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BEST PRACTICES FOR NEW PRODUCT DEVELOPMENT MANAGEMENT OF POWERTRAIN COMPONENTS

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ABSTRACT

The purpose of this research project is to outline the best practices for the management of powertrain components during a new product development project for an original equipment manufacturing firm. Research was conducted through an interview process with industry professionals maintaining experience as global procurement managers in an environment involving powertrain components. Concepts analyzed in the research process included engineering design transparency, cost data transparency, supplier embeddedness, and supplier network management.

Through research, it is clear managers should reveal engineering design specifications and component characteristics early in the new product development process, but hesitate to reveal overall new product innovation and competitive advantage until a supplier is selected. Managers should also strive for cost transparency in terms of unique engineering features within the component to understand potential fluctuations in price, and develop a mutually benefitting cost savings platform. However, original equipment manufacturers should not concern themselves with evaluating a supplier's embeddedness, but focus on the raw material indices relevant to the supply base. Overall, managers should maintain a small network of suppliers for each component within a powertrain system due to design complexity and the benefits of engineering design team familiarity with a supplier.

In order to maximize profitability, establish a long-term supplier relationship, and successfully launch a new product, original equipment manufacturers should develop a strategy considering the best practices of engineering design transparency, cost data transparency, supplier embeddedness, and supplier network management for powertrain components.

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Chapter 1

Introduction to Powertrain Components

Across a variety of original equipment manufacturers, upper management teams face challenges related to prospective supply chains. An original equipment manufacturing firm is an organization that engineers a system by sourcing the sub-systems of other firms. The overall responsibility of the supply chain in an original equipment manufacturing setting is to ensure the timely and cost efficient delivery of all components on the bill of materials for each production line in operation. Managers commonly prioritize specific components on a bill of material in order to avoid fluctuation in the production process due to failure in delivery and quality amongst strategic components. Strategic components are those essential to the assembly of an original equipment manufacturer's system, and often share similar characteristics in terms of longer lead times, higher costs, increased quality demands, and greater complexity. If a strategic component arrives late, or with poor quality, the manufacturing process stalls, as smaller assemblies are dependent on the successful manufacturing execution of strategic components. For manufacturing operations in an industry reliant on machine power generation assemblies, such as the automobile or access equipment industries, supply chain managers place emphasis and attention on components related to the powertrain commodity family. Components in the powertrain commodity family play a critical role in establishing supply chain efficiency and execution, as characteristically complex and expensive components often determine overall performance. Given this information, it becomes clear that a commodity manager's ability to successfully manage powertrain components during the new product development stage of a project will directly influence the profitability of a firm. This research seeks to identify the best practices for commodity managers strategically sourcing powertrain components for new product development. Strategic sourcing is a process to develop a plan to identify a group of potential suppliers, select a supplier, and onboard that supplier in a fashion serving the original equipment manufacturer's best practices. Through a literature review and interview process with professionals from the automobile and access equipment industries, this thesis outlines several focal areas for consideration during new product development projects. Specifically, the paper recognizes the importance of engineering design transparency, cost data awareness, supplier embeddedness levels, and supply base leveraging. The importance of understanding and optimizing these concepts for powertrain components is vital to launch a successful new product.

Commodity managers and analysts across several industries and professions define a powertrain system differently. However, a commonly agreed upon definition for a powertrain system is a system that powers the wheels of a moving vehicle by producing and converting energy into torque to ultimately propel the machine forward through transferred energy in differentials (Chatterjee, 2014). In more detailed terms, a powertrain system contains components related to creating energy through an engine, transforming that energy into torque through transmissions, and translating torque to the axle or wheel drive of the machine to make directed movement. The engine is the central component of the powertrain system, and performance requirements of other powertrain components depend on the power capability of the engine in place. Engineers in the industry acknowledge a variety of engine types, especially when considering fuel source. Traditionally, engines use fuel from gasoline or diesel, but recent developments propel alternative fuel sources into the market, such as hybrid fuels or electric power. A powertrain system includes several individual components referenced in Figure 1 (www.economymufflerandbrake.com).

