1.2 illustrates the cost-responsiveness efficient frontier, that is, the lowest possible cost for a given level of responsiveness (Chopra & Meindl, 2001). The efficient frontier assumes constant technology advancement.

Figure 1.2. The cost-responsiveness efficient frontier



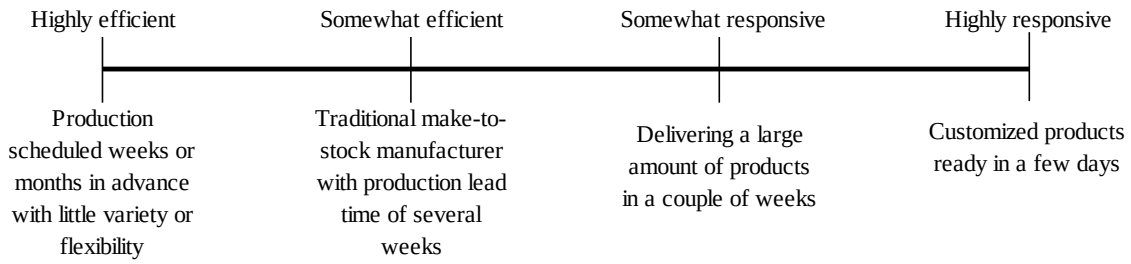
Source: Chopra & Meindl (2001), p.33

Not every company is able to perform on this frontier. In fact, the frontier refers to the cost-responsiveness performance of the best supply chains. A company which is not positioned on the efficient frontier can improve both its efficiency and its responsiveness to customer demand by moving toward the frontier. A company which is on the efficient frontier, instead, can improve one of the two variables only by decreasing the value of the other. This company, thus, will have a trade-off between efficiency and responsiveness to consider. Moreover, the company that stays on the

current frontier can also increase the rate of technology advancement and, thus, shift the frontier to the right, that is, to better performance in terms of both efficiency and responsiveness.

As already mentioned, supply chains can range from those that are efficient to those that are responsive. Figure 1.3 shows the different kinds of supply chains according to their grade of efficiency and responsiveness.

Figure 1.3. The efficiency-responsiveness spectrum



Source: Chopra & Meindl (2001), p.33

An example of a highly responsive supply chain is 7-Eleven (Chopra & Meindl, 2001). The company offers different items for breakfast, lunch, and dinner. Therefore, the variety of products managed by 7-Eleven is really high. Indeed, store managers place replenishment orders less than 12 hours before they are supplied. Thus, 7-Eleven can be considered a company with a very responsive supply chain.

In contrast, an example for a company that applies an efficient supply chain can be Sam's Club (Chopra & Meindl, 2001). This company has a limited variety of products and it sells them in large package sizes. The focus of Sam's Club is clearly on keeping costs down.

There are also some examples of companies that were able to find a good balance between efficiency and responsiveness. As mentioned earlier, Dell Computer is able to offer a large variety of products to its customers focusing efficiently on the design of components and platforms that can be used for several different products.

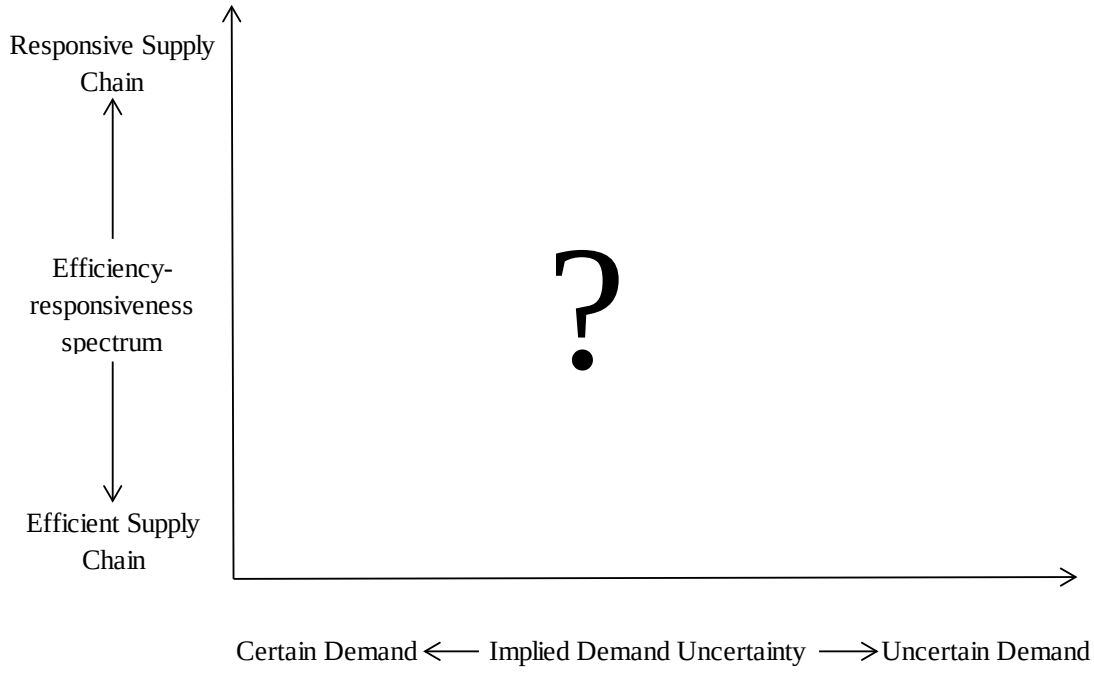
Step 3. Achieve the strategic fit.

After measuring the demand according to its level of implied uncertainty and understanding when the supply chain can be considered efficient and responsiveness, the third step is to achieve the strategic fit, that is, to make sure that the structure of the

supply chain will be consistent with the targeted customer needs. Therefore, the degree of efficiency/responsiveness of the supply chain should meet the implied demand uncertainty (Chopra & Meindl, 2001).

To combine these two concepts it is useful to look at Figure 1.4 in which implied demand uncertainty is located on the horizontal axis and the efficiency-responsive spectrum is located on the vertical axis. This graph can also be called uncertainty/efficiency-responsiveness map.

Figure 1.4. Uncertainty/Efficiency-responsiveness map



Source: Chopra & Meindl (2001), p.34

The implied demand uncertainty refers to the customer needs, while the efficiency-responsiveness spectrum represents the supply chain strategy. Of all the possible combinations of these two variables it is important to find the ones that result in strategic fit (Chopra & Meindl, 2001).

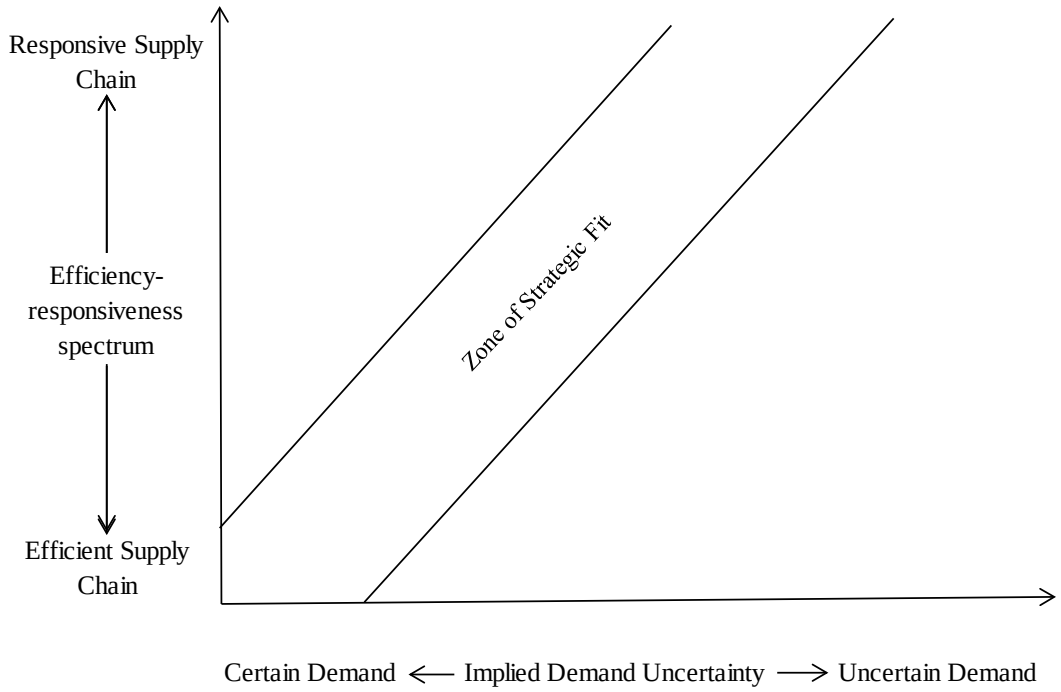
Considering the Dell Computer example once again (Chopra & Meindl, 2001), the company's competitive strategy targets customers who want to be able to customize PCs according to their needs. Indeed, they require short lead times for delivery. Since Dell customer demand is characterized by a large variety of products offered, a high innovation rate, and a fast delivery requirement, the company has to face high demand uncertainty. Dell has to choose which kind of supply chain will better fit this demand.

An efficient supply chain will lead Dell to take advantage of economies of scales but, at the same time, it will lead to an increased delivery lead time since it will have to utilize inexpensive transportations modes. Therefore, an efficient supply chain will have difficulty supporting Dell customer demand. This kind of customer demand is best satisfied by a responsive supply chain, which allows Dell to meet the needs of its customers by having a wide variety of products and low delivery times.

Now, consider the example of an Italian pasta manufacturer, Barilla (Simchi et al., 2007). Since pasta is a commodity product, its demand is relatively stable. Therefore, Barilla will have to face a lower implied demand uncertainty than Dell Computer. This kind of customer demand, thus, does not require a very responsive supply chain, which would even increase the costs of a product that, by definition, has to be kept low. Thanks to the characteristics of its demand, Barilla can plan its production in a way to exploit economies of scale and focus on cost reduction.

It follows from this discussion that in order to achieve strategic fit the higher the implied demand uncertainty, the more responsive the supply chain must be (Chopra & Meindl, 2001). This relationship is graphically shown in Figure 1.5.

Figure 1.5. Find the zone of strategic fit



Source: Chopra & Meindl (2001), p.35

For any given level of performance, companies should work on their competitive strategy, as well as on their supply chain strategy in order to enter the so called zone of strategic fit, which locates the most appropriate combinations of these two variables (Chopra & Meindl, 2001).

All company functions within the value chain must have strategies that are able to support the goals of the competitive strategy, as well as maintain the efficiency and/or responsiveness of the supply chain.

Adopting strategies to achieve strategic fit might sound easy, but most of the time this is quite difficult. Two main points are important to underline here (Chopra & Meindl, 2001):

- the supply chain strategy cannot be considered independently from the competitive strategy;
- for any given competitive strategy, it is fundamental to find the right supply chain.

Most of the time, failure to achieve strategic fit is a major reason for companies to not be successful.

Communication between the different functions of the company is essential to achieve the strategic fit. Moreover, there always has to be coordination done by high-level management in order for the global system to work (Chopra & Meindl, 2001).

Due to the aforementioned unique issues that international companies need to face, achieving the strategic fit is more challenging for them. Every single step of their global supply chain strategy has to work in such a way to allow the achievement of the goals of their global competitive strategy. As a result, the management must focus on creating an environment that fosters high collaboration and coordination throughout the entire global supply chain.

1.4.2. The drivers of supply chain performance

To understand how a company can improve its supply chain in order to face the new challenges and implications of the recession of 2008, it is important to define the drivers of supply chain performance. These are (Chopra & Meindl, 2001, p.50):

- *Facilities*. These are the places where products are fabricated, assembled, or stored. Factories can be divided into production and storage sites. Decisions

regarding a facility's flexibility, capacity, and location have a substantial impact on supply chain performance. For instance, a distributor who wants to be responsive to changes in customer demand will benefit from many warehousing facilities located close to its customers, even though this leads to reduced efficiency. In contrast, a distributor who is focused on achieving high efficiency would have fewer warehousing facilities and, thus, increase efficiency at the expense of responsiveness to customer demand.

- *Inventory*. There are three different types of inventory: raw materials, work in process, and finished goods. This is an important driver of performance because inventory policies can strongly affect supply chain efficiency and responsiveness. For example, on the one hand, several clothing retailers can be more responsive by storing large inventory. This increases the likelihood to satisfy customer demand. At the same time, however, this increases retailer's cost as well, and, thus, it decreases its efficiency. On the other hand, reducing inventory will increase retailer's efficiency but it will seriously affect its ability to be responsive to customer demand. Therefore, it is extremely important to find the right amount of inventory to hold.

- *Transportation*. This refers to moving inventory throughout the supply chain. There are several different transportation modes and combinations, each of which can be more suitable for a different kind of supply chain. The choice of the most appropriate transportation mode for a specific supply chain is particularly important since it affects a company's ability to respond to customer demand while still being efficient. For example, companies can choose to rely on a package delivery companies like UPS to be more responsive to customer needs. Less expensive ground transportation modes can also be used to increase efficiency.

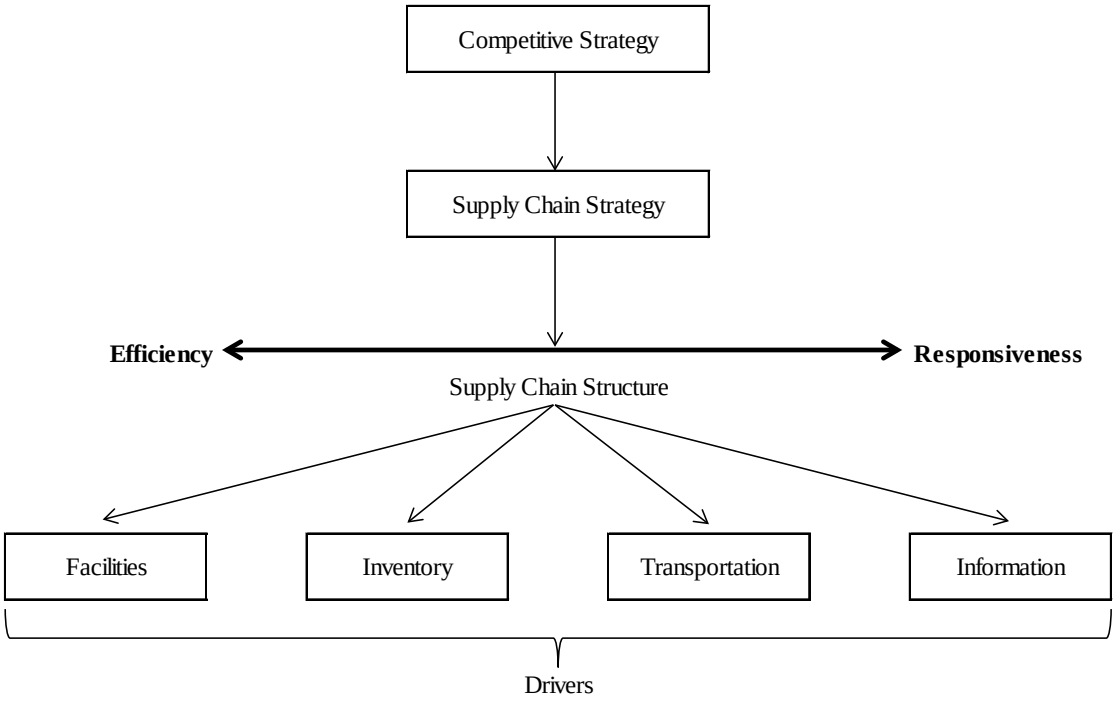
- *Information*. This consists of significant data regarding all the other drivers and, therefore, it can be considered the major driver of supply chain performance. Knowing how to use information can lead to great improvements all across the supply chain. For instance, when analyzing customer demand patterns, a grocery company can order and stock products in advance and, thus, predict customer

demand because customers will find those products in store that they need. Using information about demand can also make a supply chain more efficient because it leads to better forecasts and, thus, the company can make more precise production planning and place accurate orders to suppliers. This, however, becomes more difficult to do in a time of crisis. There are also other ways in which information can be useful to make the supply chain more efficient. For instance, information can allow a company to have a better overview of shipping options so that it can choose the alternative that allows savings in cost while meeting service requirements.

In order to achieve the strategic fit, the supply chain has to work on these four driving forces, and the management needs to find the strategic fit for each of them. The result of the combination of the four drivers determines the level of efficiency and responsiveness of the supply chain (Chopra & Meindl, 2001).

Figure 1.6 provides a visual framework of the supply chain decision making.

Figure 1.6. Supply chain decision-making framework



Source: Chopra & Meindl (2001), p.51

Initially, most companies begin with formulating a competitive strategy and, then, decide what the supply chain strategy should be focused on. The supply chain strategy

determines the degree of efficiency and responsiveness of the supply chain. Although this process is usually done from top to bottom, sometimes the analysis of the four drivers can underscore the need to change the supply chain structure, the supply chain strategy and, potentially, the competitive strategy (Chopra & Meindl, 2001).

An example of an international company will help to explain how the supply chain decision making framework works within a global environment (Chopra & Meindl, 2001). Wal-Mart's competitive strategy is based on the goal of being a reliable low-cost retailer that offers a wide variety of goods to customers all over the word. This strategy culminates in a global supply chain focused on efficiency but, to some extent, also on responsiveness. Wal-Mart needs to work on the four drivers in order to be able to achieve a successful supply chain performance.

With regards to the inventory, the company keeps an efficient supply chain by having low levels of inventory. For instance, Wal-Mart was among the first to apply the concept of cross-docking, a system in which distribution centers serve only as transfer points and do not hold inventory (Simchi-Levi et al., 2007). Goods spend only brief time in distribution centers, where they are split into trucks to be delivered to different stores. This enables the company to keep costs down since inventory is held only at store level, not at both store and warehouse levels. With regards to this driver, Wal-Mart chose to focus on efficiency.

From the transportation standpoint, the company decided to favor responsiveness over efficiency. In fact, the benefit of having a transportation system that is responsive to customer demand justifies the high cost and investment.

Concerning facilities, Wal-Mart decided to keep the number of facilities low and, therefore, to take advantage of the benefits that come from efficiency. In fact, the company has a few central distribution centers which serve a wide network of stores. When Wal-Mart consider building a new facility, it does that only if the management believes that there is enough demand to justify it, thereby increasing efficiency.

Wal-Mart considers information a fundamental resource and, therefore, the company invested significantly more on this driver than its competitors. First of all, information helps Wal-Mart to improve its responsiveness to the market. Moreover, the company shares information all over the supply chain up to suppliers, enabling them to program their production according to the actual demand from the final customer (Simchi-Levi et

al., 2007). In this sense, the large investments required to be able to share demand information have resulted in significant improvements in terms of both efficiency and responsiveness.

Wal-Mart is a great example of how an international company is able to use the supply chain decision-making framework in order to achieve strategic fit and maintain a supply chain that supports the goals set by the global competitive strategy. This company worked on the four drivers and structured its global supply chain accordingly to balance efficiency and responsiveness so that its competitive strategy and supply chain strategy can be in harmony.

The analysis of the four drivers of supply chain performance can be used as a framework to introduce ways to face the effects of 2008. As already mentioned, flexibility is central to successfully overcome these challenges. In the next chapters, several approaches to manufacturing and logistics strategies will be presented. They will be based on these drivers and will help to illuminate how companies can implement more flexible supply chains. Particular attention will be given to how international companies can apply these approaches to the complexities that their global supply chains need to confront.

CHAPTER 2. Manufacturing Strategies after the Recession

2.1. Preliminary remarks

One of the biggest challenges for companies since 2008 has been the need to respond to decreased levels of demand from customers and increasing degrees of volatility and uncertainty. Furthermore, companies now have to deal with ever shortening product and technology life cycles as well as with fiercer competition in the marketplace.

In order to survive in the market, companies must learn to deal with uncertainty. Management can respond to it with a manufacturing strategy which is designed to adjust to uncertainty in a defensive way or to take control over the circumstances proactively.

No matter whether the management decides to react passively to environmental cues or to structure initiatives to actively shape the environment, one of the most significant lessons that the current recession has already shown is the need to reevaluate established methods for manufacturing strategy.

Here, the decrease in demand volumes has made it more and more difficult to take advantage of economies of scale and keep a good level of productivity: these two were among the fundamental sources of profit for many companies in several manufacturing industries.

Moreover, the variety of product offerings required by customers keeps increasing: this, of course, does not help to find ways to standardize production and keep manufacturing costs low.

For international companies, the globalization of markets is an additional challenge. They now need to find ways to better serve markets worldwide while taking regional differences into consideration (Cavusgil et al., 2008).

Similarly, uncertainty has become part of the current business world. Instead of seeing it as an additional obstacle to face, however, companies should treat it as an opportunity to rethink about the way they manage their supply chains and manufacturing strategies. Hence, uncertainty can turn into a means as a weapon to gaining competitiveness and succeed internationally.

Based on these remarks, the literature offers different approaches to manufacturing strategy which can be successfully applied to the new market conditions. These will be

presented to illustrate how companies can face the great uncertainty brought by the recession of 2008.

2.2. Global supply chains and manufacturing strategies after the recession

As many authors believe, economic recessions provide unique possibilities to reflect about the directions that international companies take with regards to manufacturing and how, in more general terms, they structure their global supply chains. Recently, a big debate has been about outsourcing decisions. In the last few years, companies have started to compare the total costs of manufacturing products overseas in countries like China and delivering them to Western countries to avoid the costs of producing closer to the end customer ("Return of Manufacturing from China", 2012). Many supply chain executives have been questioning those decisions and consider to "in-source" some of their most crucial activities to tighten control over supply chain performance. This is a trend that has been noticed especially in the automotive industry, where 27% of companies are currently discussing or have already started to apply this approach ("Recession is Forcing Rethink of Supply Chain Strategies", 2009). Caterpillar Inc., for instance, announced in 2011 the expansion of its U.S. operations with the construction of a new manufacturing facility in Victoria, Texas. As Gary Stampanato, Caterpillar vice president, stated, "Victoria's proximity to our supply base, access to ports and other transportation, as well as the positive business climate in Texas made this the ideal site for this project" (Corbel, 2012).

Among the main priorities for international companies one in particular has become urgent: increased cash flow and working capital. According to Gordon Colborn ("Recession is Forcing Rethink of Supply Chain Strategies", 2009), director of PRTM[1]'s Global Supply Chain Innovation,

> "The global economic recession has put global supply chain networks to the test. Faced with increasingly unpredictable demand and tighter requirements from lenders, companies are forced to look at all activities through the lens of liquidity. For many, this means reducing inventory, and increasing collaboration with, and even financially supporting, their key suppliers".

[1] PRTM is a subsidiary of PwC, one of the largest management consulting organizations worldwide. PRTM operates on the areas of supply chain innovation, product innovation, operational strategy, and customer experience innovation.

Product complexity is another issue that international companies confront. The management of these companies is currently in the process of redesigning the planning of sales and operations in a way to reduce complexity in their products. This is a way in which companies can reduce costs without having to increase value-added features or services of the product and, thus, having to boost revenues. This is a pattern followed by 71% of international companies ("Recession is Forcing Rethink of Supply Chain Strategies", 2009). For instance, Hewlett Packard, considered one of the best companies in the field of supply chain management, is famous for its supply chain simplification program, which is grounded in a profound analysis that starts from the complexity present in each product (Hofman & Aronow, 2012).

Another priority for international companies is definitely to address the flexibility of their global supply chains. The ability of companies to maintain a cost-effective production process during large and unpredictable demand fluctuations is considered one of the most crucial factors for global supply chains to succeed. "The recession has sharply degraded the reliability of demand and supply forecasts beyond a three-month window. This explains why more than half the … [supply chain executives] say that supply chain flexibility is even more critical than just six months ago", notes Colborn ("Recession is Forcing Rethink of Supply Chain Strategies", 2009).

As far as decisions regarding manufacturing strategies are concerned, it is easy to recognize the significance of flexibility when dealing with uncertainty. However, at the operational level, concerns rise about the specific methods of doing it. One key point is to translate flexibility requirements into performance goals (Gerwin, 1993). Consequently, when designing a manufacturing strategy, the management will always have flexibility as an objective to achieve in mind.

2.3. The importance of agility in the supply chain

In times of recession, it is important for international companies to focus on creating a more flexible manufacturing as well as supply chain strategy. This means that companies have to achieve a greater agility within their systems so that they can respond sooner to changes both in volume and variety requested by customers (Christopher, 2005). In other words, they need to find ways to quickly adjust

manufacturing outputs to match market requirements and to rapidly switch from one variant of product to another.

Being able to achieve agility and to match supply with demand does not necessarily mean to focus solely on "leanness". In fact, "leanness" is not a synonym for agility but it can be an important element. According to Christopher (2005, p.117), leanness "is about doing more with less". Leanness has its origins in the Toyota Production System (TPS) and had its focus on cost reduction and waste (*muda*) elimination, as well as on optimization in the use of resources (Monden, 1983).

According to Lambert (2008), lean thinking applied to the supply chain is the use of the principles of the lean production to line up activities across a company's functions and to manage relationships between the company and its customers and between the company and its suppliers. In the world of business lean manufacturing plays an important role, not only in relation to the automobile industry (Womack et al., 1990), but also in relation to other industries such as retail: Tesco, for instance, implements a lean production system (Titze, & Krasojevic, 2012).

The lean approach seeks to minimize waste (*muda*) across the whole supply chain, to standardize process, and to optimize core resources. The purpose of lean manufacturing is to create the greatest value for customers at the lowest cost for the manufacturer thanks to real time synchronization between customer needs and optimal supply (Malindžák et al., 2011). In order to apply the lean thinking to manufacturing strategy, the entire supply chain of the company needs to be responsive to satisfying changes in customer need, as well as flexible to adapt its assets and production to changes in the demand. Moreover, lean thinking is also focused on the continuous improvement of processes and employees' skills across the entire supply chain (Ross, 2008).

According to Abbott and others (2005), six attributes characterize lean thinking capabilities:

1. demand management capability: the product should be "pulled" by actual demand rather than "pushed" by the company into the market;
2. cost reduction and waste (*muda*) minimization: lean thinking is truly focused on reducing any kind of useless waste such as time, inventory, redundancy, and even digital waste;

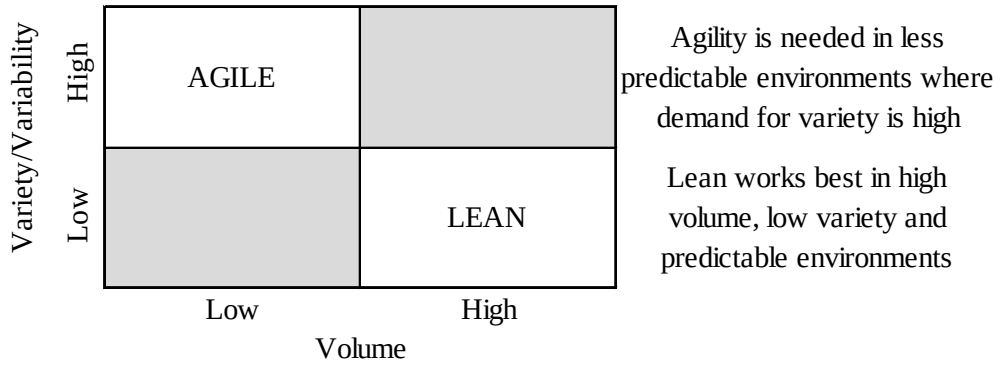
3. process and product standardization: it is fundamental to standardize both process and product as much as possible;
4. industry standards adoption: lean manufacturing is not only a matter of the particular supply chain but it involves the industry overall;
5. cultural change: a lean manufacturing strategy is possible only if its concepts are embraced and implemented by people involved in it;
6. cross enterprise collaboration: in order for lean manufacturing to be successful, all participating supply chain partners must work collaboratively to apply all its fundamentals and maximize value for customers.

