

AN AUTOMOTIVE SUPPLY CHAIN MODEL FOR A DEMAND-DRIVEN ENVIRONMENT

INTAHER M. AMBE*

JOHANNA A. BADENHORST-WEISS**

**ambeim@unisa.ac.za*

***badenja@unisa.ac.za*

*Department of Business Management
University of South Africa (Unisa), South Africa*

ABSTRACT

The purpose of this article is to demonstrate the development of a supply chain model for the automotive industry that would respond to changing consumer demand. Now more than ever, businesses need to improve the efficiency of their supply chains in order to maintain a competitive advantage. The principles of lean manufacturing and just-in-time (JIT) inventory control that were renowned for helping companies like Toyota, Dell and Walmart to rise to the top of their respective industries are no longer adequate. Leading companies are applying new technologies and sophisticated analytics to make their supply chains more responsive to customer demand. This challenge is driven by fierce competition, fluctuating market demand and rising customer requirements that have led to customers becoming more demanding with increased preferences. The article is based on theoretical reviews and suggests guidelines for the implementation of an automotive supply chain model for a demand-driven environment.

INTRODUCTION

Fierce competition, fluctuating market demand and rising customer requirements have resulted in customers becoming more demanding with increased preferences (Zhang & Cheng, 2006:668). This is because of changes in the market, characterised by shorter product life cycles, more competitive product introductions and volatility in demand, which make life-cycle demand more uncertain and difficult to predict (Christopher & Rutherford, 2004:24). The automotive industry in the twenty-first century, influenced largely by globalisation, has created significant opportunities, and at the same time, placed pressure on manufacturers to enhance quality, improve styling, increase organisational efficiencies and include innovative features in their products in an effort to attract customers and expand into new markets (Afsharipour, Afshari & Sahaf, 2007:1; James 2007:13). These challenges imply that if automotive manufacturers wish to succeed, they need to be flexible and responsive to customer demands (Binder, Gust & Clegg, 2007:318).

Supply chain management (SCM) practices started moving towards leaner process approaches in an effort to increase supply chain efficiency (reducing costs and eliminating inefficiencies) (Cox, Chicksand & Palmer, 2007:690; Swiecki & Gerth, 2008:2). Concepts such as JIT; supplier base rationalisation; virtual inventory; outsourcing; customised and global networks; reduction of buffers in material, capacity and time; and a reduction in the number of distribution facilities have led to improvements in supply chain performance, particularly in reducing costs (Papadopoulou & Ozbayrak, 2005:785; Stevenson, 2009). However, owing to vulnerability and turbulence in the business environment, the lean supply chain can no longer cope with changing customer demands (Cox *et al.*, 2007:690; Swiecki & Gerth, 2008:2). The characteristics of the traditional downstream supply chain (lean) do not make provision for responding to the changing business environment, but for low costs and waste minimisation (value stream mapping) (Swiecki & Gerth, 2008:2; Wu, 2008:3). Hence lean is not a universal solution to meet all the needs of the supply chain. To achieve a high degree of flexibility and customer responsiveness, a combination of lean philosophy and new technology is required to quickly design new streamlined operations on the shop floor and beyond (Cox *et al.*, 2007:690; Wu, 2008:3).

This article demonstrates the development of a supply chain model in the automotive industry that would respond to the changing needs of consumers. The article is based on theoretical reviews of related literature on SCM. Based on the reviews and analysis of the literature, the article suggests an efficient supply chain model for the automotive industry comprising three phases. These phases include the physical flows, the operational and planning processes and the strategies. The article should contribute to the body of knowledge in SCM. The remaining sections of the article discuss SCM in the automotive industry and an efficient supply chain model in a demand-driven environment.

SUPPLY CHAIN MANAGEMENT IN THE AUTOMOTIVE INDUSTRY

This section of the article discusses SCM in the automotive industry and deals with the changing structure of automotive and supply chain challenges in the industry.

The changing structure of the automotive supply chain

SCM can be defined as the design and management of seamless, value-added processes across organisational boundaries in order to meet the real needs of the end customer (Fawcett, Elram & Ogden, 2007:8). Generally, SCM involves relationships and managing the inflow and outflow of goods, services and information (network) between and within producers, manufacturers and consumers (Christopher, 2005:5; Samaranayake, 2005:48). A supply chain includes all activities, functions and facilities (directly or indirectly) in the flow and transformation of goods and services from the material stage to the end user (Sherer, 2005:79). It consists of an upstream supplier network and downstream channel

(Klemencic, 2006:7). The automotive industry has experienced a transformational evolution in the last two decades (Cooney & Yacobucci, 2005; Swiecki & Gerth, 2008:2). Historically, the industry operated according to a 'push' system. In this system, marketing and sales take a best guess at market demand and then feed these forecasts to the design, engineering, financial and manufacturing teams to determine make and/or model production volumes (Howard, Miemczyk & Graves, 2006:91). With the development of the internet, data have become much more accessible to both manufacturers and consumers of automobiles (Tang & Qian, 2008:288). The industry focused primarily on lean JIT manufacturing processes and their supporting technologies. Because the price tag for re-engineering and supporting technologies (e.g. enterprise resources planning [ERP]) was prohibitively high, efforts were limited to original equipment manufacturers (OEMs) and their first-tier suppliers (Van Biljon, 1998:130; Stevenson, 2009:694). As the internet became a common fixture in automotive business to business (B2B), competitive pressures grew exponentially (Tang & Qian, 2008:288).

The automotive industry is known as a typical industry adopting mass production as its standard strategy of production (Zhang & Chen, 2006:668). Traditional mass production relies heavily on a company's ability to forecast demand accurately, which in turn guides the firm's decisions about operations and production. Characterised as a push system, forecast-driven production is a highly efficient but somewhat rigid system that utilises historical data and projections to create a production plan and makes use of existing configurations to produce products for stock (Zhang & Chen, 2006:668). However, with changing demands and a shift to mass customisation, forecast-driven production may no longer be capable of coping with a rapidly changing market. The firm's operation is driven more by customer orders, and not forecasts (Holweg, Disney, Hines & Naim, 2005; Zhang & Chen, 2006:669). This is known as a customer-order-driven production approach. The approach is characterised as a pull system that manufactures the products for specific customer orders timeously, thus avoiding stockpiles (Mondragon, Lyons, Michaelides & Kehoe, 2006:552; Zhang & Chen, 2006:669). The automotive supply chains have revolved mainly around making supplier collaboration and manufacturing operations more efficient. However, the dynamics of the marketplace have changed. Today, OEMs and suppliers, their sales distribution companies and dealers are the key components of the emerging global automotive ecosystem and are poised to become the new and increasingly important links to growing revenues, market share and profits (Lam, 2008).

