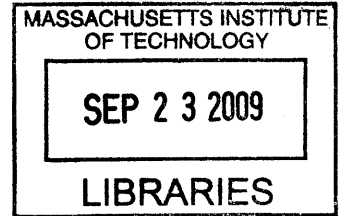


Aligning Product and Supply Chain Strategies in the Mobile Phone Industry

by

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Submitted to the System Design and Management Program in Partial Fulfillment of the
Requirements for the Degree of

Master of Science in Engineering and Management

at the

Massachusetts Institute of Technology

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Abstract

Designing and managing the supply chain of a company in the mobile phone industry is particularly challenging. Short product lifecycles, rapidly evolving technology, globally linked distribution networks, increasing product variability and high levels of demand and supply uncertainty all create problems for those managing these supply chains. As competition in this industry increases and profit margins decrease, proper supply chain management practices will only become more important to companies competing in this industry. In order to succeed, companies must implement their supply chain so that it effectively supports their corporate strategy.

This thesis investigates the relationship between corporate strategy and supply chain strategy within the mobile phone industry. Although it is directed at one industry, the wide variety of products in terms of price and functionality suggests that there isn't a "one size fits all" supply chain strategy appropriate for all companies that produce mobile phones. An extensive survey was developed that asks participants strategic, tactical and operational questions about different aspects of supply chains that deliver mobile phones. This is used to identify areas in which the stated supply chain strategy impacts the design and operation of the supply chain. Finally, differences in supply chain practices between high and low performers are identified based on supply chain strategy.

Thesis Supervisor: Professor David Simchi-Levi

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Chapter 1: Introduction

Designing and managing the supply chain of a company in the mobile phone industry is particularly challenging. Short product lifecycles, rapidly evolving technology, globally linked distribution networks, increasing product variability and high levels of demand and supply uncertainty all create problems for those managing these supply chains. At the same time, rapidly increasing global demand and increasing market segmentation forces players to ship high volumes of increasingly specialized phones.

The result is a supply chain that links dozens of suppliers to multiple manufacturing facilities and distribution channels across many continents, and which is constantly being changed to accommodate next generation phones. As fierce competition drives down the price of these phones, the relative cost of managing such a complex supply chain increases, particularly as mobile phones gain popularity in the price sensitive emerging markets. The stakes are high: history has shown that missteps in the management of the supply chain can result in a major drop in the performance of the organization as a whole¹.

Although this level of complexity represents significant challenges for those designing the supply chain, it also represents an opportunity for firms to gain competitive advantage from them. By improving flexibility in the supply chain, it may be possible to quickly adapt to the changing demands and preferences of consumers. By improving efficiency in the supply chain, it may be possible to offer lower priced phones than competitors. By protecting against systemic shortages of components from suppliers, it may be possible to continue to produce while competitors are unable to meet market demand.

The value of a high performing supply chain has been recognized in industry, and as a result many studies have been performed to help identify different ways in which companies can improve their supply chain. These have given way to a long list of

¹ Hendricks, K., & Singhal, V. (2005). Association Between Supply Chain Glitches and Operating Performance. *Management Science*, pp. 695-711.

practices, such as VMI, JIT, JIT II, ECR, to name a few². But just because certain supply chain practices are effective for one company does not mean it will work for another, even within the same industry. The focus of this study is specifically on factors that impact the performance of the supply chain in the mobile phone industry, and the practices that companies adopt to improve the performance of their supply chain.

1.1 Objectives

At the highest level, the purpose of this thesis is to understand how supply chain strategies are used within the mobile phone industry to support corporate strategy. For example, companies whose products compete on innovation in developed markets may specifically design their supply chain for flexibility, while those that compete on price in emerging markets may streamline their supply chain to improve efficiency. Although this study is directed at one industry, the wide variety of products in terms of price and functionality suggests that there isn't a "one size fits all" supply chain strategy appropriate for all companies that produce mobile phones.

In addition, this thesis explores how those supply chain strategies result in specific supply chain practices within the industry. An extensive survey was developed that asks participants strategic, tactical and operational questions about different aspects of supply chains that deliver mobile phones. This will be used to identify areas in which the stated strategy impacts the design and operation of the supply chain.

Finally, differences between high and low performers are identified based on supply chain strategy. Although companies might think they have a cohesive supply chain strategy that properly matches their product strategy, their implementation of the supply chain might actually be different than their desired strategy.

Given the complexity of the domain and the supply chain involved, a background of the industry is presented, including the relationships between the different players involved along the supply chain. These players include design firms, component manufacturers,

² Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). *Designing and Managing the Supply Chain*. New York: McGraw-Hill.

phone manufacturers, distributors, network operators, logistics providers and repair shops, although the exact players involved typically differ based on phone and market characteristics. This will be useful information for those looking to enter the mobile market, whether they are introducing a new mobile phone, or are looking to provide related services, such as logistic or design services.

1.2 Approach and Thesis Organization

This thesis is based on research done in cooperation with Kenneth Liu, a fellow SDM student at MIT, as part of a project funded by DHL. The process by which this thesis was developed is as follows:



Figure 1: Thesis Approach

The first step was to perform a comprehensive study on the mobile phone industry, as well as to perform research on the practices of designing and managing complex supply chains. This was used to provide an overview of the industry in **Chapter 2**, and an overview of topics relevant to managing the supply chain in the mobile phone industry in **Chapter 3**.

The next step was to generate hypotheses that could be tested and used to gain insight into the ways in which companies design and use their supply chain to support their corporate level objectives. These hypotheses are presented in **Chapter 4**, along with a discussion on their relevancy.

In order to test the hypotheses that were generated, an industry survey was created that was targeted at the Original Equipment Manufacturers (OEMs), who are the brand owners in this industry. **Chapter 5** outlines this survey.

An analysis of the data is presented in **Chapter 6**. This includes information regarding responses, as well as a discussion about how well the data supports the hypotheses.

Finally, conclusions are presented in **Chapter 7**. This includes general recommendations for those designing supply chains in this industry, as well as areas of potential future research.

Chapter 2: Industry Background

In order to understand the complexities involved in designing, assembling, and distributing mobile phones, the reader must first understand the technologies that enable the operation of these phones. This chapter will give the reader a background on the technologies that enable mobile phones to work, as well as to show the ways in which the market is changing. First, it will describe the evolution of mobile phones by providing a brief history of the industry. Second, it will provide an in-depth overview of Original Equipment Manufacturers (OEMs), which are the primary manufacturers of these phones. Third, it describes the different types of mobile phones that exist, and how they differ. Finally, it will describe the business ecosystem in which the manufacturers of mobile phones exist.

2.1 History of Mobile Phones

A mobile phone, also referred to as cellular or wireless phones, is a wireless electronic device that is used for voice or data communication over a regionally distributed network of cell towers. First invented in the early 1980's, the purpose of the device is to allow the user to make telephone calls without being constrained by location, though more recent phones are also now capable of much more advanced applications that involve receiving and transmitting data over the cellular network.

Since their introduction, the mobile phone has changed from a luxury item used by an elite few in the United States and Europe to an indispensable tool connecting billions around the globe. Technological advances have transformed the phones themselves from being suitcase-sized with only the capability of making and receiving telephone calls, to being pocket-sized and capable of running a wide variety of applications. At the same time, competition has yielded process improvements that have driven prices down to the point in which these phones are affordable to the masses.

The history of this market involves the co-evolution of two complementary technologies: cellular networks and mobile phones. Improvements in the capability and coverage of early cellular networks enabled massive growth in the number of mobile

phones they connected. Improvements in the capabilities of the mobile phones, particularly in the area of data-driven applications, then put pressure on cellular networks to meet the ever increasing bandwidth demands of the applications. Given the tight relationship that exists between these two technologies, the history of these technologies is presented together.

The precursor to the first modern cellular networks, referred to as 0g, was implemented by Motorola and Bell System in 1946. These systems were only practical for specialized purposes and not mainstream use, as the devices had to be mounted to vehicles or required briefcases in order to function. The modern cellular network, referred to as 1g networks, first appeared in the early 1980's. These, like the 0g networks, were analog, and the mobile phones that ran on them were barely portable, had short battery life, and poor audio quality.

In 1991, the first 2g networks were introduced. Unlike the 1g networks, this new generation of networks was digital. The digital nature of the networks resulted in drastic reductions in power consumption by the mobile phones using them, as well as increased call clarity. In addition, for the first time digital data could be sent to and from the mobile phones.

This transition had an important impact on the mobile phones themselves. The reduced power consumption allowed the mobile phones to carry substantially smaller batteries without reducing the amount of time it could be used between charges. In addition, the ability to send and receive digital data enabled innovative applications to be implemented on the phones, including SMS text messaging and email functionality. At the same time, major improvements were made in the fields of electronics and energy storage, which further improved the usability and functionality of the mobile phones.

The smaller form factor, increased performance, and features beyond simple voice telephone calls resulted in a massive increase in mobile phone sales during this period. In addition, segmentation started occurring within the products. There became a clear difference between the high end phones, which typically feature a separate operating

system to run data-driven applications, and low end phones, which focus on providing voice and SMS capabilities at the lowest possible price. At the same time, product variation transformed these phones into items of fashion, in which product selection by consumers were not necessarily based on functionality and price, but rather on form factor and brand.

In order to feed the data needs of the new segment of high end smartphones, 2.5g and eventually 3g networks were introduced. These networks are capable of sending and receiving much higher amounts of data to the phones, which enable such functionality as streaming video, World Wide Web access, and location-based services. 4g networks have begun to be implemented, which provide even higher amounts of bandwidth to the mobile phones.

2.2 Original Equipment Manufacturers

In 2008, over 1.2 billion mobile phones were sold around the world³. Not surprisingly, this exploding market has generated fierce competition among those supplying the phones to the users. For the time being, the mobile phone market is dominated by a few players, which currently hold about 80% of the market share. In order to sustain such large sales volumes, these leaders typically create a wide range of mobile phones, from low-end phones targeted at emerging markets to high-end smartphones targeted at developed markets.

³ Retrieved May 5, 2009, from Gartner: <http://www.gartner.com/it/page.jsp?id=680207>

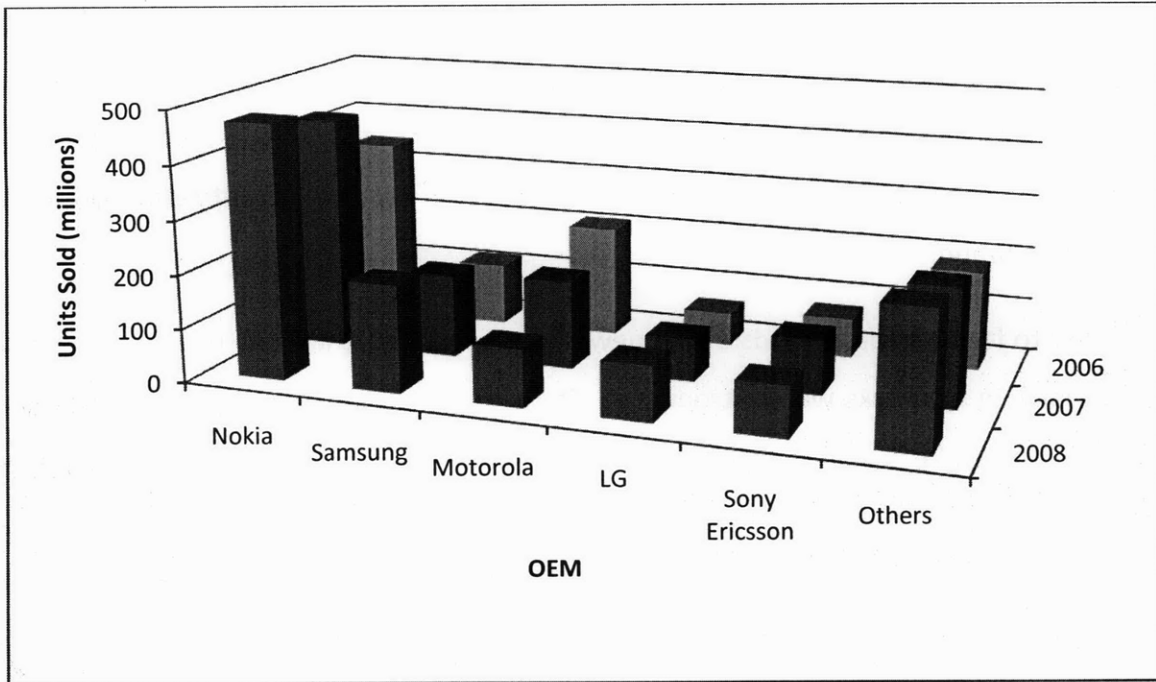


Figure 2: Mobile phone Sales by OEM⁴

According to Gartner, Nokia accounted for almost 39% of the mobile phone sales worldwide in 2008. This translates into 472.3 million phones, which was accomplished through strong offerings in both the low end mobile phones and the high end phones. Samsung is in second place in global sales, at 16.3% with 199.1 million phones sold in 2008. Samsung's strength lies in higher-end smartphones, through the introduction of better user interfaces that increases usability.

Motorola, although holding on to the third position with 8.7% of worldwide mobile phone sales, is going to lose this position within the next year due to poor performance of their mobile phone offering. Although they scored big in 2006 with their RAZR mobile phone, they were unable to follow up with another successful product, and had much lower than expected sales on their ultra-low end mobile phone that was targeted at emerging markets. And without any success at high-end smartphones, they will

⁴ Retrieved May 5, 2009, from Gartner: <http://www.gartner.com/it/page.jsp?id=680207> and <http://www.gartner.com/it/page.jsp?id=904729>

continue their slide from the 2nd largest supplier of mobile phones in 2006, to 4th or 5th by the end of 2009. Their recent lack of success highlights the volatility that exists in this market.

Filling the void left by Motorola, LG and Sony Ericsson have been increasing their market share to 8.4% and 7.6%, respectively. LG has been able to successfully provide higher end mobile phones to developed markets, particularly with the help of MNO partnerships. Sony Ericsson also has had success selling higher end mobile phones, though recent economic troubles have hit them especially hard.

Although five companies currently represent 80% of the mobile phone sales worldwide, a couple of newer entrants have been making waves. In particular, two companies have been doing well providing high-end, high-margin mobile phones for developed markets. These companies, RIM and Apple, increased their combined market share in the smartphone segment from 12.3% in 2007 to 24.8% in 2008⁵. These relatively new entrants have taken market share of this segment primarily away from Nokia, whose market share dropped from 50.9% to 40.8%.