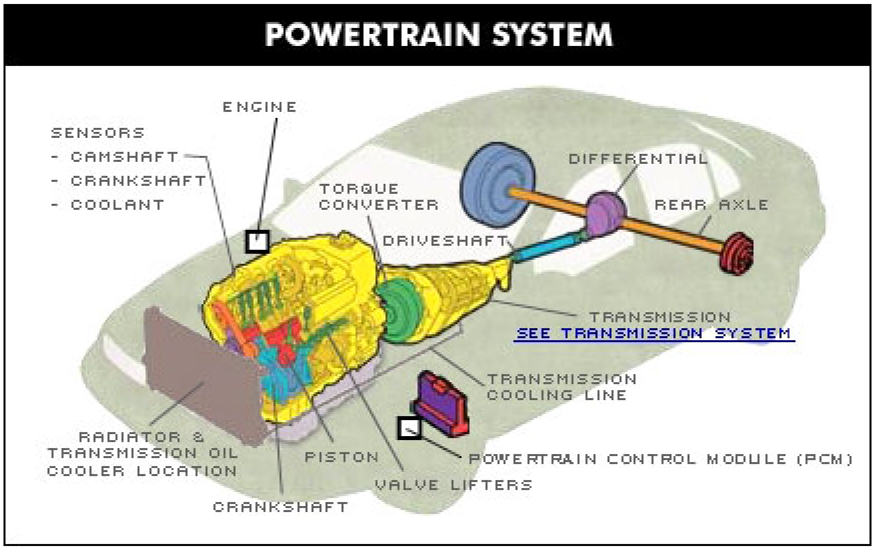

Figure 1: Powertrain System

Manufacturing organizations likely need to source powertrain components from a variety of suppliers, as it is uncommon for a single supplier to offer engine components alongside axle components. Powertrain suppliers are commonly divided into engine component providers and drivetrain component providers. Engine component providers offer engines and all components that maintain a direct physical impact to the engine itself. For example, an engine component supplier may also offer cooling fans and fuel tanks. Drivetrain suppliers offer solutions related to the components delivering the power to the wheels of the machine through the energy generated by the engine. For example, drivetrain suppliers most likely offer a product variety of axles, driveshafts, or transmissions. Commodity managers source these components of the powertrain system separately, but maintain a linked strategy to drive business decisions for the commodity family as a whole.

When analyzing the powertrain commodity family, it is important to observe the overall industry outlook from the position of engine and powertrain components providers. Commodity managers for any component within an original equipment manufacturing firm seek to understand the economics of the components within their responsibility. Global suppliers of powertrain components feel reassured through the current strength of the automobile, heavy-duty truck, and access equipment industries. Although the industry faced extreme economic downturn from the recession from 2007 to 2009, engine and component sales have increased over the previous five years and forecasts show a continued increase in 2016. Analysts predict demand will grow steadily globally as customer orders continue to rise in the post-recession era. As a result, industry experts predict industry revenue for engines and sub-components for automobiles alone to grow an annualized 3.6% over the next five years to reach $296.8 billion in 2021 (Hoffman, 2016). One should note this analysis does not include the revenue streams from every component in the powertrain system such as driveshafts, axles, and wheel-drives. However, if the demand for the nucleus of all powertrain components rises (engines) then one can reasonably assume all powertrain components will notice similar steady growth over the next five years. This anticipated growth benefit also stems from many global trends, including China's increased demand for automobiles and United States customer demand for fuel-efficient engines. According to research from the International Organization of Motor Vehicle Manufacturers, 23.7 million automobiles were manufactured in China throughout 2014; the greatest volume of automobiles manufactured in a single country in one year. This production validates a clear trend adaption of the consistent automobile market from Western markets to emerging Asian markets such as China (oica.net, 2014).