Supply chain challenges in the automotive industry

Muller (2009) contends that the automotive industry faces new and pressing challenges. According to the Kotler Marketing Group (2009), OEMs are required to enhance quality, improve styling, increase organisational efficiencies and drive innovative features into their products in an effort to attract customers and expand into new markets. The industry is

at the cutting edge and adopting new technologies. Pires and Neto (2008:328) assert that in recent years, the automotive industry has experienced strong competition on a global scale in highly competitive markets. From a worldwide perspective, it has been challenged to face issues such as: strong pressures for price and delivery time reductions; quality and overall customer service improvements and environmentally friendly products; a substantial reduction in product life cycles and the rapid introduction of new products, with strong pressure to reduce the time-to-market and product development costs; the pressure to supply new markets; and the strengthening of relationships and intensification of communication channels in supply chains in general (Pires & Cardoza, 2007). These, coupled with the effects of the economic meltdown (2008-2010) (Swiecki & Gerth, 2008:2; Lamprecht, 2010:159), imply that automotive manufacturers need to be flexible and responsive to customer demand in order to succeed.

In South Africa, as stated in the report of Supplychainforesight (2007), the automobile industry faces challenges of cost reduction and service improvement. The industry has to try to find a balance between servicing customers and dealing with suppliers. In the 2008 version of the Supplychainforesight report, it is noted that the industry faced challenges stemming from globalisation and supply chain operations to planning and forecasting. The Supplychainforesight 2009 report asserts that the automotive industry is faced with the growing severity of the economic slowdown; the task of making the supply chain lean; dealing with oil price volatility; developing an efficient planning and forecasting tool; and making the supply chain demand driven. According to the 2010 Supplychainforesight report, the major challenges in the South African automotive industry are waste and inefficiencies across the supply chain; transforming supplier relationships into true collaboration; implementing efficient planning and forecasting tools; the potential failures of key suppliers; and a shift in the strategic direction of the organisation. The report further notes that the industry supply chain is more vulnerable as a result of swings in demand and volumes experienced through the recession period. With the huge decline in the demand for cars during the recession, better understanding has become more crucial in an increasingly competitive marketplace.

The Supply Chain Intelligence Report (SCIR) (2009) indicates that the majority of companies in the automotive industry in South Africa not only operate with a low level of collaboration, but are also not market sensitive or reactive to the changing market. Furthermore, Naude (2009:99) asserts that vital challenges for the South African automotive industry are to produce at a competitive cost and have the ability to respond quickly and reliably to market demands of the developed world. Naude (2009:265) further notes that the main supply chain problems in the South African automotive industry include: pressure by OEMs to reduce prices; the price of materials; cancellation of orders; excessive inventory; the unreliability of rail transport, and rail capacity problems; the high cost of South African ports; the cost of replacing outdated technology; and BBBEE – achieving and verifying BEE scorecards.

Added to this is a lack of skills and labour problems, both of which are time-consuming to resolve. Van der Merwe (2009:1) mentions logistics issues and states that on the World Bank's Logistics Performance Index, in terms of logistics expenditure, South Africa ranked 124 out of the 150 countries reviewed. This was blamed on various logistics problems such as inadequate infrastructure, rising fuel costs and increased road freight volumes. As indicated by Lamprecht (2010), stiff competition between manufacturers has resulted in more mergers or acquisitions.

Min (2005), Jain and Gard (2008), Chussil (2009) and Muller (2009) highlight a number of issues that are currently impacting on the competitiveness of the South African automotive industry. These include: globalisation and market convergence (national markets are being increasingly globalised because of the effects of liberalisation); and individualisation, which basically means that consumers are being spoiled for choice and are no longer satisfied with accepting standardised products. Products need to be tailored and 'tailorable' to satisfy individual requirements; accelerated modification and diversification of the product portfolio is necessary and manufacturers therefore have to shorten product life cycles in order to react with innovative products to the expectations of changing consumer demands. Manufacturers also need to cope with more stringent safety requirements and regulations, and increased pressure for innovation and flexibility in development and manufacturing.

These challenges have led to contemporary automakers having to cope with supply chain issues such as long order-to-delivery lead times and unreliable production schedules resulting in excess inventory throughout the value chain (Min, 2005; Jain & Gard, 2008; Chussil, 2009; Muller, 2009). These problems drive automakers and suppliers to build up buffer inventory and limit their ability to react flexibly to changes in customer demand. Under these conditions, suppliers are unable to sense customer orders and manufacture solely on schedules. Constrained, inflexible production and assembly capacities and long delivery lead times also contribute to high dealer inventory levels in the form of safety stock (Schwarz, 2008:2). Hence the development of an efficient supply chain model for the automotive industry would enable manufacturers to make cars that would meet the needs of the customers.

Having dwelt on SCM in the automotive industry and highlighted the challenges, the next section of the article proposes an efficient supply chain model for a demand-driven environment.

AN EFFICIENT SUPPLY CHAIN MODEL

This section of the article discusses the development of an efficient supply chain model. It presents the structure and components, the physical flow, the operational and planning processes, strategies, and the framework of the supply chain model.

The structure and components of the supply chain model

The automotive supply chain is highly complex and consists of many processes which, when linked together, form a supply chain from the customer back to the various tiers of suppliers. The major players in the supply chain model are (Humphrey & Memedovic, 2003): original equipment manufacturers (OEMs); original equipment suppliers (OESs); the independent aftermarket; and the first-, second- and third-tier component manufacturers. The structure of the supply chain consists of physical components, operational and planning processes and strategies. Figure 1 shows the structure of the supply chain model that would respond to changing customer demand through innovation, cost, service and quality.

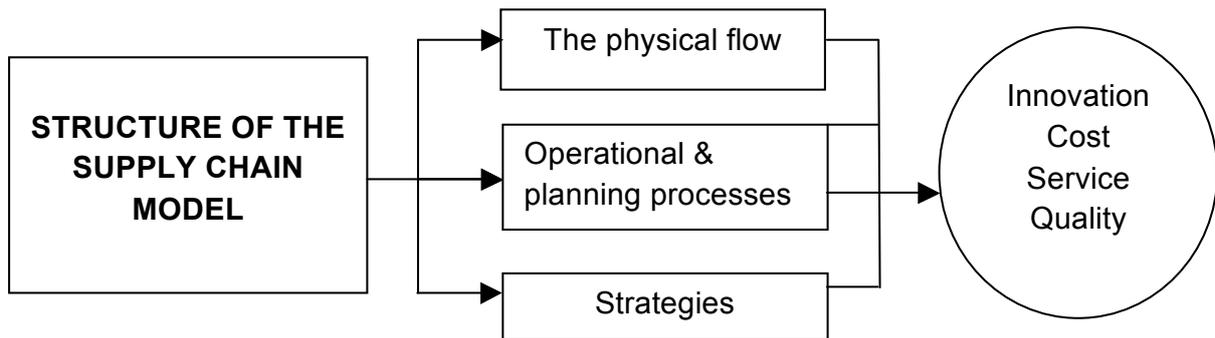


Figure 1: Components of the supply chain model

Physical flow of the supply chain

The physical flows of the supply chain involve information and processes relating to the status and movement of the physical goods in transit or storage (Iyer, Seshadri & Vasher, 2009:5). In the physical flow of this model, parts are produced by suppliers and transported by inbound logistics to the assembly plant. At the assembly plant, a vehicle goes through the body shop, moves to the paint shop, then to the assembly, and finally to inspection. Once the vehicle has been produced, it is transported to the dealership via outbound logistics. The physical flow of the supply chain consists of the suppliers, inbound logistics, production, outbound logistics and dealers. Figure 2 illustrates the physical flows of the supply chain.