2.3 Composition of the Mobile Phones

⁵ Retrieved May 6, 2009, from cellular-news: <http://www.cellular-news.com/story/36465.php>

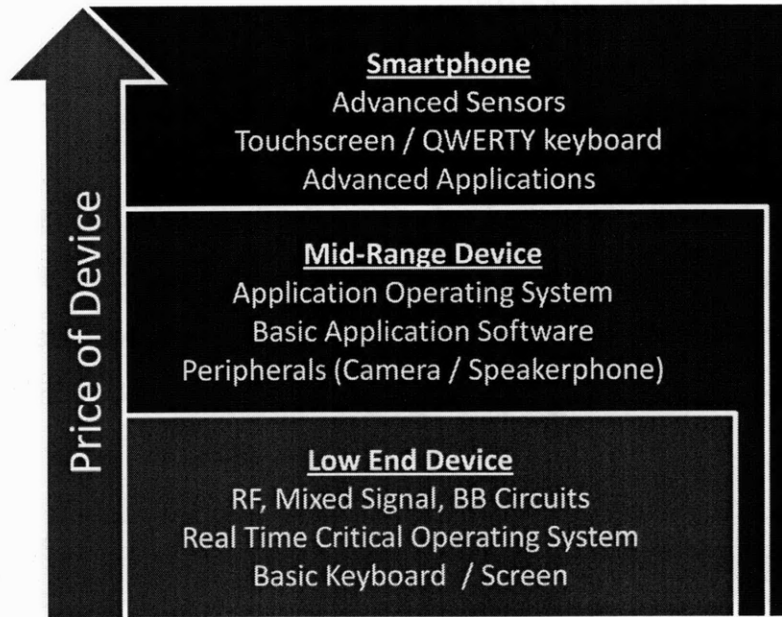


Figure 3: Composition of Phone by Type

The components of a mobile phone vary directly with its price. Low end mobile phones, typically intended for emerging markets, contain only the most basic of components necessary to deliver voice and simple text messaging services. This requires a few standard circuits, including the Radio Frequency (RF) Circuit, the Mixed Signal Circuit and the Baseband (BB) Circuit. The RF Circuit transmits and receives signals to and from the cell towers. The Mixed Signal Circuit converts these signals between analog and digital, and passes it along to the BB Circuit. The BB Circuit runs the Real Time Critical Operating System, which enables the minimum required functionality of a mobile phone. In addition, other basic components are necessary, including the keyboard, the screen, the battery and the casing. All higher end mobile phones build upon this basic set of components.

Although the level of functionality in these types of mobile phones have been around for decades, improvements in this area still occur in an attempt to reduce manufacturing price as much as possible. This typically happens through part count reduction, as well as the introduction of newer, cheaper technologies. Motorola's Motofone, for example, featured a completely different type of display than is typically

used. Of course, usability of these mobile phones cannot be sacrificed during this process of price reduction.

Mid-range mobile phones contain all the components typically found in low-end mobile phones, but they also feature more advanced circuits capable of running an additional operating system, which is called the Application Operating System. This enables the mobile phone to run other basic applications, and therefore they feature more than just the simple voice and SMS functionality on the low end mobile phones. In addition, they typically integrate other peripheral components, such as camera/video devices or speakerphones.

These mobile phones represent the bulk of the current mobile phone market. Innovation in this area typically centers on improving form factor. Differentiation between these mobile phones is becoming increasingly difficult, so successful mobile phones often are ones that are considered more fashionable in developed markets. Distribution and marketing also play an important role. Nokia's dominance today can in part be accounted for their ability to forge the best distribution relationships while successfully managing their brand⁶.

At the high end of the price spectrum are the smartphones. These mobile phones feature additional computing power upon which advance applications can run. They also contain advanced sensors, such as GPS, accelerometers, proximity sensors and digital compasses. Large screens and full QWERTY keyboards improve the usability of these applications. As mentioned, new cellular networks are being deployed to help drive the data-intensive applications.

Innovation in these mobile phones occurs through the addition of new functionality typically associated with computers. Cost is of much less importance than functionality and usability.

⁶ Zander, M., & Anderson, J. (2008). Breaking up mobile: implications for firm strategy. *INFO Journal* , pp. 3-12

2.4 Mobile Phone Business Ecosystem

Mobile phones that are built today involve complex coordination between many different players. As the market matures, the process of designing, manufacturing, distributing and repairing has become more fragmented and new players have appeared that specialize in different aspects of the process. They typically are capable of taking advantage of economies of scale by performing the same tasks for many different OEMs. The most obvious case where this occurs is in the supply portion of the fulfillment supply chain, in which components are created for the use in the mobile phones. Depending on the maturity of the component, the component may be used in the mobile phones of competing OEMs, or perhaps even in electronic devices other than mobile phones.

Companies that are often involved in creating and distributing a mobile phone are:

- **Original Equipment Manufacturer (OEM):** In this industry, these are the companies that are typically associated with the brands of the mobile phones. They include Nokia, Samsung, Motorola and Apple. They may or may not choose to design and manufacture their own mobile phones, although many outsource parts or all of the design or manufacturing processes. Even if they outsource part or all the process, they typically have visibility across the entire supply chain.
- **Original Design Manufacturer (ODM):** These companies design and manufacture mobile phones, but do not own the brand the phone. In the mobile phone market, the OEM may use these companies to develop low-cost or entry-level mobile phones with lower margins.
- **Contract Manufacturer (CM):** These companies specialize in the manufacturing of mobile phones, and do not perform any design activities. In this industry, they are typically associated with providing components, and also may be in charge of assembling the final product.

- **Electronics Manufacturing Service (EMS):** These companies are capable of performing all activities necessary to design, build, and distribute a mobile phone for the OEM, including testing and repair. Leaders in this area include Foxconn, Flextronics, and Jabil.
- **Mobile Network Operator (MNO):** The network operator controls the service upon which the mobile phones are connected, and therefore have constant contact with the customer. In the context of the supply chain of mobile phones, these can be considered the most important distributors, particularly in the United States.
- **Logistics Provider (3PLs):** Companies often outsource the activities associated with shipping goods and maintaining warehouses to hold inventory. Logistics providers add value by being able to provide an existing network of transportation and warehouses to the OEM.
- **Distributor:** Although the MNO is an important distribution point to the customer, mobile phones also go through other outlets before reaching the customer. These might be electronics retailers or other companies that buy mobile phones in bulk with the intention of reselling them.

The mobile phone industry's horizontal integration means that few mobile phones are completely created and distributed by one single company. However, the OEM is clearly the most important player, as they choose what types of mobile phones are created and to whom the mobile phones are sold. They may outsource much or all of the process, but they have visibility across the entire supply chain. Therefore, the focus of this research is on the OEMs, which are assumed to at least understand how their supply chain is structured, even if they don't know all the details by which the mobile phones are created and distributed.

Chapter 3: Managing the Supply Chain for Mobile Phones

Given the high volumes of mobile phones being manufactured, and the large number of stakeholders involved in the process of designing, producing, and distributing these mobile phones, it is of no surprise that the supply chain of mobile phones are typically very high performing, compared to the supply chains of companies in other industries. Apple and Nokia, two mobile phone OEMs, are considered to have the top two performing supply chains of all fortune 500 companies in 2008, according to AMR Research⁷.

This chapter will present a framework for understanding the different aspects of supply chain management. Each aspect of supply chain management will then be discussed, with a focus on the issues that are of concern to the supply chain of mobile phones. Next, specific challenges of managing these supply chains are discussed. Finally, different high-level supply chain strategies and their relevance to the mobile phone supply chain are presented.

3.1 A Holistic View of Supply Chain Management

One definition of supply chain management is as follows:

*Supply chain management is 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 systemwide costs while satisfying service level requirements.*⁸

As stated, the purpose of supply chain management is to minimize systemwide costs while ensuring that a minimum service level is met. *Service level* in this context represents the percentage of time that the end customer has access to the right product when desired; a low service level indicates that products are typically out of stock, while

⁷ Retrieved May 5, 2009, from AMR Research: <http://www.amrresearch.com/SupplyChainTop25/>

⁸ Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). *Designing and Managing the Supply Chain*. New York: McGraw-Hill.

a high service level indicates that the customer is usually able to buy the product that is desired. The easiest way to raise service levels is to increase inventory levels, but products held in inventory are expensive for the company. Similarly, the easiest way to reduce costs is to reduce inventory levels, but that will result in lower service levels and lost sales. Traditionally, a company will decide upon a service level and raise inventories to meet this service level. The purpose of supply chain management is to utilize practices that bypass this simple tradeoff, and enable companies to maintain service levels while simultaneously reducing costs.

Although the supply chain represents the flow of goods from suppliers to the customer, the set of practices that define supply chain management encompass areas other than those that touch the physical goods. For example, considering the supply chain during the design process can significantly improve supply chain performance, and has been shown to increase profitability⁹. In addition, the relationship between the end user and the manufacturer no longer ends at the point of sale. In the case of a faulty product, warrantees may require the manufacturer to have an effective return and repair process. This is especially important in the mobile phone industry, since mobile phones are typically paired with a cellular service contract. An efficient repair process is therefore critical to ensure that the user is not left without a mobile phone for long.

A useful framework to understand this holistic view of supply chain management can be described as follows:

⁹ Lee, H. L., & Sasser, M. M. (1995). Product universality and design for supply chain management. *Production Planning & Control*, pp. 270-277.

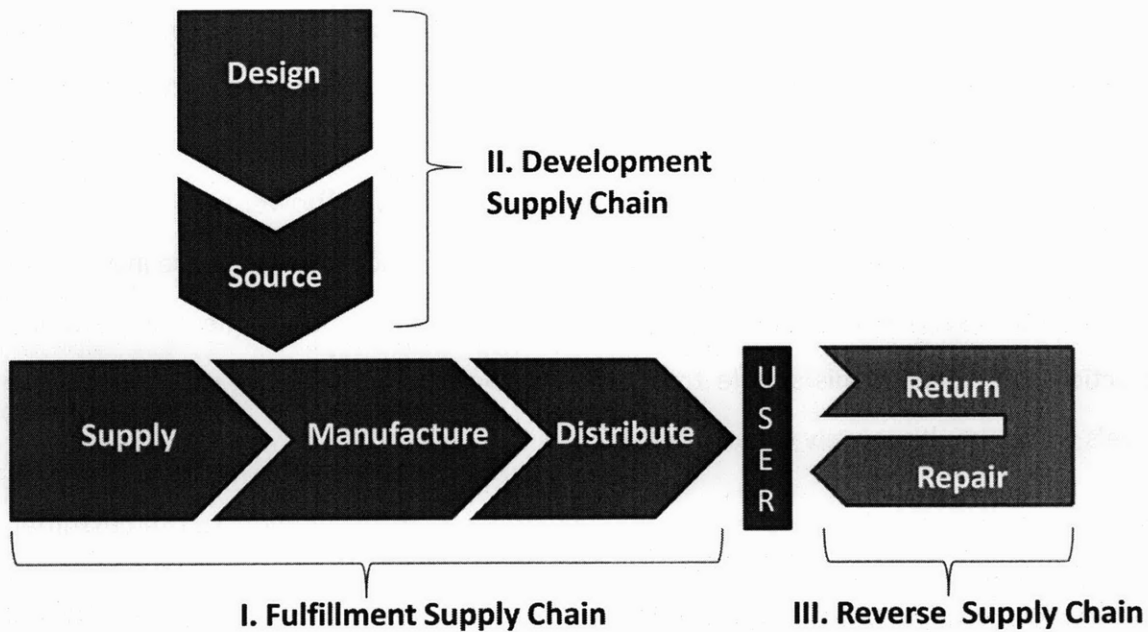


Figure 4: Scope of Supply Chain Management

- I. **Fulfillment Supply Chain:** The process in which physical goods are collected from suppliers, manufactured and distributed to the customer.
- II. **Development Supply Chain:** The process in which new products are designed, developed, and sourced. Although this supply chain does not deal with inventory levels or the movement of physical goods, the ways in which products are designed and sourced has a great deal of influence on characteristics of the fulfillment supply chain. In addition, this is a process that may take over a year, so a clear understanding of the evolving demands of the customer is critical to this process.
- III. **Reverse Supply Chain:** The process in which goods are returned to the manufacturer for repair and redistribution, for resale, or for ecologically friendly disposal. Since mobile phones are typically associated with service plans, efficiency in which this process runs is of great importance to the customer in this industry.

Each of these three interconnected supply chains will be discussed independently.

3.2 Fulfillment Supply Chain

The fulfillment supply chain is the process usually associated with supply chain management.

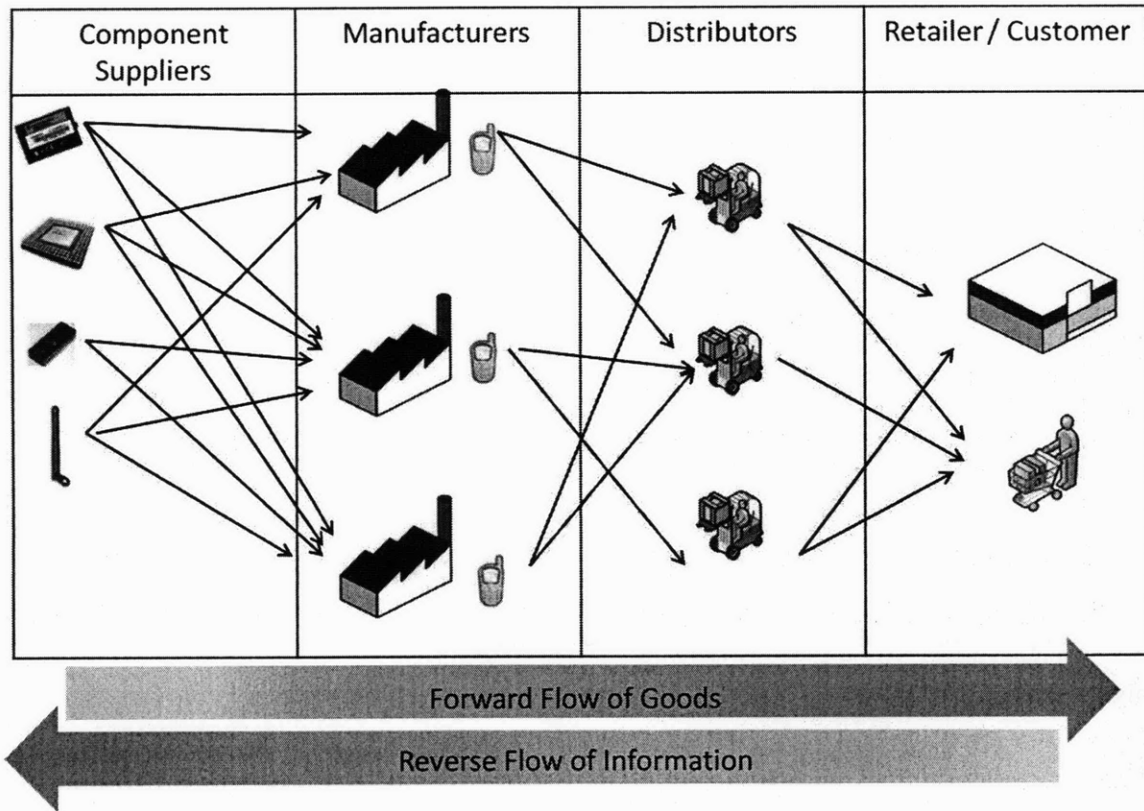


Figure 5: Fulfillment Supply Chain of Mobile Phones

Every mobile phone created today involves components made by many companies, since no company contains the necessary knowledge in-house to build all the components of a mobile phone. Therefore, every OEM must manage many (potentially dozens) of suppliers, which each supply parts of the mobile phone to the manufacturers. At this point, the mobile phones are manufactured, which may or may not be managed directly by the OEMs. Finished goods are then typically shipped to distribution points around the globe. From these distribution centers, they are either sent to retailers, or shipped directly to the customer.