In response to a global initiative for corporate sustainability, manufacturers are reacting to an emerging demand for fuel-efficient powertrain solutions, predominantly in mature markets such as the United States. The shift in demand for engine fuel efficiency stems from volatile gas prices and the consumer's intensified desire for sustainability. United States automobile manufacturers in particular continue to invest in research projects focused on efficient powertrain solutions in order to remain competitive and capitalize on an opportunity to profit from new market demand. This initiative comes in parallel with another relatable trend in the automobile and access equipment industries: hybrid fuel and electric power. Over the next several years, industry experts predict major changes in engine variation will ensue in all markets dependent on engine components. The market presents a growing desire to utilize hybrid or fully electric technology to reduce carbon emissions from gasoline or diesel dependent technology. A study by Bloomberg New Energy Finance forecasts sales of electric vehicles will reach 41 million by 2040, representing 35% of vehicle sales worldwide. This estimation is nearly ninety times the volume in 2015 and electric vehicle sales represented a figure closer to 462,000 (Randall, 2016). Although the demand for electric power is merely a small factor in the present day, the industry outlook is persistent into the future, conveying a need for powertrain components suppliers to invest in the development of cleaner engines immediately. Powertrain suppliers capable of offering a variety of fuel options for their components increase their attractiveness in the market. Overall, the powertrain components industry has a promising future with steadily growing engine revenues and a global initiative for sustainable solutions to bolster growth even further.

Despite a changing environment in powertrain components from a sustainability perspective, the function of the supply chain infrastructure for these components remains stable over time. In the powertrain component industry, organizations in the supply chain lack vertical integration; one organization in the supply chain does not own more than one node in the overall network. Many individual entities work collaboratively to deliver products downstream to end consumers dependent on powertrain components. As the Figure 2 depicts, the powertrain supply chain begins with basic raw material suppliers. Common raw material suppliers for powertrain components include global steel and iron suppliers, aluminum processors, and semiconductor/electrical parts manufacturers. Raw material suppliers deliver to the next member of the chain, powertrain solutions manufacturers. Members of this link in the chain

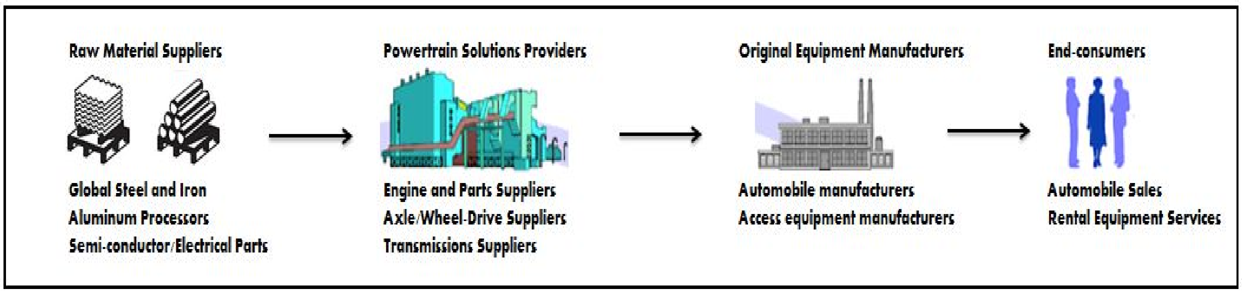

Figure 2: Powertrain Component Supply Chain

order and assemble raw materials in a manufacturing process focused on producing high volumes of powertrain components. Powertrain component manufacturers then receive orders from original equipment manufacturers, such as an automobile or access equipment designer. Original equipment manufacturers order and assemble an array of components, including powertrain components, to engineer a product consisting of a large bill of materials. End consumers comprise the final downstream member of the supply chain, as they are the key generators for overall demand for product throughout the supply chain. Transportation methods vary among the different links of the chain. International shipments typically utilize ocean freight for regular order processes, and rarely call for airfreight solutions. Domestically, raw materials, components, and final products ship through motor distribution, but the truck transport type varies among the volume and type of material being transported. Overall, the supply chain for powertrain components is simplistic, but lead times may vary depending on different shipment methods for domestic and international transportation.