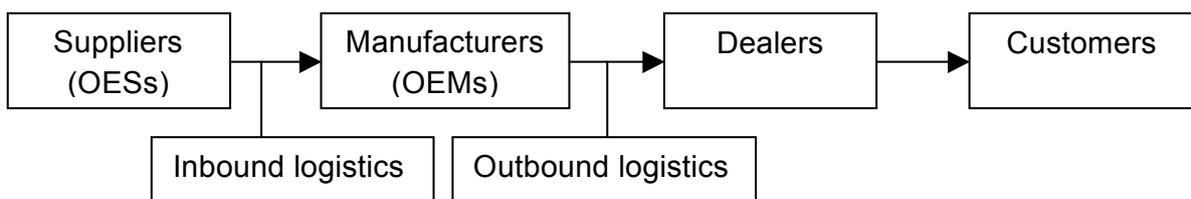


Figure 2: The physical flows of the supply chain

Suppliers

According to Fisher (1997), the major prerequisite to form the supply chain perspective is the tight integration of supplier production schedules into customer production schedules (Holweg & Pil, 2001). In this model, suppliers provide thousands of parts and components that go into the vehicle (Iyer *et al.*, 2009:6). These parts and components are received via an outbound logistics network from hundreds of tier-one suppliers. Suppliers are located in various geographic areas and the time it takes for parts to arrive from each supplier varies greatly. Local suppliers may be one or two days away from the assembly plant, whereas overseas suppliers may require several weeks to transport components to the assembly plant. This may result in suppliers and customers holding stock to cope with lead time and variability in the production schedule. To ensure flexibility and manage the challenge of lead time, this model employs concepts such as supplier parks and modularisation as strategies to cut down the lead time needed to deal with any deviation between plan production and received orders. Lyons, Coronado and Michaelides (2006: 1096) noted that, 'a supplier park is the concentration of dedicated production, assembly, sequencing or warehousing facilities run by suppliers or a third party in close proximity'. It increases the reliability of supply because the delivery time from finished component to assembly will not be more than a few minutes (Larsson, 2002).

The whole vehicle assembly relies on the timely delivery of components. Sequential JIT makes it necessary for suppliers to transport customer-ordered components in exactly the same sequence and synchronised with the final assembly process (Hoekstra & Romme, 1992). The synchronous deliveries do not only occur between the first-tier supplier and the OEM, but feasibly carry out synchronous sequential deliveries between second-tier and first-tier suppliers. Hence there is a shift in the decoupling point upstream in the chain. The decoupling point shows how a customer order enters into the goods flow and therefore splits order-driven from forecast-driven activities (Lyons *et al.*, 2006). Supplier parks help move the decoupling point to the second-tier suppliers due to close proximity between the lines. With this arrangement, it is possible for the players to make synchronous sequential deliveries between the second- and first-tier suppliers and the first tier and OEM and thus ensure a high degree of efficiency and responsiveness in the vehicle manufactured (Morris, Donnelly & Donnelly, 2004; Lyons *et al.*, 2006).

Based on this arrangement, the first-tier supplier is located a short distance away from the OEM site. The deliveries between them are synchronised sequentially. The decoupling point is located at the first-tier supplier because of the distance between the first- and second-tier suppliers (Morris *et al.*, 2004; Lyons *et al.*, 2006). Figure 3 depicts an arrangement where the second-tier level is shifted within the confines of the supplier park. This improves the ability to provide crucial demand and production information to the producer, the OEM, and communicates information directly from the OEM or an intermediary to the second-tier suppliers for execution of synchronous sequential deliveries between first- and second-tier suppliers. Hence the decoupling point is moved upstream, and synchronous sequenced

deliveries are performed between the second- and first-tier supplier and the first-tier and OEM facilities (Czuchry, Yasin & Khuzhakhmetov, 2009).

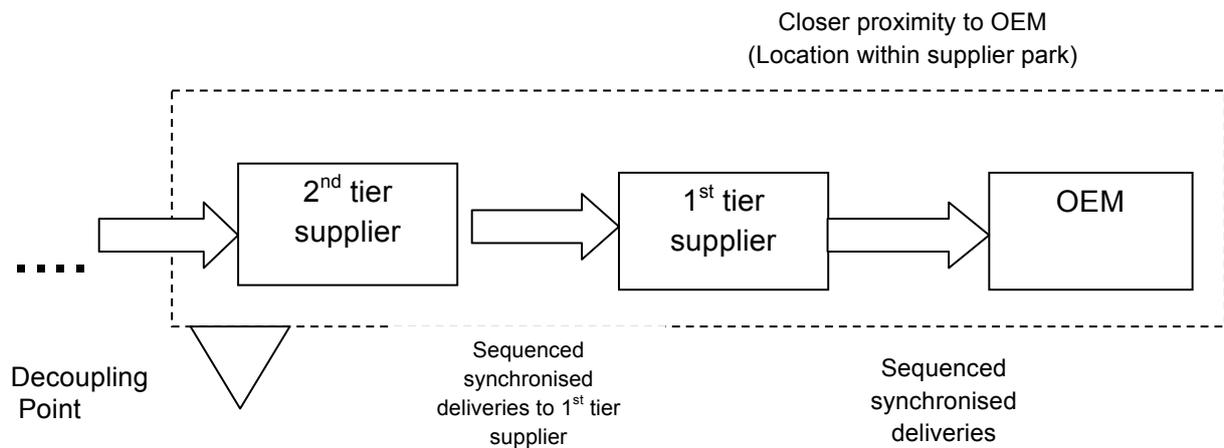


Figure 3: Close proximity to OEMs through second-tier suppliers
(Source: Morris *et al.*, 2004; Lyons *et al.*, 2006; Czuchry *et al.*, 2009)

Inbound and outbound logistics

Bowersox, Closs and Cooper (2010) describe logistics as the 'connecting element' between the subsystems in the supply chain. In new vehicle supply systems, two general types of logistics operations can be found (Iyer *et al.*, 2009:6), namely outbound and inbound logistics. Outbound logistics, or vehicle distribution from the vehicle assembly plant to the dealership, contributes directly to the responsiveness of the overall vehicle supply system by representing the lead time from the factory to customers. Justin, Daugherty and Stank (1995) point out that 'proportioning between manufacturing lead-time and distribution lead-time means little; customers only want to know when the merchandise will arrive. If assemblers are not able to call upon parts and components within a reasonable time-scale, costly inventory holding is needed. Excessive stocks may be held if assemblers are unable to predict the right inventory (volume and mix). Therefore, there is a need for responsive inbound logistics.'