Since items cannot be manufactured and transported instantaneously, each node along the supply chain maintains inventory to ensure that orders they receive from the next step in the supply chain can be met. Determining the level of inventory maintained involves a tradeoff between the desired level of service provided to the next step of the supply chain, and cost. Carrying inventory within a supply chain represents a significant

cost, so much of the activities involved in supply chain planning involve deciding the correct level of inventory at each stage along the supply chain. Success is typically determined by the firm's ability to accurately forecast demand, which can be improved through a number of different supply chain management practices.

While the physical goods flow forward through the supply chain, from suppliers to the customer, it is important to note that simultaneously there is information flowing back from the customer / retailer to the component supplier. At the very least, this information comes in the form of orders. However, recent improvement in IT systems allow for much more timely information to flow, such as point of sales orders or forecasts, which allow the entire supply chain to better predict the correct level of inventory needed in order to satisfy the downstream demand, without maintaining too high an inventory.

Some recent practices within the fulfillment supply chain that have shown to improve the performance of the supply chain include:

- *Enterprise Resource Planning (ERP)*: These IT-based systems provide a centralized view of data within an organization, as well as across organizational boundaries to suppliers and customers. This can improve the flow of information, which leads to more accurate forecasting as well as early notification of potential supply disruptions.
- *Vendor Managed Inventory (VMI)*: Instead of having customers manage order quantities, the supplier is in charge of determining order quantities based on inventory levels maintained at the customer's site. The improved visibility at the customer location allows the supplier to better understand the real demand of the product, and therefore be able to plan production capacity accordingly.
- *Just in Time (JIT)*: In a highly integrated supply chain it is possible to provide suppliers and manufacturers with point of sales information in almost real time. Given flexible manufacturing processes, it may be possible to immediately

produce the product, either to be given directly to the customer or to restock inventory.

3.3 Development Supply Chain

While goods are flowing along the fulfillment supply chain, the development supply chain is actively in the process of creating new product designs that will eventually be produced and distributed by the fulfillment supply chain. The primary goal of the development supply chain is to produce products that will generate the highest amount of profit. Given the increasing relative cost of manufacturing and logistics, it is also important that the development supply chain makes products that enable an efficient supply chain.

Practices within the development supply chain that have an impact on the whole supply chain include:

- *Postponement Strategies:* Having high levels of product variation worsen supply chain performance, because forecasting demand for multiple products is more difficult than forecasting aggregate demand of all products. In order to counter this, it is possible to design the product such that only one type of product is initially manufactured, but is then customized later once demand for the different variations is better known. This is particularly useful for regionalization of products, where different customer preferences, regulations or infrastructure require slightly different mobile phone variations.
- *Design for Manufacturing (DFM) & Design for Logistics (DFL):* It is possible to design the products specifically so that they can be easily manufactured, or easily transported. This allows for more efficient production and distribution of the products, and therefore a more efficient supply chain.
- *Standardization:* Standardization of parts and processes enable design flexibility, such that new products can be quickly introduced or altered to meet changing demand patterns.

3.4 Reverse Supply Chain

Another aspect of the supply chain that is growing in importance is the reverse supply chain. This is the process by which the mobile phones are returned back to the manufacturer for repair or disposal. Although this isn't usually considered part of the supply chain, because it occurs after the product has reached the customer, it is of importance to mobile phones for a few reasons. As mentioned, service contracts with network operators require the customer to have an operational mobile phone. If the mobile phone breaks, it is necessary to replace the mobile phone as quickly as possible, or risk the customer leaving for another operator. In addition, regulations on electronics disposal pressure mobile phone manufacturers to provide safe disposal options for their customers. Nokia, for example, will handle the shipping and disposal of all of its mobile phones¹⁰.

3.5 Challenges in the Mobile Phone Supply Chain

The supply chain of an OEM that produces mobile phones presents very unique difficulties. In order to understand the challenges faced by those managing the supply chain of mobile phones, we must look at factors that cause certain supply chains to be more difficult to maintain.

Factors that impact the supply chain within an industry can be divided into two major groups: product characteristics and market characteristics. Product characteristics include product price, technology clockspeed, supplier characteristics, product size, product variation and product shelf life. Market characteristics include demand uncertainty, location, volume and service level expectation.

The most obvious driver of the challenges faced by OEM supply chain managers is the rapid technology clockspeed, which causes a couple of major difficulties. Mobile phones often have a life span of less than two years¹¹. With the introduction of each new mobile phone, it may be necessary to update manufacturing processes or suppliers

¹⁰ See <http://www.nokiausa.com/A4761433>

¹¹ Choney, S. (2009, February 24). Planned obsolescence: cell phone models. Retrieved April 28, 2009, from MSNBC: <http://www.msnbc.msn.com/id/29258026>

might change. This also means that there is a sharp decline in the value of mobile phones that are kept in inventory for long periods of time. This is typically referred to as cost of obsolescence, which is high in this industry.

Product variation can also cause major difficulties in managing the supply chain. Motorola, for example, has 97 different versions of mobile phones available for purchase on their website¹². This doesn't include varieties introduced from servicing multiple locales, each of which might require its own variation. The more variations of mobile phones that you create, the harder it is to predict the demand for any given mobile phone, and you either have to maintain higher levels of stock or risk lost sales due to empty inventories.

Clearly price plays an important role in the difficulties within the supply chain. Despite the fact that mobile phones are some of the most complex devices ever created, they remarkably affordable. One of the ways that this is achieved is through outsourcing to countries with low cost of labor. Of course, this means that despite where the mobile phones are sold, they are most likely assembled in China or another country with low labor costs. Before a mobile phone reaches the customer, it most likely has travelled half way around the world.

The markets in which the products are targeted also introduce unique challenges to the efficient management of the supply chains in this industry. One such characteristic is demand uncertainty. Not unlike the fashion industry, it is very difficult to predict how popular a given mobile phone is going to be before it is introduced. This is problem is compounded by the fact that mobile phones may take years to develop, so capacity planning must happen well before demand is known. Apple, for example, experienced shortages of the first version of their iPhone. Some believe that this may have been intentional to further drive demand, although more likely it had to do with an underestimation of the demand on the first day. This example also highlights another difficulty in this area, in that there is a very large variation in demand based on events,

¹² See Motorola: <http://www.motorola.com>

such as new product introductions or holidays. Inventory must be stocked to meet the projected peaks, which is expensive and risky.

Although many of the factors that contribute to the challenges faced by those managing the supply chains of mobile phones are inherent to the mobile phone industry, there are many factors that the OEMs have control of. For example, it is up to the company to choose how many variations of mobile phones that it chooses to make. Although Motorola has at least 97 varieties of mobile phones available, Apple only provides one. On the one hand, it may make sense to offer different varieties to the consumer from a business perspective because it might result in more sales. However, this directly results in problems for the supply chain, which now will be able to take less advantage of demand aggregation and have a much more difficult time predicting demand. Similarly, OEMs can choose the markets in which they compete. For example, mobile phones sold in the United States typically have a substantially shorter product lifespan than that of developing countries. This causes OEMs competing in the United States to have to consistently upgrade and update their mobile phones to stay competitive. This, in turn, negatively affects the performance of the supply chain.

Understanding that there is a set of challenges that is inherent to the mobile phone industry, we will now focus on the product and market decisions that result in separate challenges, and hence separate decisions being made about the structure of the supply chain.

3.6 Choosing the Right Supply Chain Strategy

It is important to note that there isn't necessarily a "right" way to implement the supply chain. Differences that exist between products, such as demand uncertainty, supply uncertainty and technology clock speed, dictate different supply chain strategies should

be used. One such way to help determine what choices should be made when implementing the supply chain is presented in the following 2x2 matrix¹³:

Responsive Supply Chain	Mismatch	Match
Efficient Supply Chain	Match	Mismatch
	Functional Product	Innovative Product

Figure 6: Matching Supply Chain with Products¹⁴

The X axis represents the type of product, which can be categorized by the volatility of the demand of that product. Functional products are typically well-established and have little change in demand year after year, while innovative products are typically new and have very uncertain future demand. An example of a functional product is baby diapers, while an example of an innovative product is high-fashion clothing. In general, one would expect mobile phones to fall under the innovative product category, given the characteristics of the product. However, the wide range of mobile phones, from ultra-low to high end, indicates that there should be variation along this dimension.

The Y axis represents the supply chain strategy that should be implemented. Efficient supply chains focus on reducing cost through a number of means, such as minimizing

¹³ Fisher, M. (1997, March-April). What is the right supply chain for your product? Harvard Business Review, pp. 105-116.

¹⁴ Adapted from: Fisher, M. (1997, March-April). What is the right supply chain for your product? Harvard Business Review, pp. 105-116.

inventory. Responsive supply chains, on the other hand, are designed to be able to ramp up production or scale back quickly, depending on the market.

The chart then indicates which supply chain strategy is appropriate for the type of product that you are selling. One might expect mobile phones to typically fall under the Innovative product category, and therefore the chart indicates that building a responsive supply chain would make the most sense. However, as mentioned, the wide range of product variety within the mobile phone market does suggest that some companies should operate in the bottom left quadrant instead.

Although much of the focus in supply chain management is on the uncertainty of demand and the type of the product being produced, it is important that the characteristics of the upstream supply are taken into account when determining the supply chain strategy as well. If supply is uncertain, it may be necessary to take actions to ensure that supply disruptions don't hold up production. The following chart describes the four types of supply chains that can be designed based on supply uncertainty and demand uncertainty¹⁵.

¹⁵ Lee, H. L. (2002, May). Aligning Supply Chain Strategies with Product Uncertainties. *California Management Review*, pp. 105-119.

		Demand Uncertainty	
		Low (Functional Products)	High (Innovative Products)
Supply Uncertainty	Low (Stable Process)	<u>Efficient Supply Chains</u> Grocery, basic apparel, food, oil, and gas	<u>Responsive Supply Chains</u> Fashion Apparel, computers, pop music
	High (Evolving Process)	<u>Risk-hedging Supply Chains</u> Hydro-electric Power, some food produce	<u>Agile Supply Chains</u> Telecom, high-end computers, semiconductor

Figure 7: Determining Supply Chain based on Demand and Supply Uncertainty¹⁶

It would be expected that in general the demand uncertainty is high in the mobile phone industry. However, supply uncertainty could be different based on the type of component being supplied. Components used across all electronic devices, such as memory, would be expected to have a low level of supply uncertainty because of the massive volumes being produced every year. On the other hand, innovative new displays or processors that can only be supplied by a single unproven vendor might have a very high amount of supply uncertainty. This means that OEMs might adapt a responsive supply chain or an agile supply chain. A responsive supply chain is one in which changing customer needs can quickly be incorporated into products, while agile supply chains utilize inventory pooling or dual-sourcing to ensure that disruptions to supply can be accommodated without sacrificing its ability to respond to the changing demand patterns.

¹⁶ Adapted from (Lee 2002)

In addition, it is plausible that systems and policies that lead to a better performing supply chain directly conflict with the product strategy. Clearly, integration between supply chain partners can only improve the performance of the supply chain, whether the primary strategy is to reduce costs or improve responsiveness. However, literature suggests¹⁷ that integrating among supply chain partners may not make sense if it puts you at a competitive disadvantage. In those cases, it might be better to not integrate. And since improvements to the supply chain take time, it would make sense that any supply chain practice that is at odds with product strategy will be avoided.

Despite all being mobile phones, it is clear that the differences between the different types of mobile phones and the markets that they serve will prevent any single supply chain strategy from being ideal. A supply chain designed for high end mobile phones targeted at developing markets would probably be too inefficient for low end mobile phones targeted at emerging markets. Conversely, supply chains that produce low end mobile phones might not be flexible enough to accommodate the changing requirements of users of the high end mobile phones. It is therefore reasonable for OEMs to have very different strategies regarding their supply chain, based on the mobile phones they make and who they are selling them to. It must also be noted that any efforts to improve supply chain performance require time and money, so companies that share the same supply chain strategy might choose to implement certain supply chain management practices to support their strategy based on their unique situation. The remainder of this thesis focuses on a survey that was designed to help understand the relationship that exists between product strategy, supply chain strategy, supply chain structure and corporate performance in this industry.

¹⁷ Bagchi, P. K., & Skjoett-Larsen, T. (2002). Organizational Integration in Supply Chains: A Contingency Approach. *Global Journal of Flexible Systems Management*, pp. 1-10.

Chapter 4: Hypotheses

The purpose of this study is to understand relationships that exist between product strategy, supply chain strategy, supply chain structure and performance.

- *Product Strategy*: The corporate level strategy that defines the type of mobile phones that the company builds, the customers that they sell them to, and the basis upon which they compete.
- *Supply Chain Strategy*: This defines how the supply chain should function in order to support product strategy. The fact that a supply chain strategy is necessary acknowledges the fact that supply chain management practices may differ based on product strategy.
- *Supply Chain Structure*: The actual characteristics of the supply chain. This represents all of the different decisions that can be made by management that impact the supply chain, such as product development, sourcing, supplier selection, manufacturing and distribution. This also includes practices typically associated with supply chain management, including integration and logistics.
- *Performance*: Corporate level performance, relative to peers, as well as performance of the supply chain as measured by standard performance indicators.

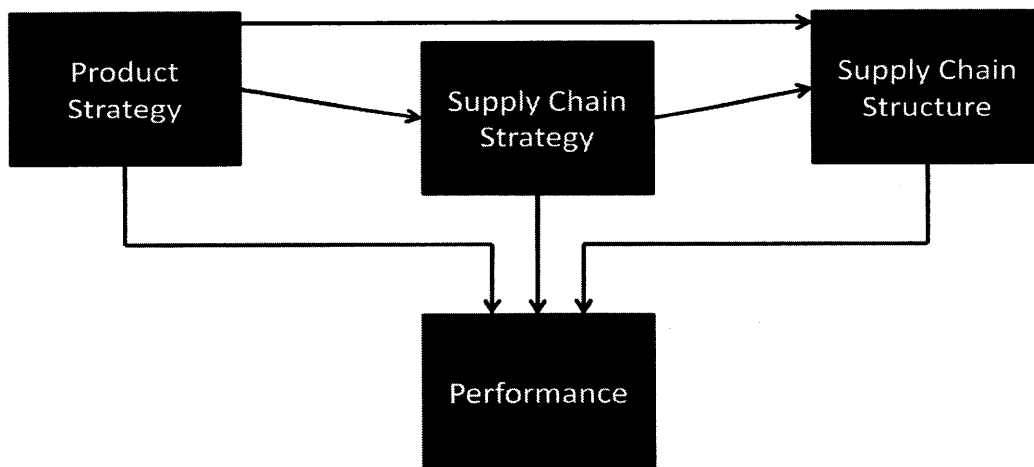


Figure 8: Conceptual Relationship between Strategy, Structure and Performance

The above diagram shows relationships between these concepts that will be tested. Clearly, product strategy should relate to the supply chain strategy. These then determine the actual supply chain structure, so the companies with different product and supply chain strategies should have a different supply chain structure. However, it is possible that companies actually choose incorrect supply chain structures and management practices based on their strategy, and this mismatch could affect overall corporate performance.