Although "leanness" might be thought of as an element of agility, it does not help companies to meet customers' needs more rapidly by itself. In fact, lean thinking works well when customer demand is relatively stable, the environment predictable, the volume high, and the variety of product offering relatively low. However, when demand is volatile, the environment less or not predictable, and customer requirement for variety high - as during the current recession - companies must meet a higher level of agility (Christopher & Towill, 2001). The purpose to meet the high variety that customers want is the reason why Rich Morris, vice president of BMW, believes that the future for the automobile industry lies in an agile approach to manufacturing rather than a lean one (BMW says flexible, not lean, is the next big thing in autos, 2009):

"The disadvantage [of lean systems] is that customers may have to compromise on colors, features and options they didn't really want. BMW customers can change their orders within five days of when their car is built. That's much later in the process than other brands"

Figure 2.1 illustrates the different contexts in which the lean and the agile concepts should work best.

Figure 2.1. Agile or Lean?



Source: Christopher (2005), p.118

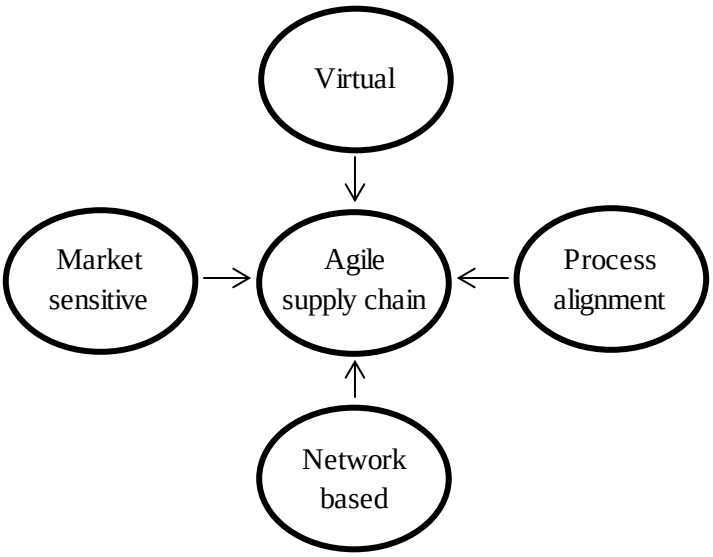
Moreover, it could be argued that the automobile industry, one great example of lean manufacturing, is one of the least agile industries in the market (Christopher, 2005). Webster's Dictionary makes the distinction between "leanness" and agility even more clear: it defines lean as "containing little fat" and agile as "nimble".

Agility is a concept that needs to be applied not merely within individual international companies but, more importantly, in relation to adjoining networks (Christopher, 2005). In fact, a key concept when thinking about an agile response is that the presence of agile partners within the global supply chain is fundamental. For example, even though a company has a very rapid response within its internal processes, its ability to be agile will be constrained by suppliers that have long replenishment lead times. Therefore, we can derive the concept of the agile supply chain.

International companies and their networks will not succeed if they adopt only a single lean or agile supply chain strategy throughout. Rather, each product made by the international company determines the kind of supply chain that needs to be set up (Christopher, 2005). Thus, using multiple supply chain solutions has become much more preferable than adhering to the rather traditional "one size fits all" strategy. Therefore, different types of product within a company will require different strategies each according to any given product's intrinsic characteristics.

In order to be agile, a company has to structure its manufacturing strategy as well as its entire supply chain according to some conditions (Christopher et al., 2004). These conditions are illustrated on Figure 2.2.

Figure 2.2. Conditions of the agile supply chain



Source: Christopher (2005), p.121

First of all, to apply an agile strategy the supply chain has to be *market sensitive*. This means that the supply chain has to be capable of reading the demand and be closely connected with end customer trends (Malindžák et al., 2011). Many companies in the past were forecast-driven rather than demand-driven. In other words, they used to make their forecasts from data on past sales and convert them into inventory. Nowadays, this kind of practice has ceased to be successful. Thanks to great enhancements in information systems, forecasts can be continuously adjusted by capturing data about demand directly from constantly updated point-of-sales. This helps companies to develop the capacity to listen to the market and respond quickly to its changes (Christopher, 2005).

The widespread use of information technology also helped to create a *virtual* supply chain, in the sense that data between buyers and suppliers are easily shared. Therefore, the entire supply chain is designed to rely on shared information. Electronic Data Interchange (EDI) and the Internet allow supply chain partners to base their activities on the same data, rather than to rely on pieces of information that are inevitably distorted when orders are transmitted from one step of the supply chain to another (Christopher, 2005).

Another important characteristic of the agile supply chain is *process alignment*, which refers to a high degree of interconnectivity between network members throughout

the entire process (Malindžák et al., 2011). Process alignment can take the form of joint product development, collaborative work, common system, and shared information (Christopher, 2005). At this point, it is important to underline that, due to the undoubtedly convenient and resource-saving practice of sharing product development costs and expertise, the business world is moving fast toward so called "extended enterprises": this refers to the concept of having no boundaries and strong commitment and trust between supply chain partners.

This leads to the fourth characteristic of agility, the *network*. As already mentioned, individual companies can no longer compete as stand-alones. In order to be successful, they rather need to be part of a great supply chain (Christopher, 2005), of networks characterized by high levels of collaboration and synchronization between members respectively. The challenge of today's world is to take advantage of the strengths of each player to gain flexibility of the entire supply chain.

2.3.1. Principles for creating agile supply chains

Structuring an agile supply chain is definitely challenging, especially because it involves not only the company itself, but also the entire supply chain network. In order to create a successful agile supply chain, a number of basic principles can be identified (Christopher, 2005):

1. *Synchronization and shared information*. New technologies help companies to collaborate on inventory and capacity planning, thereby enabling different members of the supply chain network to share information and align their processes to real demand. Companies can, then, collaborate on inventory and capacity planning. Fast moving customer goods (fmcg) are a great example of synchronization. In fact, retailers enhance their performance by sharing point-of-sale data with manufacturers. For instance, the web-based system created by UK's biggest retailer, Tesco, called Tesco Information Exchange (TIE) is an extranet that enables Tesco's suppliers to access sale data of their own products. Data have details item by item and are updated several times a day. TIE helps manufacturers to better schedule their production and to better fulfill Tesco's replenishment requirements. Another example can be found in the automobile industry. Car manufacturers work with "seamless" processes with their first tier

suppliers: by providing access to production plans, this system enables a just-in-time delivery so that there is no need for major buffers of inventory of first tiers.

2. *Supply chain restructuring*. Several studies have shown that companies often spend time on activities that create more costs than actual value for customers. Business process re-engineering (BPR) is a concept that refers to the simplification of activities and the reshaping of corporate processes to achieve the desired outcome in shorter time and at less cost. The length of processes is often caused by the way they are structured: activities are performed in a linear way, that is, in "series" one after the other. Many times it is possible to re-engineer processes so that activities can be performed in parallel simultaneously. Therefore, it is not a matter of doing things more quickly, but differently. In order to create a more agile supply chain, companies can also analyze their processes in order to find, and possibly eliminate, non-value adding activities. There are many practices in business that are being performed for historical reasons. However, when the justification for those practices is not valid anymore, such as changes in market conditions, the management should reconsider those practices and make the right changes to them.

3. *Inbound lead time reduction*. Many times companies prefer to have a long and stable relationship with their key suppliers. Opportunities exist to make this relationship strategically significant as well as reduce inbound lead time. For instance, one way to improve collaboration and responsiveness is via the so called Vendor Managed Inventory (VMI). This practice allows the manufacturer to manage the inventory of its own products at the retailer outlet. The retailer no longer places orders, but it shares information on sales, instead. Hence, the manufacturer has direct access to real demand data and, since it does not have to rely on forecasts made by the retailer, it can manage its production more efficiently as well as decide how much inventory it wants to keep and where (Simchi-Levi et al., 2007). Both the customer and the manufacturer benefit from this practice: the customer through higher levels of service and the manufacturer through better reliability of information that it can use to enhance its performance, reduce its safety stock, and, often, make a better use of its capacity.

4. *Complexity reduction*. Complexity is highly related to the concept of supply chain. Areas that can be negatively affected by complexity include different varieties of products within the same family but with greatly differing bills of material, different pack sizes and shapes, or frequent product changes. Complexity is also boosted by processes that are composed of several different stages. Simplification can be an answer to complexity but, unfortunately, this is not always a possible solution. However, there is always the chance to question the reasons why things are done in a certain way. For instance, does product variety correspond with the requests of customers or is there an imbalance? Many times operations, sales and marketing departments do not talk enough to find the right balance between variety and related costs of product offerings. Therefore, a method to achieve simplification is by seeking more commonality of components or processes across product families. For example, nowadays the automobile industry is trying to assemble many different models of cars from the same platform or from shared common parts. On a conceptual level, complexity has the ability to compromise agility; in a very practical sense, complexity also functions as a major factor regarding increases in costs.

5. *Process-based not function-based management*. For many years companies were organized upon division whereby activities were managed based on a functional mentality. Many studies show that function-based companies are usually slower to respond to changes in the market (Christopher, 2005). This is because there are many “hand-offs” since components and sub-assemblies are handed over from one function to another: this inevitably leads to longer response times. On the other side, companies that are more focused on managing processes usually respond more rapidly to changes. Whereas functions are managed vertically, processes are managed horizontally and they are cross-functional by definition. Moreover, they are often led by interdisciplinary teams. Process-based management is critical when achieving agility because process alignment is clearly facilitated when companies are managed horizontally.

6. *Performance metrics*. Many studies demonstrate that performance measurement shapes the way companies behave. In functional-based companies these measurements are focused on cost reduction, productivity improvement, and

asset efficiency. Even though these goals seem desirable, they are not aligned with the concept of agility. For example, if the performance of a facility is based on minimizing the unit cost of production, this means that management will produce for big batch sizes in order to take advantage of economies of scale. This, however, will lead to an increase of inventory and, thus, will reduce flexibility. If, instead, a company's metrics try to reduce cycle-time, this means that set-up and other kinds of time-wasting activities will be the focus of the attention. This last example of metrics encourages agile thinking. When a company is trying to achieve agility, it is a helpful practice to relate processes to customer-based metrics. For instance, a great metric to use is called "perfect order achievement". Companies achieve a perfect order when the customer gets the product when customers receive their products not only exactly as ordered but also when needed (Christopher, 2005). A fundamental driver of agility is customer responsiveness. Therefore, in order to achieve an agile supply chain, the members of the network need to concentrate their attention on it when choosing which metrics to use. International companies like Sony and Canon are applying metrics such as "time to market" and "time to volume" to rapidly respond to customer demand, which is characterized by short product life cycles and fast changing technologies.

In the past, companies strongly focused on efficiency, with a strong emphasis on cost reduction. This is certainly still an important objective, but nowadays the focus should be moved to effectiveness (Christopher, 2005). In other words, the uncertainty in today's market should lead companies to work on the flexibility of their processes and to be more responsive to the many changes that occur. Agility is strongly related to the attitudes that people who work for a company express towards it. It is not a matter of working more diligently, but to acknowledge that every member of a company needs to have the right mindset for agility. To accept changes and have the right people who are able to quickly adjust to them is never easy; however, those companies that are able to do it are the ones that will succeed in these new market conditions. This is the logic that both the individual companies as well as their entire supply chains need to consider when thinking about agile strategies for manufacturing in these new uncertain market environments.

2.4. Push-pull strategy

Traditionally, manufacturing strategies are divided into two main categories: push and pull. The origin of this classification can be found in the manufacturing revolution of the 1980s (Simchi-Levi et al., 2007). More recently, several companies belonging to different industries have started to employ a hybrid approach to manufacturing, the push-pull strategy, which combines the two strategies together so that companies can be more flexible and respond better to demand uncertainty, as well as trying to be efficient.

All of these approaches to a manufacturing strategy will be presented in the following pages and it will be explained how the push-pull approach can provide solid solutions especially for facing the new challenges of the market after 2008: uncertainty and volatility in demand.

2.4.1. The difference between push strategy and pull strategy

In order to recognize the advantages of a push-pull approach, it is important to first understand the individual characteristics of these two strategies separately.

Companies applying a push strategy to their manufacturing system base production decisions on long-term forecasts (Simchi-Levi et al., 2007). For this approach, production is planned in anticipation to customer orders (Chopra & Meindl, 2001). Since demand is not known at the time of execution, the manufacturer has to rely on orders that he receives from the retailer's warehouses. There is no access to point-of-sales data and the manufacturer plans his production based on forecasts. Therefore, it takes much longer for a manufacturing strategy, which is based on a push approach, to react to changes in the market. According to Simchi-Levi et al. (2007) this leads to:

- the inability to meet changes in demand;
- the problem of keeping a high level of inventory;
- the risk of obsolescence of inventory as demand evolves.

In addition, data that the manufacturer uses to plan his production do not come from the actual customer demand: this inevitably leads to an inefficient utilization of resources. For example, it is very difficult for the manufacturer to determine the production capacity needed. It is not clear if level of capacity should be chosen either to satisfy peaks in demand, which means that the manufacturer will be ready to face peak demand with the simultaneous downside of having resources idle, or cater to the

average demand, which entails that peaks in demand can only be served with extra, and very expensive, capacity (Simchi-Levi et al., 2007). Push strategy may also be defined as speculative strategy since it responds to speculated rather than real demand (Chopra & Meindl, 2001).

With a pull strategy, instead, production is demand driven. It is planned in coordination with the actual customer demand in mind. In its purest sense, the manufacturer does not hold any inventory and he only responds to specific orders once they are placed by customers (Simchi-Levi et al., 2007). That is why it is important for the manufacturer to have access to information about actual demand through point-of-sales data, which means that the various participants of the supply chain have to share information about the demand of final customers. Pull strategy can also be considered as reactive strategy since it is bound to wait until the actual customer demand is certain and, then, react to it (Chopra & Meindl, 2001).

The pull strategy seems attractive because it leads to (Simchi-Levi et al., 2007):

- a decrease in lead times since it can better help to plan production according to actual orders;
- a decreased inventory both at the retailer's and at the manufacturer's location;
- an increase in reliability of data, since they come from weekly or even daily updated actual orders rather than from forecasts.

Compared to the push strategy, the pull strategy can bring a company to reduce its level of inventory, to improve its ability to manage resources, and to decrease costs.

However, a pull strategy is usually more difficult to implement, especially for international companies which have a supply chain characterized by such long lead times that it becomes almost unfeasible to react to changes in demand. Moreover, since this strategy is demand driven, it is more difficult to take advantage of economies of scale (Simchi-Levi et al., 2007).

2.4.2. Understanding the push-pull strategy

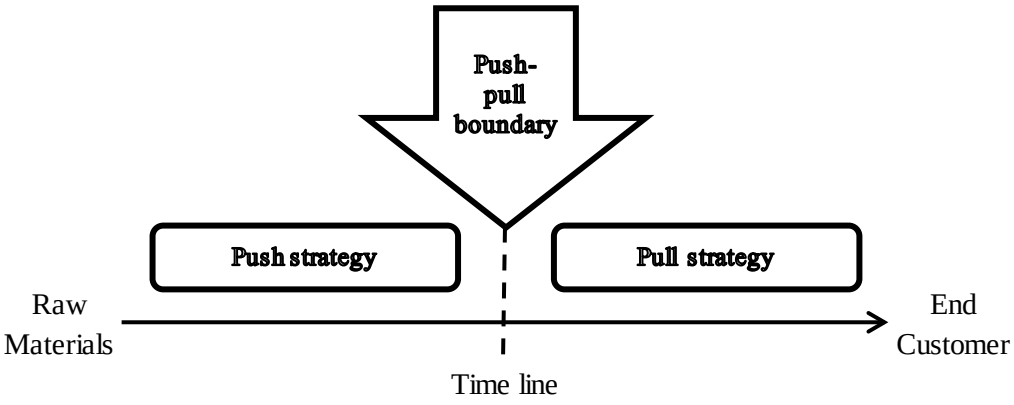
The push-pull strategy is an approach to manufacturing that combines push and pull strategies. It is especially useful when considering strategic decisions which concern the entire supply chain design, not only with regards to the individual manufacturer. This approach forces companies to have a global mindset because its focus lies on optimizing

the performance of networks as a whole while providing the customer with the best possible service level (Chopra & Meindl, 2001).

The push-pull strategy tries to keep the advantages of both push and pull by pushing usually the initial stages and pulling the remaining stages of the entire supply chain. Between these two stages there is an interface which is commonly called push-pull boundary.

In order to better comprehend this strategy, consider a time line which embraces the time between procurement of raw material and the delivery of the order to the end customer (Simchi-Levi et al., 2007). The push-pull boundary, located along this time line, indicates the point where the company switches from one strategy to the other, typically from a push to a pull strategy. Figure 2.3 shows a graphical illustration of this concept.

Figure 2.3. Push-pull strategy



Source: Simchi-Levi et al. (2007), p. 190

When a manufacturer wants to use a push-pull strategy, he can, for example, build inventory for components based on forecasts, but make the final assembling specifically geared to requests received from customers. Therefore, the push portion of this manufacturer's strategy is the portion before assembling activities, while the pull portion is the one that involves activities from assembling once the actual demand from customers has been revealed (Simchi-Levi et al., 2007).

An interesting observation to make at this point is that, using the push-pull strategy, the manufacturer is able to take advantage of the fact that aggregate forecasts for an entire family of products for example, are more accurate than forecasts for specific

products. If a group of products shares some common components, it is clear that the demand for a common component can be derived from the aggregated demand for all finished products that use that specific component. Uncertainty in the forecasts will be less for shared components compared to finished products that share a particular part (Simchi-Levi et al., 2007). This leads to the reduction of safety stock that the manufacturer should always have available.

Dell Computer is a great example of the effective implementation of the push-pull strategy for an international company (Simchi-Levi et al., 2007). Initially, the company had implemented a pure pull strategy: instead of keeping inventory of components, it placed orders to its suppliers only when it received data from actual demand of final customers. When Dell started to grow, this approach to manufacturing was not possible anymore because the complexity and the lead time became unfeasible to manage while ensuring a high service level. Therefore, the company switched to a push-pull strategy designing its products in such a way to have as much common parts as possible. Hence, it is now able to keep a low inventory level of common parts and to build actual products only when orders are placed by final customers. Dell is able to carry significant lower safety stock than other companies in the same industry, such as Compaq. Since Compaq has to storage finished products at the retailer, it uses a push strategy that forces it to assemble to stock. Therefore, Compaq has to plan its production based on demand forecasts for each individual product (Chopra & Meindl, 2001).

The push-pull strategy helps Dell Computer to enhance its performance while improving forecasts, reducing both inventory costs and safety stock, and keeping a high service level. This company, ranked fourth in the Gartner Supply Chain Top 25 for 2012, has been able to implement this strategy thanks to its ability to employ design-to-value techniques and to steadily reduce product complexity (Hofman & Aronow, 2012).

With regards to product design, the so called postponement or delayed differentiation is an excellent example of a push-pull strategy. According to Chopra and Meindl (2001), postponement can be described as the ability of the supply chain to delay the differentiation and the customization of a number of products as much as possible before products reach final customers. By delaying decisions regarding specific product's actual production parameters as much as possible (Simchi-Levi et al., 2007),

the push-pull boundary is moved as much as possible to the right side of the time line so that the products can be kept non-specified for as long as possible (see Figure 2.3).

The portion prior to the differentiation is managed using a push strategy. In other words, a generic product is built according to aggregate long-term forecasts. Since the forecast for a generic product is the aggregation of the demand for a variety of different products, it is more accurate and inventory levels can be reduced (Simchi-Levi et al., 2007). Of course, the portion after the differentiation applies a pull strategy because products are differentiated and customized according to the specific demand that is, then, revealed.

Table 2.1 illustrates a numerical example of how a push-pull strategy can help decreasing the level of safety stock required for a manufacturer.

Table 2.1. Marginal benefit of component commonality

Number of finished products per component	Safety stock	Marginal reduction in safety stock	Total reduction in safety stock
1	399,699		
2	282,63	117,069	117,069
3	230,766	51,864	168,933
4	199,849	30,917	199,850
5	178,751	21,098	220,948
6	163,176	15,575	236,523
7	151,072	12,104	248,627
8	141,315	9,757	258,384
9	133,233	8,082	266,466

Source: Chopra & Meindl (2001), p. 205

A great example of postponement is the system implemented by the Inditex group and, more specifically, by its brand Zara (Hofman & Aronow, 2012). Its strategy is to buy large quantities of fabrics and raw materials in advance in order to take advantage of economies of scale. Then, its production process and supply chain are structured in such a way that the company decides how to use and combine these components according to demand information it receives with a nonstop flow from stores right before and even during the selling season.

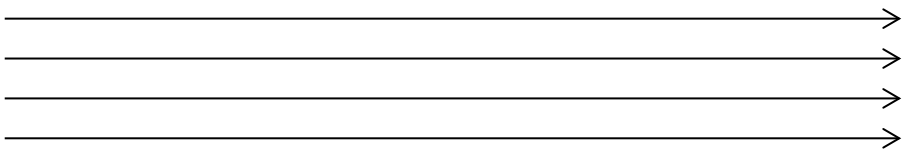
Another example of this strategy is the production process that Benetton has utilized to make colored garments (Chopra & Meindl, 2001). The traditional process was structured in the order of drying, knitting, and then assembling garments. This process required up to six months and, since colors had to be chosen from the very beginning, it

necessitated up to six months of forecasts. Benetton developed a manufacturing technology that allowed it to purchase, knit, and assemble garments before drying them. Hence, Benetton would dry garments much closer to the selling season. Part of the drying could even be done after a season started, according to the actual demand. In this way, Benetton was able to postpone the color customization of its products. When it purchased fabric, it could rely on aggregate forecasts, which were likely to be more accurate. As the selling season moved closer, forecast uncertainty for each specific product decreased. Thus, Benetton could start drying garments according to a higher degree of accuracy of actual demand.

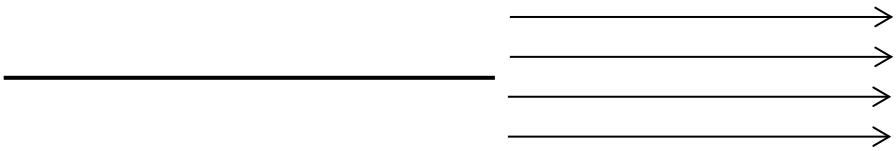
Benetton has used the concept of postponement to exploit demand aggregation and significantly reduce inventory costs as well as safety stock without hurting product availability.

Figure 2.4 shows a graphical interpretation of manufacturing strategies with and without the use of postponement.

Figure 2.4. Manufacturing strategy with and without postponement



Manufacturing strategy without postponement



Manufacturing strategy with component commonality and postponement

Source: Chopra & Meindl (2001), p. 205

Coming back to the push-pull strategy, it is good to underline that it can be a powerful weapon for e-commerce industries (Chopra & Meindl, 2001). When customers choose to order online, they implicitly agree to wait some time to receive products. This delay allows companies to locate the push-pull boundary later in the time line, so that they can build inventory for generic products and, thus, reduce safety stock before differentiating products according to customer orders. In order to be able to apply

a push-pull strategy it is important to have a manufacturing process designed to enable a quick assembling so that the manufacturer can be responsive to customer requests, as, for example, Dell Computers was able to do.

The major benefit of a push-pull strategy is that it allows the manufacturer to better match supply with demand. However, the downside of this strategy is that the cost of a production system that uses a push-pull strategy is usually higher than the one of a system that does not use it. For example, the production cost at Benetton is 10% higher than a traditional production system for garments (Chopra & Meindl, 2001).

Another example in this sense is the multinational hardware and software company Hewlett Packard (Simchi-Levi et al., 2007), which ranks among the best supply chains in the world (Hofman & Aronow, 2012). Its strategy for products, like printers, exploits the concept of the push-pull strategy. The company produces all its printer models based on aggregate forecasts, without thinking about where these products will be sold. The problem of selling printers in several markets is that power plugs used all over the world differ in design and applied load. The Hewlett Packard strategy is geared towards assembling the printers ready for some markets such as the U.S., and, in the case, of European markets, for example, sending the products to its European distribution center that has the appropriate means to equip the printers with the correct power plug. This method allows the company to delay the decisions of the differentiation of printers in different European markets, since it can rely on an aggregate and more accurate forecast for the entire European market. However, this also leads to higher costs because printers must be packed, sent, and unpacked at the European distribution center in order to take care of the last assembly step (equipping the correct power plug) before packing the finished products and delivering them to the different markets.

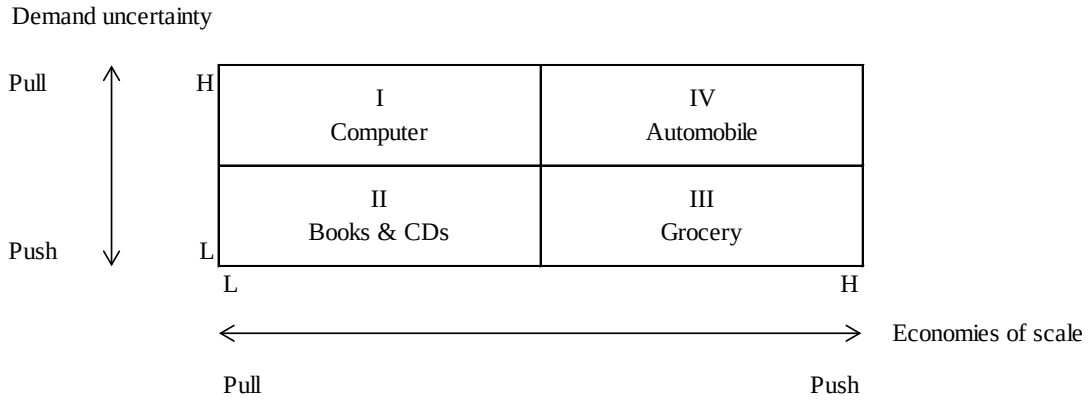
Therefore, the push-pull strategy is a great way to answer to uncertainty and volatility of the demand, as during the current recession. The benefits gained with this strategy, however, have to be viewed in connection with the associated increase in production cost (Chopra & Meindl, 2001).

Push strategy, pull strategy and push-pull strategy are approaches that are essentially connected to the characteristics of the demand and the industry of a company. It follows that companies have to analyze those characteristics to determine the best approach to

use in their supply chain. The following pages will investigate several examples to show how these manufacturing strategies should be implemented.

Figure 2.5 provides a framework for finding the right strategy to use according to different products and their industry (Simchi-Levi et al., 2007). The vertical axis illustrates the degree of uncertainty in customer demand. The horizontal axis shows the degree to which economies of scales can be exploited.

Figure 2.5. Find the appropriate strategy: the impact of demand uncertainty and economies of scale



Source: Simchi-Levi et al. (2007), p. 191

If the demand uncertainty is high and everything else remains equal, it is preferable to use a pull strategy: this can help to avoid the problem of dealing with long-term forecasts which are most likely wrong. If the demand is less uncertain, long-term forecasts are more reliable and, so, a push strategy can and should be used.

Similarly, if the importance of economies of scale in reducing costs is high and everything else stays equal, it is important to plan the production on long-term forecasts: this leads to the use of a push strategy. If economies of scale are not important a pull strategy would be more appropriate.

From Figure 2.5, it is possible to derive four different situations, each of which, indicated with a number, is referred to as an example of a product that has these characteristics.