Once parts have been produced, they are shipped to the assembly plant. Two key factors determine the structure or 'gestalt' of the inbound logistics subsystem, namely the number of suppliers per manufacturer, and the average distance between suppliers and the vehicle assembly plants these are supplying into. In the outbound logistical system, the location of the end customer needs to be taken into consideration in managing the logistics – hence significant geographical differences need to be managed. However, this problem is managed by employment of the concepts of modularisation and supplier parks.

Production

The production system in this model comprises the following four stages (Iyer *et al.*, 2009:6):
1) stamping the metal sheet blades in the press shop; 2) welding the parts in the white body

shop; 3) painting the car body in the paint shop; and 4) the final assembly of the car, where the painted body, engine, transmission and further equipment are brought together or built in for the final assembly. A vehicle is produced at the final assembly plant from the parts provided by suppliers. In this model, the typical assembly plant has one or more separate lines on which vehicles are assembled. The plant is subdivided into shops. A vehicle is born in the body shop where the frame and body are found. The body parts are stamped in the stamping shop by presses. In the body shop, numerous robots are used to weld the body parts together. Once the body has been assembled, the vehicle moves to the paint shop and its exterior is painted. After painting, it is moved to the final assembly line. At this point, most of the supplier-provided parts are installed to make a finished vehicle. Each part is assigned a line location so that parts can be delivered from the dock to a line addressed on a bar code label affixed to the parts container by the supplier. The assembly line is divided into three main sections: trim, chassis and final assembly. Lightweight parts are installed in the trim section, while heavier parts, such as the engine and transmission, are installed in the chassis section. Once a vehicle has been assembled, fuel is added and the vehicle is driven off the assembly line. The production process ends in the final assembly, where a number of small operations are performed, such as filling various fluid reservoirs, making numerous quality checks and conducting minor repairs as necessary. Figure 4 depicts the activities in the assembly process.

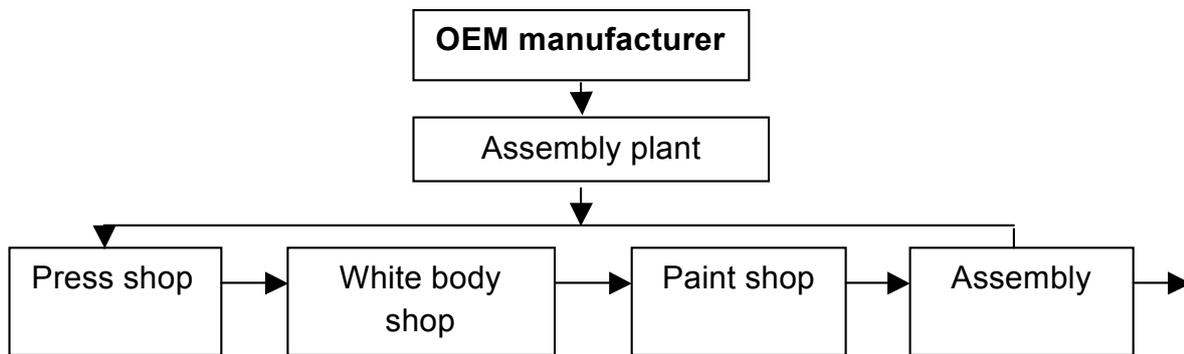


Figure 4: Activities in the production process of the model

Dealers

Dealers play a key role in the supply chain (Iyer *et al.*, 2009:5) because they have face-to-face contact with the company (OEM) and the customer. They are responsible for selling the vehicles produced by the manufacturers to the customers. Dealers also have a significant influence on customer satisfaction. Dealers are involved in aftermarket activities such as order management, vehicle sales, customer relationship management, spare part sales, workshop management and service schedules.

The operational and planning processes of the supply chain model

In the supply chain, several operational processes are performed on a periodic basis to guarantee that the physical flows in the supply chain operate efficiently and effectively (Iyer

et al., 2009:5). These processes integrate and synchronise the operational processes with the physical processes to ensure an efficient and responsive supply chain (Meyr, 2004). The objectives of the operational and planning processes are to fulfil customer orders in time, reduce inventories and throughput time and establish schedules for work that will ensure optimum utilisation of materials, workers and machines (Fisher & Ittner, 1999; Swaminathan & Tayur, 1999). In this model, orders are made by customers via the internet or dealers. The respective sales personnel inform the customers about the expected delivery dates. A granularity of the time frame is thus set, thereby promising a reliable delivery date to the customer (order promising). In cases where a free quota of the dealer is available, the customer receives the desired delivery date as promised. The customer may accept the promised date or change the options of his or her desired car (in order to obtain an earlier delivery date). Dealers need to specify the options for the part of their quotas that has not been filled up with final customers' orders until the agreed date of specification. To reduce inventories at the dealers' sites, the desired options of potential customers should be anticipated as precisely as possible.

The respective sales organisations responsible for a certain dealer collect specified orders and send the order (e.g. daily or weekly orders) to a higher level in the sales hierarchy (Meyr, 2004). A central order management department of the manufacturer selects an assembly plant where the car will be manufactured. The manufacturing plant considers the production quantities and capacities per plant that have been agreed upon in the master production planning (co-ordinating production and sales plans to meet targets as closely as possible in the short term) (Holweg & Pil, 2001; Meyr, 2004). At this point, production orders should be available in the production planning departments of the assembly plant ready to be assembled. The shorter the planning horizon, the more restrictive the model mix constraints will be. Line assignment and model mix planning (creating a production schedule in the medium- to long-term planning horizon) therefore have to distribute the production orders among possibly parallel assembly lines and assign days of production to the orders.

It is known what the daily assembly buckets in the manufacturing plant should contain because of line assignment and model-mix planning. Hence it is possible to directly determine the daily demand for components. Components and materials collected by regional carriers are temporarily stored in an intermediate warehouse, in accordance with material resources planning (MRP) and lot-sizing. This procedure is appropriate to balance the trade-off between inventory holding costs and the degressive transportation costs of the regional carriers, and determines adequate supply frequencies. The daily buckets of the line assignment and model-mix planning guide the daily sequencing of the assembly lines. These sequences can be determined on a rolling horizon basis with a planning horizon. The JIT principle is used to smooth the material supply at the stations in order to keep the inventory of components constantly low. Figure 5 shows the operational and planning processes of the model.