4.1 Product Strategy and Supply Chain Strategy

The first step in this study is to identify the relationship that exists between product and supply chain strategies. In reality, many factors contribute to what can be called product strategy, including the price range of mobile phones, variety of mobile phones and characteristics of the market. But in the case of mobile phones, recent growth in the industry has been driven in one of two areas: high end smartphones that compete on innovative features, and ultra-low end phones that compete on price. This suggests that companies will most likely align themselves with one of these two strategies, or if they are large enough, attempt to compete in both areas. Therefore, the determining factor for product strategy here is basis of competition: competing over price, or competing over innovative features. This aligns well with other aspects of the strategy, such as emerging versus developed markets, and low-end versus smartphones. We would expect that mobile phones that compete with low prices are mainly targeted at emerging markets and are low-end phones. Conversely, we would expect mobile phones that compete with innovative features to be targeted primarily at developed markets and be high-end phones.

As discussed, there is no single “right” supply chain. Instead, different supply chain practices work best in different situations. Given a single dimension, the simplest description can be efficient versus flexible supply chains. Efficient supply chains have been highly optimized to ensure that all costs have been minimized. Most likely they are highly integrated, and have high levels of demand forecast accuracy. Flexible supply

chains, on the other hand, aren't as efficient, but are capable of changing as demand changes. Manufacturing may be able to switch between products quickly, or new products might be able to be developed quickly to react to evolving competition.

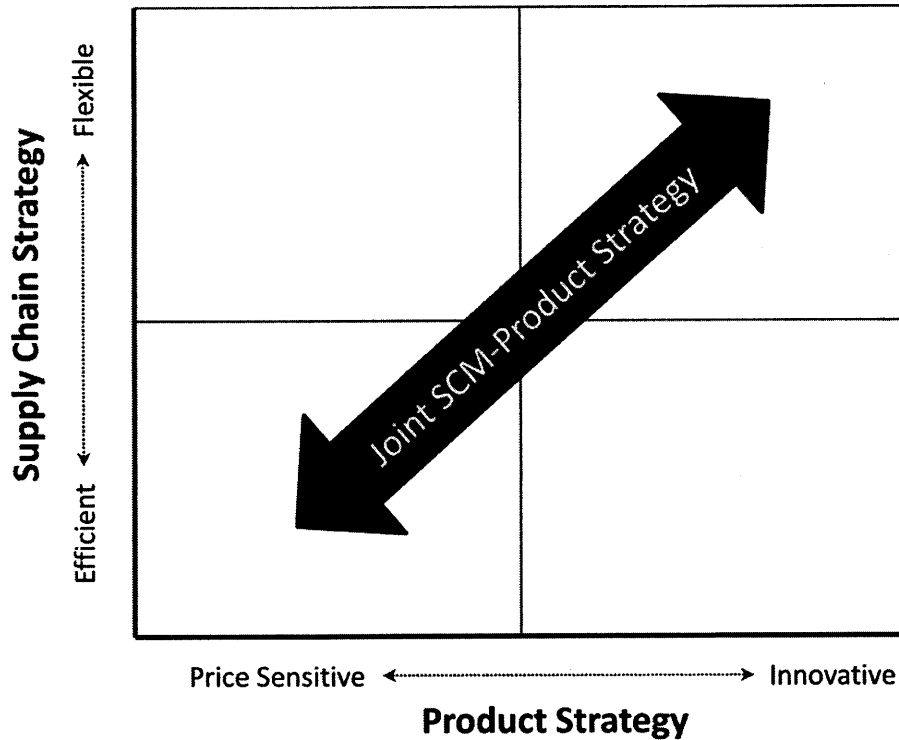


Figure 9: Expected relationship between Supply Chain Strategy and Product Strategy

The above chart shows the expected area in which the product and supply chain strategies will meet. Price sensitive products most likely have more efficient supply chains, while innovative products most likely have flexible supply chains. Given a strong correlation, these two scales can be joined into one, called the Joint SCM-Product strategy, which can represent both the supply chain and product strategy of the company on a single scale.

4.2 Supply Chain Structure and its relationship with Product Strategy and Supply Chain Strategy

It is expected that companies would implement their supply chain in a manner consistent with their strategy. Therefore, companies with similar product and supply chain strategies should also have similar implementations of their supply chain. Unlike product and supply chain strategy, the implementation of their supply chain structure cannot be represented on a single scale. Instead, we break up the supply chain into its parts, and look to see if different parts are aligned with the supply chain and product strategies.

4.3 Performance and its relationship with Product Strategy, Supply Chain Strategy and Supply Chain Structure

Finally, we would like to link the product strategy, supply chain strategy, and supply chain structure to the performance of the firm. Companies with similar product and supply chain strategies are placed into groups, and within each group the supply chain structure is compared to corporate performance. Given a specific strategy, it is possible to identify how the high performers deviate from the lower performers.

In addition, it is possible to look to see how discrepancies between the expected structure of the supply chain based on the strategy of the firm and the actual supply chain structure relates to corporate performance. We postulate that high performers within each strategy implement their supply in a manner that is consistent with their strategy, while lower performers deviate from their strategy.

Chapter 5: Industry Survey

The primary research method used in this study is an industry survey that was administered to OEMs. The survey can be broken out into three major sections:

- I. Strategy
- II. Supply Chain Structure
- III. Performance

The relationship between these sections and the hypotheses being explored is shown in the following diagram:

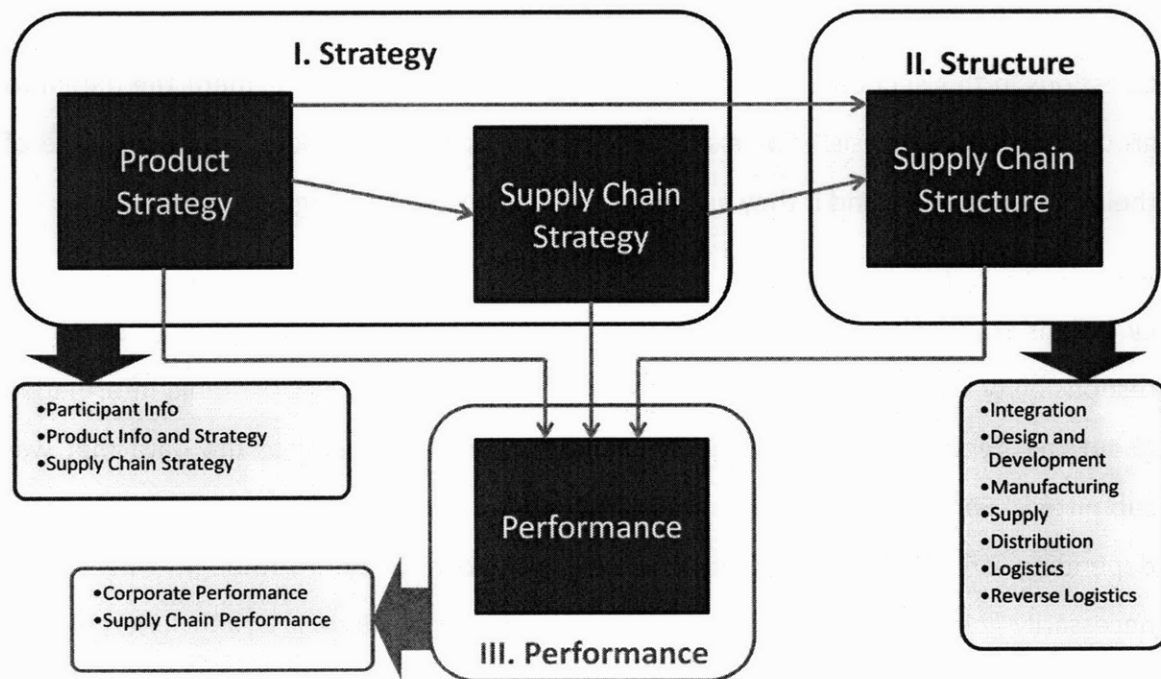


Figure 10: Study goals mapped to Survey Sections

These sections closely mirror the objective of this research: linking corporate and supply chain strategy, supply chain practices, and performance.

In order to ensure adequate participation, no questions could be asked that would jeopardize the anonymity of the participants. Therefore, a delicate balance had to be struck between providing enough information to be able to prove or disprove the hypotheses, without being too specific as to scare away potential participants.

5.1 Part I: Strategy

The purpose of this section is to identify the different ways in which OEMs compete, based on product type and market type. It also is used to help understand the positions of the participants within their organization.

The strategy section is composed of four subsections:

- 1) Participant Information (4 questions)
- 2) Product and Market Information (6 questions)
- 3) Supply Chain Management Strategy (5 questions)
- 4) Supply Chain Challenges (6 questions)

Questions in this section are all multiple choice, and are used to segment the data into groups for later analysis. For example, the participants are asked the price range of their mobile phones, and if they are targeting developed or emerging markets.

5.1.1 Participant Information

Questions regarding job title, area of responsibility, and geographic scope of responsibility were first asked of the participants. This basic demographic information about the person was included to help understand the validity of the data that was submitted. For example, different answers may be given about the same supply chain depending on the position and geographic responsibility. Although this wasn't necessarily going to be used in correlation with any other data, it was included to help understand the different types of people involved in the survey.

5.1.2 Product and Market Information

Information about the product is then asked of the participants. This includes the price of the mobile phone, the features available, the geographic region they are sold in, and if they considered their primary market emerging or developing.

It is entirely possible that multiple, independent supply chains are set up based on product attributes, so the supply chain can be optimized to fit the product and the market. Tailoring supply chains to meet the needs of the individual products and

markets could result in better overall performance. In order to account for this situation, the participant is instructed to choose a single supply chain for the rest of the survey.

5.1.3 Supply Chain Strategies

It is also important to understand the general strategies of the supply chain and to see how they relate to the corporate strategy and actual implementation. Participants were asked if the focus of supply chain management is reducing costs, or if it is to improve flexibility, robustness, or to help reduce the time to market of new products.

5.1.4 Supply Chain Challenges

Finally, a set of forward looking questions were put together regarding the current challenges of the supply chain. These include:

- Increasing number of component suppliers
- Increasing amount of product variation
- Increasingly global supply chain
- Pressure to reduce costs
- Increasing amount of uncertainty in demand
- Pressure to reduce environmental impact

5.2 Part II: Supply Chain Structure

In the second part of the survey, questions regarding specific practices of the supply chain were asked of the participants. This section is divided loosely around the framework for understanding the supply chain presented earlier, which presents the entire supply chain as a combination of the fulfillment supply chain, the development supply chain, and the reverse supply chain. Additional questions were also asked regarding the interaction between the different pieces of the supply chain, including integration and logistics questions.

- 1) Supply Chain Integration (10 questions)
- 2) Product Design and Development (10 questions)

- 3) Manufacturing (14 questions)
- 4) Component Supply (6 questions)
- 5) Distribution (11 questions)
- 6) Logistics and Transportation (13 questions)
- 7) Reverse Logistics (8 questions)

5.2.1 Supply Chain Integration

An important factor that determines the performance of the supply chain is the level of integration that exists between the different entities involved in the supply chain process. Higher levels of integration allow for better prediction of required inventory levels, which leads directly to better performance.

This survey determines level of integration through a series of ten questions which measure different aspects of integration. These ten questions can be broken into two groups: internal integration and external integration. Internal integration questions include the level of consistency of measures and the level in which central repositories are used to share information within the organization. External integration questions include if point of sales information is shared between partners, how much forecasting data is shared between partners, and how well goal and incentives are aligned between partners.

These questions will be combined to create a score of supply chain integration. Companies that are better integrated along the fulfillment supply chain will perform better in respects to key performance measurements, such as inventory days or forecast accuracy. However, it is unclear if this has any unintended consequences that hurt corporate performance. Fully integrating the supply chain might take many years, and would be difficult to do without a long term agreements between suppliers and customers. It might, in fact, be advantageous to not integrate in certain situations, particularly early in the lifecycle of a technology when competitive advantage outweigh the benefits of sharing information with suppliers and customers.

5.2.2 Product Design and Development

As discussed, product design plays an important role in the ability for the supply chain to work effectively. Some areas of consideration include:

- Level of design outsourcing
- Level of modularity
- Level of collaboration with partners during design

OEMs need to decide if they want to design all mobile phones that they eventually sell to their customers, or if they choose to outsource the design of some of these phones. It may be desirable, for example, to outsource the design of cheaper mobile phones to Original Design Manufacturers (ODMs), which are capable of producing mobile phones at a lower cost. The OEM may want to provide a low cost, entry level mobile phone under its own brand to help capture customers, but might not necessarily want to focus its own design teams on this type of product. Outsourcing the design of the mobile phones might be a reasonable strategy in this situation.

Modularity in product design can be an effective way to help improve the performance of the supply chain. By having parts that can be easily swapped between products, it is possible to take advantage of demand aggregation. For example, if only one battery model is used for all models of mobile phones, it will be much easier to determine the number of batteries needed to be ordered from suppliers. It also can be an effective way to decrease the amount of time needed to design a product. Modular architectures allow for increased reuse between product lines and across product generations, which reduces the amount of time necessary to design the product. Of course, this comes at a price. Modularity typically reduces the potential design space, which means more innovative designs cannot be achieved.

Level of collaboration between customers and suppliers during the design process must also be decided. Studies indicate that higher level of collaboration allow OEMs to produce better products faster, especially when that collaboration occurs with

suppliers¹⁸. However, it may not be desirable from a competitive standpoint to be completely transparent with all parties if you are competing on innovation, because more information that is shared outside of the company may lessen competitive advantage.

5.2.3 Manufacturing

Many choices must be made from a manufacturing standpoint that directly affects the performance of the supply chain. These choices include:

- Level of Outsourcing
- Manufacturing Strategy
- Plant specialization and flexibility
- Plant location

Level of outsourcing for manufacturing is the first decision that must be made. Some OEMs choose to completely outsource the manufacturing of their products. This is typically outsourced to Electronic Manufacturing Service (EMS) providers, who specialize in manufacturing electronics. It is quite common for the same EMS to manufacture products for two competing OEMs. Adding another organizational boundary may make it more difficult to efficiently operate the supply chain; however, it can also improve supply chain performance given the large size of the EMSs and their ability to leverage commodities of scale.