Box I illustrates products with high demand uncertainty and low importance of economies of scale. From the framework it can be deducted that a pull strategy fits better with this situation. This is exactly the strategy that Dell Computer had applied before it reached a dimension that was not manageable anymore, as discussed earlier.

Box III is a situation characterized by low demand uncertainty and high economies of scale. This is the case of many grocery products, such as pasta and beer. These products have a quite stable demand, while, in order to make profit, it is important to take advantage of economies of scale. Using a pull strategy would not be appropriate since it is hard to take advantage of economies of scale with it. Instead, a push strategy is more correct since the manufacturer can use long-term forecasts to plan its production accordingly.

Boxes I and III refer to situations in which it is quite easy to detect the most appropriate strategy to use. The other two cases, boxes II and IV, are more difficult to analyze because there is a mismatch between what demand uncertainty and economies of scale suggest to do.

Box II illustrates a situation in which low demand uncertainty, that indicates a push strategy, has to coexist with low economies of scale, which suggest a pull strategy. Products such as books and CDs belong to it. If a manufacturer falls into this category, a more careful analysis is needed. A push-pull strategy could be appropriate in this case.

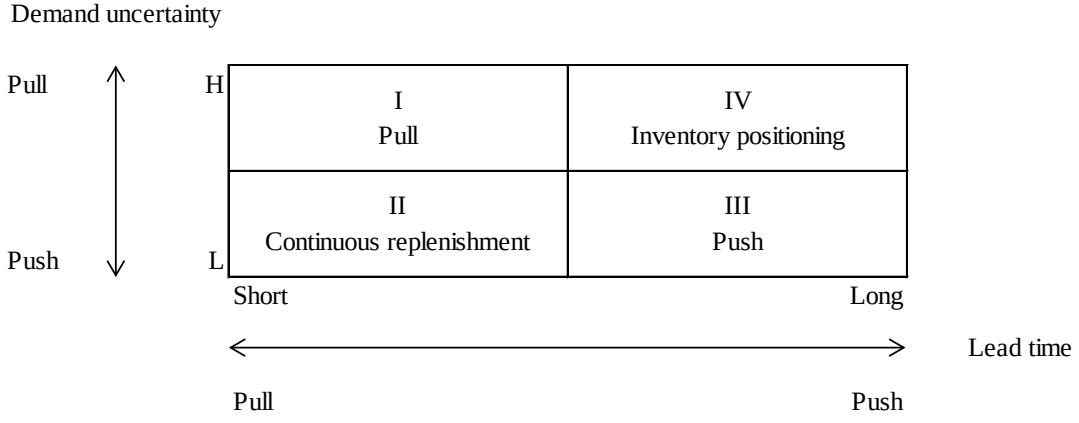
A great example of this is the multinational electronic commerce company Amazon.com which is considered one of the top supply chains in the world (Hofman & Aronow, 2012). With regards to fast-moving and high-volume products, Amazon keeps inventory at a few central distribution center warehouses and it manages them by using a push strategy (Simchi-Levi et al., 2007).. Then, when orders from customers arrive, it satisfies them through the delivery of products wherever they are required, without having many warehouses just to be closer to customers. In fact, having many warehouses would mean to locate inventory, most of the time of duplicated items, in each of them without knowing if that will be enough or too much. For slow-moving and high-volume products, instead, Amazon applies a pure pull strategy by ordering them from its suppliers only when they are actually requested from customers.

Finally, box IV refers to a situation in which there is uncertainty in the demand and economies of scale are very important in reducing costs. A great example in this sense is the automobile industry. A typical car manufacturer has to offer a large amount of products which might differ in functionality, color, number of doors, and so forth. As a result, demand uncertainty for a specific configuration of a product is very high. Indeed, it is very important for car manufacturers to take advantage of economies of scale to

reduce the incidence of costs on each single item. Traditionally, car manufacturers have applied a push strategy by keeping inventory and using a dealer distribution system. However, knowing about the possibility to switch from a pure push strategy to a push-pull strategy, the multinational automobile company General Motors (GM) tried to chance the way it approached the market (Simchi-Levi et al., 2007). GM created a system with which customers could choose, order their cars online and have them delivered to their place in less than ten days. By keeping inventory only for certain components that needed to stay with a push strategy due to lead times of 50 or 60 days on average, the company wanted to control the remaining steps of its production process in correspondence with actual orders from customers, that is, switching to a pull strategy. In order to achieve this goal, the company had to rethink its entire supply chain, signing special agreements with partners and suppliers, redesign its production system, and restructure its distribution organization. Indeed, in order to ensure deliveries within ten days, GM had to significantly reduce the number of options offered to customers. This was a good idea that GM devised especially in view of the special characteristics of its industry. Unfortunately, this project did not successed. The problem was that it seems difficult in the automobile industry to get rid of the entire system of dealers spread out all over the market.

When talking about push, pull, and push-pull approaches, another interesting relationship to consider surrounds the impact of demand uncertainty and lead time on the appropriate strategy to use (Simchi-Levi et al., 2007). Figure 2.6 shows a graphical framework of it.

Figure 2.6. Find the appropriate strategy: the impact of demand uncertainty and lead time



Source: Simchi-Levi et al. (2007), p. 195

As in Figure 2.5, the vertical axis illustrates the degree of uncertainty in customer demand. The horizontal axis shows the length of lead time.

If the lead time is short it is possible to apply a pull strategy and wait for the customer demand to be revealed, since the service level is not really affected by lead time. In contrast, if the lead time is long a pull strategy is not applicable because it becomes extremely important to plan manufacturing according to long term forecasts in order to offer a satisfying service level.

Box I illustrates a situation characterized by short lead time and high demand uncertainty, which suggests the use of a pull strategy. Again, the computer industry is an example that perfectly describes both these conditions.

Box III is constituted by long lead time and low demand uncertainty. Examples of this situation can be found in the grocery industry. In the case of many grocery's products, such as diapers, washing powders, and pasta, there is a long supply chain, which implies long lead time, and the demand remains fairly stable over time. Therefore, it is possible to use long forecasts to plan manufacturing: there are quite accurate.

More challenging situations are the ones that present characteristics represented in boxes II and IV.

Box II is described by short lead time and low demand uncertainty. This is the case for grocery's products with a short life cycle, such as dairy products. These are products that, by definition, cannot be supported by a long lead time. Indeed, it is difficult to predict customer demand since slight changes can occur on a daily basis, but these kinds of product, unfortunately, perish very fast.

In order to face this kind of situation, the grocery industry uses a strategy called continuous replenishment. This is an advanced version of the basic quick response strategy, in which the manufacturer receives point-of-sales data from retailers and he uses them to improve its forecasts and plan its production and inventory in order to reduce lead time. The continuous replenishment strategy, also called rapid replenishment, is considered an evolution of the quick response strategy because the manufacturer receives point-of-sales data and he uses them to organize shipments in regular intervals in order to keep a specific level of inventory at the retailer location (Simchi-Levi et al., 2007).

Continuous replenishment uses an approach that combines push and pull strategy within the supply chain: the pull portion of this supply chain is at the production and distribution stages. Then, the pull portion starts at the retailer location with it inventory management. The multinational Procter & Gamble (P&G) has been one of the first to implement this strategy. Continuous replenishment allows the company to connect the customer demand to its supply chain and to optimize decisions across the entire supply chain network (Hofman, & Aronow, 2012).

The most difficult situation to manage is described in box IV, where there is high uncertainty in the demand and the lead time is long. In this situation, inventory management, and especially its positioning, is critical. This is, for example, the case of many manufacturers of metal components for the automobile industry. Different stages throughout the entire supply chain, including the manufacturer location, are managed in different ways according to the importance of economies of scale among others. When the importance of economies of scale is low, it is possible to apply a certain degree of pull strategy. However, most of the stages will have to face a long lead time together with a high level of economies of scale to exploit; therefore, a push strategy is more appropriate. In order to face the long lead time, a certain level of inventory has to be maintained in all the stages managed with a push strategy. In this kind of situation, inventory management and its positioning is fundamental for the manufacturer and for all the supply chain to keep a high service level.

2.4.3. Implementing the push-pull strategy

It is not easy to achieve the appropriate manufacturing strategy. Choosing between push and pull strategy requires a deep analysis of factors such as product complexity, manufacturing lead times, and the relationship between the manufacturer and all the other members of the supply chain (Simchi-Levi et al., 2007). Indeed, if a company chooses to apply a push-pull strategy an additional factor to consider is where to locate the push-pull boundary.

So far it has been shown how a push strategy is more appropriate when demand is very predictable and the system can rely on long-term forecasts. A pull strategy, instead, is applied when demand uncertainty is high, which correspond to a system based on realized demand (Simchi-Levi et al., 2007).

The choice between one of these strategies is also related to the objectives that a company wants to achieve, which requires a different set of organizational skills (Chopra & Meindl, 2001). Table 2.2 illustrates the different characteristics of push and pull strategies.

Table 2.2. Characteristics of the push and pull strategies

	Push strategy	Pull strategy
Objective	Minimize cost	Maximize service level
Complexity	High	Low
Focus	Resource allocation	Responsiveness
Lead time	Long	Short
Processes	Production planning	Order fulfillment

Source: Simchi-Levi et al. (2007), p. 194

When applying a push strategy, since the demand is highly predictable, service level is not a main issue for the company. The objective, instead, can be to achieve cost minimization (Simchi-Levi et al., 2007). This is because a company that bases its manufacturing strategy on a push approach has the possibility to take enormous advantage from economies of scale. Most of the times, lead time is long due to the complexity of the supply chain structure. Cost minimization is achieved through push strategy by better utilizing resources while putting efforts into minimizing inventory, transportation, and production costs.

In contrast, if a company decides to apply a pull strategy the principal objective is to maximize the service level (Simchi-Levi et al., 2007). In this case, the company waits for information from the actual demand to be revealed before starting to produce. Since the company, in the most extreme interpretation of this strategy, will not even hold any inventory before it is completely sure about demand from customers, its main goal is to provide the customer with the best service level possible, and not to minimize costs. High service level is achieved by implementing a flexible and responsive strategy that allows the company to quickly adjust its production to changes in customer demand.

Of course, different processes must be applied depending on which strategy is used (Simchi-Levi et al., 2007). For a push strategy, since the focus is on resource allocation,

production planning processes are used to structure an effective strategy for the long term. For a pull strategy, instead, with its focus on service level, order fulfillment processes are more appropriate.

Concerning the implementation of a push-pull strategy, there are some considerations to make. As already mentioned, when a company applies this approach it has to decide which stages it wants to manage with a push and with a pull approach. Therefore, it is fundamental to define where to locate the push-pull boundary. This is the interface where the system switches from one approach to the other. An important observation to make at this point is that, in order to coordinate the two different strategies, a buffer inventory is established at the location of the boundary (Simchi-Levi et al., 2007). This inventory plays a different role in each strategy. For the push strategy, the buffer inventory is the output generated by the production planning process. For the pull strategy, this is the input needed to fulfill orders.

With regards to the push-pull strategy, another consideration to make is that it can be argued that the interface between the two strategies is constituted by forecast demand (Simchi-Levi et al., 2007). This is what the push strategy uses to plan its production and to determine the right amount of buffer inventory and it is based on customer demand data acquired from the pull strategy.

It is not possible to define a strategy that works in every situation. In this section it was demonstrated that, even with a high demand uncertainty such as during the recession started in 2008, it is not possible to determine an always-valid strategy. As it was explained, there are several other factors that companies need to consider before making a decision regarding the best manufacturing strategy to implement.

The push-pull strategy is an interesting approach which can be useful especially for international companies with an articulated global supply chain. When it is feasible, implementing this strategy by forcing all members of the supply chain to collaborate and to achieve a global optimization, that is, the optimization of the supply chain as a whole - not of a single stage of it - will allow the global supply chain to enhance its flexibility.

By definition, some global supply chains are structured in a way that it is not possible to implement a pure pull strategy. Hence, the push-pull strategy allows companies in those global supply chains to still utilize at least some of the advantages of

the pull strategy and, thus, better respond to the uncertainty in today's international markets.

Fast paced environment makes it necessary for companies to respond quickly to changes in customer demand. Still, a certain level of stability is important. Such an approach will be illustrated in the next sections.

2.5. Concurrent and parallel processing

A major issue that companies are confronted with in marketplaces characterized by uncertainty is long manufacturing lead times. These long lead times are caused by the fact that, most of the time, manufacturing processes are performed in sequence.

One way to reduce long lead time is to apply the so called concurrent and parallel processing (Simchi-Levi et al., 2007). This refers to modifying the company's manufacturing process in such a way that certain steps that were performed in sequence can be done at the same time. Other than reducing lead time, concurrent and parallel processing can also help to lower inventory level and decrease safety stock requirements.

The key concept in concurrent and parallel processing is decoupling. This means that if many components of a final product can be physically separated during the manufacturing process, they can be prepared in parallel (Simchi-Levi et al., 2007). Redesigning the manufacturing process in this way can help companies to reduce lead time since it is not necessary to wait for a step to be over in order to start another. Even though manufacturing processes designed in this way can take longer to perform, there are usually still advantages in lead time reduction.

Figure 2.7 provides an illustration of the concept of concurrent and parallel processing.

Great examples of concurrent and parallel processing can be found with most electronic products. The multinational Hewlett Packard produces thousands of different kinds of PCs and printers, each of which is a combination of different components. Since almost all of these components are independent from each other, there is no problem to manufacture them at the same time, even in different part of the world. Then, the final products can be assembled in a single location where all the components converge ready to be used.

Figure 2.7. Concurrent and parallel processing

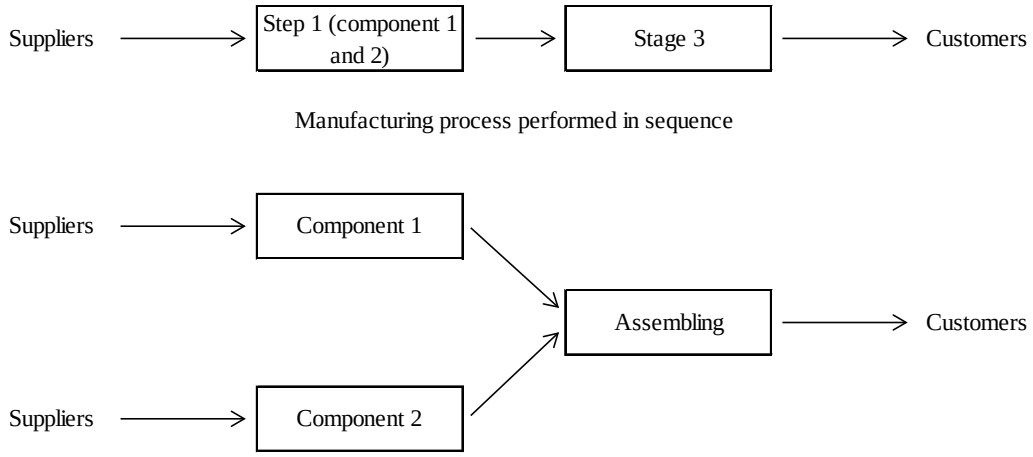


Figure created by B. Piva and adapted from Simchi-Levi et al. (2007), p. 344

Concurrent and parallel processing is a way for companies to reduce lead time and, thus, better respond to changes in customer demand. Sometimes, however, it is not possible to decrease lead time beyond a certain threshold. The next section presents another method that can be used to achieve the same goals as current and parallel processing, albeit in a different way: standardization.

2.6. Standardization

Aside from increased uncertainty, a reduction in the volume of orders has also been a major consequence of the recession that started in 2008. In order to face both conditions, companies have to find ways sustain a high manufacturing stability while taking full advantage of their capacity and maintain a good level of productivity.

Standardization can help companies to delay the decision about which specific product to manufacture until later on in the production process. In fact, standardization, in this case, does not reflect the idea of decreasing product variety, but it refers to the different approaches used to increase the level of stability in production while maintaining the appropriate differentiation and customization of final products.

When applying the concept of standardization, it is important to understand the concept of aggregate demand information. This refers to the fact that demand variability is reduced considering aggregate demand for a group or a family of products. If a

company considers aggregate demand across various products, it is more likely that a high demand from customers of a product will balance a low demand from customers of another product (Simchi-Levi et al., 2007). Therefore, the aggregate demand information is more accurate than the demand information for each individual product.

Aggregate demand information can be used by the manufacturer to effectively implement the different approaches to standardization that will be described below. Aggregate demand information helps the company to reduce uncertainty in the marketplace through standardization.

J. Swaminathan (2001) has developed a framework for the effective use of the different approaches to standardization according to the appropriate operational strategy. His theory is based on two main concepts:

- *Modular product*. Defined as a product consisting of a combination of various components, an example of a modular product is the personal computer: this is a modular product because it can be customized both in terms of hardware such as hard drives, memory cards, and input devices, as well as software such as operating systems and word processing programs. The main characteristics of a modular product are: independent and interchangeable components, standard interfaces between one component and the other, changes in the design or functionality of each component that not affect the others, and high level of customization (Simchi-Levi et al., 2007).

- *Modular process*. This is a process that allows for the storage of partially manufactured products between various stages of manufacturing. In this way, semi-finished products can be stored during the manufacturing process after they have gone through a certain number of stages; then, decisions can be made on the further differentiation of these semi-finished products. While many processes can be defined as modular, some of them cannot such as processes in the chemical industry. In fact, it is not possible to stop a chemical reaction and readdress it later on.

An important observation to make is that modular products are not necessarily manufactured through modular processes, since it might not be possible to store components at intermediate stages along the production line (Simchi-Levi et al., 2007).

Modular products and modular processes are the key drivers that allow strategies based on standardization to reduce the impact of demand uncertainty on manufacturing.

Swaminathan (2001) defines four approaches to standardization:

- *Part standardization*. This refers to the idea that common parts can be used in many different final products. The use of common parts reduces the uncertainty in their deployment since the number of products that share the same parts is higher and the high use of the common parts in a product will be offset by low use of the same part in another product. Sometimes, of course, in order to achieve part standardization, it is necessary to redesign certain families of products. This strategy is commonly used in several different industries, from automobile to electrical appliance. Manufacturers who want to implement this strategy must be aware of the risk of reducing product differentiation due to excessive part commonality (Simchi-Levi et al., 2007). Thus, manufacturers have to pay attention to always offer an array of products which meets the degree of variety requested by customers.

- *Process standardization*. This approach is also known as postponement or delayed differentiation. As already explained, this concept refers to the idea that processes should be standardized for different products as much as possible so that the decision about what specific product to manufacture can be delayed until uncertainty about the actual customer demand is lower. In order to take advantage of process standardization, it might be necessary to re-sequence the manufacturing process. Re-sequencing is the action of modifying the order of the steps within a process so that it is possible to keep products in their generic forms for as long as possible. If implemented successfully, re-sequencing and process standardization allow to keep generic products up until they reach distribution centers or even retailer locations. Delaying the decision about product differentiation, a company is able to respond more rapidly to changes in customer demand. Most of the times, especially when differentiation is implemented at the retailer location, the design of the product is focused on modularity, and modules are created for several functionalities that can be easily added to the product (Simchi-Levi et al., 2007). For instance, printers and copiers of the multinational Xerox are offered in their most basic version; then,

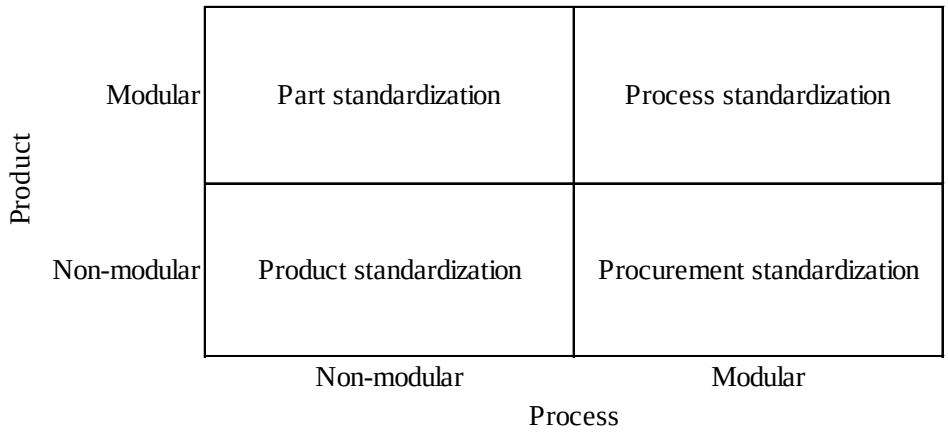
different modules can be added by the customer according to the specific features needed.

- *Product standardization*. This refers to the practice of redesigning the product in such a way that it can be adjusted to meet different customer requirements. For instance, in many industries, products are the same for any market and they only differ for small features, such as power supplies. In this case, instead of producing several different versions of the same product, the manufacturer can redesign the product so that it will be standardized for any market with the possibility to switch power supply according to the specific market served. This is an interesting way to standardize products without losing variety. Another example in this sense is the so called world car. This term is used to describe a car designed with the aim to be suitable for any market worldwide. To produce this kind of car, manufacturers use the same platform and components. Examples of world car are the Ford Mondeo and Ford Focus. In spite of having a global design, these cars are adjusted with specific changes made in order to fulfill different national regulations, cultural differences and/or customer tastes. For instance, the engine follows the preferences of different customers around the world: in Brazil ethanol automobiles are popular, while in United States petrol engines are the most common since this fuel is less expensive and largely present. Another way to see product standardization is by thinking about the idea that when a product requested by the customers is not in stock, the order can be fulfilled by another product that offers a superior set of features compared to the not-in-stock product. This process, also called downward substitution, is used in many industries, such as the semiconductor industry (Simchi-Levi et al., 2007). In this industry it is not unusual to see, for example, orders requesting not in stock low-speed chips which are then fulfilled by chips with higher performance.
- *Procurement standardization*. This refers to the fact that companies can also put their efforts into standardizing processing equipment without doing the same on the product itself. This is especially useful in industries where processing equipment is expensive, for instance, in the production of application-specific integrated circuits (ASICs). In this way, companies can use procurement

standardization independently from the actual customer demand for final products.

The framework proposed by Swaminathan (2001), illustrated in Figure 2.8, shows how companies should choose the appropriate approach to standardization according to the modularity of their product and process.

Figure 2.8. The standardization framework



Source: Simchi-Levi et al. (2007), p. 348

To put this framework in perspective, Swaminathan (2001) constructs an explanatory pattern that is based on the question whether any given product, process, or both are modular or not. As long as product and process are both modular, process standardization can lead to minimized inventory costs and increased forecast accuracy. If the opposite is the case, a company can concentrate on product standardization in order to gain flexibility. Procurement standardization will help a company to lower equipment expenses if only the process is modular; if only the product is modular, a company can work on commonality in parts to take advantage of part standardization.

The various standardization strategies described above can be useful when a company faces inaccurate forecasts and, at the same time, has to offer a large variety of products to its customers, as during the current recession. However, when deciding for one of these strategies, a company must evaluate and compare expenses resulting from implementation, which might require product redesigning or assembly line retooling with saving gained under the new system. Sometimes, it is also necessary to place manufacturing capability at distribution centers or at retailer locations (Simchi-Levi et al., 2007). In order to get the highest value possible out of these kinds of investment, it

is usually advisable to implement them at the beginning of the product life cycle: in this way such an investment can be amortized throughout the entire product life (Lee, 1992).

Besides investments, a new system might also lead to a more expensive way to manufacture the product (Simchi-Levi et al., 2007). For example, with process standardization a new stage has to be added at the distribution center or at the retailer location in order to delay the product differentiation. Therefore, it is fundamental to compare savings gained from a more effective design of products or processes with increase in manufacturing cost.

One of the major difficulties when comparing costs and savings of a new manufacturing strategy is that many of the benefits of a new system such as increased ability to respond to changes in the market, better customer service, and improved flexibility, are problematic to quantify (Simchi-Levi et al., 2007). Indeed, it is not clear how broad the perspective should be when making these kinds of decisions.

All in all, it is important to stress that nowadays finding ways to improve forecast accuracy, maintain a high service level and offer a wide range of product variety while keeping manufacturing costs down has become even more critical for companies in order to stay in business. In times of recession, benefits from standardization seem to be even more valuable.

2.7. The value of information

Managers might believe that information accuracy regarding production, orders, and inventory level remains steady throughout the entire supply chain regarding the effectiveness of the management of each link in the chain. However, the accuracy of information usually fluctuates which makes it important for companies to pay attention to the way information is disseminated across the entire supply chain. If the management neglects not recognize the value of information, then companies overlook a highly significant aspect of supply chain effectiveness which can certainly inhibit their performance. Information becomes even more significant when dealing with increased uncertainty in customer demand and untrusted forecasts, as during the current recession.

The availability of information can help manufacturers to (Simchi-Levi et al., 2007):

- reduce variability across the entire supply chain;
- increase the accuracy of forecasts;

- react and adapt to changes in customer demand more quickly;
- better coordinate their distribution systems;
- offer an improved service to customers;
- lower lead times.

All these advantages are possible only if each member of the supply chain commits to sharing information. Unfortunately, situations quite often occur in several industries where individual companies are not willing to release information to others, even though they all belong to the same supply chain. Moreover, they may even attempt sometimes to inflate their forecasts to suit their own interests. On the other hand, when information is widely shared, supply chain members might feel tempted to abuse information for their own benefits.

In general, the availability of information can provide a great opportunity to improve the performance of the entire supply chain. In this section, after a discussion of the importance of information and the benefits associated with sharing it, incentive mechanisms that have the potential of motivating supply chain members to collaborate actively on the basis of information sharing will be introduced.

2.7.1. Transferring information

It is always hard to predict the exact demand for any product before the customer actually makes his decision (Treville et al., 2004). However, information about customer demand is extremely important for the manufacturer who has to plan and schedule his production in order to be able to offer a good service to his customers. The recession of 2008 has given renewed emphasis for this dilemma.

There are many patterns in which information on demand can be revealed (Treville et al., 2004). In many situations, the availability of information that is useful to make accurate forecasts increases proportionally until the actual demand is known (Figure 2.9a). However, in some cases, it happens that information becomes available all at once because of logical and expected consequences (Figure 2.9b). This is the case, for example, when a building is completed with a certain amount of apartment units and it is clear that each of them will require at least basic furniture such as refrigerators and toilets. It is possible that some events might lead to the situation described in Figure 2.9c, in which information on demand is made visual according to a step pattern.