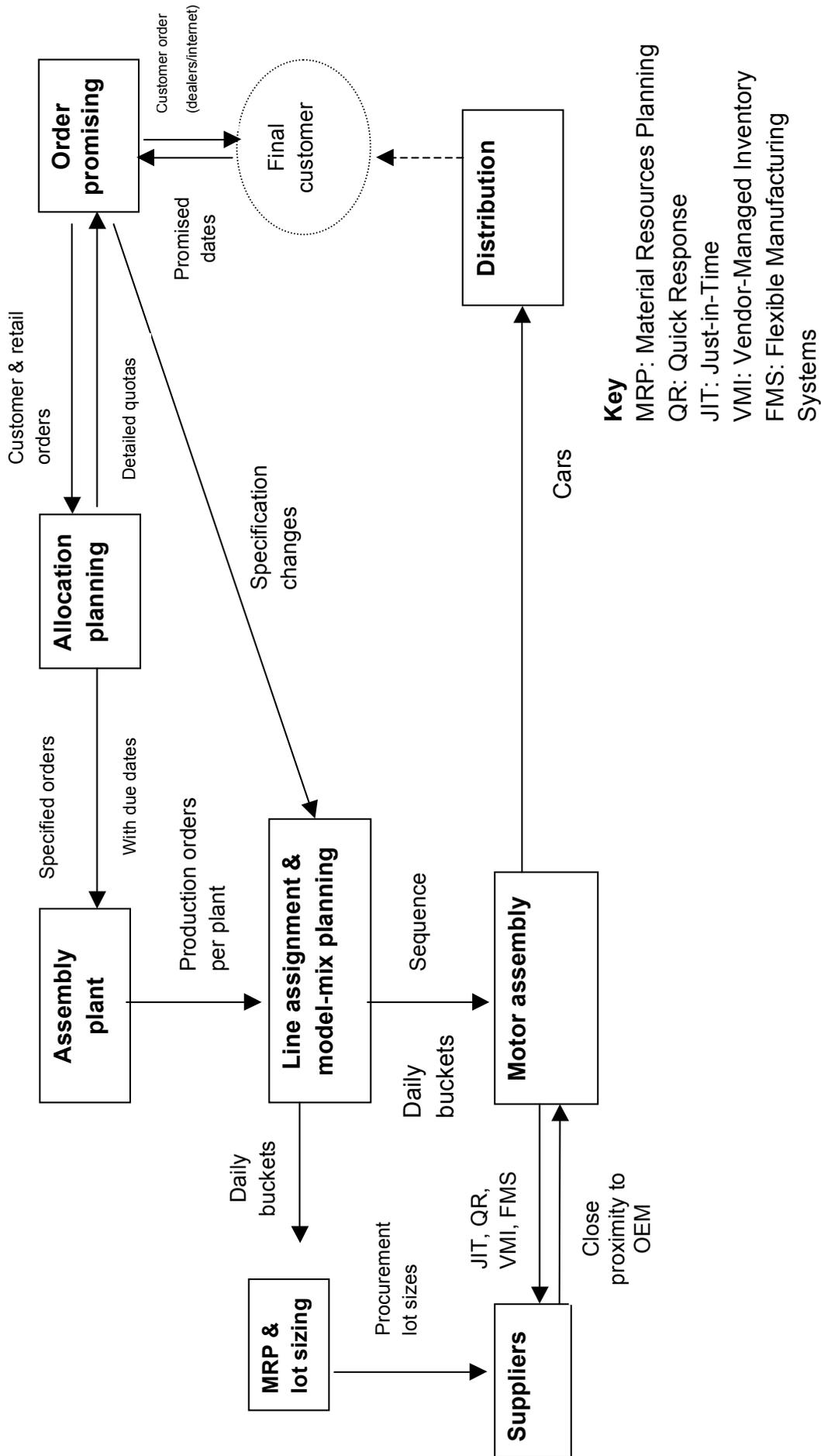


Figure 5: Operational and planning processes of the supply chain model

The strategies of the supply chain model

This model brings together the configuration of forms and capabilities in the supply chain which creates a high degree of flexibility and responsiveness to changing market/customer requirements in a cost-effective manner. The model employs two production strategies: make-to-stock (MTS) and make-to-order (MTO) (Taylor, 2004). According to Chopra and Meindl (2007), a supply chain strategy is defined in relation to its competitors' set of customer needs that it seeks to satisfy through its products and services. In the automotive industry, there are two production strategies: demand/customer-driven and forecast-driven production systems (Zhang & Chen, 2006). In the customer/demand-driven production approach, a product is scheduled and built in response to a confirmed order received by the customer. This strategy excludes the order amendment function. In the forecast-driven production strategy, orders in the pipeline are amended to customer requirements (Zhang & Chen, 2006). This is seen as another level of sophistication for an MTS system (also known as build to forecast [BTF]).

The forecast-driven production system is a dominant approach used today across many companies in the automotive industry (e.g. Ford). This strategy requires products to be built before a final purchaser has been identified and it is driven by historical demand information (Cavusoglu, Cavusoglu & Raghunathan, 2006). This high stock level, which is endemic across the auto industry, allows some dealers to find an exact or close match to the customer's desired vehicle in the dealer networks and supplier parks. The vehicle can then be delivered as soon as transport can be arranged. This approach has been used to justify stock levels. However, while it does provide a rapid response to customer demand, the approach is expensive, mainly in terms of stock as well as transportation because finished goods are rarely in the place where they are required. Holding stock of such a high cash value as finished goods is a key driver of the current crisis in the automotive industry. In a demand-driven production system, not all suppliers in the supplier chain should be producing. This should only happen when a customer order has been confirmed. It does not make economic sense for a manufacturer of low-value, high-volume parts to employ a make-to-order strategy. Hence the production strategy of this model is a demand-driven approach based on the combination of MTO and MTS.

Furthermore, the two production strategies are differentiated by a decoupling point (Wikner & Rudberg, 2005). However, depending on the type of product manufactured, the decoupling point can be moved backwards (to the supplier) or forwards (to the customer/distribution) (Christopher, 2005; Wikner & Rudberg, 2005). In this model, the supply side of the supply chain is made up of MTS while the demand side is an MTO. The application of this (more efficient) supply chain model will provide an environment of high product variety. In other words, the customer receives the exact product specification required, ensuring reduction of costly sales discounts and finished goods inventory, as well a reduction in

stock obsolescence risk. It also ensures an appropriate balance between MTO and MTS in order to maintain stock levels appropriate to both the market requirement and operational stability.

The major generic supply chain strategies are lean and agile supply chains (Mason-Jones, Naylor & Towill, 2000; Christopher & Towill, 2001). A lean and agile supply chain meets at the decoupling point (Christopher, 2005). The decoupling point plays a vital role in the supply chain and separates the lean and agile parts of the supply chain model (the so-called 'leagile' supply chain) (Christopher, 2005). As a strategic decision, this model positions and shifts the decoupling point (Olhager, 2003) because it affects the competitive priorities, standardisation-customisation relationship and efficiency-flexibility balance. Postponing a task (delayed differentiation) moves the decoupling point upstream. Figure 6 illustrates the application of strategies in the supply chain model.