The powertrain system consists of a large number of individual components interrelating through their direct function of generating and transforming energy to drive the movement of an engineered product. Managers often focus on powertrain components during the new product development stage of a project due to long-term impacts on performance. Relationships between original equipment manufacturers and powertrain component providers are critical to the organization's success in achieving timely and cost efficient delivery of quality components throughout new product development and large-scale production. Managers stress the importance on the powertrain commodity strategy due to the distinct nature of the components. Powertrain components also represent a large share of the overall cost to produce the machine, thus contract negotiations and supplier network management are crucial to ensuring optimal final product profitability. Powertrain components are also one of the more complex systems from an engineering perspective in a final product assembly. New product development lead times for powertrain solutions derive not only from transit times, but also from the substantial amount of time original equipment manufacturer's design engineers spend collaborating with powertrain components suppliers on design and performance parameters. Therefore, powertrain components are critical due to the time constraints of a new product development project schedule. Powertrain components demand significant attention during the new product development stage of a product's lifecycle in order to achieve cost, delivery, and quality goals.

Chapter 2

New Product Development Process Synopsis

The goal of this research is to provide unique insight into best practices regarding the management of powertrain components during the new product development process of an original equipment manufacturer. As an introduction, one should understand the general process of a typical new product development process within a manufacturing firm.

Companies sourcing engineered components are often associated with a complex procurement process in order to operate efficiently and make strategic business decisions. Typically, a firm may dedicate an entire department focused on achieving global procurement goals. A global procurement and supply chain team is responsible for interacting cross functionally in order to support design engineers, manufacturing engineers, and marketing teams by providing the resources they need to achieve the financial team's expectations. One might argue every firm outlines four basic goals to summarize a supply chain team's basic initiative: on time delivery of components, acceptable component quality, cost competitiveness in sourcing decisions, and successful new product development. The four priorities all interrelate as manufacturing firms expect supply chain managers to achieve these goals simultaneously to optimize business performance. In fact, many professionals credit the new product development stage of a product's life cycle as a crucial aspect of the product's base for long-term success in supply chain management (Hilletofth, Eriksson, 2011). To support this claim, supply chain managers cite the new product development phase as the initial point for development of delivery, cost, and quality goals within the supplier network. Overall, the new product development team within a global procurement and supply chain department aspires to an overall goal: to provide a continuous supply of goods and services required to support research and development concepts and prototype production schedules. In an optimal setting, global procurement teams consider company interests at all times in an attempt to generate profitable relationships with suppliers while encompassing performance metrics related to delivery, cost, and quality.

In order to achieve the stated wide array of goals, a supply chain department develops a cross functional team to meet performance standards. Traditionally, a global procurement and supply chain department will split the team into several subsets to focus on key areas. One of those areas is simply the ‘new product development team’ consisting of ‘project managers’ and ‘buyers’. Project managers manage the supply chain goals of the new product throughout the duration of the development project. These managers work closely with engineers to understand the requirements for the delivery, cost, and quality of components within the emerging bill of materials. Buyers are team members performing duties in a tactical sense; ordinarily they are responsible for sending and receiving request for information and quotation packages and purchase orders to suppliers, carefully tracking such activities. In certain scenarios, buyers naturally work through the data entry process for ‘component specifications’ within the organization’s enterprise resource planning system. In an original equipment manufacturer setting involving sourcing of highly engineered components, a procurement team will consist of a subdivision known as ‘strategic commodity management’. This subdivision of the department contains a group of ‘commodity managers,’ each responsible for individual commodity families with subsequent components. For example, a commodity manager may be responsible for the powertrain commodity with components such as engines, cooling fans, and transmissions.