Figure 2.9. The availability of information over time

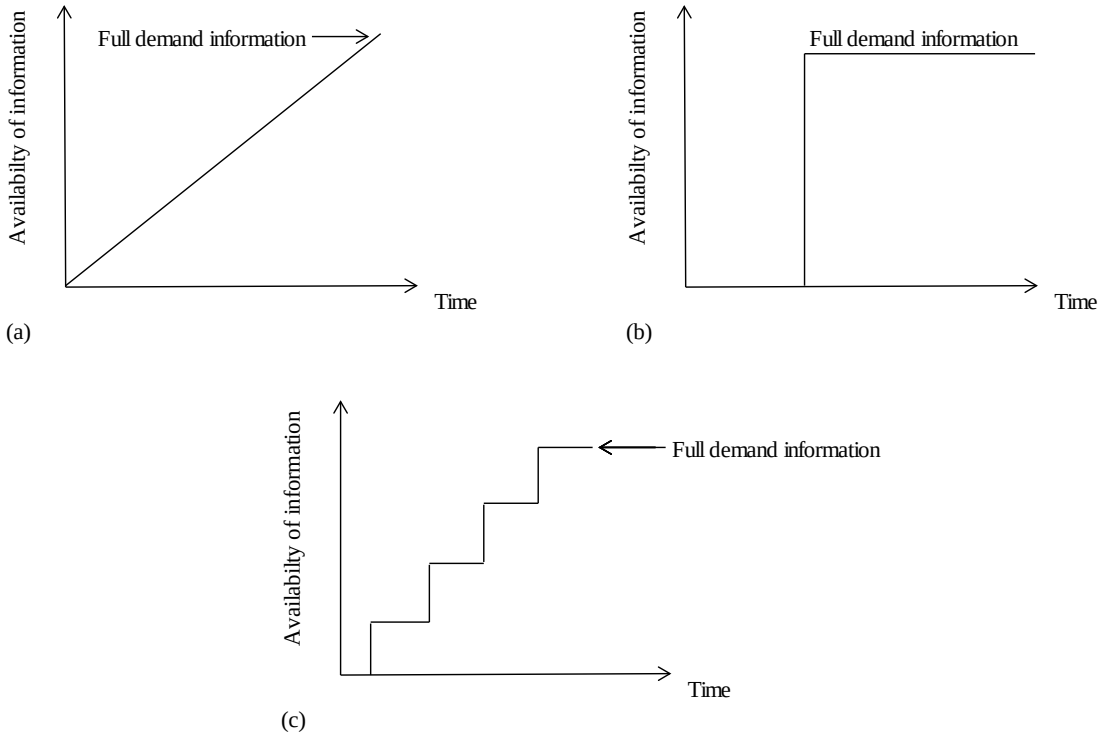


Figure created by B. Piva and adapted from Treville et al. (2004), p. 620

Figure 2.10 illustrates the dissemination of information over time on customer demand. The time line in the figure is divided into three periods: T_0, when actual demand lies too much in the future; T_1, when information on demand starts to be revealed; and T_2, when products are actually chosen and delivered to customers.

Figure 2.10. The acquisition of information over time

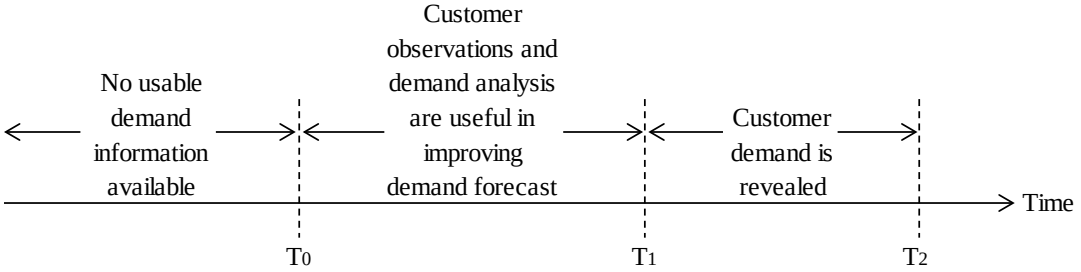


Figure created by B. Piva and adapted from Treville et al. (2004), p. 620

As Figure 2.10 illustrates, any observation or demand analysis left of the T_0 point in time is either not accurate enough or too costly to conduct, considering benefits that the company could get. Between T_0 and T_1, partial information starts to become available.

Therefore, it is possible to start to analyze customer behavior and try to elaborate the first forecasts. Finally, between T_1 and T_2, that means right before the customer actually makes decisions on product purchases, information on demand becomes incessantly more available and it is easier to predict the actual customer behavior.

So far it was illustrated how information on customer demand becomes available and observable according to different patterns. However, the release of demand information does not necessarily constitute a supply chain environment which is marked by the ability of members to acquire data, let alone the willingness to disseminate them upstream (Treville et al., 2004).

Three degrees of demand information transfer across the entire supply chain can be described (Treville et al., 2004): full demand information transfer, partial demand information transfer, no demand information transfer.

Full demand information transfer refers to situations in which information passes from customers upstream with no distortion. This is the first step towards full market mediation (Treville et al., 2004). The growth of the Internet in particular has made it easier for members of the same supply chain to fully transfer demand information. However, examples exist outside the Internet context. For instance, Toyota Motor in its Georgetown (Kentucky, U.S.A.) plant applies an interesting system to link its automobile assembly line with seat suppliers (Mishina, 1993). When automobiles start to be produced in the plant they transmit an electronic signal directly to seat manufacturers with information about which specific type of seat they will need. In this way, seat suppliers can prepare and deliver customized seats to the Toyota assembly line right when automobiles reach the point in the manufacturing process where seats need to be installed.

Partial demand information transfer, instead, refers to the exchange of information about customer observation between members of the same supply chain. Even though it is not possible for companies to have access to full demand information, partial demand information transfer can still help them to improve forecast accuracy as well as minimize distortion that usually occurs when going upstream in the supply chain (Treville et al., 2004). For instance, partial demand information transfer occurs when retailers transfer point-of-sales data to manufacturers: this allows manufacturers to better estimate demand in the near future. For instance, Zara has implemented a system

of nonstop flow of point-of-sales information from stores in order to capture customer behavior and use these data to create new fashion collections (Titze, & Krasojevic, 2012). Moreover, Apple uses this approach in the sense that it tracks customer demand by store and even by hour. This allows the company to better predict future trends (Satariano & Burrows, 2011). However, it is necessary to point out that point-of-sales data are historical data. This means that they might not reflect future demand.

Whereas full demand information is well defined for specific quantities of specific products, partial demand information needs to be completed with forecasts and impressions made by manufacturers in order to be useful. In fact, partial demand information often requires complex and significantly difficult handling to be converted into usable data (Treville et al., 2004). Indeed, most of the times this kind of analysis is expensive and manufacturers need sophisticated forecasting techniques to get the data that they can use for their production systems.

It is certainly more challenging to transform partial demand information into data applicable to production planning than doing the same using full demand information. Many studies demonstrate that, in order to acquire demand information that is as close to full demand information as possible, it is fundamental for any company to construct a strong relationship with all members of its supply chain (Heikkilä, 2002). In order to be successful, these relationships must be stable and they have to be based on trust and mutual support: coordination and collaboration between the links of the supply chain is extremely important. Trust and collaboration are especially difficult to achieve for international companies. In fact, cultural differences such as language, beliefs, and customs can dramatically hamper the creation of a strong and solid relationship between members of a global supply chain.

The transfer and effective use of information, especially of partial information, requires the support of an appropriate leadership, which takes care of relationships with the entire supply chain and is able to recognize the accuracy of information that the company can gather. Without this important factor, it becomes very difficult to analyze such information and utilize it to plan production for the near future.

Sharing is important not only with demand information but also with any other kind of critical information that can affect the entire supply chain. Here is a great example of the consequences of poor communication and information sharing between members of

a supply chain (Simchi-Levi et al., 2007). The Philips semiconductor factory located in Albuquerque (New Mexico, U.S.A.) provided companies such as Ericsson and Nokia with radio frequency chips. On March 17, 2000, a lightning struck the plant and caused a fire that destroyed almost all of the products in stock. Three days after the incident, Philips informed its customers about it; however, the company reported that the plant would be closed only for a week. As soon as customers knew it, they sent engineers to the plant to evaluate the damage. Philips, however, did not allow those engineers to access the plant. At that point, many customers such as Nokia decided to work with other suppliers. Other customer decided to stay with Philips, instead, and to wait for them to start production again. Two weeks after the incident, Philips declared that months of orders could not be fulfilled. Ericsson was one of the companies which decided to trust Philips and, when the severity of the situation was revealed, it was too late for it to contact other suppliers since they were already full with orders coming from companies such as Nokia that did the same earlier. This issue caused a $1.68B loss to Ericsson Cell Phone Division that year and it even forced the company to exit the market.

New information technologies have made it easier for international companies to collaborate and exchange information with their supply chain partners all over the world. This helps to work as a single entity and enhance the performance of the overall supply chain ("The Role of Information Sharing in Global Supply Chain Operations", 2011).

The goal of information sharing is to gain a better understanding of the end consumer behavior as well as be able to effectively respond to the changes in the market. From a supply chain perspective, information sharing allows manufacturers to make their products only when there is an actual demand to satisfy, drastically decreasing inventory levels and associated costs. In the long term, information will improve supply chain responsiveness, boost profitability and cash flow of every member of the supply chain and, ultimately, increase service level and consumer satisfaction.

2.7.2. The bullwhip effect

Even though coordination is paramount when it comes to information sharing many times a lack of coordination occurs. One of the reasons why this happens is because

different stages of the supply chain can have conflicting objectives as, most of the times, several companies with different owners are involved in the supply chain (Chopra & Meindl, 2001). Hence, each company tries to maximize the performance of its own stage: this leads to a local optimization. This behavior, however, affects the entire supply chain as without coordination and real support it is not possible to reach a situation in which all the members of the supply chain take decisions as a whole and, thus, try to do what is best for the entire system, that is, global optimization.

Nowadays, it is very common to find supply chains composed of stages owned by hundreds of different companies. For example, Ford Motor Company has thousands of suppliers such as Goodyear and Motorola. Then, each of its suppliers has hundreds of suppliers itself. When looking at the big picture of a supply chain, it becomes clear how hard it is to find a global coordination between all these links.

Lack of coordination leads to distortion in information as it moves upstream in the supply chain. Many studies have highlighted that for several industries. While customer demand for a specific product does not change much, production and inventory levels fluctuate considerably going further away from the final stage of the supply chain. For example, managers at Procter & Gamble (P&G) noticed that while final sales for diapers were fairly stable over a certain period of time, orders placed by distributors to the company fluctuated significantly (Simchi-Levi et al., 2007).

Hewlett Packard also found the same phenomenon in its printer division. Although demand from final customers had low variability, the analysis of orders placed from resellers up the supply chain showed increasing fluctuations (Chopra & Meindl, 2001).

The grocery industry features several other examples of information distortion. Barilla, the Italian pasta manufacturer, even quantified that weekly orders placed by one of its distribution centers fluctuated up to 70% a year. However, weekly sales at the same distribution center, represented by orders placed by supermarkets, did not fluctuated more than 3% over the same period of time (Chopra & Meindl, 2001).

All these examples refer to a phenomenon called the bullwhip effect. Russell and Taylor (2006, p.415) assert that the bullwhip effect “occurs when slight to moderate demand variability becomes magnified as demand information is transmitted back upstream in the supply chain”.

The bullwhip effect is a phenomenon created when members of a supply chain take decisions following their own interests and making their own demand forecast. Since there is not communication and exchange of actual demand information between companies, the accuracy of forecasts drops dramatically. As orders move upstream in the supply chain, and thereby further away from the final customer, the distortion of information becomes greater. This leads to less reliable demand forecasts.

In other words, if a company is not confident about the actual customer demand information that it receives from succeeding members of the supply chain, it becomes only natural for it to commission its own forecasts and stock extra inventory in order to compensate for uncertainty and maintain a satisfying service level. Further upstream in the supply chain this practice then likely repeats itself. This leads to an increased variability across the supply chain which is not reflective of the actual demand of final customers.

Before discussing techniques that allow to control and curb the bullwhip effect, it is important to identify the major factors that contribute to the increases in variability across the supply chain (Simchi-Levi et al., 2007).

- *Demand forecasting*. Traditional forecast techniques are designed in a way that estimations of demand patterns are regularly modified as more data about actual customer behavior are observed. As forecasts are adjusted to more accurate data, the company is forced to change order quantities, thus, increasing variability.

- *Lead time*. It is easy to recognize how increased variability is magnified by longer lead times. In fact, when dealing with a long lead time, a company needs to be sure to keep enough inventory to face changes in its own forecasts. In order to offer a good service level, a small change in demand forecasts leads to a significant change in order quantities to suppliers. This boosts variability across the supply chain.

- *Batch ordering*. If a company uses batch ordering, its supplier will observe an unsteady order pattern such as large orders, followed by several periods of no orders, followed by a big order, and so forth. Therefore, the information on demand that the supplier will receive is distorted and does not reflect the actual demand that is manifested further down in the supply chain, closer to the final

customer. Batch ordering is used in many industries mainly to take advantage of transportation discounts, such as full-truckload quantities, and incentives on bigger orders.

- *Price fluctuation*. If prices fluctuate considerably, a company often attempts to purchase a bigger quantity and stock the surplus when prices are low. This practice can be observed especially in industries where promotions and discounts are common during certain periods of the year: it can also be called forward buying.
- *Inflated orders*. Inflated orders placed during shortage periods increase supply chain variability. This kind of situation is common when companies exaggerate their real needs as a consequence of the perception of rationing order fulfillment made by the supplier when demand exceeds its manufacturing capacity. Here, the aim of the company is to ensure that it will receive a sufficient quantity during periods of shortage. When a period of capacity constraints is over, the company suddenly drops its orders and goes back to its standards. This leads to a great increase in variability across the supply chain.

The bullwhip effect is a consequence of the lack of coordination between members of the supply chain who seek to optimize their local objectives without considering the impact on the entire supply chain (Chopra & Meindl, 2001). Therefore, the bullwhip effect has a significant impact on several aspects of the supply chain performance. These are listed in Table 2.3 as well as discussed below (Chopra & Meindl, 2001).

Table 2.3. The impact of the bullwhip effect on supply chain performance

Performance measure	Impact of the bullwhip effect
Manufacturing costs	Increases
Inventory costs	Increases
Transportation costs	Increases
Labor costs	Increases
Level of product availability	Decreases

Figure created by B. Piva and adapted from Chopra & Meindl (2001), p. 363

- *Manufacturing costs*. As a result of the bullwhip effect, manufacturers build extra capacity and hold excess inventory in order to be able to offer a good service level and to respond to the increased variability.
- *Inventory costs*. As already mentioned, to handle the increased variability resulting from the bullwhip effect companies need to carry a higher level of inventory. As a consequence, the inventory costs of the single company as well as of the entire supply chain increases. A higher level of inventory also requires a bigger warehousing space, which has the effect of boosting warehousing costs as well.
- *Transportation costs*. The bullwhip effect also has an impact on transportation costs. Transportation costs are strictly related to the amount of orders and their volume. Since orders fluctuate significantly over time, companies must maintain a high transportation capacity to cover peaks in the demand. Therefore, transportation costs increase due to higher variability across the supply chain.
- *Labor costs*. As with transportation costs, the bullwhip effect cause labor costs to increase. Due to high variability, companies are forced to maintain excess labor capacity or vary it according to fluctuation in orders. Both these options boost labor costs.
- *Level of product availability*. Even though companies try to keep more inventory of various products, when variability is high it is more likely that stock out situations will occurs and orders will not be delivered on time.

Since the bullwhip effect hurts performance of each stage of the supply chain, it also hurts relationships between all its members. Every company is focused on doing its best to achieve local optimization. Therefore, when performance is low the tendency is to blame the other members of the supply chain. As a result, the bullwhip effect causes a loss of trust between members of the supply chain, which makes coordination even more difficult.

For this discussion, it follows that the bullwhip effect resulting from a lack of coordination affects supply chain performance by increasing costs and decreasing responsiveness of each stage as well as of the supply chain as a whole. In other words,

this phenomenon reduces supply chain profitability and makes it extremely expensive to offer a satisfying service level to customers (Chopra & Meindl, 2001).

2.7.3. How to control the bullwhip effect and provide incentives for information sharing

Being able to control the bullwhip effect is a desirable goal for any company. A number of methods can be suggested for reducing this phenomenon or for eliminating its impact. These are discussed below (Simchi-Levi et al., 2007).

- *Uncertainty reduction*. The most common method utilized to cope with the bullwhip effect is to reduce uncertainty across the entire supply chain. Uncertainty reduction is implemented by centralizing demand information, that is, by structuring a system which allows all the members of the supply chain to access complete information on actual customer demand. If each stage of the supply chain uses the same demand data to plan and schedule its activities, it will be possible to eliminate the problem of increased variability of demand when going upstream in the supply chain. However, even though the members of the supply chain share the same information, each of them might still apply different forecasting practices. This could create the bullwhip effect. Indeed, numerous studies (Simchi-Levi et al., 2007) have shown that even in the case of centralized demand information, congruent forecasting method, and equal ordering policy across the entire supply chain, the bullwhip effect can still be present.

- *Variability reduction*. Decreasing the variability inherent in the customer demand process can help to reduce the effect of the bullwhip effect. If a company finds some way to reduce the variability of the customer demand, the variability seen by members of the supply chain upstream will also decrease even if the bullwhip effect is still present. For instance, a method implemented by Wal-Mart to reduce the variability of customer demand is the so called “everyday low price” strategy (EDLP). This pricing strategy allows Wal-Mart customers to have certain products at a constant low price without the need for them to wait for promotion to get a better deal. By eliminating price promotions,

Wal-Mart is able to avoid dramatic shifts in demand due to promotion periods. This makes customer demand patterns more stable and, thus, the bullwhip effect can be reduced for the entire supply chain.

- *Lead time reduction*. As already mentioned, lead time is one critical factor that contributes to increased variability across the supply chain. This means that if a company is able to decrease its lead time it will be possible to reduce the impact of the bullwhip effect as well. Lead time is usually composed of two components: order lead time (e.g., the time necessary to produce and ship the product), and information lead time (e.g., the time needed to process an order). It is extremely important to be aware about this distinction because different methods are used to reduce each of these lead times. Order lead time can be reduced, for example, through the implementation of cross-docking [1]. Information lead time can be reduced through the use of electronic data interchange (EDI) between members of the supply chain.

- *Strategic partnership*. The bullwhip effect can be controlled using one of the several types of strategic partnerships. In fact, strategic partnerships modify the way information about demand is shared making easier for companies to access them. Some strategic partnership can even eliminate completely the impact of bullwhip effect. For instance, with the vendor managed inventory (VMI) the manufacturer directly manages the inventory of his products at the retailer location. Hence, the manufacturer have direct access to information on final customer demand and, thus, he can improve the accuracy of his forecasts as well as better plan and schedule his activities.

As mentioned earlier, coordination and information sharing are important principles that underpin the methods that supply chain members can apply together to control or, even, avoid the impact of the bullwhip effect. Manager should also work on creating trust and cooperation in the supply chain. In order to do that, these relationships must be

[1] Cross-docking is a logistics strategy that Wal-Mart made famous. According to this strategy, warehouses are not considered inventory storage points anymore. They become inventory coordination points. With cross-docking, goods arrive at the warehouse and they are organized and transferred to vehicles serving customers within a short period of time. Goods typically spend at the warehouse less than 12 hours.

designed in a way that they can be beneficial and fair for all the members of the supply chain. Without any benefit no companies will be willing to share their own information and make the effort to cooperate with the others. If companies are able to set these requirements, the relationship between all the members will lead to lower costs and increased profits for all stages of the supply chain involved (Chopra & Meindl, 2001). For example, the relationship that Apple has built with its suppliers is so close that they even work together to create new tooling equipment to produce innovative products and to translate prototypes into mass-produced devices. This cooperation is beneficial for both sides because, on the one hand, Apple can develop innovative products without having to build capacity and expertise internally and, on the other hand, suppliers are sure that their investments will lead to high volumes of sales (Satariano & Burrows, 2011).

Sometimes, however, it is not possible to create a collaborative environment in which companies all work together to achieve global optimization. Nevertheless, it is still possible to find some kinds of incentive mechanisms that allow companies to have access to more accurate information.

For example, two types of contracts can be used to force a buyer to reveal his demand data with the manufacturer (Özer & Wei, 2006). The first one is the capacity reservation contract. In this type of contract, the manufacturer provides the buyer with a menu of specified different levels of capacity with corresponding prices. The per-unit price decreases as the level of capacity increases. In order to take advantage of the lower prices offered with capacity reservation, the buyer is forced to reveal his true data and, thus, share information with the manufacturer.

Another type of contract that can be applied for this purpose is the advance purchase contract. This contract allows the manufacturer to know orders before building capacity for them. In fact, the manufacturer offers better prices for advance purchases and he charges a higher price for any additional order placed after a certain period of time. In this scenario, the buyer will let the manufacturer know his plans in advance so that the manufacturer can schedule his production with a lower level of uncertainty about demand.

The bullwhip effect is a phenomenon that is difficult to completely avoid, especially in supply chains that involve many different companies, each of which having different

goals to pursue. Finding a way to deal with it has become an even more urgent task for companies in today's markets affected by the recession of 2008. Nowadays, the difficulty to plan both capacity and production due to reduction in orders and uncertainty in demand makes the value of information one of the main focal points of companies as well as entire industries.

Managers should consider the following ideas to successfully control the bullwhip effect and to take full advantage of information (Chopra & Meindl, 2001).

- *Quantifying the bullwhip effect*. Most of the times, companies are not even aware of the impact the bullwhip effect is having on their supply chain. In order to start realizing it, companies can compare the variability of the orders they receive from their customers with the variability of orders they place to their suppliers. This will help them to quantify their own contribution to the creation of this phenomenon. Hence, it will be easier for them to see the presence of the bullwhip effect in the supply chain and the corresponding loss in profits. If companies are not able to recognize this phenomenon, they will concentrate their efforts on dealing with the demand variability rather than trying to minimize it. This means that companies will make significant investments in inventory management and scheduling systems. However, they will see a little return on those investments and minimal improvements in profits. Noteworthy enhancements in performance can be seen, instead, when different companies work together to achieve coordination and to lower variability across their entire supply chain.

- *Getting top managers committed to coordination*. Coordination can only succeed if top managers are actively involved into relationships with other companies. The focus on coordination might require many divisions to change their traditional practices. Indeed, objectives that were previously working when the company was trying to achieve local optimization may not be valid anymore. Such massive changes can only be achieved if top management is strongly committed to making the coordination successful. For instance, top management had an extremely important role when Wal-Mart and P&G decided to create a collaborative forecasting system and replenishment teams.

- *Reserving resources to coordination*. In order for coordination to work, each company has to devote a significant amount of managerial resources to achieve this task. The difficulty for companies to understand this is based on the fact that they either think coordination is not so important or they believe it can be achieved even without putting too much effort and resources into it. Chopra and Meindl (2001) suggest that one way to make coordination work is to create teams composed of members who come from different companies across the supply chain. These teams should not only be in charge of dealing with coordination between different stages of the supply chain, but also be allowed to implement changes that they deem necessary. It is extremely important for teams to have the power to act in order to avoid arguments with functional managers, who want to achieve local goals. Therefore, trust between team members and managers is fundamental to achieve coordination and benefit from that.
- *Communicating with the other members of the supply chain*. Very often companies do not communicate much with other members of the supply chain. Indeed, most of the times, there is no trust: companies are unwilling to share information because they think information might be used to facilitate competitors. To change this mindset, companies can start to regularly communicate with each other and, once trust is built, share their goals and identify mutually beneficial actions that can be taken together using coordination. For instance, a major international PC manufacturer used to order microprocessors in batches for numerous weeks of production (Chopra & Meindl, 2001). The manager assumed that the supplier would have been reluctant to reduce his lot sizes and to increase the frequency of delivery of orders. When the PC manufacturer tried to open a communication with the supplier it turned out that the supplier was actually willing to implement the changes that the PC manufacturer wanted.
- *Achieving coordination across the entire supply chain network*. Significant benefits from coordination can be achieved only if the entire supply chain network is well coordinated. Therefore, it is advisable that the most powerful member of the supply chain takes control and leads all the others towards global

coordination. For instance, Toyota made a really good job in helping its entire supply chain to be widely coordinated and to share information.

- *Improving connectivity in the supply chain through technology*. Visibility of information across the entire supply chain can be improved through technologies such as the Internet and ERP systems. Companies invest a significant amount of their budget to support information systems that can help them to better use information internally. However, they should understand that with a small extra effort these technologies can be used to facilitate collaborative forecasting and planning between members of the supply chain.
- *Equally sharing the benefits of coordination*. One of the biggest obstacles to coordination is the fear of some members of the supply chain that the benefits coming from coordination will not be equally shared. The strongest company of the supply chain should be sensitive to that and it should ensure that all parties will be treated equally. If each member of the supply chain will know that he can get the same benefits as everybody else, he will be more willing to share information and collaborate with all the others to achieve global optimization.

All the concepts expressed in this chapter can be used by companies to reflect about the current business environment. All the approaches to manufacturing strategy presented are suitable to face the new challenges of the post-recession era.

On the one hand, each individual company needs to find the right approach to use based on the characteristics of its market and competitive environment. On the other hand, information sharing brings with it strategic advantages for any company.

Manufacturing strategy and information sharing are extremely important themes for the current business world. The next chapter will serve as a reflection about another big topic which is strongly affected by the current recession: the logistics strategy. It also introduces approaches that are helpful to managing inventory and, more generally, logistics in order to make the supply chain ready to face the new market conditions.

CHAPTER 3. Managing New Market Conditions with Logistics Strategies

3.1. Preliminary remarks

The variability and the uncertainty of the market pose significant issues for a company's supply chain. One key area in this respect is logistics. In fact, the success of a company is measured, among others, by the way it manages logistics. Moreover, if companies consciously address those issues by rethinking the way their respective logistics strategies are implemented and how these contribute to the supply chain, they can gain competitiveness. Inventory management, in particular, is a critical area in this sense as companies need to be both cost efficient and maintain a high service level at the same time.

The management of logistics becomes even more challenging for international companies, which see the challenges of the new market magnified by their global supply chain.

3.2. The role of inventory in the supply chain

As it has been shown in the previous chapter, supply chain management embraces everything that makes any company able to connect its suppliers to its customers through production activities. Thus, it functions as a crucial backbone of a company. One of the most important components of a supply chain is inventory management. Inventory is a dynamic subject that has to be constantly monitored and carefully evaluated, taking into consideration several external and internal factors such as customer demand, lead times, and product availability at the location of both the company and the supplier. By effectively managing inventory, a company can significantly improve its overall performance.

Inventory is present in different forms throughout the entire supply chain (Simchi-Levi et al., 2007):

- raw material inventory;
- work-in-process (WIP) inventory;
- finished product inventory.

Each of these forms of inventory needs to be managed using specific inventory mechanisms and approaches. However, this is not as easy as it seems. These mechanisms are difficult to identify because one has to take into account the interaction of several stages of the supply chain as well as fit the objective of the production and distribution strategies of all supply chain members to reduce system costs and improve customer service level.

The objective of inventory management is to ensure that enough inventory is held throughout the entire supply chain so that it is possible to meet customer demand as well as be more effective (Russell & Taylor, 2006). Before thinking about how to manage inventory, companies need to be aware of the various reasons why inventory is held (Simchi-Levi et al., 2007):

- *Unexpected changes in customer demand*. Customer demand, especially in a time of recession, is extremely difficult to predict. Indeed, in the last few years the trend towards shorter product life cycles, increased product variety, and tougher competition has caused an increase in customer demand uncertainty. Therefore, inventory needs to be held in order to face unexpected peaks.
- *Uncertainty*. This is related to uncertainty in the quality and the quantity of products coming from suppliers. Inventory is essential for companies in order for them to prevent their production schedules to be negatively affected by uncertainties in supply.
- *Lead times*. When supply chain members have to deal with long lead times, they need to hold inventory.
- *Economies of scale*. Many suppliers as well as transportation companies encourage companies to purchase items in large quantity. This, however, leads to the creation of inventory.

The primary goal of supply chain management is to offer to customers what they need where and when they need it, that is, to provide them with a high service level. In today's business environment, this is a fundamental requirement to stay in business. To provide a high service level, it would be easy for companies to keep a large amount of in-stock items. However, companies have always to consider the tradeoff between the service level they want to offer to their customers and the cost of it (Russell & Taylor, 2006). With regards to inventory management, the costs that need to be considered are:

- carrying or holding costs,
- ordering costs,
- shortage or stockout costs.

Carrying costs are related to holding items in inventory. This cost is usually the sum of different components (Russell & Taylor, 2006):

- facility-related costs such as rent, power, heat, security, insurance, taxes, etc.;
- labor, that is people who are in charge of receiving, keeping, and organizing products for delivery at the storage location;
- record keeping tools;
- material handling, that is the equipment needed at the storage location;
- cost related to product risk, such as deterioration, breakage, obsolescence.