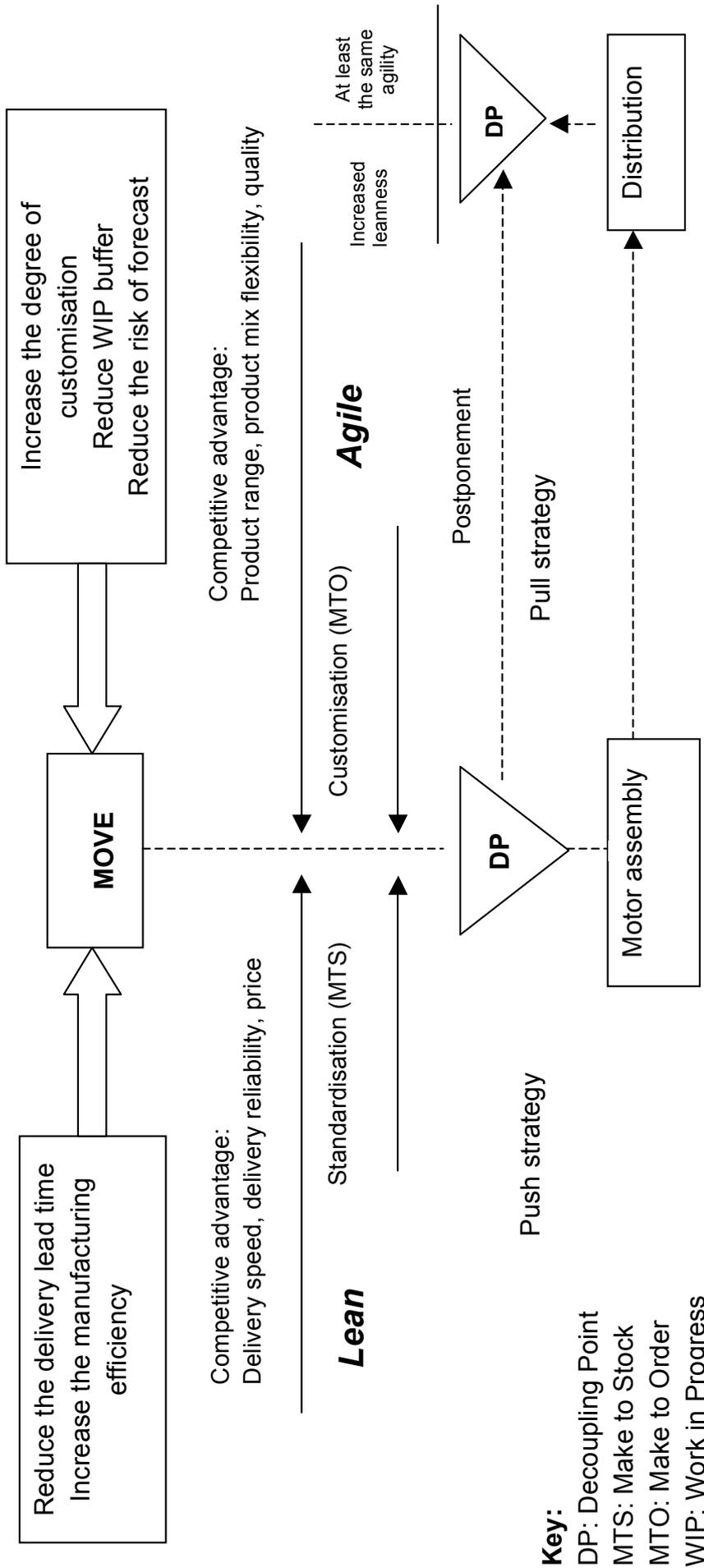


Figure 6: Strategies of the supply chain model

Framework of the efficient supply chain model

In this section of the article, an automotive supply chain model for a demand-driven environment is presented. The model comprises three processes which include the physical flows, operational and planning processes and strategies. The article suggests a supply chain model that would respond to customers' changing demands or requirements in the automotive industry. Therefore, to ensure efficiency and responsiveness in the supply chain, the model utilises a demand-driven approach. Efficiency is enhanced through supplier park arrangements, JIT principles, flexible manufacturing systems and a lean supply chain strategy (Howard *et al.*, 2006), while responsiveness is enhanced through a quick response and an agile supply chain strategy (Perry, Sohal & Rumpf, 1999; Christopher 2005).

The supply chain process starts when an order is made through the dealer or the internet. This means that production starts when there is a market demand or when the manufacturer notices a demand (Figure 5). The model employs both the MTS and MTO production strategies and lean and agile supply chain strategies differentiated by the decoupling point (Figure 6). This is to ensure that parts and semifinished inventory can be executed on the supply side of the supply chain in bulk to minimise production cost while differentiating the product (car specifications) at the decoupling point in response to customer requirements (Figure 6). This differentiation may take place when the semifinished product (car) goes through the assembly line to the various shops (press shop, white-body shop, paint shop and assembly). A movement of the decoupling point further to the demand side increases the leanness, while the movement of the decoupling point to the supply side increases the agility (reduces leanness).

Daily buckets of parts are delivered in sequence (Figure 5). The model is enhanced by practices such as quick response, JIT manufacturing, flexible manufacturing systems, and vendor-managed inventory (VMI) that ensures that parts, components and cars are delivered on time as promised (Figure 5). Furthermore, modularisation and supplier parks ensure close proximity between the tier suppliers and the manufacturers. This ensures that parts and components are delivered to the assembly plant in the shortest possible time. To improve the execution of the model, the researchers made a number of propositions against which the effectiveness of the model can be benchmarked. Figure 7 illustrates the framework of a more efficient supply chain model.