During a new product development process, a commodity manager awards new or current suppliers with contracts for the supply of components for the new product line. The commodity manager works cross-functionally with the 'new product development team' to learn the requirements demanded by design engineers and financial managers leading the project. Utilizing the project managers as liaisons, commodity managers match their strategic sourcing strategy with organizational visions to launch a successful project.

An organization with a proper distribution of responsibility across a global procurement and supply chain department may begin to fine-tune a unique process for new product development projects. A manufacturing organization with highly engineered components may identify with a sensible, yet detailed, six stage process for onboarding all supply chain related functions and knowledge necessary to complete required tasks. As shown in Figure 3, each stage owns primary objectives collaboratively serving the project needs to achieve a successful launch to the target market of customers.

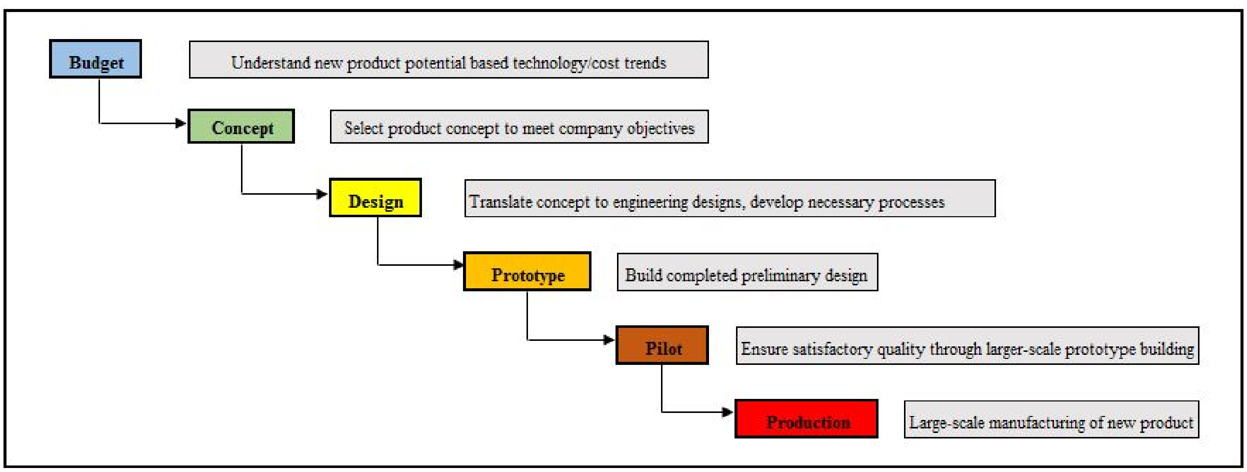

Figure 3: New Product Development Process

The first stage, known as the 'Budget Phase', is primarily a time period focused on outlining the key performance indicators and deliverables for the project. The origination of a project naturally arises from communication with customers and internal technology experts. Based on technological capability and customer demand, organizational executives responsible for new product innovation devise a plan for new product development projects. One should recognize often times in a manufacturing environment with highly engineered powertrain components, new product development may not always be defined as an entirely ‘new’ product. In fact, many new product development projects are defined as significant modifications to an existing product or product line. At the end of the Budget Phase, management identifies key parameters for engineering design, cost management, and an overall project timeline. For example, the organization will identify a target selling price and total material cost for a unit of new product. The global procurement and supply chain team usually initiates involvement after the Budget Phase, but utilizes the overarching goals developed in this phase, such as target unit cost, to define the sourcing strategy going forward.