Choices also must be made in regards to the level in which plants are specialized to manufacture certain products. For example, plants can be made to specialize in building only a few different products, which would help reduce costs because they can be streamlined to meet the needs of those products. On the other hand, it is possible to have one plant be able to manufacture any type of product. This costs more, but it also

¹⁸ Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, pp. 371-388.

allows for much more accurate prediction on how much capacity in which to invest due to aggregation.

Finally, plant location has an impact on the performance of the supply chain. Having plants near suppliers or customers reduces the amount of time and money spent transporting unfinished and finished goods. However, having centralized manufacturing facilities also can be beneficial, because it is easier to predict demand for higher volume facilities.

5.2.4 Component Supply

The beginning point in the fulfillment supply chain is the suppliers. Suppliers, in the case of OEMs, represent the network of component suppliers that provide the pieces in which comprise the mobile phone.

There are a couple of factors that the OEMs must take into account during the component supply phase. First, they must choose the basis upon which to select suppliers. They may choose suppliers based on cost, quality, or reputation. Also, they must choose how many component suppliers that they want to use for a given part. Using multiple component suppliers for a given part will help safeguard against supply disruption¹⁹. However, it may be much more difficult to establish multiple relationships between suppliers, if it is even possible to do so.

5.2.5 Distribution

From a distribution standpoint, there are a couple of different options for the OEM. They may choose to sell directly to the mobile phone users, to network operators, to wholesalers, or to some combination thereof. An agreement must be made as to where exactly the handoff from the OEM to the next step in the supply chain takes place. This might be directly to the customer, as must be the case when sold direct through the web. Alternatively, this may be at a regional, country, or local distribution center, if they are selling to network operators or wholesalers.

¹⁹ Tomlin, B. (2009). Disruption-management strategies for short life-cycle products. *Naval Research Logistics*, pp. 318-347.

5.2.6 Logistics and Transportation

An important aspect of the supply chain occurs between the different steps along the fulfillment supply chain. This is the act of physically transporting good from the suppliers to manufacturers, the manufacturers to distributors, and the distributors to the customer.

There are a couple of considerations that must be taken into account when choosing the logistics portion of the supply chain. The first consideration is the level of outsourcing that is done. By outsourcing logistics, it is possible to take advantage of existing infrastructure that is owned by logistics firms, including warehouses, planes and ships. However, if superior logistics is considered a source of competitive advantage within the OEM, it wouldn't make sense to outsource.

Another choice that needs to be made is the mode of transportation used to ship components and finished goods along the supply chain. The major consideration is between air and ocean freight. Shipping by ocean may have a lower cost per unit, but given the high cost of obsolescence in this domain, using air freight in certain situations might make sense.

5.2.7 Reverse Logistics

An increasingly important aspect of consumer electronics is managing the reverse supply chain, which is the process by which goods are returned to the manufacturer for the purpose of repair, disposal, or resale.

The level in which the OEM is involved with the reverse logistics activities must also be determined. This depends on the level of contact that the OEM has with the customer. If the OEM has no direct contact with the customer, it might not be involved at all with the reverse logistic process, besides supplying parts to repair shops. Alternatively, it may be involved in the process, and is responsible for the entire process of receiving phones from the customer and shipping it back to the customer. If this is the case, some or all of these activities may be outsourced to a third party that specializes in the reverse logistics process, or the repair process.

Given the fact that it is involved directly in the reverse logistics process, the OEM must also choose the type of return and repair policy is used for its mobile phones. There are two basic methods of doing this:

1. Replace like-for-like
2. Fix and replace same unit

The like-for-like repair policy involves the customer returning the mobile phone to a store or a retailer, and the retailer immediately (or shortly thereafter) giving the customer a replacement mobile phone. Meanwhile, the unit in need of repair is sent back to the repair shop, and after being fixed is sent back into a pool to be distributed back to another user in need of a replacement mobile phone. This typically results in a better customer experience since the user doesn't have to wait for the unit to be completely repaired before receiving a new unit. However, this is also a more expensive option for the OEM. It requires maintaining an inventory of repaired units to quickly redistribute back to the customers.

The fix and replace same unit policy simply has the customer return the unit, have it shipped to a repair facility, where it is fixed and shipped directly back to the customer. This takes much longer than the other option, but costs less for the OEM, because no inventory of repaired mobile phones is maintained.

5.3 Part III: Performance

Finally, questions regarding the performance of the company are used to help determine how the strategies and implementation by the OEM affect performance of the supply chain and of the company.

5.3.1 Corporate Performance

In order to facilitate participation, corporate performance measures are asked in relation to competitors. These measures include profitability, growth of profitability, market share, growth of market share, and return on investment.

5.3.2 Supply Chain Performance

Supply chain performance measurements are industry standard measures. These are by no means a complete set²⁰, but should be enough to determine supply chain performance. These include inventory days of supply, cash-to-cash cycle time, obsolescence cost as percentage of revenue, on time delivery performance to requested date, order fulfillment lead time and forecast accuracy.

²⁰ Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. *International Journal of Production Economics* , pp. 333-347.

Chapter 6: Analysis and Results

The survey was administered through a web site so it could be accessed by anybody in the world, and invitations were sent via email to approximately 1,700 professionals in the mobile phone industry. This list of invitees represented employees of almost every mobile phone OEM. Typically, the invitees were senior managers or higher, with visibility across multiple areas in the company.

Since there aren't 1,700 mobile phone OEMs, there typically were multiple invitees per OEM. Complete anonymity was required in order to guarantee a reasonable amount of participation, so it is not possible to determine how many of the participants were within the same company. This analysis assumes that there was little overlap in the employers of the participants. Invitees were asked to complete the survey within two weeks of receiving the invitation. A reminder email was sent after seven days. Both emails are included in the appendix of this paper.

Of the 1,700 invitations, 75 chose to participate in the survey. However, not all participants completed all three sections of the survey. The number of responses received by section is:

- 1) *Strategy*: 40-75 responses
- 2) *Structure*: 20-35 responses
- 3) *Performance*: 16-21 responses

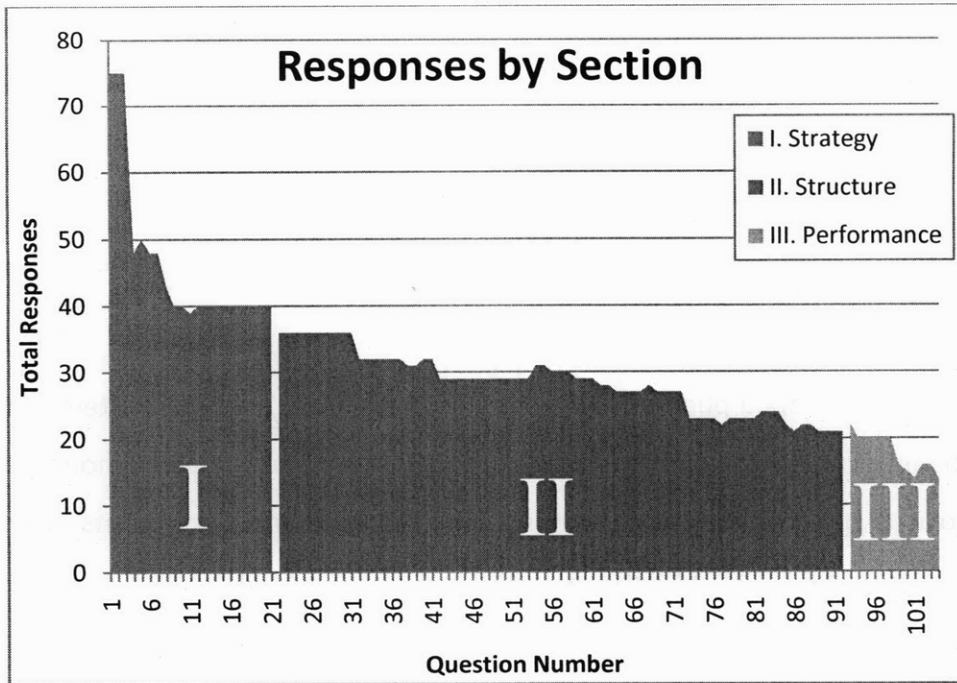


Figure 11: Responses by Section

All 16 participants that completed the *Performance* section also completed the *Supply Chain Structure* section. Similarly, all 21 participants that completed the *Supply Chain Structure* section completed the *Strategy* section. Therefore, it is possible to link the responses in the later sections to those of the earlier section for analysis.

Given the low number of participants in the *Performance* section of the survey, it is difficult to draw statistically significant conclusions involving performance data. Therefore, the analysis will first focus on identifying relationships that don't involve performance data, such as linking product strategy with supply chain strategy, and then linking the supply chain strategy with specific supply chain practices. Afterwards, the performance data will be presented, understanding that limited conclusions can be made with such a small data set.

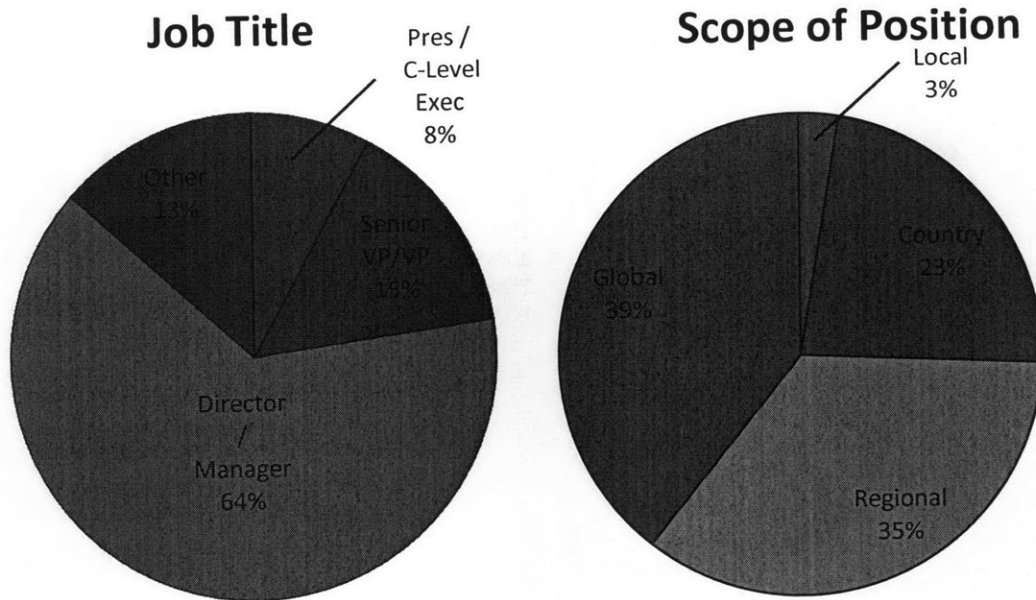
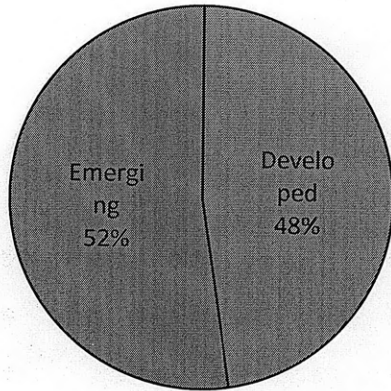


Figure 12: Participant Information

Of the participants, the majority were at the director or manager level. The scope of their responsibilities was fairly split between global, regional, and country levels. In the context of this survey, a region typically signifies a large group of countries, or an entire continent.

Target Market



Phone Types

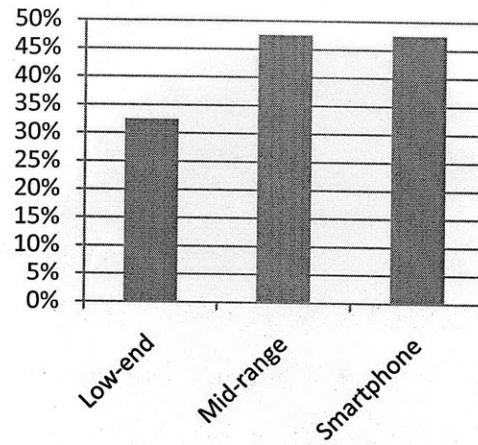


Figure 13: Product and Market

About half of the participants considered their primary market to be emerging, while the other half considered their market to be developed. 33% of the OEMs surveyed sold low-end phones, while 48% sold mid-range phones and 48% sold smartphones. Many sold a combination phone types, which is why these values do not add up to 100%.

6.1 Hypothesis Testing

The following figure describes the process by which the 3 hypotheses are tested:

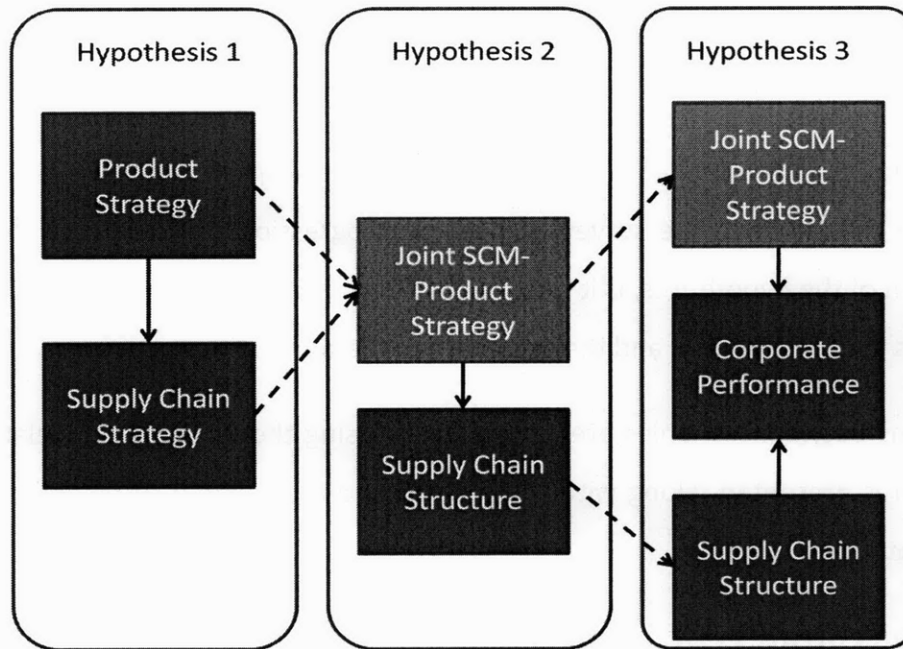


Figure 14: Hypothesis Testing Process

First, the product strategy and the supply chain strategy are calculated from the survey responses. The correlation between these two variables is calculated, and a statistically significant correlation would prove the validity of the first hypothesis.