Typically, this kind of cost grows linearly with the number of units in stock: the greater the inventory, the higher the carrying costs. The carrying cost ranges between 10% and 40% of the value of the entire product (Russell & Taylor, 2006).

Ordering costs are determined by the replenishment of products held in inventory. They are independent from the amount of items ordered and, hence, they are expressed in money per order. Ordering cost can be any cost that occurs every time a replenishment order is placed that grows linearly with the number of orders. This includes: order, shipping and transportation, reception, inspection, and handling. With regards to order size, ordering costs behave oppositely to carrying costs. The more products are compiled per each order placed, the fewer orders are needed: this reduces ordering costs (Russell & Taylor, 2006). Ordering a large amount of products, however, leads companies to deal with a higher inventory level. As a consequence, lower ordering costs equal higher carrying costs.

Shortage costs occur when it is not possible to satisfy the demand coming from the customer because of a shortage of products held in inventory. These costs cause customer dissatisfaction, which can lead to loss of sales and, therefore, loss of profit. As Russell and Taylor (2006) mention, studies have demonstrated that around 8% of customers do not find the specific products they want at retailer locations in stock. This results in a total loss of 3% of the sales value. When demand comes from the inside of the company, a product shortage can stop an entire production process and, then, create delays in order fulfillment. Compared to the other two types of costs, shortage costs are

the most difficult to quantify since accurate data are not available. As a result, these costs are usually estimated subjectively by managers. The reason why shortage costs are generated is because keeping inventory is expensive. However, shortage costs stand in an opposite relationship to carrying costs, which are determined by the amount of inventory on hand: when the latter increases, the former decreases (Russell & Taylor, 2006).

When a supply chain is efficiently managed, products move across the different stages according to a system based on constant communication between the company and its suppliers as well as between the company and its customers. Every stage does not maintain a high level of buffer stock because it does not have to compensate for issues caused by uncertainty in the supply chain. Unfortunately, these kinds of systems are rare and supply chains are usually full of dysfunctions (Russell & Taylor, 2006). Therefore and in order to compensate for production bottlenecks and maintain the flow of production, companies hold buffer inventory between production stages.

Managers need to understand that, at any stage, a large amount of inventory masks problems and areas of inefficiency which might destabilize the entire supply chain. Inventory management is fundamental to determine the health of the supply chain. Companies struggle to find and maintain an optimum level of inventory that meets customer demand as well as keeps costs down.

Companies define how they are going to manage inventory through the so called inventory policy. When deciding an effective inventory policy, many aspects of the supply chain must be taken into account as it has been done by Simchi-Levi and others (2007) in the following ways:

- Customer demand which can be forecast to a certain degree using different forecasting tools. Historical data can help to estimate the average customer demand as well as trends related to it. Sometimes, especially in time of recession, variability in demand is so high that it becomes extremely difficult to predict future patterns. In these cases forecasts lose their reliability;
- Composition of product offering, which significantly affects the investment and the space of inventory reserved for each product;
- Short or long term goals;

- Order and inventory holding costs. The first can be divided into product and transportation cost: both of them can take advantage of economies of scale in the sense that as the order quantity increases, the unit price decreases;
- Replenishment lead time, which is either a piece of information that the supplier provides to the manufacturer or it may be uncertain;
- Service level requirements, due to uncertainty in demand, it is very hard to satisfy customer 100%. Therefore, it is important for managers to define the level of service that the company commits to its customers.

In the past, companies did not always consider inventory management an important lever to control costs. Traditionally, companies used to maintain an extensive inventory level to meet long-term customer demand. This was possible because competition was not very fierce and product variety was relatively low. Nowadays, in the current global business environment, where competition is tough and companies have to deal with highly diverse markets and products that are continually introduced and that evolve rapidly, knowing how to manage inventory has become fundamental.

Finding the right amount of inventory to hold at the right time and in the appropriate location most of the time determines the success or failure of an inventory strategy. In 1993, for example, Liz Claiborne Inc.[1], now Fifth & Pacific Companies Inc., declared unexpected drops in earnings caused by an excess of inventory in its warehouse. An ineffective inventory management, instead, led the IBM's ThinkPad line to a critical shortage of its products (Simchi-Levi et al., 2007). These examples illustrate the critical relationship between inventory management and demand forecasting. Uncertainty in demand amplifies the value of forecasts in determining what and when to order.

In a time of recession, demand drastically drops and companies struggle to increase their market share. Therefore, companies analyze their cost structure to find where they can lower costs and not sacrifice the quality of their products. Inventory is a logical area to start doing so. In order to lower the cost of inventory, companies can focus on increasing the efficiency of both the supply chain and the quality management (Russell

[1] Founded in New York City in 1976, Liz Claiborne Inc., which later changed its name to Fifth & Pacific Companies Inc. on May 15, 2012, is a fashion company headquartered in New York City and it engages in markets all over the world. The company produces a wide range of products such as women's and men's apparel, perfumes, and accessories.

& Taylor, 2006). Inventory is closely aligned to the level of uncertainty in the supply chain in the sense that reducing uncertainty across the entire supply chain will lead to significantly lower inventory costs. As can be deduced from the previous chapter, uncertainty in the supply chain can take the form of uncertain lead times, inaccurate information and poor forecasts on demand, uncertain production schedules due to late deliveries, and of large numbers of defects that entail an unnecessarily high level of production (Russell & Taylor, 2006).

In the next section, several of the most popular models for taking cost-effective decisions about inventory will be analyzed in detail to highlight the significance of this part of supply chain management.

3.2.1. The economic lot size model

Introduced for the first time by Harris W. Ford in 1915, the economic lot size model represents a simple way to illustrate the trade-offs between ordering and storage costs. To illustrate this model, an initial assumption that must be made is that a warehouse is dealing with constant demand for a single product. Another assumption is that the supplier is able to offer an unlimited quantity of the considered product. The components of this model are the following (Simchi-Levi et al., 2007):

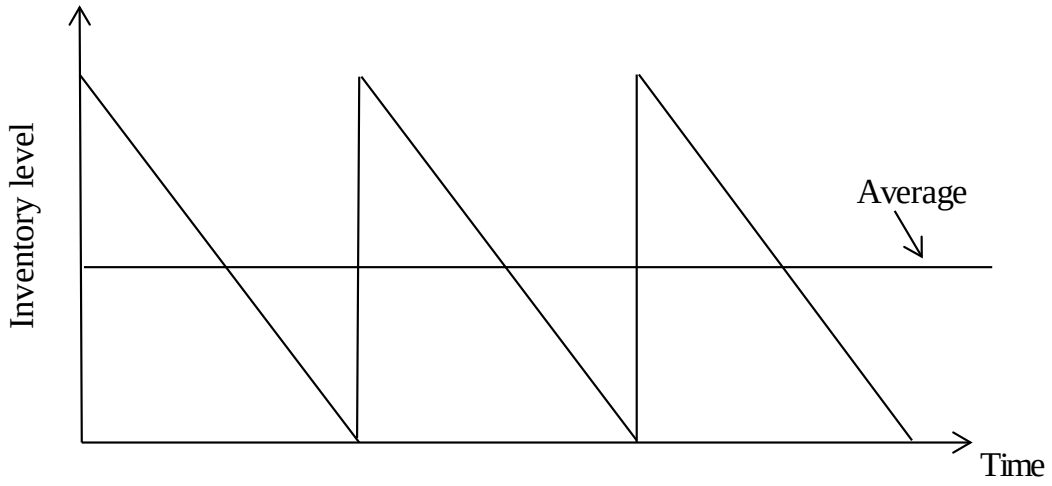
- the demand for the product is stable with D items per day;
- the warehouse orders a fixed amount of Q products every time an order is placed;
- every time an order is placed there is a fixed setup cost, K, to consider;
- the holding cost per single item per day is h;
- no lead time is assumed to exist and, therefore, there is no time gap between the moment when an order is placed and the time items are received;
- there is no initial inventory;
- the planning horizon is infinite.

The aim of this model is to meet the customer demand while minimizing inventory costs so that no shortage costs will occur. It is quite straightforward to understand that an optimal order policy to apply to the model illustrated above is to receive orders at the warehouse location exactly when the amount of items held in inventory equals zero. This policy, also described by Simchi-Levi and others (2007) as the zero inventory ordering property, assumes that, given no lead time, it is possible to wait until inventory

level drops to zero before placing and, at the same time, receiving the order. In view of the above assumptions, this is the optimal policy that allows to save the most in holding costs.

Figure 3.1, also called the saw-toothed inventory pattern, helps to understand the optimal ordering policy in the economic lot size model representing how inventory level changes over time.

Figure 3.1. The inventory order cycle in the economic lot size model



Source: Simchi-Levi et al. (2007), p.34

The cycle time is defined as the time between two replenishment orders placed by the warehouse to the supplier (Simchi-Levi et al., 2007). The total inventory cost of a cycle time T is equal to:

$$K + \frac{hTQ}{2}$$

where K is the fixed setup cost, h is the holding cost per unit per period of time, Q/2 is the average inventory level, and T is the cycle time.

From the previous explanation it is easy to understand that the inventory level goes from Q to 0 over the cycle time T. Since the demand is constant and it is assumed to be equal to D, this leads to state that Q = TD. Now, using some calculus, It can be demonstrated that Q*, that is, the optimal order quantity that minimize inventory costs equals

$$K + \sqrt{\frac{2KD}{h}}$$

From the economic lot size model two major considerations can be deducted (Simchi-Levi et al., 2007):

1. An ideal inventory policy balances setup costs and holding costs. The setup cost can be defined as KD/Q; the holding cost as hQ/2. When the order quantity Q rises, the setup cost drops down and the holding cost goes up. The optimal order quantity can be found at the point where setup cost encounters the holding cost:

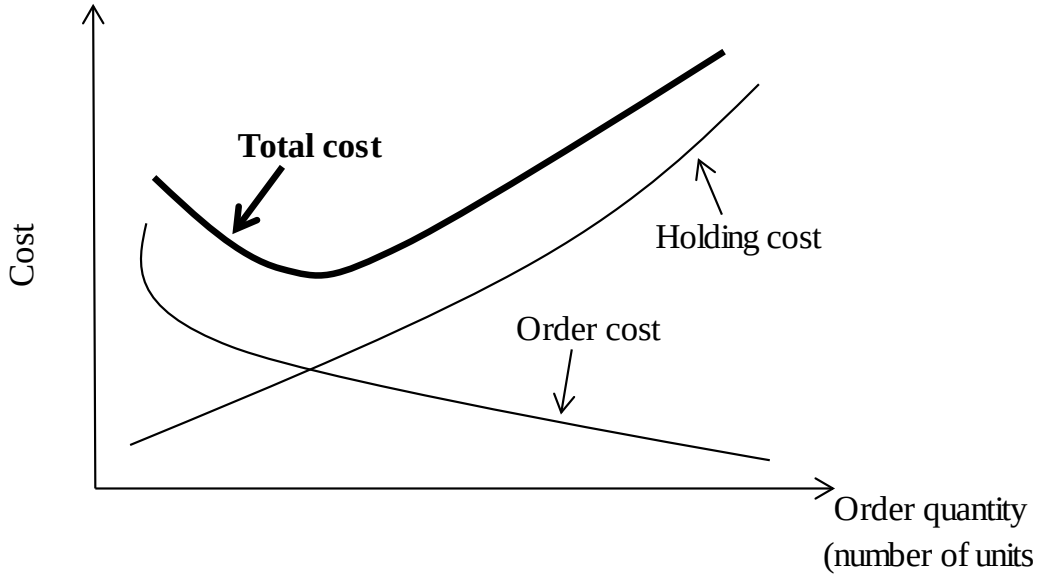
$$\frac{KD}{Q} = \frac{hQ}{2}$$

Therefore, the optimal order quantity can be expressed as:

$$Q^* = \sqrt{\frac{2KD}{h}}$$

Figure 3.2 provides a graphical explanation of this concept.

Figure 3.2. Total cost in the economic lot size model



Source: Simchi-Levi et al. (2007), p.34

2. Changes in order quantities have a limited impact on total inventory cost, which means that they do not affect setup costs and holding costs too much. Consider an order quantity Q, a multiple of Q*. This implies that, for any given *a*, Q = *a*Q* or Q* = Q/*a*. If *a* = 1 this means that the actual quantity ordered Q corresponds to the economic order quantity. However, if *a* = 1.2 (1/*a* = 0.8) the quantity actually ordered is 20% less than the optimal order quantity. At this point it is possible to calculate the impact of changes in order quantity on total

inventory cost (Table 3.1). In the previous example, if the actual order quantity is 20% higher than the optimal order quantity, that is, a = 1.2, total inventory cost increases by roughly 1.6% compared to total inventory cost in case of optimal order quantity.

Table 3.1. Sensitivity analysis

a	0.5	0.8	0.9	1	1.1	1.2	1.5	2
Increase in cost	25%	2.5%	0.5%	0	0.4%	1.6%	8.9%	25%

Source: Simchi-Levi et al. (2007), p.35

The economic lot size model is a great tool that company can use to determine the order quantity to keep in inventory in such a way to optimize the trade-off between order setup costs and inventory holding cots. However, as Simchi-Levi and others (2007) underline, this model does not consider two important factors that influence the inventory management: demand uncertainty and forecasting accuracy.

When companies make decision about their inventory they need to come up with forecasts, which need to reflect the future demand as much as possible. Based on these forecasts, companies then decide on their inventory policy. The problem with this approach is that the business world is treated in a predictable fashion. Surely, forecasts do not provide an accurate representation of the reality, especially in the current recession that has caused a great increase in both demand variability and uncertainty. Although companies are aware of this issue, they find that using forecasting methods to predict future customer demand can still be the basis of making production and inventory decisions.

Managers must not forget the principles of all forecasts listed by Nahmias (1997):

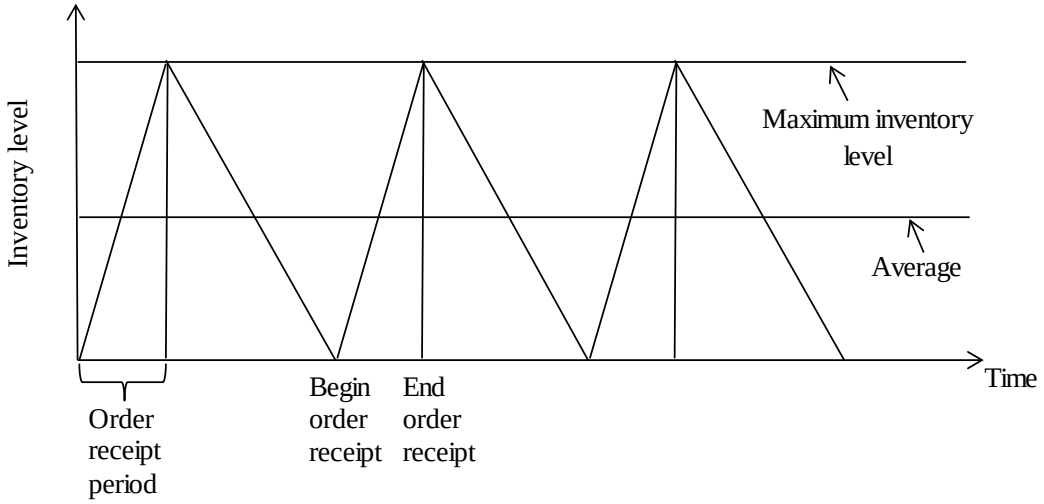
- Forecasts are always wrong.
- The longer the forecasts are projected into the future, the more they risk being inaccurate.
- When forecasts are aggregated they become more accurate.

According to the first principle, it is hard to match demand and supply when processes are planned on the basis of forecasts. However, it is also true that any production and distribution system cannot work without some kind of demand forecasts.

Especially during this current recession, a forecast, in order to be accurate, can represent a time frame not longer than 3 month. This goes along with the second principle which states that customer demand is hardly predictable in the long term. The third principle, instead, says that it is easier to predict the demand for a family of product than for a specific single product: this is an example of the so called risk pooling, which will be explained in sub-section 3.3 of this chapter.

Another significantly important assumption of the economic lot size model is the absence of lead time. This means that in the economic lot size model the items are received right after an order is placed. To overcome this issue, a variation of the basic economic lot size model has been formulated: the production quantity model. This model, also called the gradual usage and non-instantaneous receipt model, is based upon the statement that the inventory level of a certain product is gradually replenished over a specified period of time, called the order receipt period (Russell & Taylor, 2006). Figure 3.3 provides a graphical illustration of this model.

Figure 3.3. The production quantity model



Source: Russell & Taylor (2006), p.540

This variation of the economic lot size model eliminates the too simplistic assumption of zero lead time that cannot be accepted especially by international companies that have a widespread supply chain all around the world. When customers are far away from the location where the company produces or orders its product, like in the case of international companies, lead time is one of the most important components to consider. International companies that, for example, sell to markets in Europe or the

U.S. and have facilities and/or suppliers in the Far East usually have a lead time of 30 to 35 days. This amount of lead time crucially puts emphasis on the importance of a proper inventory policy.

3.2.2. Inventory policies facing demand uncertainty

As already explained, uncertainty in demand heavily affects a company's decision regarding its inventory. In order to understand the impact of this market condition, the following sub-sections will present a series of scenarios, ordered along the lines of increasing complexity, to highlight the implications of this market variable.

The first scenario concerns a product with a short life cycle. With regards to this product, the company can only order or produce this product once during the chosen period of time and no initial inventory is available (Simchi-Levi et al., 2007). Therefore, the company has to make forecasts and decide the amount to produce and then make it long before the actual demand is revealed. Determining the right amount needed of that product for the entire period is tricky. In fact, if the company decides to order or produce more than the actual demand, it will have an unsold excess inventory to deal with at the end of the period. Instead, if the company orders or produces less than the actual demand, it will lose possible sales and, thus, will get a lower-than-potential profit. This is the case of, for example, manufacturers in the fashion industry. For seasonable products such as swimsuits they have to decide on a specific production quantity about six months before the summer. No later decisions are possible since there would not be enough time to produce additional quantity and reach the customer before the season ends.

Having only one opportunity to order what is needed to serve the market for the entire period, the company has to find a way to identify the optimal quantity needed for that product. A good way to deal with this situation is to classify a variety of scenarios for different levels of demand[1] and define the likelihood for each of them to actually occur. Then, every scenario will be associated with a specific quantity of the product and, therefore, with a specific inventory policy. Using these data, the company can also quantify the profit for each scenario and weigh it with the likelihood of each scenario to

[1] Future demand can be extrapolated using historical data or other forecasting methods such as market research, time-series, causal, and judgment methods.

occur. This will help to calculate an average expected profit for each specific product quantity (Simchi-Levi et al., 2007). Hence, it is easy for a company to identify the quantity that maximizes the average profit, that is, the optimal quantity.

What is interesting to underline about this practice used to identify the appropriate quantity and, thus, inventory policy is that the quantity which maximizes the average expected profit does not necessarily equal the average demand. Here, the difference between the marginal profit and the marginal cost of an additional unit sold has to be considered. The marginal profit for an additional unit sold is equal to the difference between the price per unit and the variable cost per unit. The marginal cost, instead, is equal to the difference between the variable cost per unit and the salvage value per unit. All this being said, if the marginal profit for an additional unit sold is greater than its marginal costs, the optimal quantity will be higher than the average demand. Vice versa, when the marginal cost for the additional unit sold is greater than the marginal profit of that same unit, the optimal quantity is lower than the average demand (Simchi-Levi et al., 2007). Even though the company has sold more units of the product, the additional unit(s) sold would bring more cost than actual profit.

The most important implications of this scenario are (Simchi-Levi et al., 2007):

- The optimal quantity and the average demand do not necessarily need to be the same. It all depends on the difference between the marginal profit and the marginal costs of an additional unit.
- The profit typically increases along with the increase in quantity until it reaches a point after which the profit starts decreasing.
- In inventory policy decisions there is always a significant level of risk involved. As the quantity of a specific product increases, the probability of a large loss in the case of lower-than-expected demand increases. However, the probability of a big profit also increases. Therefore, there is always a trade-off between risk and reward.

A second scenario to consider is when there is still a single ordering or production opportunity available within a selected period of time but, compared to the first scenario, the company has already inventory of the product considered and it has to decide whether to place an order or to go into production. This can be the situation of an inventory left over from a previous season which can still be sold in the market (Simchi-

Levi et al., 2007). If the company decides to only use the inventory already stocked it has to be sure to meet the demand but, at the same time, it would risk to lose some potential profit. On the other hand, if the company decides to place an order or to produce the product, fixed costs will occur. Therefore, the company needs to be convinced of the necessity of this action to meet the customer demand.

When the company already has inventory available for a certain product, the trade-off to ponder is between having a limited inventory and avoiding fixed costs or deciding for a higher level of inventory but having to deal with fixed costs (Simchi-Levi et al., 2007). In order to make a conscious decision for this situation the company has first of all to define what will be the quantity that the management finds appropriate to produce. Independent of the amount produced, the company will always have to pay fixed costs. Therefore, the management has to quantify the right quantity for production in order to cover appropriately the fixed costs. Then, a best practice to follow is to compare the average profit associated only with the initial inventory, not producing anything, and the average profit associated with the inventory that includes the added produced quantity. If the first is larger than the second, the optimal policy is to serve the market only with the initial inventory. Even when the demand is higher than the initial inventory, it would not be convenient to meet it entirely since the profit would be lower due to the occurrence of fixed costs. If the average profit associated only with the initial inventory is lower than the profit with the produced quantity added to the already-existing inventory, the optimal policy is to produce that quantity. Even though the company has to pay fixed costs, in this case this will not prevent a higher profit.

The scenarios just illustrated refer to situations in which there is only a single opportunity to order or produce the quantity needed for the entire selected period. This is what typically happens in the fashion industry where the selling season is short and, thus, there is not enough time to have a second opportunity to reorder the product on the base of the revealed customer demand. In many other industries, however, it is usual to have several opportunities to order or produce additional units of a product over the selected period of time. To manage inventory effectively, in these cases companies need to control items they have in stock and decide when and how to order. Different policies to control inventory can be used to manage these situations and they will be introduced in the next sub-section.

3.2.3. Inventory control systems

An inventory control system provides the means to decide when and how much to order. There are two basic types of inventory control systems:

- continuous inventory system, also called perpetual system or fixed-order-quantity system;
- periodic inventory system, also called periodic review system or fixed-time-period system.

The continuous inventory system serves as a constant monitoring of the inventory level of every single product kept in stock. Whenever the system records that the inventory level of a certain product goes down to a predefined level, also known as the reorder point, it automatically places an order to the supplier to replenish the product. The system is structured in such a way that it orders every time the optimal order quantity, which can be found using the economic lot size model described above, is reached (Russell & Taylor, 2006).

An advantage of the continuous inventory system is that, at any moment, managers can check the inventory status. This helps them, for example, to control how the inventory of critical products varies over time. Especially for international companies with a widespread supply chain, this can be a good start for reconsidering the inventory policy used for those critical products in the process of finding less expensive and more efficient ways to stock them.

This inventory control system of constantly monitoring the levels of inventory for all in-stock products can be really expensive, though (Russell & Taylor, 2006). A lot of resources, especially time and equipment, are necessary to set up and maintain the control of inventory levels. It is especially expensive for international companies to find the appropriate way to track items in the company's warehouse(s) as well as within the portion of the supply chain managed by the company itself.

The continuous inventory system is most appropriate when the company can afford and maintain computerized information technology tools (Simchi-Levi et al., 2007). In fact, information technology helps to improve the speed of the control system and the accuracy of data entry (Russell & Taylor, 2006). In the dynamic fashion industry, companies such as H&M and the Inditex group, which includes Zara, Pull and Bear,

Bershka, Oysho, Massimo Dutti, and other brands, implement a continuous inventory system (Titze, & Krasojevic, 2012).

The period inventory system, instead, is a control system in which inventory level is monitored at specific time intervals, for example, every week or at the end of every month (Simchi-Levi et al., 2007). When the inventory control is done and the level of inventory is known, an order is placed for such an amount that allows the inventory to be back at a previously-determined level. This type of inventory control system is most appropriate for systems such as the ones of small and medium size companies in which it is impossible or not convenient to apply a continuous inventory system (Simchi-Levi et al., 2007).

An advantage of this system is that the inventory does not have to be monitored during the time interval. Therefore, no sophisticated tracking technology is required. Of course, the disadvantage of this system is that there is not direct and continuous control over inventory levels. In order to overcome this disadvantage, higher inventory levels are usually stocked compared to the ones in the continuous system. This is done to prevent unexpected stockouts during the time interval. Another disadvantage of the periodic inventory system is that every time the inventory control is done it is necessary to decide an amount to order (Russell & Taylor, 2006). Doing so, it is quite difficult for companies to ensure good deals with suppliers as the quantity ordered can vary significantly from a control to the other.

An example of periodic inventory system is the one used by college bookstores for textbooks (Russell & Taylor, 2006). After the first weeks of a semester, college bookstores make inventory control for each textbook and, then, they order a certain quantity according to the selling expectation for the next semester and the amount that is still in stock. Another example is small retailers and grocery stores (Russell & Taylor, 2006). The control on their inventory level is often done by vendors who check the amount of products still in stock every few weeks or every month.

3.3. Risk pooling and product logistics in the global supply chain

One cannot talk about inventory systems without mentioning their strong connection to production systems (Benjaafar et al., 2005). Granted, in certain situations it is reasonable to consider these two systems as independent from one another. For example,

a company can treat these systems independently if its inventory buffer at the production location is large enough so that bottlenecks in one of these two systems do not negatively affect the other. Here, these two systems can be regarded as virtually separate within a single company. Similarly, the separation between the inventory and productions systems is even more apparent when these systems are owned and managed by separate entities. Furthermore, in the case of international companies, lead time can be a determining factor for managing these two systems separately. Since these companies have widespread supply chains it is likely that transportation lead times are significantly longer than production lead times. In these cases, it would be impractical to apply the same management approach to both systems. These situations, however, are very rare.

For the most part, production and inventory systems are too much intertwined to be considered on their own. In view of entire supply chains, this principle - strengthened by practices such as Vendor Managed Inventory (VMI) [1] - becomes even more applicable because of the interdependence of suppliers, manufacturers, distributors, and retailers. Due to the current emphasis on lean manufacturing and the constant pressure to reduce material-handling times and inventory levels, problems and delays at the factory level have an even greater impact on distributors and retailers (Benjaafar et al., 2005).

An example of an industry where production and inventory systems are strongly connected is the electronics industry. For instance, Apple has implemented a system with such a close relationship with its suppliers, first of all Foxconn, that every part of their business is aligned around Apple's strategy. Indeed, Apple requires its key suppliers to keep two weeks of inventory within a mile of Apple's assembly plants in Asia. Although Apple controls nearly every piece of the supply chain, from design to retail store, it often happens that Apple's produts are even shipped from supplier locations diretly to stores (Satariano & Burrows, 2011).

Contract manufacturers such as East West Manufacturing and Solectron own several production facilities all over the world and provide outsourcing services to a whole host of original equipment manufacturers (OEMs). In order to satisfy their customers, these

[1] Another practice worth mentioning is inventory consignment. Here, the manufacturer owns the products in stock until they are sold.

contract manufacturers entertain flexible technologies, which allow them to manufacture a wide range of different products without major losses in changeover time or cost[1](Benjaafar et al., 2005). Since lead times usually tend to be high for these international companies due to having manufacturing facilities far away from customers, production must be planned ahead of demand using a make-to-stock approach. Company facilities may manufacture many products, each of them for a different customer, or each of their products can be manufactured in different locations. Indeed, contract manufacturers hold inventory for finished products either at their factory locations, regional warehouses, or directly at customer sites. This has the effect of boosting the variability that these companies have to face.