The Budget Phase is complete after key deliverables and project rationale translate into more defined items (see Figure 4). The next stage of the process, the Concept Phase, outlines the basic strategic plan for the global procurement department moving forward with the project’s new product development process. The initial development of the bill of materials often triggers global procurement team members to schedule cross-functional meetings with engineering design team members to gage the technical specifications for perspective components. Project managers from the supply chain side often hold several initial meetings to identify long-lead time items, new technology expectations, and supplier risks. Commodity managers account for key information communicated by project managers to plan for a commodity strategy for each specific new project. Following cross-functional meetings between global procurement and engineering design teams, organizational executives responsible for new product innovation create an official schedule for the project. The preliminary cross-functional meetings play a substantial role in ensuring accuracy and feasibility for the master schedule, as understanding component lead times and the impact of new technology developments for suppliers helps determine the length of a new project. As the bill of materials and schedule develop, commodity managers and project managers work to devise a ‘sourcing plan’ for the project. The source plan lists each commodity grouping and tabulates specific sub-components. For example, a source plan would track the powertrain commodity and list axles and driveshafts as sub-components. The source plan outlines key strategic points for each sub-component including the component category, general lead time, sourcing strategy, target cost, potential suppliers, and key team members from the engineering side involved with the component’s design. Considering the design engineering team’s requirements, the project manager assigns each sub-component one of three categories: carryover/modified, directed buy, or new technology. Carryover/modified components are simply requests for a modification to the current component from the engineering team. Commodity managers should strongly analyze the costs of moving carry over/modified volume away from the current supplier considering the time and energy involved with onboarding a new supplier to meet current design specifications. Alternatively, the engineering team will call for a directed-buy, meaning the customer-base demands a component from a pre-determined supplier. This decision removes a majority of strategy away from the global procurement team. A new technology component category represents the largest range for development in engineering design and global procurement alike. Together, each team works with suppliers to determine capability and performance for a component dependent on substantial technological advancement from current components in operations. Commodity managers commonly schedule ‘supplier workshops’ to communicate the new technology requirements to the supply base in hopes of gathering a group of suppliers capable of manufacturing to new specifications. By defining each sub-component into one of the three categories, the project manager may better align a component with a precise sourcing strategy. For example, if a component is categorized as a ‘new technology’, a commodity manager will develop a sourcing strategy prepared to obtain information from a large range of suppliers. New technology components force commodity managers to identify a number of suppliers in order to find an optimal selection to deliver complex high quality components. Project managers collaborate with commodity managers to establish the sourcing strategy for each sub-component based on not only the component category, but also the component’s current overall strategy developed by the strategic commodity team. New product development provides commodity managers with a unique opportunity to negotiate with suppliers and diversify the supply base if necessary. Increased component volume stemming from a new project serves as leverage for commodity managers to execute strategic initiatives with suppliers. Outlining each commodity’s sourcing strategy during the Concept Phase enables project managers to oversee a new project in an optimal sense. As seen in Figure 4, upon finalization of the preliminary bill of materials, master schedule, and sourcing plan the new product development process shifts from the Concept to Design Phase.