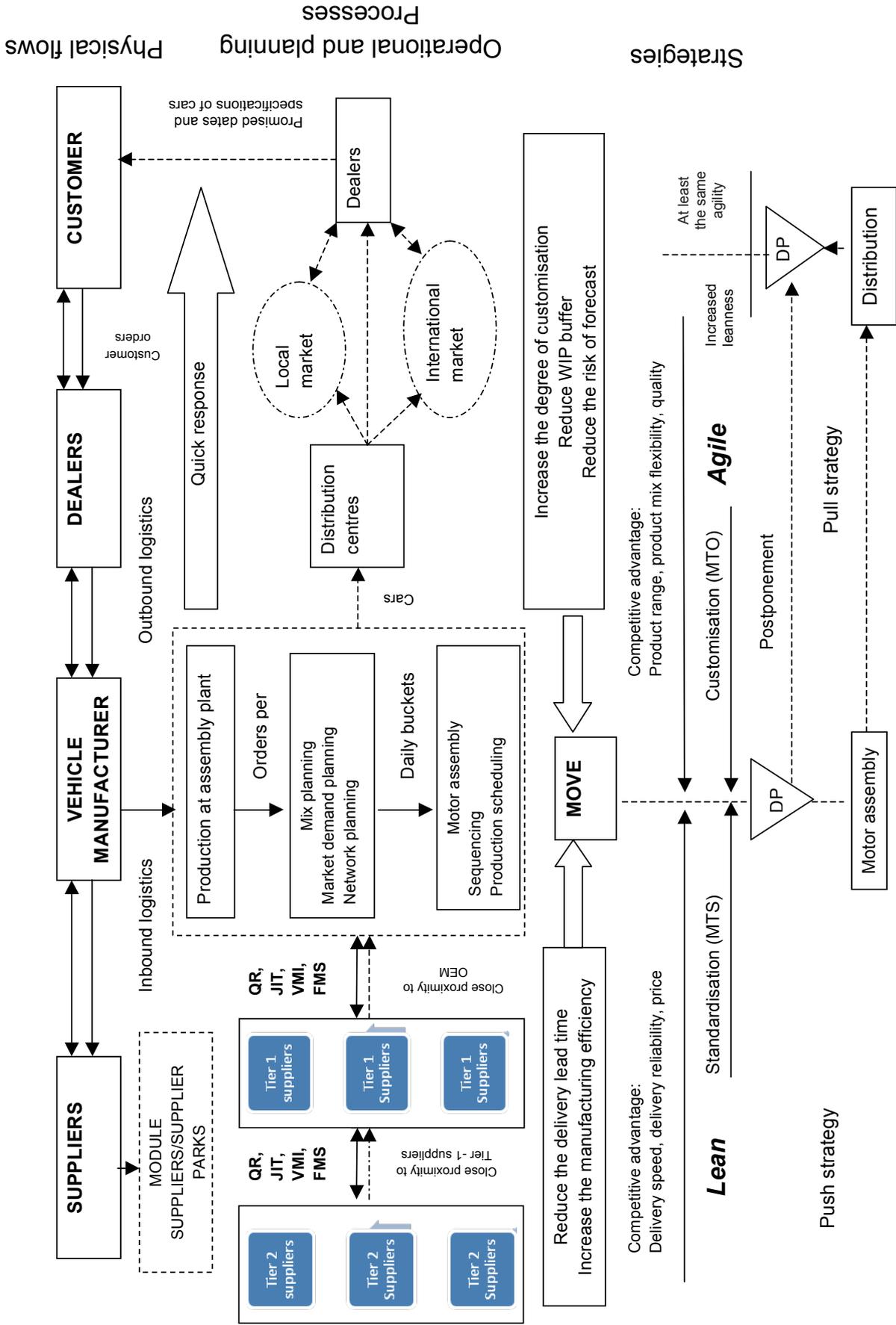


Figure 7: An automotive supply chain model for a demand-driven environment

CONCLUSION

The article, which is based on theoretical reviews, demonstrates the development of an automotive supply chain model for a demand-driven environment. The changing structure of the automotive supply chain and challenges in the automotive industry were reviewed. This revealed that the automotive industry operates in a highly competitive environment characterised by increasingly demanding customers throughout the world. These challenges are the result of, *inter alia*, globalisation, stiff competition, fluctuating market demands and rising customer requirements (Lamprecht, 2010:160) – hence the development of an efficient supply chain model that would meet the challenges of the customers and manufacturers in the automotive industry.

The supply chain model consists of three processes, namely the physical flows, operational and planning processes, and strategies. The physical flows represent the flows of information and processes relating to the status and movement of the physical goods in transit or storage. In the operational and planning processes, activities are performed periodically to guarantee that the physical flows in the supply chain operate efficiently and effectively. The strategies in the model merge the configuration of forms and capabilities in the supply chain which creates a high degree of flexibility and responsiveness to changing market/customer requirements in a cost-effective manner. The model is based on a built-to-order system employing two types of supply chain strategies, namely lean and agile supply chains (the so-called 'leagile' supply chain strategy).

The application of the model will ensure that automotive manufacturers not only remain locally viable but also internationally competitive by improving on strategies and processes that make the supply chain resources flexible; establishing a pull system in the product development process of the entire supply chain; improving integration with the manufacturing processes in the suppliers and sub-suppliers; and enhancing information technology. The model is an example of a responsive supply chain strategy in the automotive industry.

However, the article is limited by the fact that the model has not yet been tested to determine its applicability. The researchers have made a number of propositions that could be tested to promote the model in further research. These propositions include practices that need to be embraced by automotive manufacturers to ensure that their supply chains are efficient and responsive to changing customer demands.

REFERENCES

- Afsharipour, A. Afshari, A. & Sahaf, L. 2007. E-procurement in the automobile supply chain of Iran. Master's Thesis, Lulea University of Technology, Available from: <http://epubl.ltu.se/1653-0187/2006/08/LTU-PB-EX-0608-SE.pdf>. (Accessed: 23 July 2009).
- Binder, P. Gust, P. & Clegg, B. 2007. The importance of collaborative frontloading in automotive supply networks. *Journal of Manufacturing Technology Management*. 19(3):315-33.
- Bowersox, D.J., Closs, D.J. & Cooper, M.B. 2010. *Supply chain logistics management*. 3rd edition. Singapore: McGraw-Hill.
- Cavusoglu, H., Cavusoglu, H. & Raghunathan, S. 2006. Selecting a customization strategy under competition: mass customization, targeted mass customization, and product proliferation. *IEEE*.
- Chopra, S. & Meindl, P. 2007. *Supply chain management: strategy, planning and operation*. Upper Saddle River, NJ: Pearson.
- Christopher, M. 2005. *Logistics and supply chain management: creating value-added networks*. 3rd edition. Harlow, UK: Prentice Hall.
- Christopher, M. & Rutherford, C. 2004. Creating supply chain resilience through agile six sigma. *Critical Eye*. June-August: 24-28.
- Christopher, M. & Towill, D. 2001. An integrated model for the design of agile supply chains. *International Journal of Physical Distribution and Logistics*. 31(4): 234-46.
- Chussil, M. 2009. Honey, we shrunk the industry: an automotive war game. *Competitive Intelligence Magazine*. 12(4).
- Cooney, S. & Yacobucci, B.D. 2005. US automotive industry: policy overview and recent history. The Library of Congress, Congressional Research Service.
- Cox, A., Chicksand, D. & Palmer, M. 2007. Stairways to heaven or treadmills to oblivion? Creating sustainable strategies in red meat supply chains. *British Food Journal*. 109(9):689-720.
- Czuchry, A., Yasin, M. & Khuzhakhmetov, D.L. 2009. Enhancing organizational effectiveness through the implementation of supplier parks: the case of the automotive industry. *Journal of International Business Research*. (8):1-45.
- Fawcett, S.E., Ellram, L.M. & Ogden, J.A. 2007. *Supply chain management: from vision to implementation*. Upper Saddle River, NJ: Prentice Hall.

- Fisher, M.L. 1997. What is the right supply chain for your product? *Harvard Business Review*. 105-16.
- Fisher, M.L. & Ittner, C.D. 1999. The impact of product variety on automobile assembly operations: empirical evidence and simulation analysis. *Management Science*. 45(6):771-86.
- Hoekstra, S. & Romme, J. 1992. *Integral logistic structures: developing customer-oriented goods flow*. Maidenhead: McGraw-Hill.
- Holweg, M., Disney, S.M., Hines, P. & Naim, M.M. 2005. Towards responsive vehicle supply: a simulation-based investigation into automotive scheduling systems. *Journal of Operations Management*. 32(5):507-30.
- Holweg, M. & Pil, F.K. 2001. Successful build-to-order strategies start with the customer. *MIT Sloan Management Review*. 43(1):74-83.
- Howard, M., Miemczyk, J. & Graves, A. 2006. Automotive supplier parks: an imperative for build-to-order? *Journal of Purchasing and Supply Management*. (12):91-104.
- Humphrey, J. & Memedovic, O. 2003. The global automotive industry value chain: what prospects for upgrading by development countries? *UNIDO*.
- Iyer, A.V., Seshadri, S. & Vasher, R. 2009. *Toyota supply chain management: a strategic approach to Toyota's renowned system*. McGraw-Hill.
- Jain, S. & Gard, R.K. 2008. Business competitiveness: strategies for automobile industry. Conference on Global Competition and Competitiveness of Indian Corporate, India.
- James, J.P. 2007. *Field and laboratory analysis of manual tasks in the South African automobile industry*. Available from: <http://eprints.ru.ac.za/878/>. (Accessed: 4 July 2008.)
- Justin, C., Daugherty, P. & Stank. T. 1995. The effects of information availability on logistics integration. *Journal of Business Logistics*. 16(1):1-21.
- Klemencic, E. 2006. Management of supply chain: case of Danfoss District Heating Business Area. Master's dissertation, Faculty of Economics, Ljubljana University, Slovenia.
- Kotler Marketing Group. 2009. Sales best practices in the global automotive supplier industry. Washington, DC, Available from: www.kotlermarketing.com. (Accessed: 25 December 2010).
- Lam, K. 2008. Oracle for automotive sales and distribution. ORACLE.