In order to address massive variability in the supply chain it is useful to apply the concept of risk pooling. Risk pooling refers to the aggregation of several inventory locations into one (Simchi-Levi et al., 2007). Companies that maintain many inventory locations - commonly demarcated by geography, type of product, or customer - would fuse these locations into a single one. In this way, the diverse needs of customers are served by using a single central inventory[2]. This, in turn, lowers demand variability across different locations because the individual high and low end demand from customers of various locations potentially evens out over time. Risk pooling is especially beneficial for companies that offer a high variability of products to their customers such as major retailers such as Tesco, considered a true multichannel and technology-driven retailer, which has undertaken an intense logistics program for, on the one hand, inventory centralization and, on the other hand, increasing the daily service level to retailers (Titze & Krasojevic 2012).

The current recession has put an even greater emphasis on the advantages that can be achieved when pooling inventory in a centralized system. In today's markets, a centralized inventory system can offer the opportunity to better confront unstable levels of demand and high demand uncertainties: if the demand from one market is higher and from another lower than expected, pooling the inventory in a central location will improve the management of overall demand. This prevents stockouts in the first market

[1] For further information, consult Plambeck and Taylor (2005).

[2] In 1979, G. D. Eppen (1979) already demonstrated the potential savings in cost through satisfying a widespread demand via a centralized system of inventory.

and makes products available in the second. In turn, the tendency of having to deal with peaks in demand is reduced. As can be expected, however, if the demands of the two markets are positively correlated, the advantage gained by a centralized system decreases (Simchi-Levi et al., 2007). By managing inventory as a shared resource at one central location, risk pooling allows companies to decrease safety stock and, thus, reduce the average inventory needed to keep a satisfying service level (Simchi-Levi et al., 2007). Risk pooling offers the possibility for companies to control the level of variability across the entire supply chain.

Figure 3.4. Centralized distribution system

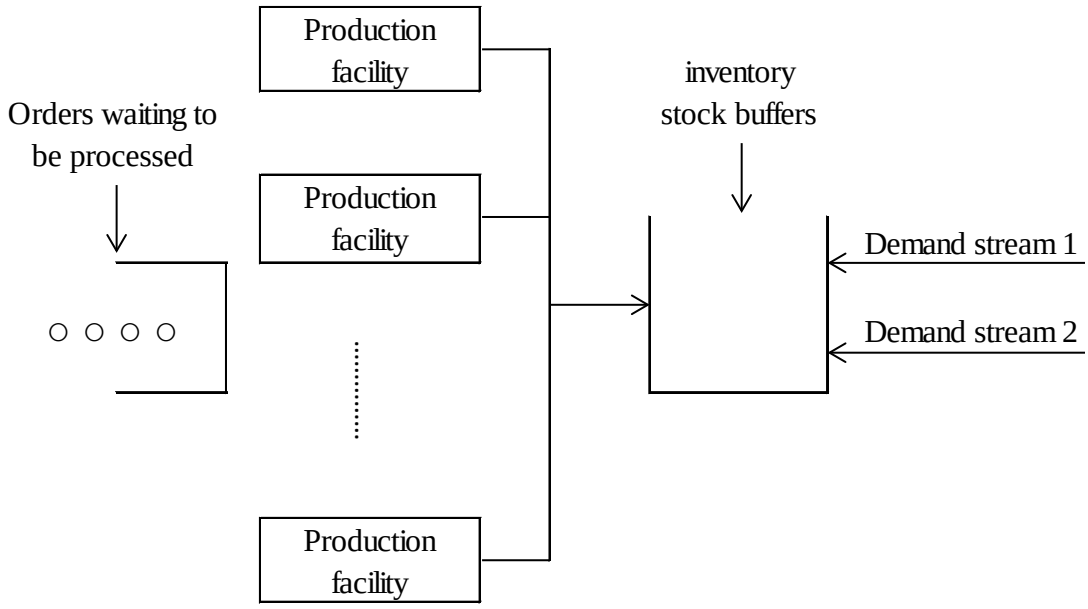


Figure created by B. Piva and adopted from Benjaafar et al. (2005), p.560

It has to be noted that risk pooling is a concept that can not only be applied in the context of inventory for finished products. Rather, companies that have a make-to-stock model can implement this concept also with regards to semi-finished products, i.e. when strong commonalities exist between different product types (Benjaafar et al., 2005). A contract manufacturer such as East West Manufacturing, for example, offers a wide variety of screws to an almost equivalent number of customers. In this case, the concept of pooling can offer an easy and cost effective opportunity to avoid separate individual production processes throughout the entire supply chain by keeping an inventory of common semi-finished products instead. This provides the possibility to exploit risk

pooling because the company can differentiate the final manufacturing stages to suit incoming orders once actual demand is revealed[1].

It becomes clear, then, that risk pooling is very much a context and setting-based effect. To pursue such an approach is only reasonable as long as the aforementioned requirements are present. For international companies, which engage in global market spheres characterized by high volatility in demand, this can pose problems. The issues that international companies face about their inventory are lead times and wide spread and ever-changing end markets. A single, all-encompassing inventory location will not be feasible due to these issues. For these risk pooling works better in local, smaller-scale market environments. Here, chances are relatively high that all requirements can be met.

Ultimately, risk pooling cannot be regarded as the Swiss army-knife of inventory and distribution management. Granted, a centralized distribution system has a positive effect on safety stock, which has been shown above. Also, the quality of the service level is higher because a company can respond to demand variability in a more controlled fashion. Furthermore, fix costs are lower when a company decides to take advantage of risk pooling because there are less inventory locations to be managed. See Figure 3.4 for an illustration of a centralized distribution system.

However, there are a number of trade-offs to consider which makes a decentralized approach to inventory and distribution management a viable option. The decentralized distribution system, illustrated in Figure 3.5, is characterized by the distribution of production outputs among several warehouses located closer to different markets.

[1] See 2.4.2 for further information regarding postponement or delayed differentiation.

Figure 3.5. Decentralized distribution system

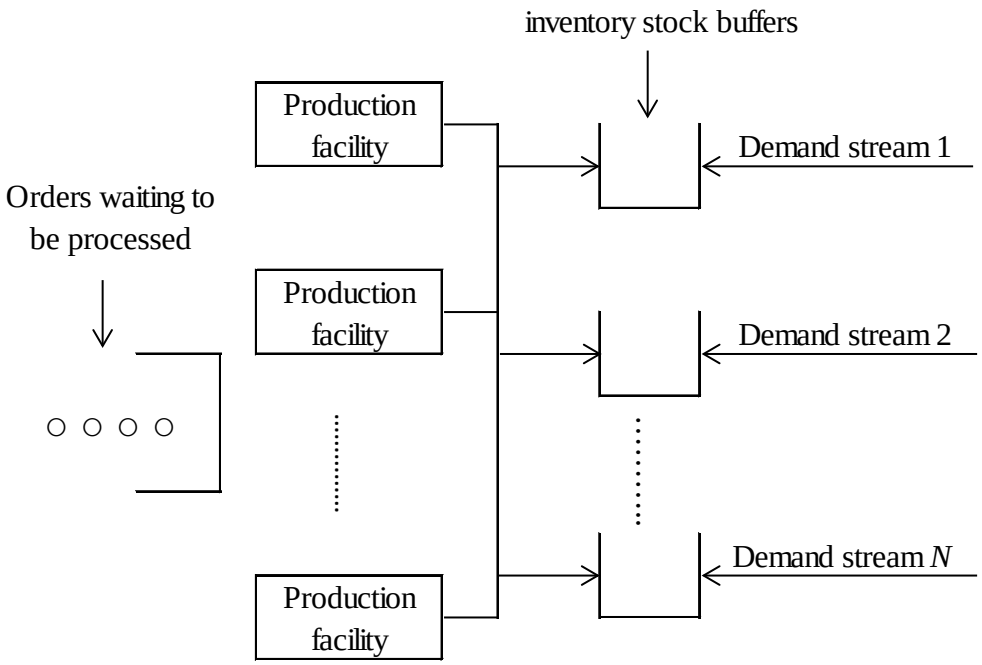


Figure created by B. Piva and adopted from Benjaafar et al. (2005), p.550

Lead times, for instance, are increased in a centralized distribution system because warehouses are further away from end customers. With a decentralized distribution system, instead, companies can engage more directly with customers. Similarly, transportation costs rise when the inventory of the company is managed through a centralized inventory. Still, the advantages of this inventory and distribution system outweigh the disadvantages.

Even though the decentralized distribution system remains important for its advantages, a centralized inventory system allows companies to better face instability and certainties in demand, major issues of today's market environment.

3.4. The importance of managing safety stock after the recession

In order to meet unpredictable peaks in demand and avoid the risk of stockout, companies always carry a certain level of extra stock: the safety tock.

Supply chain managers have to take a potential trade-off into consideration when they define the level of safety stock (Chopra & Meindl, 2001). Of course, when a

company holds more safety stock, it is able to avoid product shortages during peaks in demand and, thereby, increase the overall margin for purchases. However, such an approach also increases overall inventory holding costs. Nowadays, companies are concerned about this second consideration due to the growing pressure of cutting costs. While this trade-off did not pose significant problems when the demand was informed by relatively stable demand margins, it certainly affects companies now since demand is volatile and products tend to have short life cycles.

Product availability is a defining feature of success in the international market. And with the rise of the Internet as a means for customers to check the availability of products instantly, more emphasis has been bestowed on companies to compete with one another in that sector as well. This is especially true for online shopping sites such as *Amazon.com* or *Borders.com,* particularly in the book market (Chopra & Meindl, 2001). These companies usually carry the same book titles, and therefore engage in increasingly heterogeneous international markets where the demand for individual products is very difficult to predict. As a result, the level of safety stock in relation to overall inventory is nowadays greater than in the past because of the differences in markets and the pressures for product availability (Chopra & Meindl, 2001). To meet these challenges, companies have to find a safe balance between the amount of safety inventory they carry without compromising the availability of their products.

It becomes clear, then, that a company needs to consider two questions in particular when it comes to designing a sustainable inventory strategy:

- How much safety stock should be held at inventory locations?
- What measures can be taken to reduce safety stock without compromising product availability?

3.4.1. Settling on appropriate levels of safety stock

In order to determine the appropriate level of safety stock, two factors need to be considered (Chopra & Meindl, 2001):

- the uncertainty in demand;
- the requested level of product availability.

As in the current recession, when uncertainty in demand increases, the level of safety stock that a company needs to keep increases as well. Usually, this situation occurs

when the product is in the introduction phase of its life cycle: the demand for the product is highly uncertain and a high level of safety stock is needed. As the product passes this first phase, demand becomes more predictable and, thus, uncertainty decreases. Therefore, a lower level of safety stock is needed. However, in times of recession, uncertainty in demand is present for product in any phase of their life cycle most of the time.

Similarly, when the requested level of product availability increases, a high level of safety stock is needed. Product availability is the measure of the ability of a company to fulfill a customer order using the available inventory and, thus, avoiding stockout. Some measures of product availability are (Chopra & Meindl, 2001):

- *Product fill rate*. This is the percentage of products that are filled from products in stock. It can also be defined as the probability to supply a product taking it from the available inventory.
- *Order fill rate*. This is the percentage of orders that a company is able to satisfy from available inventory. In contrast to the product fill rate, this rate is more suitable in multi-product scenarios, where orders are composed by more than one products. In these cases, an order is considered filled only if all the requested products are available in stock. For example, if a customer requests a monitor along with a keyboard, the order is filled only if both products are in inventory. For this reason, order fill rate is usually lower the product fill rate.
- *Cycle service level*. This is the percentage of the customer demand met before any inventory replenishment is made. It can also be defined as the probability of not having stockout during the period between to replenishments.

In a single product scenario, there is not a significant difference between product fill rate and order fill rate. When it comes to a multi-product scenario, however, this difference may be relevant. For instance, a company can have an order of 10 or more products and it is able to supply all the products but one. In this case, the company has a high product fill rate although its order fill rate is low. Keeping track of order fill rates is crucial especially when the simultaneous fulfillment of the entire order is important for the customer (Chopra & Meindl, 2001).

As already mentioned, the goal of any company is to have a level of safety stock that should be as low as possible. At the same time, this defined level also needs to meet the customer demand and, therefore, not affect product availability. In order to achieve this goal two main levers can be implemented (Chopra & Meindl, 2001).

1. *Reduce lead times*. If lead times are reduced, there is no reason to keep a high level of safety stock. In fact, products can arrive to inventory locations within a shorter amount of time. Reducing lead times is not easy and it requires a significant effort, especially from international companies with a widespread supply chain. Companies such as Wal-Mart, 7-Eleven, and Dell worked extensively with their suppliers to lower lead times.

2. *Lower uncertainty in demand*. Many times in order to lower uncertainty in demand it is useful to improve the quality of demand forecasts. The use of sophisticated market intelligence methods can certainly help to face this issue. In times of recession, however, improving the accuracy of forecasts may not be functional since it is not possible to predict future demand based on historical data or analysis of trends. In this case, there are other approaches can be used to reduce demand uncertainty. For example, a company can work on the design of its product and of its production line so that strategies such as postponement or delayed differentiation and different types of standardization are possible [1]. Indeed, as already presented in the previous chapter, information sharing throughout the entire supply chain is certainly another useful tool to lower demand uncertainty.

Even during the current recession, many companies are implementing the same "set and forget it" approach to decisions such as the ones on lot production size and parameters for logistics as before (Holter, n.d.). Because of the major changes that have recently occurred in the business environment, this practice disrupts the synchronization between production and logistics systems and the reality of the market.

The same reasoning is applicable to decisions about safety stock levels. In fact, many companies use pre-set safety stock levels which correspond to a "weeks' supply"

[1] Postponement or delayed differentiation, standardization, and other manufacturing strategies can be found in chapter 2.

formula (Holter, n.d.). This fixed amount, however, has been revealed to often be too high compared to the actual demand conditions. Hence, it has only brought about unnecessary excess inventory. This kind of approach is dangerous and it dramatically affects business performance. To avoid this risk, companies should calculate the appropriate safety stock level monthly based on the revealed demand. Due to the volatility of this market variable, it is not feasible to determine an always-correct level for safety stock.

One of the major implications of the 2008 recession has been that drops in demand now function as much more critical indicators to test whether a company's supply chain can withstand rapid changes in the market place or not. Inventory policies are largely affected by this. Of course, if a company fails to address the effectiveness of its inventory policies, such as underlying processes and parameters, it will surely produce excess inventory during these kinds of demand periods (Holter, n.d.). Moreover, if companies fail to have a general mindset that recognizes the currently growing instability in demand and to adjust their supply chain planning system accordingly, they will also not be able to respond swiftly to swings of the demand pendulum. This creates unnecessary costs that must be avoided.

The global recession has tested the durability of established strategies for manufacturing and logistics. The last chapters have shown that even if companies are now dealing with a potentially game-changing scenario when it comes to their supply chain, the fact of the matter is that the means to confront this situation in a successful way already exist. It becomes clear that it is important to perceive the characteristics of the new environment as an incentive to rethink and refine these strategies to gain competitiveness.

At this point, it is crucial to move towards a case study to illustrate how an international company hit by the effects of the recession can realign its supply chain and be successful.

CHAPTER 4. East West Manufacturing

4.1. Company overview

East West Manufacturing[1] is an international company that applies a complex and interesting global supply chain. Founded by Jeff Sweeney and Scott Ellyson in Atlanta (U.S.A.) in 2001, East West Manufacturing (hereafter referred to as EW) is a contract manufacturer considered an expert in the planning, design, and implementation of outsourced and offshored products, which are manufactured for U.S. and European companies, mostly original equipment manufacturers (OEM). EW products are customized and fall into projects developed in collaboration with customers to offer a complete range of products. All of EW products, approximately 3000, can be categorized as follows:

- plastics;
- rubber;
- industrial textiles;
- metal;
- electronics;
- assemblies;
- motors.

With sales of $40 million in 2011 and an expected growth of 15% in 2012, the EW business can be broken down in this way: products such as plastics and electronics count for 30%, motors for 27%, other non-electronic products for 15%, metal for 15%, rubber for 10%, and the rest for 3%[2].

EW has 470 employees, 100 of which are professional staff and 50 are engineers. Its global organizational structure is illustrated in Figure 4.1 and can be described as follows:

[1] This case study is the result of several hours of interviews conducted with the management team of East West Manufacturing both in the US and in China.

[2] These percentages are based on sales for 2011.

- EW (Atlanta, U.S.A.). This is the company's headquarters; the top management and the US operations team are located here. Even though EW does not manufacture in the US, it has a US operations presence in its warehouse in Conyers, a small city outside the Atlanta metropolitan area, where it performs cross-docking, inventory-holding, and some simple re-packaging (private label branding) there using full-time employee and some temporary workers[1].
- EWA (Shenzhen, China). This is the office that supervises the company's Asian operations. Composed of 50 employees, it is mainly in charge of sourcing, engineering, logistics, and quality assurance.
- EWVN (Saigon, Vietnam). This is another office, composed of 12 employees, which acts as sourcing and engineering office like EWA.
- EWILO (Chennai, India). This is a brand-new office that just opened in India - currently it has only one employee. This is going to be another location for sourcing.
- EWI (Binh Duong, Vietnam). This EW location is composed of three factories in which 200 employees work on producing rubber, plastic, and the assembling o electronic products. These are the only three locations for production that EW fully owns.
- CBM (Changzhou, China). This is a joint venture owned by EW for 25%. Due to Chinese regulations, in order to open this facility the company had to create this joint venture with other two Chinese partners. This factory, composed of 200 employees, mainly concentrates on the production of motors for air conditioning systems.

Approximately half of the products EW offers is done by the facilities that they own or partially own, the other half is done by its suppliers through sourcing. EW supports its customers by allowing them to access a global supply chain. Many of EW customers, in fact, do not have enough resources to invest in their own global supply chain. Indeed,

[1] EW owns another small warehouse in Adelanto, California, which is used as a cross-docking location for customers on the West Coast of the US who are treated with direct shipping (see Figure 4.1).

they do not have experience in dealing with suppliers in these countries and have concerns about quality standards. EW takes care of all these issues by managing the production and all the relationship with suppliers in these countries. With its experience and knowledge about China, Vietnam, and India, EW works closely with its customers to identify the optimal location where to manufacture or source products in a way that minimizes costs while paying attention to quality. A major advantage customers have when doing business with EW is that they can get the high quality they need to compete in their markets at the lowest price possible. The competitiveness of countries like China and Vietnam in terms of low price is well known. Quality, however, has always been a major concern. EW has relationships with around 60 active suppliers and works closely with them to define rigid quality procedures which ensure that quality standards are met. EW allows its customers to become more competitive in their markets by producing their components or assemblies with high quality in countries where this is strategically advantageous.

Figure 4.1. The organizational structure of East West Manufacturing

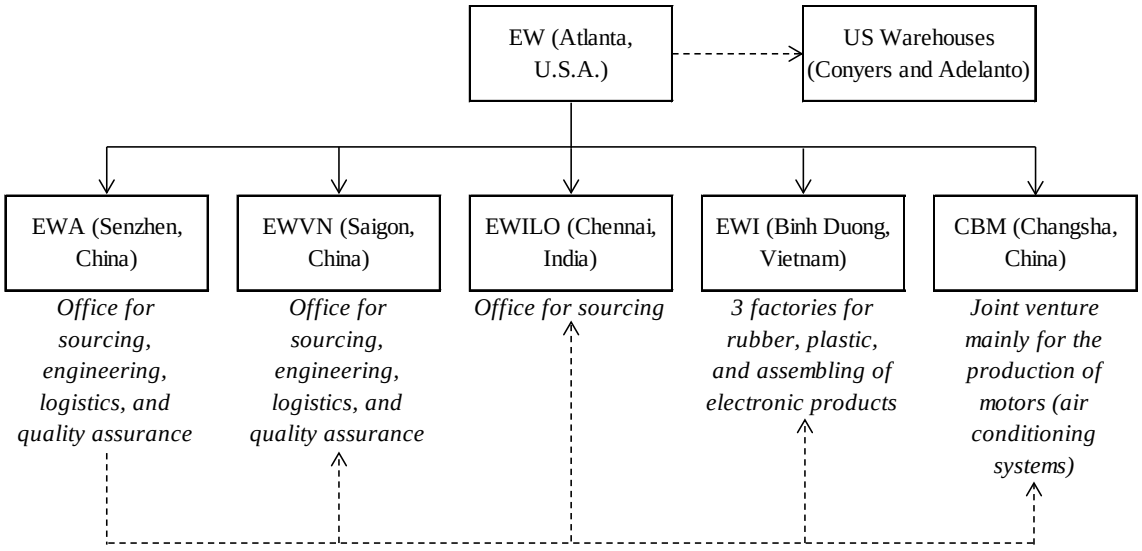


Figure created by B. Piva

EW is mainly present in the US where it is one of the major contract manufacturers as it controls, for instance, approximately 60% of the US market for after-market air-conditioning motors. Its main competitors are Arc-Tronics Inc., ASH Industries, Premier Tooling & Manufacturing Inc., Rapid Product Development Group Inc., and Solid Concepts Inc.

EW has around 60 active customers mainly located in the US and only a few of them are in Europe, more specifically in the UK, Belgium, and Italy. EW customers can be divided into two groups: direct customers and inventory customers. The first group consists of customers who receive products directly shipped from one of EW's locations in Asia. The second group is made up of customers who take advantage of the so called "EW inventory program". These customers, roughly 30%, buy products which are, however, kept at EW inventory locations; EW provides inventory management for these bought products and it delivers only upon customer requests. Product inventory is handled in EW's main warehouse located in Conyers. The "EW inventory program" has been created to mitigate the negative impact of the long lead time - 30 to 35 day - of shipments from Asia. Hence, customers can have an agreed-upon amount of their products closer to their location and eliminate inventory costs for them. The "EW inventory program" soothes the worries of customers about lead times and allows them to shorten the planning time necessary to receiving products form the Far East. With this program EW is able to offer a more responsive solution to its customers.

4.1.1. The East West Manufacturing business process

One of the biggest challenges of EW is the fact that it does not have a standardized product catalog to offer. This issue strongly influences the ability of the company to apply an efficient supply chain. Every product that EW offers is highly customized and it needs to be developed together with customers. For this reason, the business process of EW needs to be fully understood before analyzing the core characteristics of this company. Figure 4.2 provides an illustration of this process.

Everything starts with the first contact with the customer. This activity is done by the sales team at the US office in Atlanta. During this phase, also called new opportunity evaluation, the attention is focused on listening to the customer needs and wants and on discussing with him if and how a product can be realized according to the customer requirements. New opportunities can often come from existing customers: even though EW has around 60 active customers, there are close to 100 customers in its portfolio.

Figure 4.2. The business process of East West Manufacturing

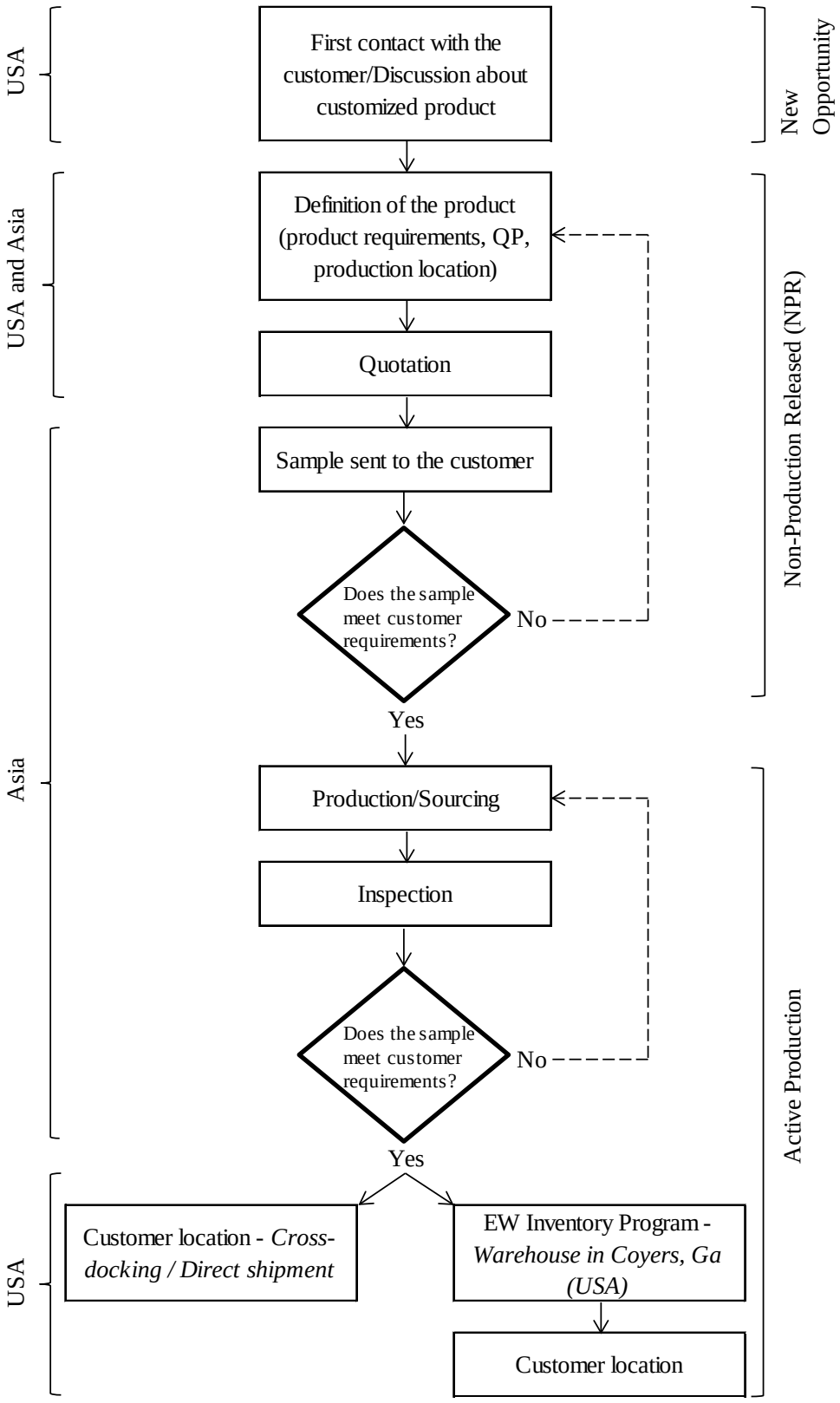


Figure created by B. Piva

Once a new opportunity is evaluated, the process of defining the product in detail begins. Here, the new opportunity becomes an active project, also called non-production released (NPR). The definition of the product requires intense communication with the customers to agree about all the required characteristics of the product such as shape, dimension, materials, durability, and performance. EW engineers have to find a way to define proper requirements that the customer will agree with. During this phase, daily interactions between the US office and the offices in the Far East are fundamental. The US office hosts the sales team that communicates with the customer and some of EW engineers who take care of the product design. The offices in China and India do not engage with customers directly but are in charge of deciding if all the requirements are actually feasible for production and advising which location would be most suitable for manufacturing or sourcing.

Sometimes it is difficult to define how a product should be made. Hence, EW has created and is constantly updating bundled of documentation helpful during NPR and the following phases. EW has a rigid documentation control to make sure that every aspect of its products is revised and managed properly. One of the most important documents is the quality procedure, often called QP: this document defines exactly the characteristics of an acceptable product, including all the physical and functional requirements. In the QP each requirement is categorized as minor, major, and critical according to the importance the customer gives to it. Once the QP is established in each of its part, it is submitted to the customer for final approval and signature. This document is considered the agreement on product quality standards between EW and the customer and it is used during the inspection phase to test the quality of the products on an ongoing basis.