Given a correlation between the product strategy and the supply chain strategy, we can combine these two concepts into one scale, which will be referred to as the Joint SCM-Product Strategy. Conceptually, this represents the company's own perception of how they should be implementing their supply chain based on their product and supply chain goals. This calculated variable is then compared with their supply chain structure, to see how the different strategies result in different supply chain practices in this industry. If the hypothesis is true, there will be a statistically significant correlation between some parts of the supply chain and the company's Joint SCM-Product Strategy.

Finally, the responses were segmented into two groups based on their Joint SCM-Product Strategy. One group represents companies with an efficient supply chain and price sensitive products, while the other group represents companies with a flexible supply chain and innovative products. Within each group, analysis is performed to see how the high performers differed in their supply chain structure from the other

companies with similar strategies. This will yield insight into which supply chain practices might be adopted by the lower performing companies.

It is important to note is that many more participants responded to questions early in the survey than later in the survey. Since the progression of the survey follows the progression of the hypotheses, is it much easier to gain statistical significance in the first hypothesis than the second, and the second than the third.

Correlations between variables are calculated by using the Pearson's correlation. The correlation is presented, along with the p-value and the number of responses used in the calculation.

6.2 Product Strategy and Supply Chain Strategy

6.2.1 Establishing Product Strategy

The survey included two questions that were directed towards understanding the product strategy of the company, or more specifically, the basis upon which their products compete.

To what extent do you agree with the following statement (1 strongly disagree, 5 strongly agree).

- The products in this supply chain compete on price
- The products in this supply chain compete on features

Both were on a scale of 1 to 5, with 1 representing a "Strongly Disagree", and 5 being "Strongly Agree".

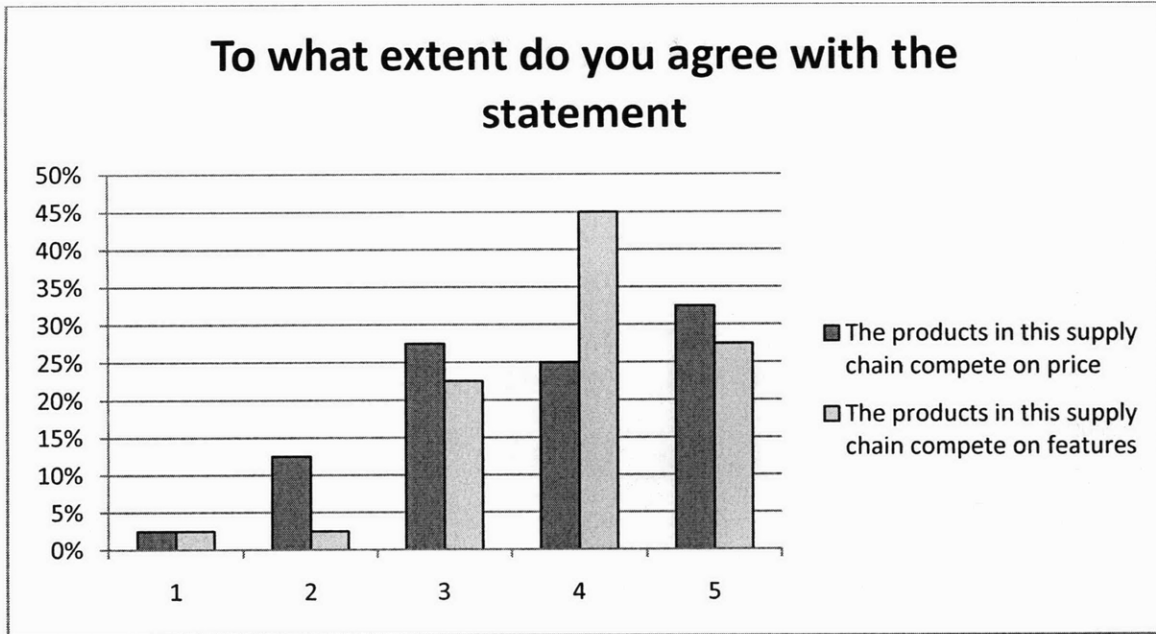


Figure 15: Basis of Competition of Products

This does not directly provide information as to which mode of competition is preferred by the company. In order to get the relative importance of competing by price over competing by features, an aggregate variable was created in the following manner:

$$\frac{f-p}{2} + 3$$

f : products compete on features

p : product compete on price

This creates a scale, from 1 to 5, in which 1 represents a company that is focused on competing completely on price, and 5 in which a company is focused on competing completely on features. A 3 on this scale would indicate that price and features are equally important.

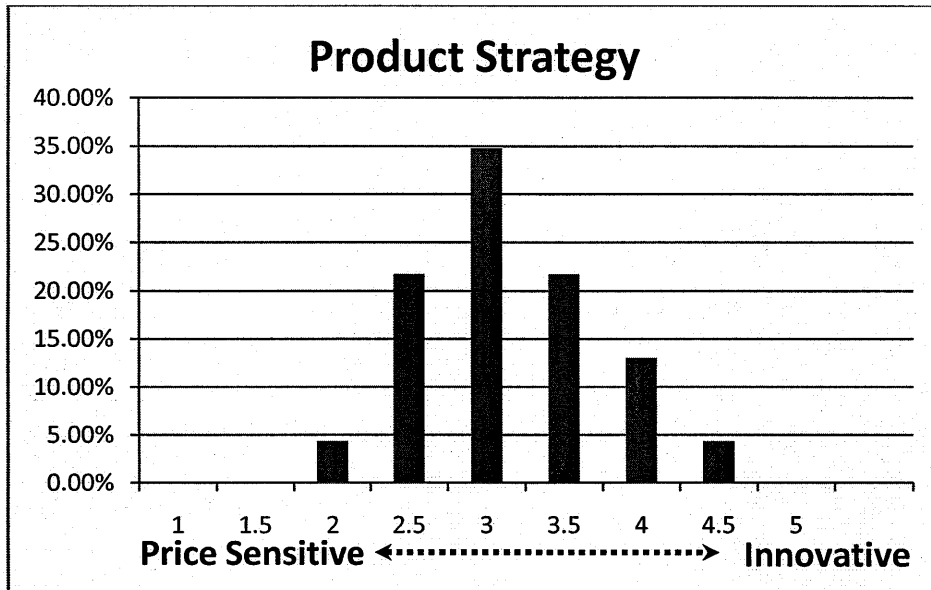


Figure 16: Product Strategy Distribution

6.2.2 Establishing Supply Chain Strategy

Questions about supply chain strategy were specifically asked to the participant as well.

These were in a similar form to the product strategy questions:

To what extent do you agree with the following statement (1 strongly disagree, 5 strongly agree).

- Reducing cost is the primary objective of supply chain management activities
- Increasing supply chain flexibility is the primary objective of supply chain management activities

Both were on a scale of 1 to 5, with 1 representing a “Strongly Disagree”, and 5 being “Strongly Agree”.

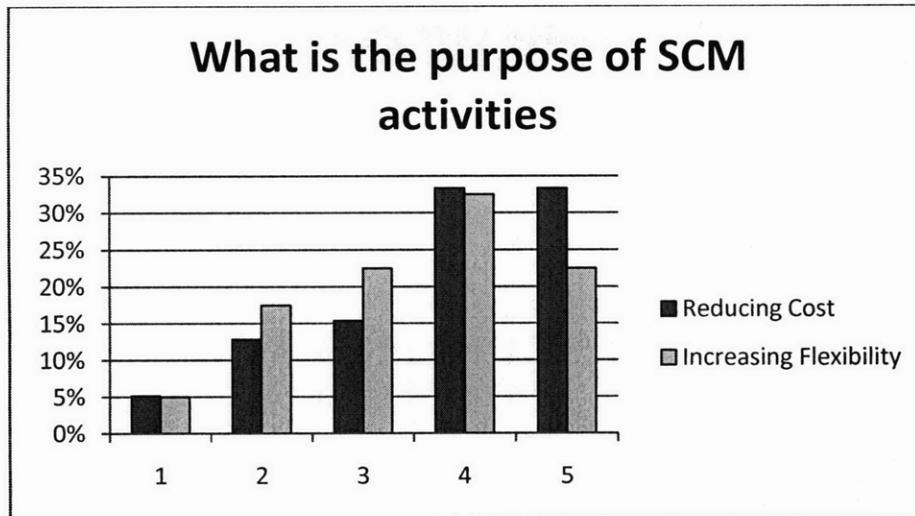


Figure 17: Purpose of Supply Chain Activities

Just as in the product strategy, these questions did not directly provide the information that is needed. In order to come up with a single dimension that represents the tradeoff between flexibility and efficiency, these responses are combined in the same manner as product strategy. This results in the following distribution:

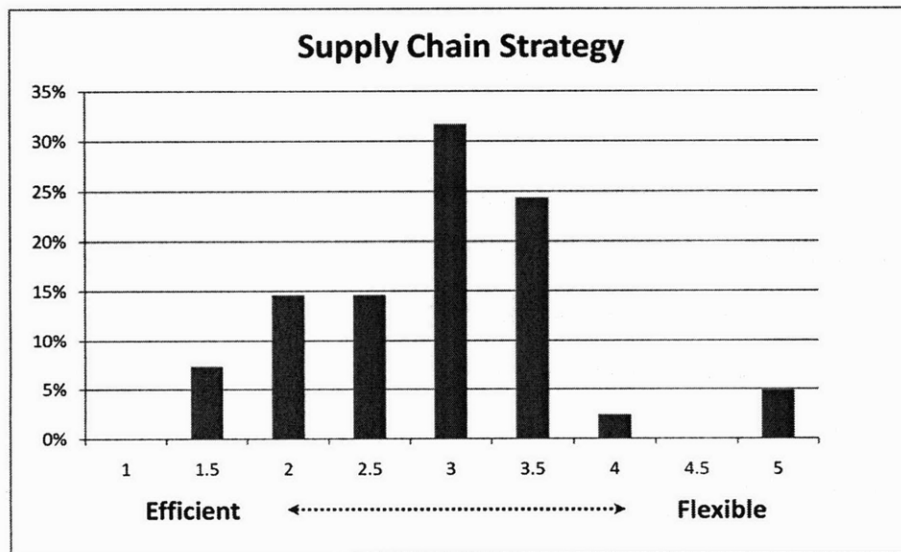


Figure 18: Supply Chain Strategy

6.2.3 Linking Product Strategy and Supply Chain Strategy

Now that we have two dimensions that represent product strategy and supply chain strategy, we can look to see if there is any correlation between the two. The following scatterplot shows the responses, as well as a trend line.

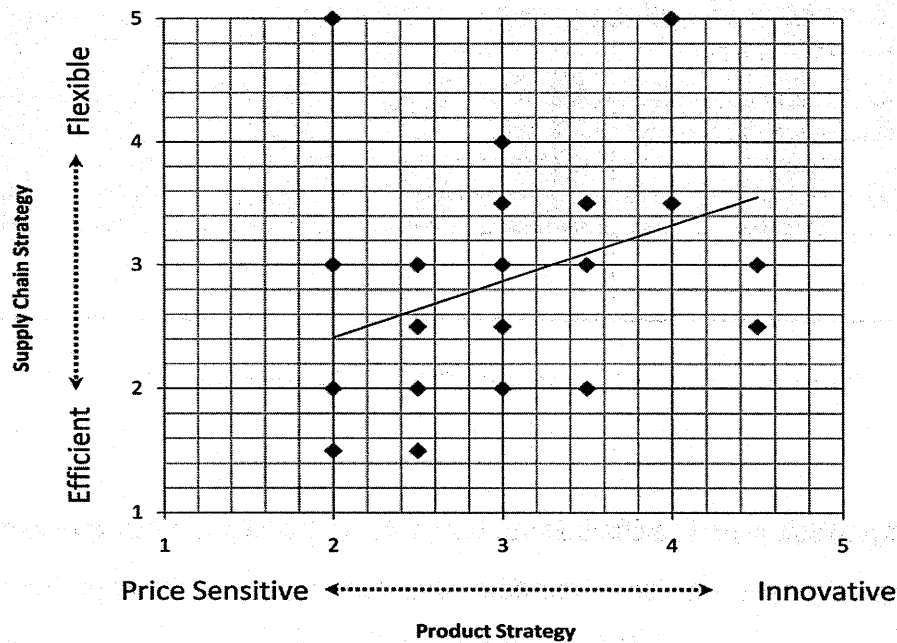


Figure 19: Supply Chain vs. Product Strategy

Visually, it is possible to see the relationship that exists between product and supply chain strategy. The Pearson's correlation is as follows:

- Correlation: .356
- Count: 36
- p-value: .024

This represents a medium correlation with a strong statistical significance. This indicates that the first hypothesis, which states that there is a relationship between the product and supply chain management strategies, is valid.

6.3 Joint SCM-Product Strategy and Supply Chain Structure

6.3.1 Establishing Joint SCM-Product Strategy

According to the survey, the participants, for the most part, matched their product strategy with the appropriate supply chain strategy. These are represented in the following graph, in which the responses can be readily associated with the top-right or bottom-left quadrants.

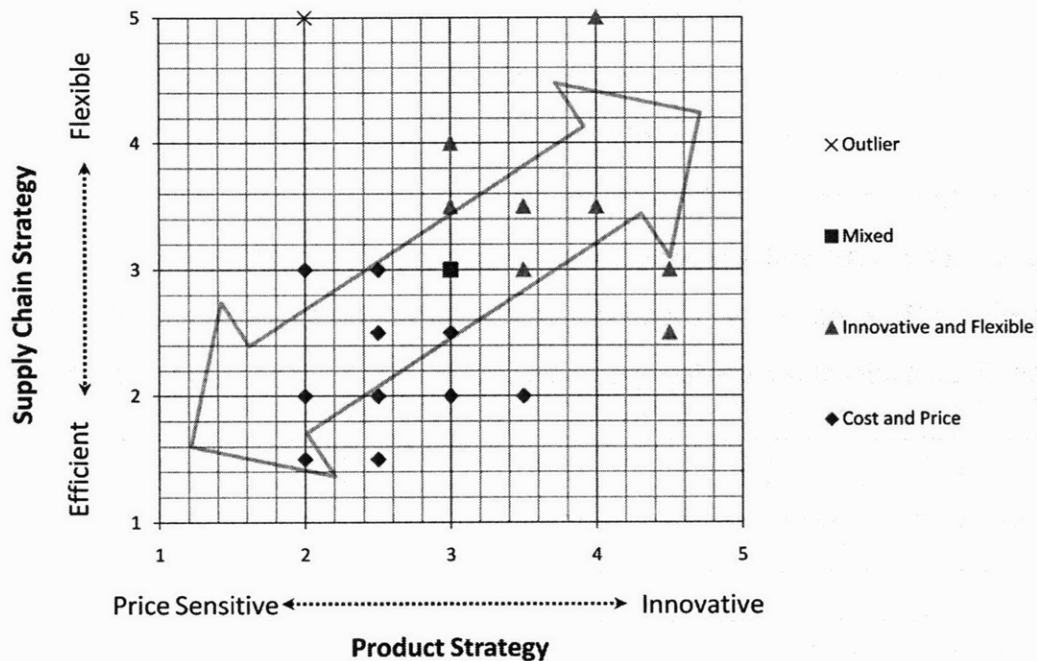


Figure 20: Removing Outliers

There is one outlier, which has a Price Sensitive-Flexible joint strategy. By removing this outlier, the correlation increases to .545, with a significance of .000. This single response is removed from further analysis.