- Lamprecht, N. 2010. The impact of the motor industry development programme (MIDP) on the export strategies of the South African light motor vehicle manufacturers (1995-2008). Doctoral thesis, University of South Africa, Pretoria.
- Larsson, A. 2002. The development and regional significance of the automotive industry: supplier parks in Western Europe. *International Journal of Urban and Regional Research*. 26(4):767-84.
- Lyons, A. Coronado, A. & Michaelides, Z. 2006. The relationship between proximate supply and build-to-order capability. *Industrial Management and Data Systems*. 106(8):1095-1111.
- Mason-Jones, R., Naylor B. & Towill, D.R. 2000. Engineering the leagile supply chain. *Int. J. Agile Manage. Syst.* 2(1):54-61.
- Meyr, H. 2004. Supply chain planning in the German automotive industry. *OR Spectrum*. 26:447-70.
- Min, Z. 2005. Five competitive forces in China's automobile industry. *The Journal of American Academy of Business*. 7(1).
- Mondragon, A.E.C., Lyons, A.C., Michaelides, Z. & Kehoe, D.F. 2006. Automotive supply chain models and technologies: a review of some latest developments. *Journal of Enterprise Information Management*. 19(5):551-62.
- Morris, D., Donnelly, T. & Donnelly, T. 2004. Supplier parks in the automotive industry. *Management*. 9:2-129.
- Muller, M.L. 2009. Current automotive industry: how leaders practise CI. *Competitive Intelligence*. 11(3).
- Naude, M.J.A. 2009. Supply chain management problems experienced by South African automotive manufacturers. Doctoral thesis, University of South Africa, Pretoria.
- Olhager, J. 2003. Strategic positioning of the order penetration point. *International Journal of Production Economics*. 85(3):319-29.
- Papadopoulou, T.C. & Ozbayrak, M. 2005. Leanness: experience from the journey to date. *Journal of Manufacturing Technology Management*. 16(7):784-807.
- Perry, M. Sohal, A. & Rumpf, P. 1999. Quick response supply chain alliances in the Australian textiles, clothing and footwear industry. *International Journal of Production Economics*. 62:119-32.

Pires, S. & Cardoza, G. 2007. A study of new supply chain management practices in the Brazilian and Spanish auto industries. *International Journal of Automotive Technology and Management*. 7(1):72-87.

Pires S.R.I. & Neto, M.S. 2008. New configurations in supply chains: the case of a condominium in Brazil's automotive industry. *Supply Chain Management: an International Journal*. 13(4):328-34.

Samaranayake, P. 2005. A conceptual framework for supply chain management: a structural integration. *Supply Chain Management: an International Journal*. 10(1):47-59.

Schwarz, M. 2008. Trends in the automotive industry: implications for supply chain management. Cisco Internet Business Solutions Group (IBSG), the White Paper 2008.

Sherer, S. 2005. From supply-chain management to value network advocacy: implications for e-supply chains. *Supply Chain Management: an International Journal*. 10(2):77-83.

Stevenson, W.J. 2009. *Operations management*. 10th edition. Boston: McGraw-Hill.

Supplychainforesight. 2007. Survey conceptualised and initiated by Barloworld Logistics, South Africa. Available from <http://www.supplychainforesight.co.za>. (Accessed on 6 June 2010.)

— 2008. Survey conceptualised and initiated by Barloworld Logistics, South Africa. Available from <http://www.supplychainforesight.co.za>. (Accessed on 6 June 2010.)

— 2009. Survey conceptualised and initiated by Barloworld Logistics, South Africa. Available from: www.supplychainforesight.co.za. (Accessed on 6 June 2010.)

— 2010. Survey conceptualised and initiated by Barloworld Logistics, South Africa. Available from: www.supplychainforesight.co.za. (Accessed on 25 May 2010.)

Supply chain intelligence report (SCIR). 2009. *Auto industry crisis: part own making*. Available from: <http://www.bizcommunity.com/Article/196/168/38180.html>. (Accessed on 25 June 2010.)

Swaminathan, J.M. & Tayur, S.R. 1999. Managing design of assembly sequences for product lines that delay product differentiation. *IIE Transactions*. (31):1015-26.

Swiecki, B. & Gerth, R.J. 2008. Collaboration in the automotive supply chain: realizing the full potential of a powerful tool. Centre for Automotive Research, October.

Tang D, Qian, X. 2008. Product lifecycle management for automotive development focusing on supplier integration. *Computers in industry*. 59:288-95.

Taylor, D.A. 2004. *Supply chains. A manager's guide*. Mason, OH: Pearson Education.

Van Biljon, E.H.B. 1998. Supplier network re-engineering by automotive assemblers in the province of the Eastern Cape. Doctoral thesis, University of Port Elizabeth. Port Elizabeth.

Van der Merwe, J.P. 2009. *The state of the automotive sector in South Africa: trade invest*. Available from: http://www.tradeinvestsa.co.za/feature_articles/344969.htm. (Accessed on 2 February 2010.)

Wikner, J. & Rudberg, M. 2005. Integrating production and engineering perspectives on the customer order decoupling point. *International Journal of Operations and Production Management*. 25(7):623-41.

Wu, T. 2008. Responsive lean supply chain: Case study in a Japanese vehicle manufacturer in the UK. POMS 19th Annual Conference, La Jolla, California, U.S.A. May 9-12.

Zhang, X. & Chen, R. 2006. Forecast-driven or customer-order-driven? An empirical analysis of the Chinese automotive industry. *International Journal of Operations and Production Management*. 26(6):668-88.

Table of acronyms

BTS	Build to Forecast
DP	Decoupling Point
ERP	Enterprise Resources Planning
FMS	Flexible Manufacturing System
JIT	Just in Time
MRP	Material Resources Planning
MTO	Make to Order
MTS	Make to Stock
OEM	Original Equipment Manufacturer
OES	Original Equipment Supplier
QR	Quick Response
SCM	Supply Chain Management
VMI	Vendor-Managed Industry
WIP	Work in Progress