According to all the requirements established a quotation is sent to the customer for review. Then, upon customer approval, EW develops a statistical standard sample plan at the location that is in charge of the actual production or sourcing. This is a crucial moment because an actual sample of the product can be tested by the customer.

If the sample meets the requirements and it is approved by the customer, the production done by EW or by one of its suppliers (sourcing) in the Far East can go underway. From this moment on, the project passes from the NPR phase to the active production phase.

Once customer orders for the product are placed, the people in charge of manufacturing or sourcing in the designed location have to follow defined procedures and make sure that the actual product reflects the requirements and quality standards requested by the customer. Once orders are ready to be sent out from the Far East, the inspection phase starts. This is a very delicate phase because samples of items from every order are checked and verified to make sure that all requirements are met. Both the manufacturing/sourcing phase and the inspection phase base their activity on the documents, like for instance the QP, previously agreed with the customer. The inspection phase usually does not take more than a few hours but, sometimes, it can require up to a week to be performed, according to the results of the inspection. Such an uncertain time frame can dramatically affect the lead time and, thus, the service level offered to the customer.

When the inspection phase is completed the items ordered are ready to be shipped. Many times, the volume of orders that EW receives allows the company to fill a full container only using a single order so that it can take advantage of economies of scale. When this is not possible, EW makes sure to consolidate orders coming from different orders.

As already mentioned, the delivery of the products to the customers can happen in two ways:

- Direct shipment to customer location. Here, when many orders are consolidated in one shipment, the logistics practice of cross-docking is used in the warehouses, especially in the one in Adelanto, California, to unload items from incoming shipments and load them directly into outbound trucks that frequent to customer locations.
- “EW inventory program”. As explained earlier, EW provides inventory services and it delivers the products only upon customer requests. This program is offered in the main EW warehouse located in Conyers, Georgia and it has been created to mitigate the negative impact of the long lead times. The customers who choose this program claim a specific quantity that they commit to take from EW inventory at given times and within a certain time frame. Knowing that, EW handles the inventory in such a way to guarantee the delivery of the products within a short lead time.

This whole process lasts 45 to 50 days on average, including 30 to 35 days for shipment. Even though EW commits itself to respond and process an order within 5 days, lead time cannot be easily lowered when keeping the process as it has been illustrated above.

4.2. East West Manufacturing and the global recession of 2008

Not unlike many other companies in the world, EW has experienced dramatic changes in the market as a consequence of the global recession. As mentioned earlier, the result of the down economy on companies has been that they are now more than ever focused on finding ways to reduce costs. In this area, EW was actually able to slightly cushion the repercussions of the recession. In contrast to other companies, EW was able to offer a service suitable to the new conditions of the market: a cost reduction solution. In comparison with many other US-based contract manufacturers, the strength of this company lies in its capacity to offer customized products at a lower cost by manufacturing or sourcing them in strategically advantageous areas such as in China or Vietnam. For this reason, many customers who might not have looked for EW offerings a few years ago are now more open and willing to start collaborations. At the same time, EW has shown that it is aware of customer concerns regarding the quality of products coming from those areas and it has always ensured it meets customer requirements and market quality standards. As a consequence, the value that existing and prospective customers give to the EW service is now higher than before the global recession.

All these factors have led EW to have good performance in terms of sales over these last few years. Even though customer demand has generally dropped due to the recession, a good adjustment of the product mix has allowed the company to increase its annual sales of at least 5% per year since 2008, as Figure 4.3 shows.

Figure 4.3. East West Manufacturing annual sales

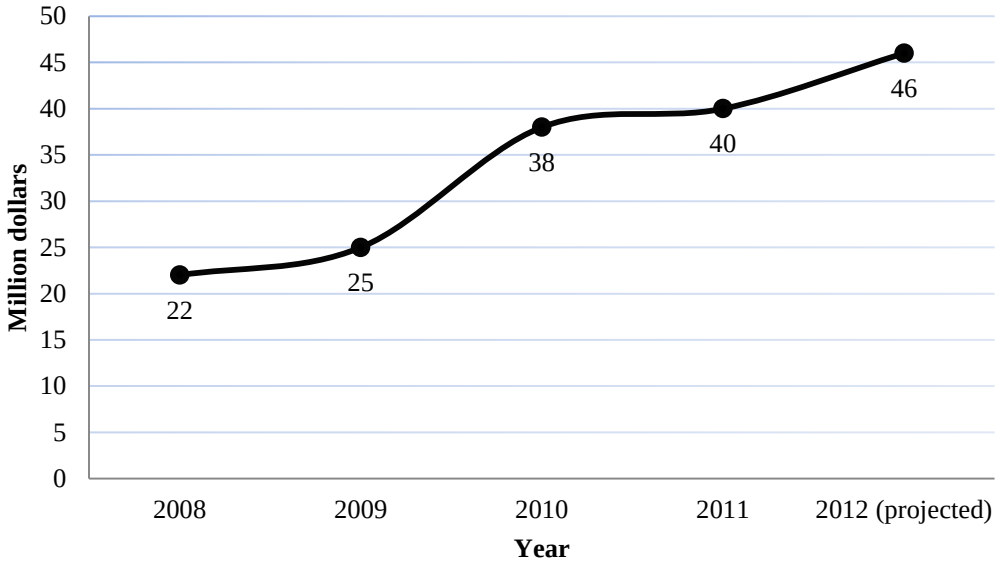


Figure created by B. Piva

This is not to say, however, that EW has moved through the recession without a few setbacks. In fact, one of the biggest concerns for EW has been a lack of customer commitment for long term contracts, that is, contracts that last for two or more years. The instability and high variability in today's market have made it impossible for any company to agree to long term commitments, especially in markets such as for OEMs. EW is a contract manufacturer that works in a business-to-business environment and its customers are mainly OEMs. Therefore, it is indirectly affected by changes in the final customer demand. Due to the ubiquitous phenomenon of the bullwhip effect and its position in the supply chain, the company is subject to more intense demand variability compared to those companies that work closer to the end customer. This makes planning and demand forecasting more difficult. In fact, the instability of the final demand has caused EW customers to be more inclined to place orders rather on a short to medium term basis.

With regards to order volumes, EW also noticed that its customers tended to reduce order quantity and, thus, inventory cost as much as possible. Before the global recession, EW customers used to keep around three months' worth of inventory, now they are down to one. This tight inventory dramatically affects long supply chains. For this reason, EW cannot afford to be late with orders as its long lead time magnifies any delay. As the risk of stockout is much higher now, customers are putting a lot of

pressure on EW to have a quicker respond and no late orders. Due to the long lead time from Asia, it is now more challenging for EW to satisfy customers, as they are also not able to provide their suppliers with reliable forecasts about their needs due to the extreme variability of the final demand.

In view of the complexity of products, the recession has not had the effect of slowing it down; rather, the competition is now fiercer and it is based on offering products with more and more features at the lowest price possible. This is a natural result of the structure of today's economic situation. The recession has dramatically affected the capacity of the market to expand and, in many cases, it has reduced its dimension. Hence, companies' efforts to grow are now focusing on gaining a bigger market share at the expense of their competitors by exponentially increasing industry standards. Companies that do not keep up with this new market reality are quickly pushed out of the market. Every player of the supply chain is affected by this rise in complexity and must work hard on that, EW included.

That being said, a clear consequence is that many companies who were able to survive before have been wiped from the market or were bought up by stronger companies. Another effect relating to this is the increase in insolvency rate. Since2008, EW had some customers who went bankrupt and some others who are really close to it. This, of course, has threatened the ability of EW to raise money from sales. The company has been very careful to extend credit terms but it took a small hit nonetheless. In order to avoid such situations in the future, the management of EW states that the company is now focusing more on analyzing the profile of prospective customers and project margins before deciding to start collaborations.

Of course, in order to remain profitable, each customer lost has to be substituted with a customer gained. This, however, becomes challenging in times of recession. EW worked hard to avoid to be dragged down and lose sales. The sales team at EW balanced customers who did not survive with new ones. Their work was supported by the fact that, as already mentioned, many companies are now actually looking for a supplier with the characteristics of EW; this increases the perceived value of EW products and services. EW was fortunate to be able to report a constant, even if sometimes small, growth every year since the beginning of the recession. However, it

was noticed by the management that the same amount of efforts the sales team put in gaining new customers would have translated into exceptional growth a few years ago.

The global recession of 2008 has not only had detrimental effects on the companies. It has taught a valuable lesson. By working with tighter budgets and focusing on cutting unnecessary costs, customers are now seeing the benefits of managing a more flexible and efficient supply chain. The new market conditions, in fact, do not allow companies anymore to maintain processes and activities that create a waste of resources: continuing with old inefficient practice only leads to bankruptcy in the end. The recession has taught companies to reconsider and restructure their entire business models and to implement more agile supply chains which allow them to adapt more swiftly to future changes in the market. And US companies that survived the recession seem to understand that. In the last 18 months EW has noticed a slight recovery in the sales volume and it can clearly see that the current market conditions invite much tighter supply chain strategies for healthy growth.

4.3. An analysis of the supply chain of East west Manufacturing

In order to face the new market environment, EW needs a supply chain that is appropriate for the new challenges. The EW supply chain is characterized by a variety of aspects that help the company to meet customer needs and align its functions accordingly. One of the key points of the EW supply chain is its ability to offer customized products according to the exact standards expressed by customers. In this sense, the EW product offerings can be defined as extremely various as customers can build their own products using the numerous materials that EW treats (plastics, rubber, metal, electronics, etc). When a company offers such a large variety of products, the attention needs to be focused on product profitability and their mix. The ABC analysis illustrated in Table 4.1[1] helps to gain a better understanding of these concepts.

[1] The ABC analysis has been made on sales data for motors as this category of products counts for 27% of the entire business of the company. EW controls approximately 60% of the US market for after-market air-conditioning motors.

Table 4.1. The ABC analysis

	2010		2011	
	Sales (USD)	**Products**	**Sales (USD)**	**Products**
A products	80.26% 12,441,076	17.83% 23	79.94% 11,619,175	15.04% 20
B products	14.87% 2,305,226	19.38% 25	14.99% 2,178,408	19.55% 26
C products	4.87% 754,251	62.79% 81	5.07% 737,201	65.41% 87
Z products	0	144	0	140
Total	15.500.554	273	14.534.784	273

Note: The table aggregates data of EW motor products.

Table created by B. Piva

The first consideration that can be made from this analysis is the increase of concentration of sales on a smaller number of products from 2010 to 2011. In fact, the percentage of products which makes up 80% of the annual sales, the products in class A, decreased by 2.79%, that is from 23 to 20 products. Therefore, the market is responding on fewer products. This is demonstrated by the fact that 2.62% of the products that belonged to classes A and B in 2010 dropped to class C in 2011. In this situation, the risk of the product portfolio is increasing.

Hence, the number of products belonging to class C, which counts for approximately 5% of the annual sales, has dramatically increased from 81 to 87. Indeed, if the products in class Z, that did not have any sales over the year but that are still part of the product offering, are included in the analysis, the situation appears even more critical. In fact, roughly 48% of the entire product portfolio contributes to the generation of sales and only around 8% of them actually belongs to class A.

Even though products in class B and C are necessary in order to offer a complete range of products, EW product characteristics must be reconsidered and enriched for features in order to increase their appeal on the market. In more general terms, the company must think to question and, ultimately, eliminate not only rarely used product features but also service offerings that are not sufficiently valuable for the customer.

Even though the total sales of EW have generally increased in the last few years, there are some business units that did not contribute to the increase. For instance, with

regards to motors, the company has seen a decrease in the volume of demand as an effect that impacted the supply chain of EW. EW noticed a 19.17% reduction in total annual demand for motors from 2010 to 2011. The number of orders dropped by 29% during the same period. This fall in customer demand has put EW in a critical situation. EW has always tried not to concentrate all the sourcing only on some suppliers but to maintain an appropriate mix in order to diversify any related risk and not be too dependent on a few. This was considered one of the key success factors of the company. However, due to the decrease in demand, EW is now experiencing considerable pressure from suppliers that are now less inclined to offer facilitations such as lower prices and lower minimum quantities. These circumstances will also certainly affect the EW price policy for its customers.

A big challenge that EW has to face is the long lead time that is necessary to ship products from Asia to the doors of its customers. The management is aware about the fact that long lead times dramatically affect the ability of a company to be responsive and to rapidly adapt to changes in customer demand. For this reason, some initiatives have been undertaken with the aim to minimize the impact of this factor on the company supply chain. For instance, EW commits to confirm orders coming from the client within 5 business days. Another major initiative in this sense is the "EW inventory program". This program has particularly gained value for EW customers for two main reasons:

- having products available closer to their location, customers can respond more rapidly to changes in final customer demand as they do not have to worry about long lead times when placing an order;
- customers can get significant cost advantages by joining this program and let EW manage inventory of products in the US for them.

When a company has such a long supply chain, one of its main concerns is to track delivery performance. This kind of KIP[1] is crucial for defining the service level offered to customers. Figure 4.4 illustrates the analysis of EW delivery performance from September 2011 to August 2012.

[1] KPI stands for Key Performance Indicator.

Figure 4.4. East West delivery performance KPI

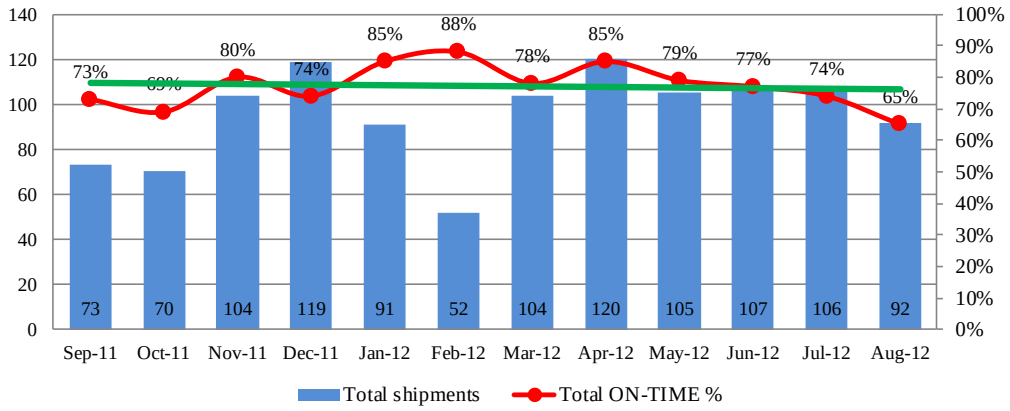


Figure created by B. Piva

The design of these KPIs is strict: they measure the amount of orders completely delivered to the customer. An order is counted as late even if only one item or its quantity is not delivered exactly how it is supposed to. This strict criterion to measure KPI is particularly appropriate in the contest of these new market conditions. In fact, since customers are drastically reducing both their inventory, they demand that their suppliers always deliver every product according to its agreed quantity.

The target of EW for this KPI is 80%. The linear regression (the green line in Figure 4.4) shows that the company was generally able to achieve the goal in the period considered. However, the same KPI applied to single EW subsidiaries expose performance breakdowns for CBM (Changzhou, China) and EWI (Binh Duong, Vietnam)[1]. Indeed, it has to be notice that, even though the linear regression was in line with the goal, the monthly variability of the performance is considerable and goes from a maximum of 88% to a minimum of 65%. In view of the new challenges of the market, this result should be considered a new starting point to achieve even better performances.

With regards to the use of information, EW put into practice a series of initiatives which allows the company to better satisfy the customer. When products are highly customizable, communication becomes crucial to achieve both responsiveness and efficiency. EW contracts are based on the premise that the customer signs for a certain quantity of a product, called blanket, and he commits himself to placing actual orders

[1] See Appendix for more detailed delivery performance KPIs for each EW subsidiary

within specified periods of time, usually six months. However, EW has not been in the fortunate position to receive accurate forecasts from its customers. This has made customer behavior difficult to predict.

In order to address this problem, EW considerably shortened the interval of communication exchanges with customers. Whereas EW used to talk once a month with its customers, now it tries to contact them weekly especially when a customer is having a highly unstable conduct or when he is close to finishing an agreed blanket and he seems not to realize it. This helps the company to better adjust its planning as miscalculations are magnified by the long lead time of its supply chain. Customers can also verify the status of their orders and blankets on the online customer portals. However, EW has noticed that some of its major customers have not been checking this portal and have not communicated often with the company. Hence, EW has created the so called status report. Presently only used for managing the communication with one of EW major customers, who joined the "EW inventory program", this report is sent twice a month to the customers and it is divided in three sections:

1. the first section lists the products that the customer is ordering more quickly than what he claimed he would;
2. the second section lists the products that are currently slow-moving and for which EW is starting to keep too much inventory in its warehouse in Conyers;
3. the third section lists the products that the customer is continuing to order but the prior commitment, based on quantity, is already over; therefore, if the customer wants to continue ordering he has to agree for another blanket order.

EW noticed that the status report helps to share information and to improve its service level. Moreover, this report allows the customer to better manage and plan its activities. Thanks to all these initiative, EW is able to keep a good level of customer retention.

As already mentioned, EW customers have lowered their inventory from three to one month as a consequence of the recession. This has led to a phenomenon which is exerting a huge impact on EW: the shift of inventory from customers to EW. Since customers do not hold a lot of inventory, the risk of stockout increases. As a result, EW must now manage a larger amount of inventory in order to satisfy its customers and

maintain the same service level. Hence, more resources need to be devoted to inventory management as it has become a key success factor for the company. Figure 4.5 shows data for this phenomenon.

Figure 4.5. East West annual sales and inventory

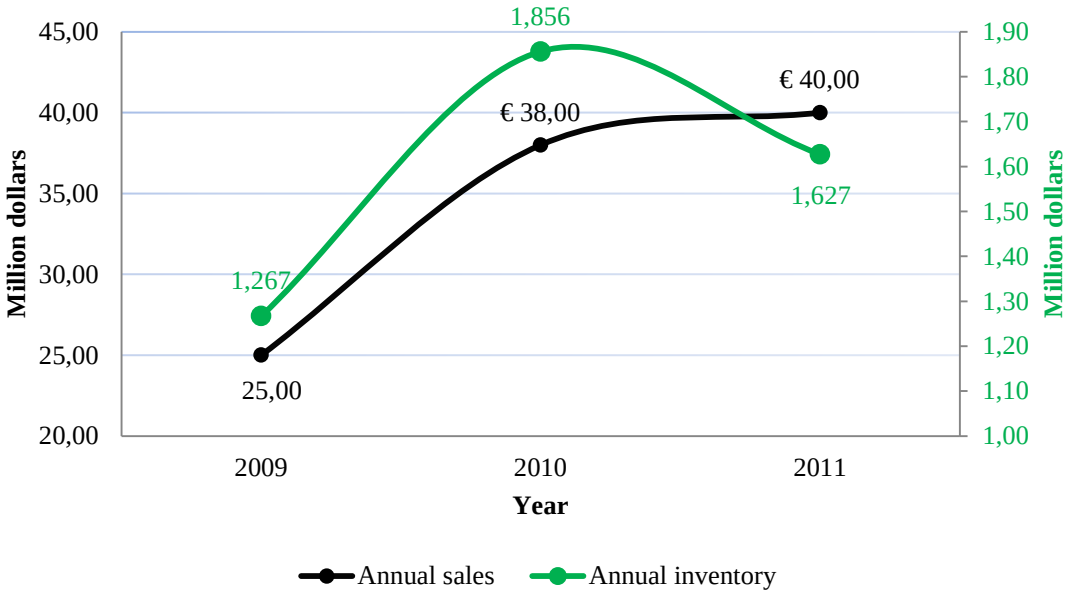


Figure created by B. Piva

According to the data, a significant rise in the value of working capital has occurred in the last few years. Although sales are also increasing, the rise in inventory is for the most part related to the decrease of the same value at the customer location. With regards to 2011, the data are invalidated because one of EW's major customers exhibited significant lower sales in the last part of that year. Accordingly, this lowered the inventory that EW needed to keep for them.

The phenomenon of the rise in inventory over the last few years directly relates to the substantial increase of the number of orders (approximately 30%) against decreases of items held in stock by the customer. It becomes evident that EW has not been able to quickly adjust its supply chain to the changes imposed by the market. The way in which the company reacted was by raising its inventory and, thus, its working capital.

Considering the analysis of the company business made above, some ideas emerge on how EW can improve the management of its global supply chain.

4.4. Recommendations for improving the East West Manufacturing supply chain

Before introducing the recommendations for EW, it is necessary to clarify that the design and the management of supply chain provides a company the means to reach customers with its products. Yet, the supply chain also functions as part of a more comprehensive strategic plan decided by the company. Therefore, all of the following ideas are as valuable as they are in line with the overall competitive strategy of the company.

As this thesis has demonstrated, a high level of flexibility is the answer to successfully compete in today's market. The global recession of 2008 has forced the more rigid supply chains to find ways to become more agile and suitable to face the new unstable environment.

The analysis underlines that one of the biggest challenges of the EW supply chain is its long lead time. This issue has affected the company's ability to respond rapidly to the instability of the market and it magnifies problems and delays in any part of its supply chain.

It is possible to see these characteristics of EW supply chain not only as challenges but also as potential key success factors for the company. First of all, the management should extensively analyze the structure of its entire business process, from suppliers to customers. This analysis should be conducted with the aim of improving the agility of the entire supply chain. Due to their high customization, each of EW products is differentiated from the very first stage of the supply chain. For this reason, EW needs to decide exactly which products to produce and in what quantity in great advance to the actual demand. This becomes a major issue as demand is now very unstable and hardly predictable.

EW should undertake a deep business process re-engineering (BPR) action in order to analyze and radically restructure its business process and supply chain by focusing on the ground-up design of its products and workflows. Of course, it is not in the nature of EW to standardize final products but many commonalities can still be found within families of products, e.g. electronics or motors. For instance, it might be possible to redesign some products so that they will share, either partially or totally, their bills of materials (raw materials, components, etc.). Many advantages in this sense can be

gained when working on product complexity. Quite often, EW has difficulties to see similarities in its products. The management should spend a consistent amount of time examining how its products are structured and will be manufactured. By devoting effort and resources on this, the company can reorganize the workflow so that it is possible to implement some degrees of part or procurement standardization and/or the first steps of different products can be made together. Process innovation requires consistent amounts of investments and resources but it can lead to great advantages. As a result, these initiatives will sustain a high level of product customization and, at the same time, they will allow the company to take more easily advantage of economies of scales as different products share the same raw materials, components, and/or parts.

Another initiative that can be of great value for EW is the implementation of postponement or delayed differentiation. This would allow the company's supply chain to delay the differentiation and the customization of a number of products as closely as possible to customers, which means to bring some of its operations to the US. Thanks to the business process re-engineering mentioned earlier, EW would be able to ship to the US unassembled parts, shared among several different products, and perform the last steps of its supply chain based on the actual demand coming from the customer. In this way, the EW supply chain would become more responsive because customers would be less impacted by long lead time. At the same time, the company would still have cost advantages as it would perform most of its operations in areas of the world where this is more advantageous. EW is already performing some basic activities such as re-packaging in its warehouse in Conyers. By investing in the appropriate technologies EW can execute more complex activities in the same location without increasing fixed costs. An issue related to this initiative is that EW needs to be careful to identify the appropriate boundary where the customization should start: the push-pull boundary. This boundary should be decided after a profound analysis of the product structure.

The initiatives introduced above would also be beneficial in terms of inventory management. In fact, EW can take advantage of risk pooling. By managing inventory as a shared resource at one central location, risk pooling would allow EW to decrease safety stock and, thus, reduce the average inventory needed to keep a satisfying service level. Hence, risk pooling would offer EW the possibility to control the level of variability across the entire supply chain.

EW is currently experiencing two big pressures: one coming from customers that order less quantity but would like to maintain the same price; the other stems from suppliers who are not inclined to lower minimum quantity orders without raising prices. One important move EW should pursue in the future is to revise its suppliers' portfolio. In fact, EW should put all of its suppliers under discussion and work with the ones that apply advanced technologies for, among other things, the reduction of setup time. By reducing this unproductive time, these suppliers are able to be more flexible and switch more rapidly from one production to another. As a result, they can offer smaller batches of items. EW can, thus, rely on suppliers that are able to work with smaller quantities and still offer competitive prices. This advantage would become a key success factor for the company and it could be transferred to its own customers.

A last recommendation is addressed to the marketing activity of EW. When approaching its markets, EW should pay minute attention to the customers it serves. A deep vertical segmentation analysis should be conducted within the markets in order to identify customers with common characteristics which are developing similar products. This way, the company will be able to deliver only what each customer class really wants and not more. Then, EW should work with the goal of achieving simplification and creating a product offering which will have similar features or, at least, analogous components and bills of materials. Product formulation and supply chain capabilities will be based on the maturity of each market and on customer behavior. This initiative reveals to be a critical enabler of supply chain simplification. With regards to complexity, the implementation of optimization strategies allows to eliminate low-requested product features and service offerings that do not add enough value from the customer perspective. As this practice to approach the market, it will make it easier to take advantage of all the other initiatives.

The sum of all these actions requests a significant organizational effort. All the company's functions are in fact involved in this process of restructuring the company's business process.

CONCLUSION

The rules of today's business environment have changed. Demand has drastically shrunk and the market is presently not able to absorb all the quantity manufacturers would need to gain cost advantages from high volume. The new environment is characterized by risk, uncertainty, and rapid change. Hence, companies can no longer rely on the past as a good predictor for the future. They must improve their ability to be flexible and to quickly adapt to changes. The market has changed at such a rapid pace that most supply chains have not been able to keep up. Therefore, the recession has given birth to an environment of constant supply chain uncertainty. For international companies this is even more challenging because their global supply chains magnify any effect.

The purpose of this thesis has been twofold: to analyze the consequences of the global recession of 2008 that have impacted the way companies, especially international ones, manage their supply chains, and to illustrate the extent to which established supply chain theories are still beneficial to stay competitive.

Understanding the customer and recognizing the challenges of the new business environment are fundamental for identifying the actions needed to make a supply chain meet customer needs. Companies must question the degree of flexibility of their manufacturing and logistics strategies. Helpful in this sense is the reevaluation of the drivers of supply chains: facilities, inventory, transportation, and information. This process is necessary to regain competitiveness and succeed after the recession.

As managers recognize uncertainty as part of the current business world, they should treat it as an opportunity to succeed and grow rather than an additional obstacle to face. This thesis is intended to serve as a contribution to the question of how companies can re-align their manufacturing and logistics strategies to a market environment that, due to the recession of 2008, has evolved much faster than the development of the supply chain. This raises the question if the presumably "old" theories on these topics still have a significant value. As shown in the case study of East West Manufacturing, a best

practice lies in the approach of reevaluating and refining these theories to make them suitable for the current market conditions.

Several approaches to manufacturing and logistics have been introduced. These can be useful weapons for companies to fundamentally rethink how they do their work in order to dramatically improve service level to their customers, cut operational costs, and become first-class competitors in this new game-changing market. These aspects are fundamental and they become critical when it comes to international companies. Their long supply chains force them to consider any move carefully. Any distraction or inaccurate calculus, in fact, can have a major effect that spreads over the complex supply chain network like a virus. And the recession only contributes to increase the exposure of supply chains to disruptions and shocks.