Finally, a single scale representing the joint SCM-Product strategy was created, simply by averaging the responses to the SCM and product strategies. The distribution contains approximately 25% mixed strategies, with the remaining responses falling evenly between Flexible-Innovative strategies and Efficient- Price Sensitive strategies.

Joint SCM-Product Strategy

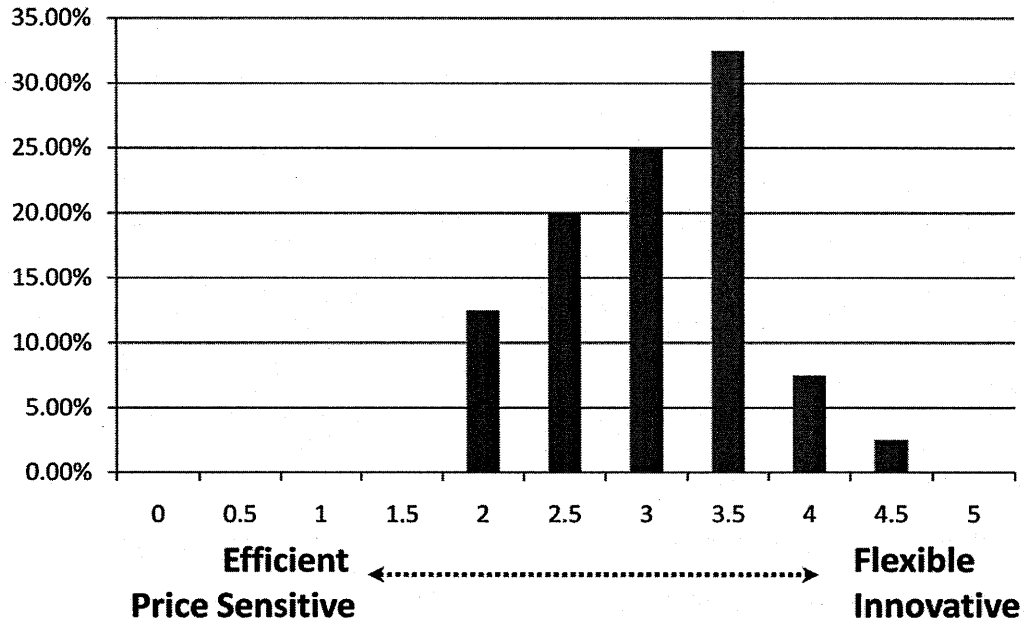


Figure 21: Joint SCM-Product Strategy

This single scale will be considered the joint SCM-Product Strategy, in which lower numbers represent products that compete on price and have supply chains that are efficient, while higher numbers represent products that compete on innovation and have supply chains that are flexible.

Correlation between this Joint SCM-Product Strategy scale and product and market characteristics exist, as would be expected. The companies that have Flexible & Innovative strategies do not attempt to compete in the ultra-low price mobile phones, while companies with Efficient-Price Sensitive strategies do (correlation of $-.334$ with p-value of $.054$).

6.3.2 Supply Chain Structure

The next task was to identify relationships that exist between the SCM-Product strategy and the structure of the supply chain. The following table shows the specific practices that differed based on supply chain strategy:

	Pearson Correlation	p-value	Count
Manufacturing Flexibility	0.498	0.007	28
Level of Outsourcing	0.383	0.065	24
Control of Distribution	0.306	0.137	25
Design Integration	0.306	0.100	30
Cost-based Supplier Selection	-0.434	0.017	30

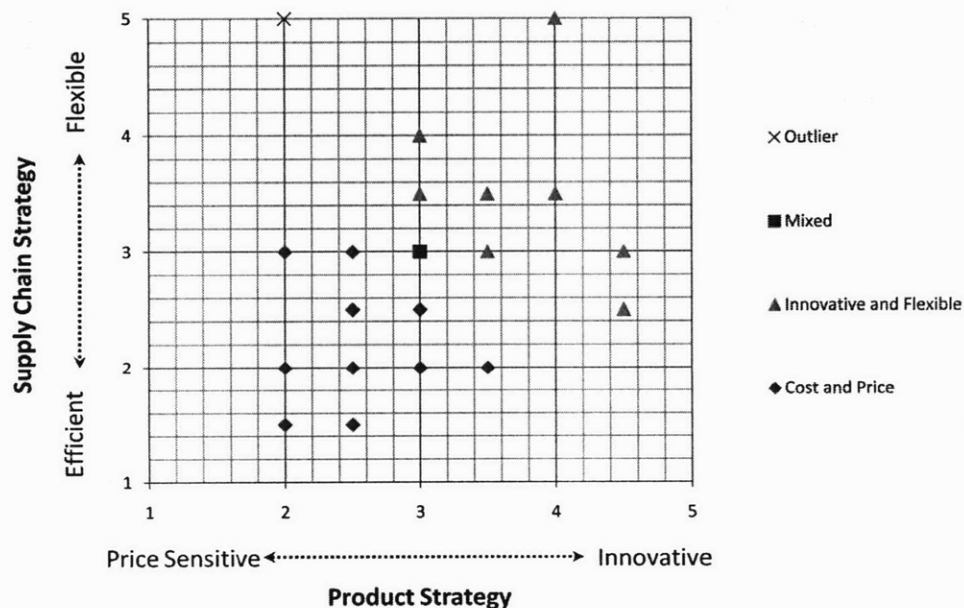
- *Manufacturing Flexibility:* The participants were asked if their manufacturing operations are capable of switching between products quickly. There was a strong correlation between this and the company's strategy, indicating that the more Flexible-Innovative the joint strategy, the more flexibility is embedded within the manufacturing operation.
- *Level of Outsourcing:* An aggregate variable representing the company's tendency to outsource was created, which has a medium level of positive correlation with the company's strategy. The more flexible the supply chain and innovative the products, the more outsourcing is done by the company.
- *Control of Distribution:* Multiple questions were asked regarding how much control the company has over the distribution of their mobile phone. Companies that have a high level of control over distribution tend to be in charge of distribution all the way to the customer or to the retailer, while companies with a low level of control of the distribution go through distributors or wholesalers. Companies with more innovative products and flexible supply chains tend to have more control of distribution than the companies with price sensitive products and efficient supply chains, although the statistical significance of this finding is relatively low.
- *Design Integration:* Integration of design activities is assessed based on questions about the level of collaboration that exists between design teams, both internally and externally with other partners along the supply chain. More

innovative companies tend to have higher levels of design integration than the price-sensitive companies.

- *Cost-based Supplier Selection:* Participants were also asked to what extent cost comes into consideration during supplier selection. Not surprisingly, the innovative companies tended to consider cost to be less important than their price-sensitive counterparts.

6.4 Practices of Top Performers by Strategy

Finally, analysis was performed to see what top performers within each strategy group did differently than their peers. In order to do this, two groups were formed, one containing all companies that exhibited a flexible-innovative strategy and one for companies that exhibited an efficient-price sensitive strategy. Companies that indicated no preference (a mixed strategy), as well as the single outlier, were omitted.



The Efficient-Price Sensitive group contained 16 responses, while the Flexible-Innovative group contained 17 responses. Within each group, the structure of their supply chain was compared against their performance. In the survey, participants were asked to

gauge their performance relative to their peers in five areas: *profitability, growth of profitability, market share, growth of market share* and *return on investment*. Statistical analysis shows that there is a strong correlation with high statistical significance between *profitability* and all of the other performance metrics, so we will simply use *profitability* as the primary metric for determining corporate performance. Of the 16 responses in the Efficient-Price Sensitive group, only 8 responded with performance statistics. And of the 17 responses in the Flexible-Innovative group, only 9 responded with performance statistics. The small data set inhibits the statistical significance of these findings. However, there were a few areas in which the high performers acted differently than the low performers.

6.4.1 Flexible-Innovative Group

The following table describes four areas in which high performers in the flexible-innovative group differ from the low performers in the group:

	Pearson Correlation	p-value	Count
Regional Manufacturing Specialization	0.7392	0.0229	9
Shared Components Between Products	0.617	0.0768	9
3PL Usage	-0.5446	0.1295	9
Independent Forward and Reverse Logistics Design	-0.4764	0.2327	9

- *Regional Manufacturing Specialization*: Besides manufacturing flexibility, the survey also asked participants how specialized their manufacturing practices are based on the regions in which the product serves. Higher performing companies with innovative products tended to have manufacturing facilities that are specialized to service specific regions.
- *Shared Components between Products*: Although no statistically significant conclusions can be drawn regarding overall product modularity, the responses

indicate that higher performers in this group tended to share more components between product groups.

- *3PL Usage*: High performers indicated that they outsourced their logistic services less than the lower performers in this group.
- *Independent Forward and Reverse Logistics Design*: High performers tended to consider reverse logistics while designing the supply chain.

6.4.2 Efficient-Price Sensitive Group

The following table describes four potential areas in which high performers in the efficient-price sensitive group differ from the low performers in the group:

	Pearson Correlation	p-value	Count
Independent Forward and Reverse Logistics Design	-0.6667	.071	8
Manufacturing Specialization	-0.619	0.1018	8
3PL Usage	-0.4671	0.2432	8

- *Independent Forward and Reverse Logistics Design*: Like high performers in the flexible-innovative group, high performers in this group considered reverse logistics while designing the supply chain.
- *Regional Manufacturing Specialization*: Unlike the flexible-innovative group, high performers in this group actually had less regional specialization.
- *3PL Usage*: Like high performers in the flexible-innovative group, high performers in this group outsourced less logistics activities than low performers in this group.

Chapter 7: Conclusions

The purpose of this study was to do the following:

- 1) Identify a relationship between product strategy and supply chain strategy in the mobile phone industry, and establish a joint SCM-Product strategy.
- 2) Identify relationships between the joint SCM-Product strategy and actual supply chain structure
- 3) Link corporate performance with the supply chain practices based on strategy

A clear relationship was found to exist between the product strategy and the supply chain strategy in the mobile phone industry. Companies whose products compete on innovation over price tend to want a supply chain that is more flexible than efficient. Of the 36 valid responses, only one did not follow this pattern. Therefore, given a company's product strategy, it is possible to deduct their overall supply chain strategy.

Second, a relationship was found between the supply chain strategy and various aspects of the supply chain structure. Specifically, design integration, tendency to outsource, manufacturing flexibility and control of distribution showed a medium correlation with the supply chains strategy with medium statistical significance.

Third, there were a few areas in which there was a clear difference in the supply chain practices of high performers over poor performers, based on the strategy of the company. This information can be used to help understand ways that the poor performers can specifically change portions of their supply chain to match that of high performers.

5.1 Limitations

The primary limitation of this study is the number of participants in the survey. Ideally, a study of this nature would have at least a hundred responses to help ensure the statistical significance of the findings. More responses may have helped identify additional relationships that exist between strategy, supply chain practice and performance.

In addition, given the size and scope of supply chain activities, it is very difficult to identify employees that are at a high enough level to have visibility across the supply chain while also having enough knowledge within each area to answer the questions with a high level of accuracy. Having targeted surveys based on role within the organization was considered, but this would require respondents to identify their organization, which would prevent anonymity of the survey. Anonymity was considered a requirement for participation, so this method was not chosen.

Also, in some cases invitations were sent to multiple employees of a single company, since it was assumed that not everybody would fill out the survey. Therefore, it is possible that some companies are represented multiple times within the data, and the anonymous nature of the survey prevents us from knowing if this is the case. However, we do know that nobody filled out the survey more than once, since this was not possible given the design of the web survey.

5.2 Further Research Opportunities

Although this research was targeted at a specific industry, many of the questions within the survey are broad enough to apply to the strategies and supply chain practices of different industries. Therefore, the scope of this study could be broadened to be cross-industry, which would allow for more participation and potentially further findings.

In addition, alternate methods of linking performance with supply chain strategy and practices could be explored. For example, although a company might have a cohesive product strategy and a properly formed supply chain strategy, they might implement their supply chain in ways that are contrary to that strategy. An expected supply chain structure can be predicted based on their strategy, and this can be compared with what the company has actually implemented. The difference between these two values is referred to as the Structure-Strategy Alignment, with a higher value representing worse alignment. We would expect that Corporate Performance to be negatively correlated with this value: better performers have better alignment, which is represented by a lower value in the Structure-Strategy Alignment variable.

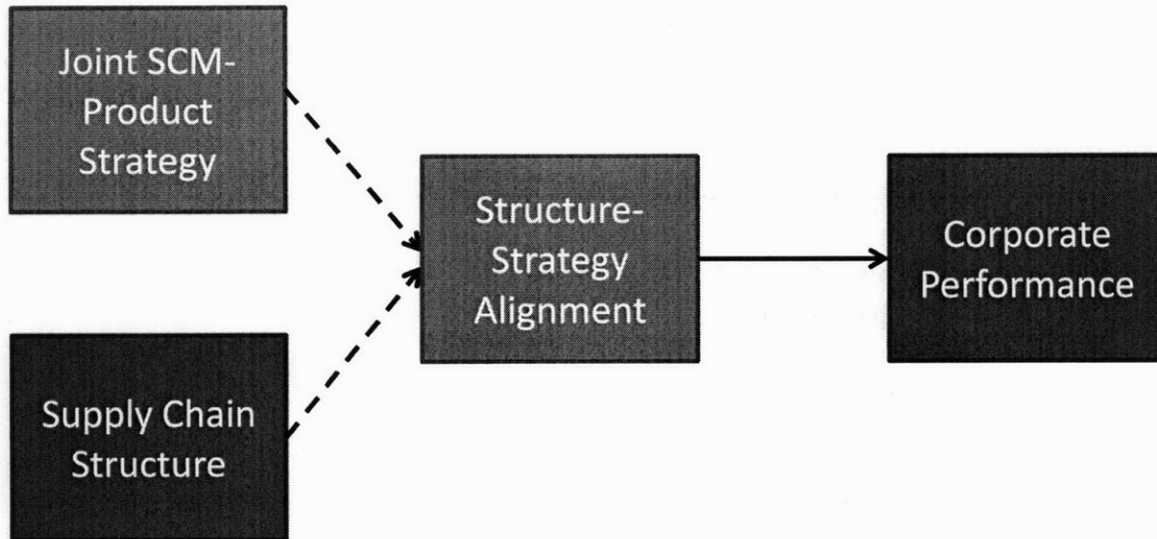


Figure 22: Structure-Strategy Alignment

This analysis was performed, although the limited data set prevented any conclusions to be made. Further research in this area could yield insight into common mistakes made by companies when attempting to implement their supply chain strategy.

Appendix 1: OEM Survey

Demographic Information

1. Which of the following best describes your job title
 - a. President / C-Level Executive
 - b. Senior VP/VP
 - c. Director/Manager
 - d. Other : _____
2. Your primary area of responsibility is
 - a. Procurement
 - b. Product development
 - c. Manufacturing
 - d. IT
 - e. Supply chain
 - f. Transportation
 - g. Other : _____
3. Your scope of responsibility is
 - a. Local
 - b. Country
 - c. Regional
 - d. Global
4. If your scope of responsibility is local, country, or regional, please specify the region in which your responsibility lies
 - a. Europe
 - b. Asia Pacific
 - c. North America
 - d. South America
 - e. Middle East
 - f. Africa

5. To the best of your knowledge, your company maintains multiple independent supply chains ...
- Based on average sales price of product
 - Based on functionality of product
 - Based on target consumer market
 - Based on other attribute: _____
 - No, independent supply chains

If your company maintains multiple supply chains, please select one supply chain for the remainder of the survey

6. What types of products are produced by this supply chain
- Ultra Low End (average selling price around \$30 USD)
 - Low Cost (average selling price around \$50 USD)
 - Enhanced (average selling price around \$120 USD)
 - Smartphone (average selling price above \$240 USD)
7. The customer of these products are primarily located in
- Europe
 - Asia Pacific
 - North America
 - South America
 - Middle East
 - Africa
8. Your target markets are best categorized as
- Developed
 - Emerging

Please use the following scale to answer each question unless otherwise specified.

	1	2	3	4	5
	Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent
9. The products in this supply chain compete on price	1	2	3	4	5
10. The products in this supply chain compete on features	1	2	3	4	5
11. Reducing cost is the primary objective of supply chain management activities	1	2	3	4	5
12. Increasing supply chain flexibility is the primary objective of supply chain management activities	1	2	3	4	5
13. Increasing supply chain reliability is the primary objective of supply chain management activities	1	2	3	4	5
14. Reducing time to market is the primary objective of supply chain management activities	1	2	3	4	5
15. Reducing order fulfillment lead time is the primary objective of supply chain management activities	1	2	3	4	5

Supply Chain Challenges

Please use the following scale to answer each question unless otherwise specified.

1	2	3	4	5
Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent

Over the next 5-10 years, major challenges in managing the supply chain will be:

16. An increasing number of component suppliers	1	2	3	4	5
17. An increasing amount of product variation/customization on devices	1	2	3	4	5
18. An increasingly global supply chain	1	2	3	4	5
19. Pressure to reduce costs	1	2	3	4	5
20. An increasing amount of uncertainty in demand	1	2	3	4	5
21. Pressure to reduce environmental impact	1	2	3	4	5

Please use the following scale to answer each question unless otherwise specified.

	1	2	3	4	5			
	Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent			
22. Key performance measurements are well known and used consistently within your organization				1	2	3	4	5
23. Processes are well documented and are consistent within your organization				1	2	3	4	5
24. Common data repositories exist for sales, inventory, and forecast information, and have high visibility within the organization				1	2	3	4	5

Supply Chain partners include suppliers, manufacturers, distributors, logistics providers, and retailers.

25. Point of sales information is shared among supply chain partners				1	2	3	4	5
26. Inventory levels are shared among supply chain partners				1	2	3	4	5
27. Work in progress levels are shared among supply chain partners				1	2	3	4	5
28. Common technologies for data exchange are used between supply chain partners				1	2	3	4	5
29. Sales forecasting is a collaborative process between supply chain partners				1	2	3	4	5
30. Supply chain partners are involved in key decision making activities				1	2	3	4	5
31. Goals and incentives are aligned between supply chain partners				1	2	3	4	5

Please use the following scale to answer each question unless otherwise specified.

1	2	3	4	5			
Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent			
32. We design the entire product primarily in-house			1	2	3	4	5
33. We design strategic components in-house <i>(Strategic components are components that provide competitive advantage)</i>			1	2	3	4	5
34. We design non-strategic components in-house			1	2	3	4	5
35. We design software in-house			1	2	3	4	5
36. Our products are designed so that components can be shared between products			1	2	3	4	5
37. Our products use components with industry standard interfaces.			1	2	3	4	5
38. Our products use components that can be designed or upgraded independently			1	2	3	4	5
39. Design team members are shared between product groups			1	2	3	4	5
40. Our design team collaborates with downstream supply chain partners <i>(network operators, external content providers)</i>			1	2	3	4	5
41. Our design team collaborates with upstream supply chain partners <i>(software suppliers, component suppliers)</i>			1	2	3	4	5

Please use the following scale to answer each question unless otherwise specified.

	1	2	3	4	5			
	Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent			
42. Our products are primarily manufactured in-house				1	2	3	4	5
43. We manufacture strategic components in-house (<i>Strategic components are components that provide competitive advantage</i>)				1	2	3	4	5
44. We manufacture non-strategic components in-house				1	2	3	4	5
45. We assemble final products in-house				1	2	3	4	5
46. Our manufacturing strategy is "make to order"				1	2	3	4	5
47. Our manufacturing strategy is "make to stock"				1	2	3	4	5
48. Our manufacturing strategy is "configure to order"				1	2	3	4	5
49. Our manufacturing facilities are designed to have surplus capacity				1	2	3	4	5
50. Our manufacturing process can be changed from one product line to another product line quickly				1	2	3	4	5
51. Our products are manufactured at facilities located near the final market				1	2	3	4	5
52. Our manufacturing facilities are specialized to produce specific products				1	2	3	4	5
53. Our manufacturing facilities are specialized to service specific regions				1	2	3	4	5
54. How many components are sourced from regions other than the one in which the product is manufactured?								

a) none b) less than half c) half d) more than half e) all

55. How many devices are sold in regions other than the one in which it is manufactured?

a) none b) less than half c) half d) more than half e) all

Please use the following scale to answer each question unless otherwise specified.

- | 1 | 2 | 3 | 4 | 5 |
|--------------|-------------------------|----------------------------|--------------------------------|-------------------------|
| Do not agree | Agree to a small extent | Agree to a moderate extent | Agree to a considerable extent | Agree to a great extent |
-
56. Cost is the most important criteria in selecting suppliers 1 2 3 4 5
57. Quality is the most important criteria in selecting suppliers 1 2 3 4 5
58. Reputation is the most important criteria in selecting suppliers 1 2 3 4 5
59. How many component suppliers are used in total for the production of an average mobile phone?
a) Less than 10 b) 10-25 c) 25-50
d) 50-100 e) over 100
60. How many suppliers do you use on average for strategic components?
Strategic components are components that provide competitive advantage.
a) 0 (supplied in-house) b) 1 c) 2-5 d) 5-10
e) over 10
61. How many suppliers do you use on average for non-strategic components?
a) 0 (supplied in-house) b) 1 c) 2-5 d) 5-10
e) over 10

Please use the following scale to answer each question unless otherwise specified.

1	2	3	4	5					
Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent					
			1	2	3	4	5		
62. We rely on third parties to develop the distribution network									
			1	2	3	4	5		
63. We rely on third parties to operate the distribution network									
			1	2	3	4	5		
64. The end of our distribution network is at the regional distribution center									
			1	2	3	4	5		
65. The end of our distribution network is at the country distribution center									
			1	2	3	4	5		
66. The end of our distribution network is at the local distribution center									
			1	2	3	4	5		
67. The end of our distribution network is at the retailer									
68. How many distributors are used for a typical product?									
a) 0	b) 1	c) 2-5	d) over 5						
69. How many devices are distributed through wholesalers?									
a) none	b) less than half	c) half	d) more than half	e) all					
70. How many devices are distributed through independent retailers?									
a) none	b) less than half	c) half	d) more than half	e) all					
71. How many devices are distributed through operator owned stores?									
a) none	b) less than half	c) half	d) more than half	e) all					
72. How many devices are distributed directly to customers?									
a) none	b) less than half	c) half	d) more than half	e) all					

Please use the following scale to answer each question unless otherwise specified.

1	2	3	4	5					
Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent					
73. Third party logistic providers are used extensively			1	2	3	4	5		
74. Logistics is a source of competitive advantage in your industry			1	2	3	4	5		
75. A general trend is to use more third party logistics providers			1	2	3	4	5		
76. If used, third party logistics providers are used primarily to allow your organization to focus on its core strengths			1	2	3	4	5		
77. If used, third party logistics providers are used primarily to increase flexibility of your distribution			1	2	3	4	5		
78. Cost is the most important criteria in selecting logistic providers			1	2	3	4	5		
79. Flexibility is the most important criteria in selecting logistic providers			1	2	3	4	5		
80. Reliability is the most important criteria in selecting logistic providers			1	2	3	4	5		
81. Components are shipped using different modes of transportation (air, sea) based on component price			1	2	3	4	5		
82. How many finished devices are shipped by air?	a) none	b) less than half	c) half	d) more than half	e) all				
83. How many finished devices are shipped by sea?									

a) none b) less than half c) half d) more than half e) all

84. How many finished devices are shipped **exclusively** by ground?

a) none b) less than half c) half d) more than half e) all

Please use the following scale to answer each question unless otherwise specified.

1	2	3	4	5		
Do not agree	Agree to a small extent	Agree to a moderate extent	Agree to a considerable extent	Agree to a great extent		
85. Reverse logistics and repair activities are outsourced			1	2	3	4 5
86. Cost is the most important consideration when designing the reverse logistics supply chain			1	2	3	4 5
87. Turnaround time is the most important consideration when designing the reverse logistics supply chain			1	2	3	4 5
88. Different return and repair processes are used based on phone type (Ultra low cost, low cost, enhanced, smart)			1	2	3	4 5
89. Different return and repair processes are used based on market			1	2	3	4 5
90. Different return and repair processes are used based on sales channels			1	2	3	4 5
91. Reverse logistics are designed independently from forward supply chain logistics			1	2	3	4 5
92. Reverse logistics is gaining importance in supply chain planning activities			1	2	3	4 5

Competitive Performance

Please use the following scale to answer the following questions

1	2	3	4	5
Way below average	Slightly below average	Average	Slightly above average	Way above average

Please compare your performance to the industry average in the following categories:

93. Profitability	1	2	3	4	5
94. Growth of profitability	1	2	3	4	5
95. Market share	1	2	3	4	5
96. Growth of market share	1	2	3	4	5
97. Return on Investment	1	2	3	4	5

Please provide an estimate of the following quantities:

98. Inventory days of supply (days)	_____
99. Cash-to-cash cycle time (days)	_____
100. Total obsolescence for raw material, WIP, and finished goods inventory (% of revenue)	_____
101. On time delivery performance to requested date (%)	_____
102. Order fulfillment lead time (days)	_____
103. Forecast accuracy (% of sales revenue)	_____

Appendix 2: Survey Invitation Email

Dear Sir/Madame,

You have been selected to participate in a study being conducted by the Massachusetts Institute of Technology on supply chains in the phone industry. The purpose of this study is to understand how the characteristics of this industry impact supply chain design and performance, and to help identify potential opportunities for improvement in this space.

If you would like to participate, please follow the link at the end of this email and fill out the short survey. The survey takes approximately 10 minutes to complete.

Your participation in this study is highly valued and appreciated. Please note that this survey is completely anonymous and all responses will be analyzed in aggregate. Responses to this survey will be analyzed April 15, 2009. A report of the findings will be available June 2009.

If you have any questions regarding the survey, please contact Kenneth Liu at klcliu@mit.edu.

Sincerely,

Supply Chain Research Team
Room 1-176, Massachusetts Institute of Technology (MIT)
77 Massachusetts Avenue
Cambridge, Massachusetts 02139-4307 USA.

Appendix 3: Survey Invitation Reminder Email

Dear Sir/Madame,

This email is a reminder that you have been selected to participate in a study being conducted by the Massachusetts Institute of Technology on supply chains in the mobile communication device industry. Your participation in this study is highly valued and appreciated. Responses will be only be accepted until April 15, 2009.

The purpose of this study is to understand how the characteristics of this industry impact supply chain design and performance, and to help identify potential opportunities for improvement in this space. If you would like to participate, please follow the link at the end of this email and fill out the short survey.

Please remember that this survey is completely anonymous and all responses will be analyzed in aggregate. If you have any questions regarding the survey, please contact Kenneth Liu at klcliu@mit.edu.

Sincerely,

Supply Chain Research Team
Room 1-176, Massachusetts Institute of Technology (MIT)
77 Massachusetts Avenue
Cambridge, Massachusetts 02139-4307 USA.

Bibliography

Bagchi, P. K., & Skjoett-Larsen, T. (2002). Organizational Integration in Supply Chains: A Contingency Approach. *Global Journal of Flexible Systems Management* , pp. 1-10.

Choney, S. (2009, February 24). *Planned obsolescence: cell phone models*. Retrieved April 28, 2009, from MSNBC: <http://www.msnbc.msn.com/id/29258026>

Fisher, M. (1997, March-April). What is the right supply chain for your product? *Harvard Business Review* , pp. 105-116.

Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. *International Journal of Production Economics* , pp. 333-347.

Hendricks, K., & Singhal, V. (2005, May 5). Association Between Supply Chain Glitches and Operating Performance. *Management Science* , pp. 695-711.

Lee, H. L. (2002, 4 1). Aligning Supply Chain Strategies with Product Uncertainties. *California Management Review* , pp. 105-119.

Lee, H. L., & Sasser, M. M. (1995). Product universality and design for supply chain management. *Production Planning & Control* , pp. 270-277.

Mobile World Celebrates Four Billion Connections. (2009, February 11). Retrieved May 5, 2009, from GSM World: <http://gsmworld.com/newsroom/press-releases/2009/2521.htm#nav-6>

Mouritsen, J., Skjott-Larsen, T., & Kotzab, H. (2003). Exploring the contours of supply chain management. *Integrated Manufacturing Systems* , pp. 686-695.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management* , pp. 371-388.

Reinhardt, A. (2009, April 30). *Mobile Phone Sales Figures Not Pretty*. Retrieved May 5, 2009, from Businessweek:

http://www.businessweek.com/globalbiz/blog/europeinsight/archives/2009/04/mobile_sales_fi.html

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). *Designing and Managing the Supply Chain*. New York: McGraw-Hill.

Tomlin, B. (2009). Disruption-management strategies for short life-cycle products. *Naval Research Logistics* , pp. 318-347.

Zander, M., & Anderson, J. (2008). Breaking up mobile: implications for firm strategy. *INFO Journal* , pp. 3-12.