The case study of East West Manufacturing has given the opportunity to reflect on the implications of the global recession. In order to succeed in the market, the company must confront uncertainty. Even though the company's total sales are slightly increasing overall in the time frame considered, the decrease in demand volumes in some of its business units has made it more and more difficult to take advantage of economies of scale and keep a good level of productivity. The phenomenon of the decrease of inventory at the customer location and the always-present high level of variety of product offerings required by market standards has caused a significant increase of the company's working capital. Moreover, the recession has significantly degraded the reliability of demand forecasts, which makes it difficult for the company to work on a long-term prospect when planning its activities.

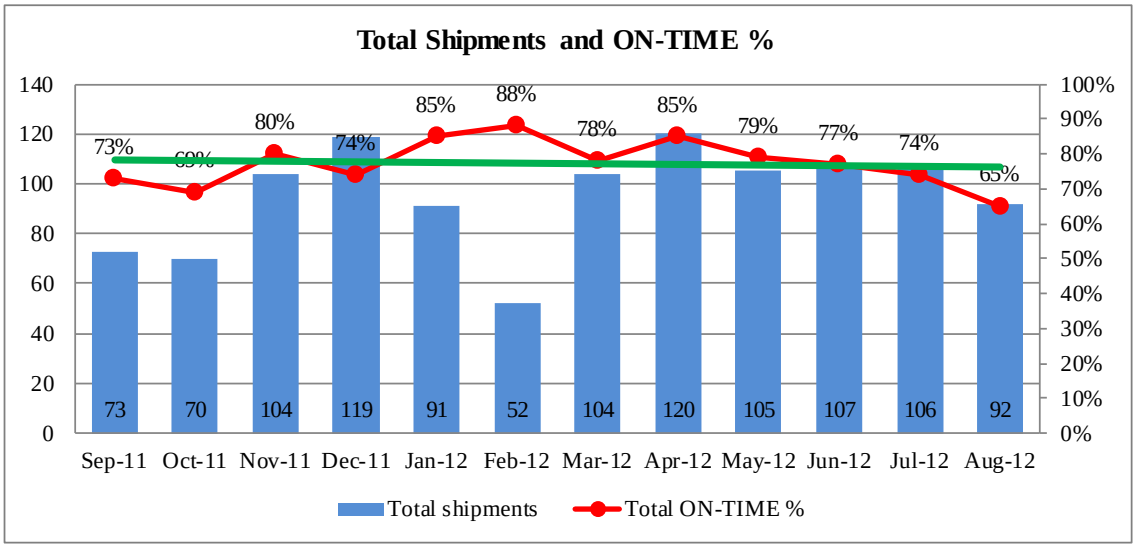
In times of recession, companies need sustainable and resilient supply chains to support their profitability and become leaders in their markets. Given the intricate characteristics of the market, East West Manufacturing has to achieve a greater agility within its systems so that it can rapidly respond to changes both in volume and variety requested by its customers. The company needs to lower the complexity of its products and work on the supply chain process so that it can simplify and, thus, enjoy the advantages of different products sharing commonalities.

It becomes clear in the discussion that East West Manufacturing has to adopt a flexible supply chain which will serve to respond to the sudden changes in both product variety and quantity requested by customers. In this contest, the company must reanalyze its network of suppliers in order to find technologically-advanced partners that are able to meet the variable and irregular demand while keeping competitive costs. Indeed, the development of sales will have to be based on a profound market analysis in order to identify and serve customers with similar characteristics and products.

Since today's market is characterized by uncertainty, it is clear that the customization of East West Manufacturing products will have to be brought closer to customers. Therefore, the company will continue to manufacture and source components, possibly standardized, in countries close to raw materials that can offer low labor cost but it will assembly the final products in the US according to the configurations of the requests coming from the market. This will allow East West manufacturing to respond more rapidly to changes in customer demand.

The tendency of bringing phases of operations processes back to developed countries is a circumstance reported by many other companies both in the US and in Europe. Due to the topicality of this issue, it will be interesting to see future studies that trace subsequent developments of this phenomenon.

APPENDIX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20%
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73%
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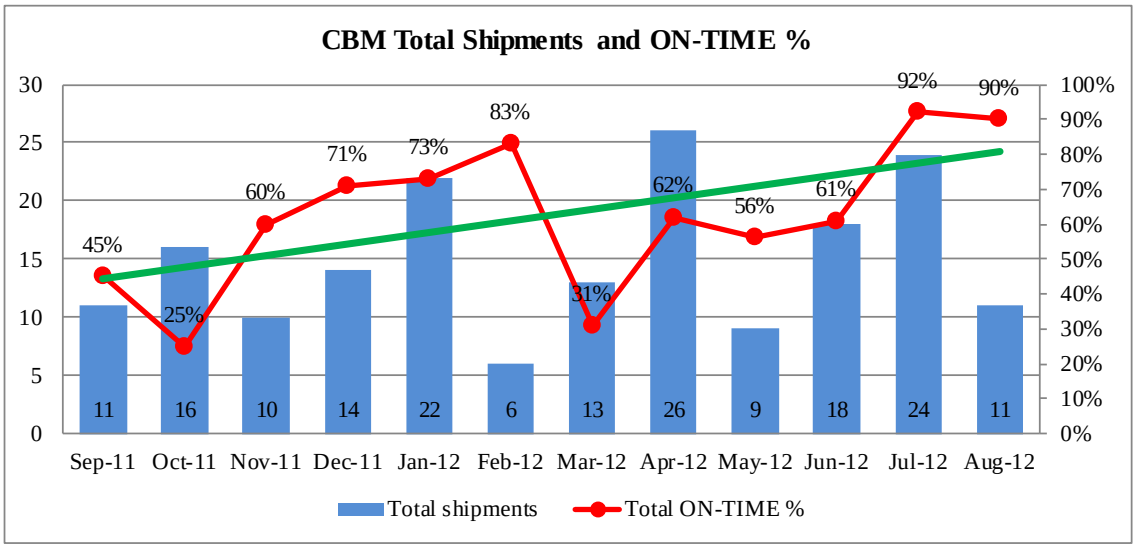
May-12
Jun-12
Jul-12
Aug-12
Total shipments
Total ON-TIME %


CBM Total Shipments and ON-TIME %
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70%
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20%
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25%
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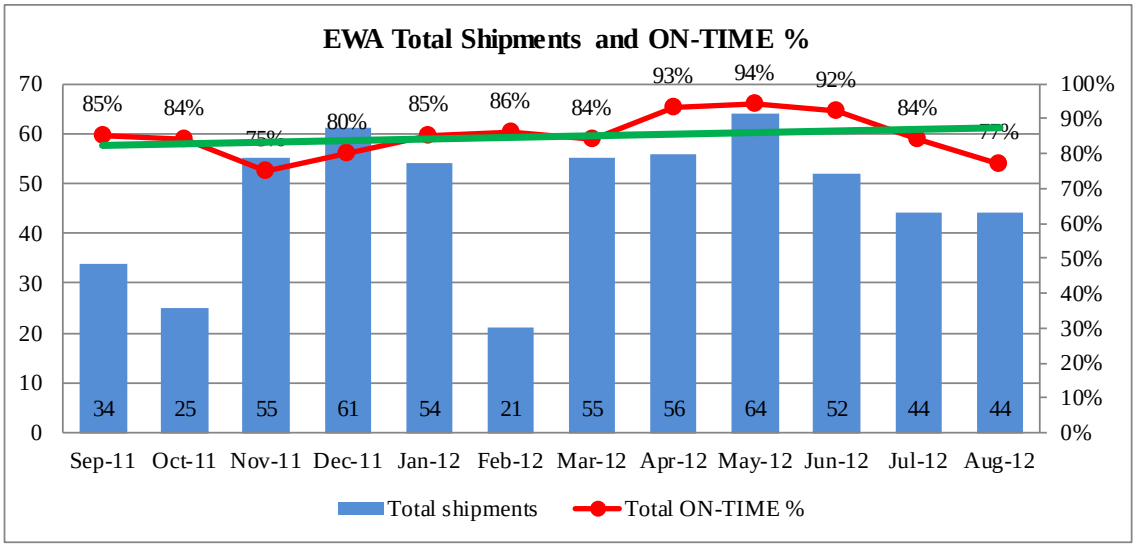
Total shipments
Total ON-TIME %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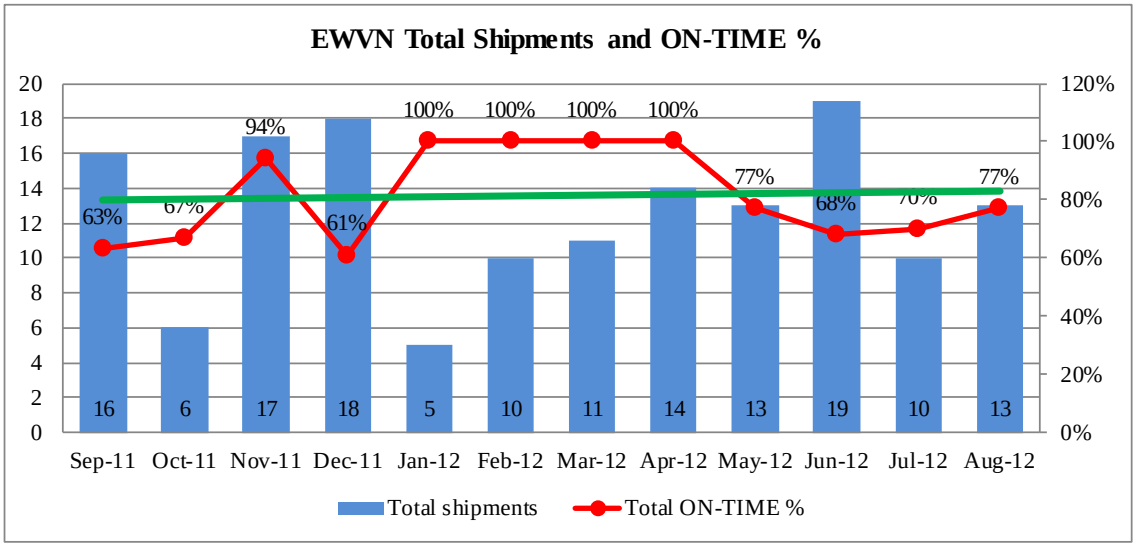
Total shipments
Total ON-TIME %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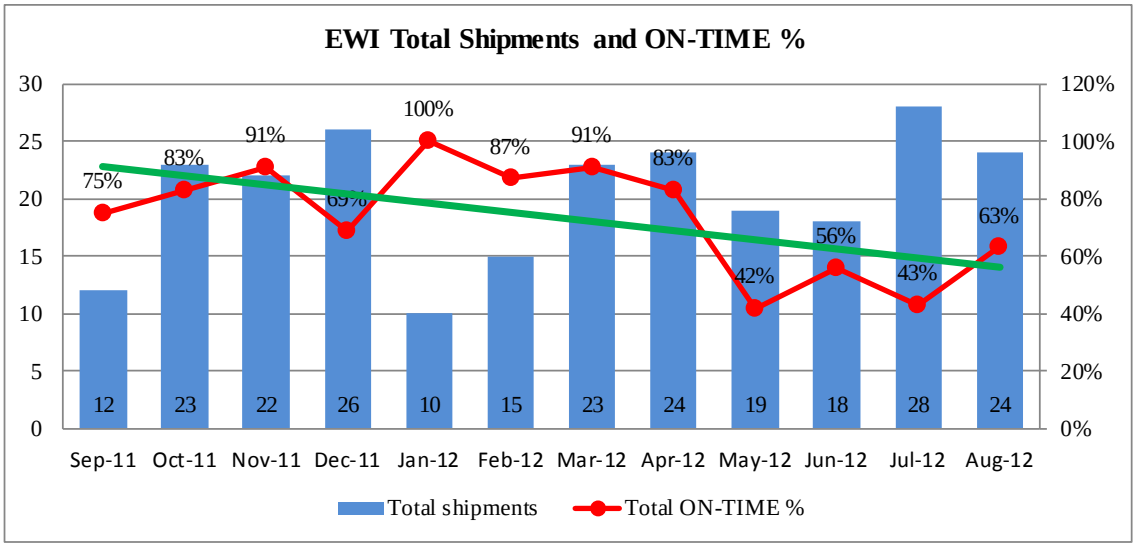
Total shipments
Total ON-TIME %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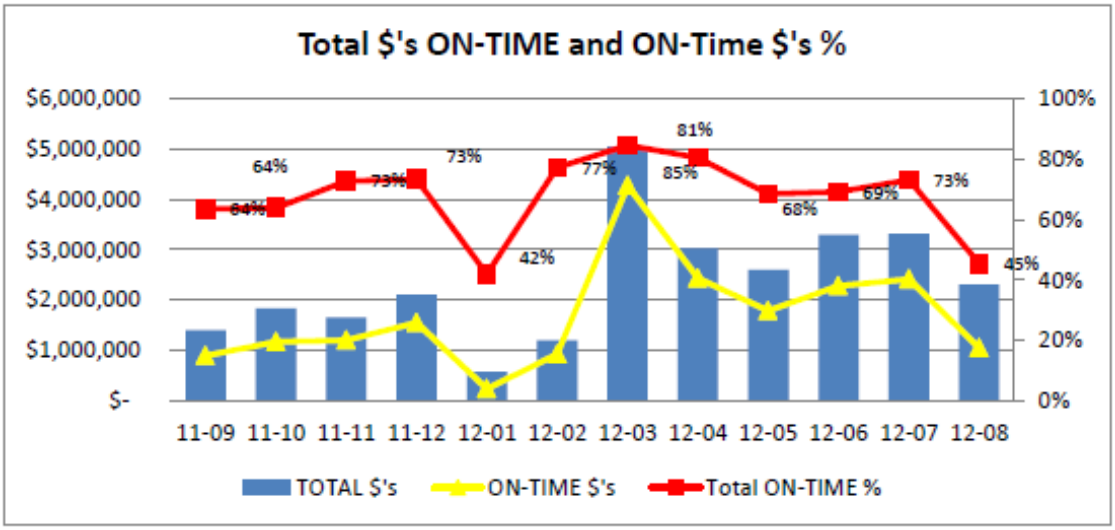
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Total shipments
Total ON-TIME %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$3,000,000
$2,000,000
$1,000,000
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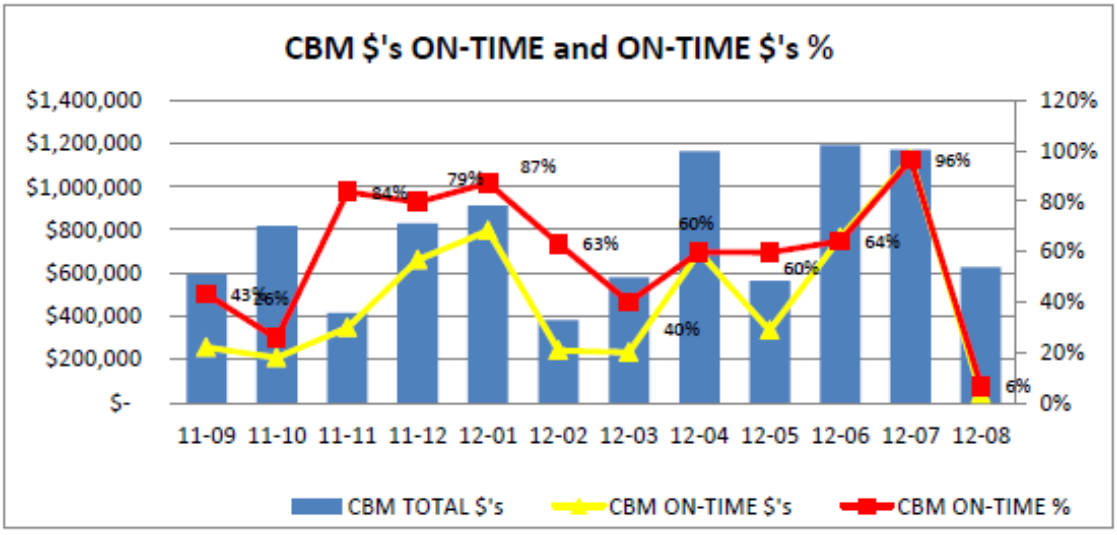
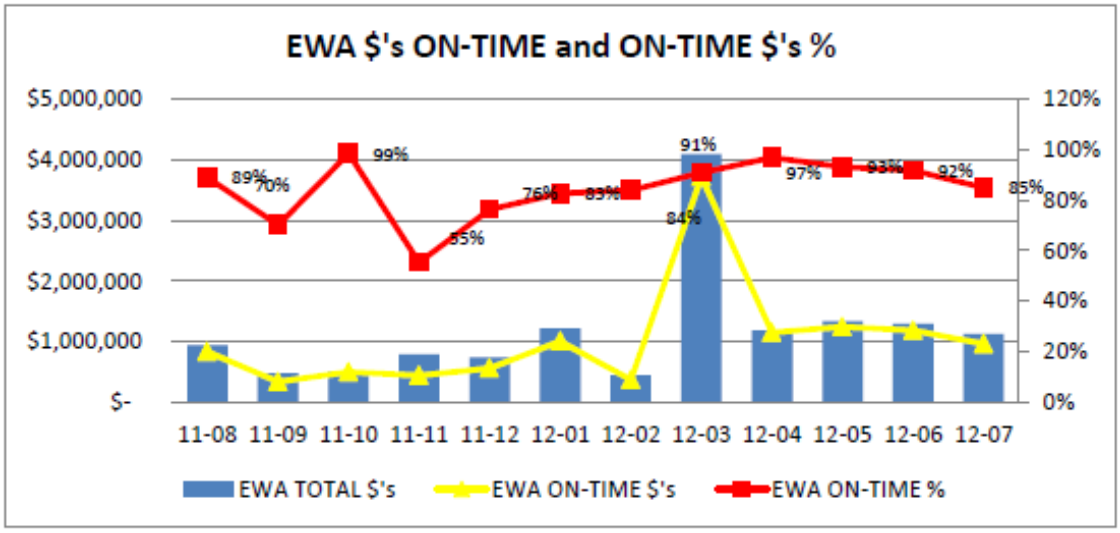
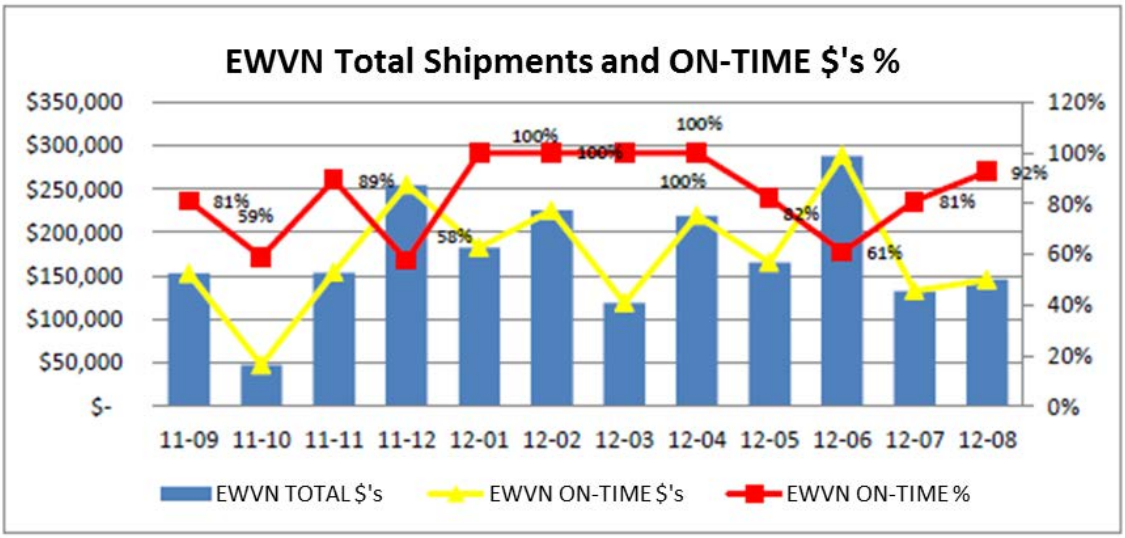
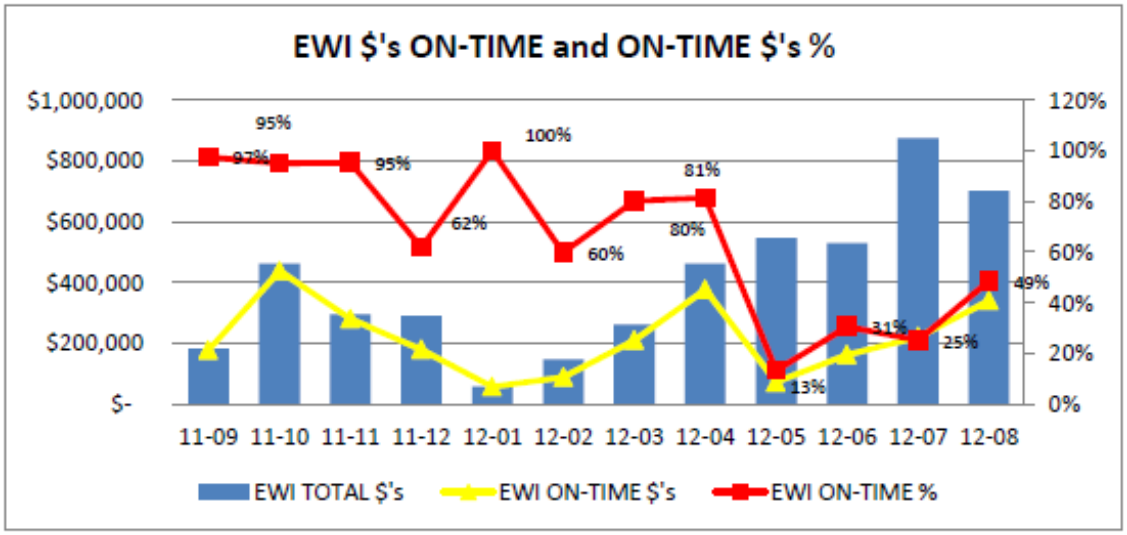
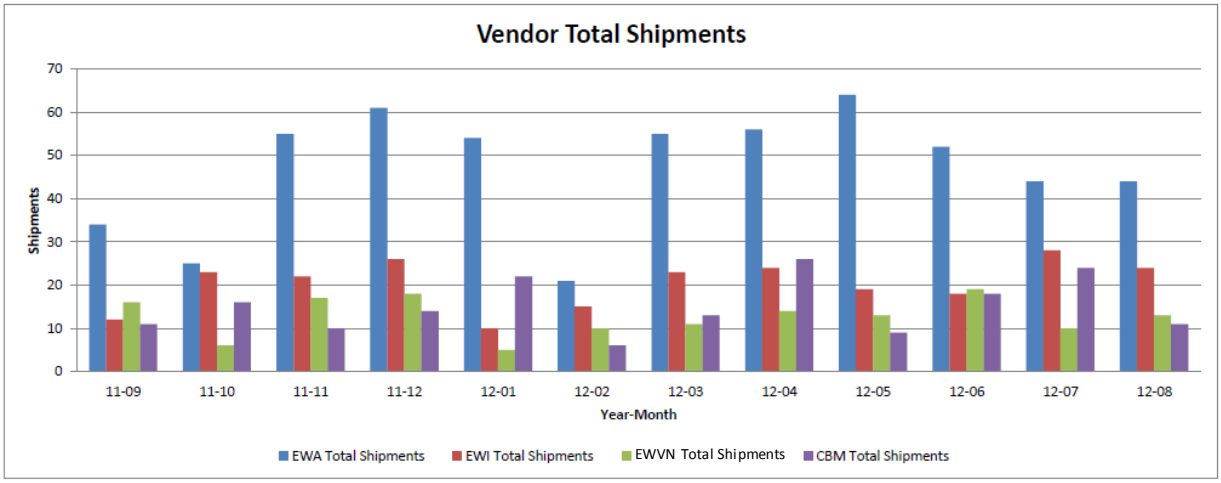
12-08
TOTAL $'s
ON-TIME $'s
Total ON-TIME %

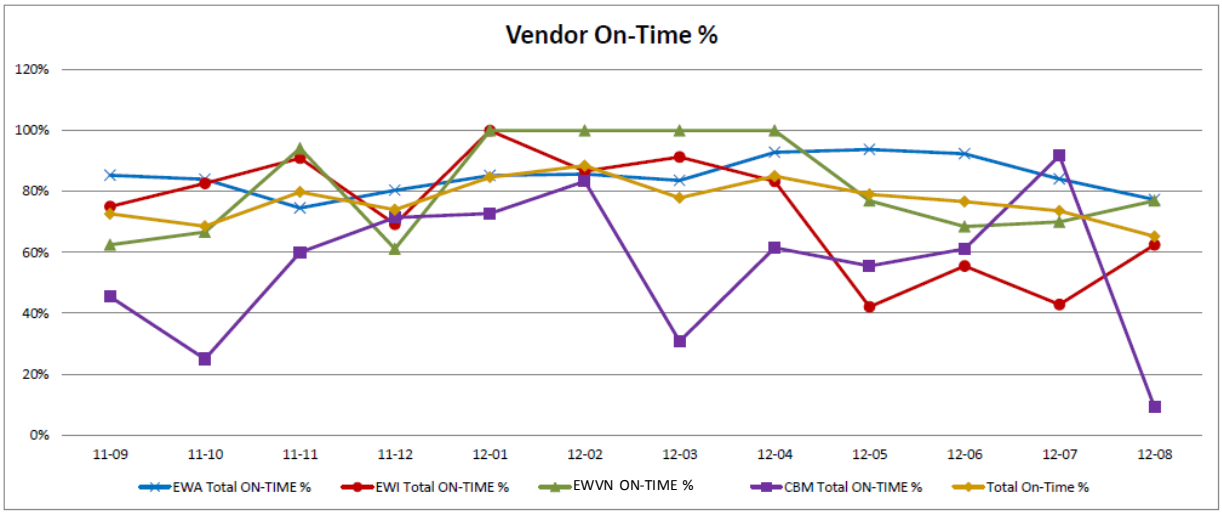

CBM $'s ON-TIME and ON-TIME $'s %
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
120%
100%
80%
60%
40%
20%
0%
43%
26%
84%
79%
87%
63%
40%
60%
60%
64%
96%
6%
11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07 12-08
CBM TOTAL $'s
CBM ON-TIME $'s
CBM ON-TIME %


EWA $'s ON-TIME and ON-TIME $'s %
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$-
120%
100%
80%
60%
40%
20%
0%
89%
70%
99%
55%
76%
83%
84%
91%
97%
93%
92%
85%
11-08 11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07
EWA TOTAL $'s
EWA ON-TIME $'s
EWA ON-TIME %


EWVN Total Shipments and ON-TIME $'s %
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$-
120%
100%
80%
60%
40%
20%
0%
81%
59%
89%
58%
100%
100%
100%
100%
82%
61%
81%
92%
11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07 12-08
EWVN TOTAL $'s
EWVN ON-TIME $'s
EWVN ON-TIME %


EWI $'s ON-TIME and ON-TIME $'s %
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
120%
100%
80%
60%
40%
20%
0%
95%
97%
95%
62%
100%
60%
81%
80%
13%
31%
25%
49%
11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07 12-08
EWI TOTAL $'s
EWI ON-TIME $'s
EWI ON-TIME %


Vendor Total Shipments
Shipments
70
60
50
40
30
20
10
0
11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07 12-08
Year-Month
EWA Total Shipments
EWI Total Shipments
EWVN Total Shipments
CBM Total Shipments


Vendor On-Time %
120%
100%
80%
60%
40%
20%
0%
11-09 11-10 11-11 11-12 12-01 12-02 12-03 12-04 12-05 12-06 12-07 12-08
EWA Total ON-TIME %
EWI Total ON-TIME %
EWVN ON-TIME %
CBM Total ON-TIME %
Total On-Time %

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