The ‘Design Phase’ in the new product development process translates the generalized plans from the Concept Phase into specific actions for the global procurement team. The goal of this stage of the process is to finalize the official bill of materials, send out request for quotations to suppliers, and begin the purchase order process for long lead-time components. The initial sourcing plan and preliminary bill of materials lack detail in terms of component numbers and exact engineering specification data. The summary data from these supporting documents assist project and commodity managers in determining overall strategy, but further detail is necessary for the ensuing request for quotation and purchase-ordering practices. In order to provide finer detail, the engineering design team initiates a progression known as the ‘component revision process’. Throughout the Design Phase, the engineering team will release a ‘component revision’ for each component in need of engineering design modification. The component revision documentation includes all the information required for a supplier to engineer a component through a list of engineering ratios and measurements along with an engineering drawing of the component. The component revision release is also an opportunity to assign a new component number for ‘new technology category’ component, or update an existing component’s information based on a modification for the new project. An organization demanding this nature of engineering data should maintain an engineering specification database to track all components and their progression of component revisions and drawings. Global procurement and supply chain team members will reference this database when communicating information to suppliers for purchase orders and request for quotation packages. Typically, once the design engineering team releases a component revision, buyers and commodity managers work together to send ‘request for quotation’ (RFQ) packages to suppliers to begin the capability assessment and negotiation process. Commodity managers are responsible for selecting an assortment of suppliers for the buyer to communicate with during the quotation aspect of the Design Phase. This selection of suppliers may include current suppliers of various current projects and potential new suppliers interested in producing some of organization’s volume for the first time. Buyers will generate the RFQ package employing an individual organization’s RFQ standardized template. This template characteristically includes areas for component number data, engineering drawings, a confidentiality agreement, expected annual volume, and cost breakdown information. Outside of manufacturing performance and capability, the cost breakdown information is a critical aspect of the quotation process for commodity managers attempting to implement decisions meeting global procurement's goals of delivery, quality, and cost. Ordinarily, buyers separate cost into "five buckets of money" including materials, labor, burden, sales and general administrative expenses, and profit. By segregating these costs, commodity managers obtain knowledge necessary to negotiate and communicate to suppliers their level of cost competitiveness. One may find acquiring explicit cost data from suppliers difficult to achieve, but access to information related to the "five buckets of money" truly presents optimal negotiating power to commodity managers. Commodity managers aware of detailed cost data maintain advantage over suppliers, and communicate a supplier's lack of competitiveness in relation more cost efficient suppliers. This sometimes allows commodity managers to convince a supplier to lower unit costs to match competition. Once the buyer collects and organizes the RFQ responses, the commodity managers meet with project managers and the design engineering team to share a sourcing strategy and plan for supplier selection. Collaboratively, the team determines the best source of supply for prototype machines with an idea for future production plans. However, one should note complex engineered components, such as powertrain components, are frequently dual-sourced during the Design Phase. The global procurement and engineering teams often monitor the progress of each supplier's quality and cost improvements in order to select a new product development supplier prior to an official purchase order. Trial runs remain commonplace in the engineering component manufacturing environment to secure acceptable performance capability. Upon a supplier selection decision, the project manager will continue organizing and updating an ongoing 'plan for every component' document. This encompassing document contains all data relevant to the delivery of components for prototype builds. The project manager will update the document with every component revision and supplier selection, facilitating the buyer's purchase order action. In general, organizations elect to prioritize the component revision and supplier selection process with high lead-time commodities such as powertrain components. Depending on the compatibility of certain engineered components in relation to one another within a machine, this methodology may aid the global procurement team in avoiding a delay in the project schedule. Buyers retain all responsibilities in the purchase order process and spend time uploading necessary part information into the enterprise resource planning system to ensure an automated ordering process for production in the future. Buyers communicate with suppliers based on the agreed upon negotiations and set delivery dates and payment expectations. Typically, commodity managers remain in constant contact with suppliers during the Design Phase to relay all engineering related questions to the design engineering team. Commodity managers work diligently with suppliers throughout the order cycle to guarantee on-time delivery and sufficient quality of components.

The difference between the end of Design Phase and the beginning of the Prototype Phase to represents an undefined area. However, one might argue upon ample delivery of components required to begin Prototype building, the Design Phase is complete. Normally, at the end of the Design Phase all supplier selection decisions are complete (after a successful quotation and negotiation process for each component.) One will find the delivery of certain components to continue throughout the Prototype Phase. As seen in Figure 4, key deliverables created or completed during the Design Phase include the 'plan for every component' document, supplier selection process, and initiation of all Prototype build purchase orders.

As engineers manufacture the first machine of the new development project, the Prototype Phase officially begins. The stages of this new product development process are not independent, and constantly overlap to achieve production goals set by the master schedule. Prototype engineers assemble the essential building blocks of the machine, accordingly planned to arrive first, as shorter lead-time and less complex components arrive throughout this stage of the process. The key goals of the Prototype Phase are to ensure the final product is functional and every component contains acceptable quality. One sub-division of engineering, known as the quality-engineering department, works with prototype engineers to ensure all components meet performance and safety standards during prototype production. Quality engineers communicate with project managers to help populate the 'plan for every component' document upon quality approval for each component. Unacceptable component quality forces global procurement and engineering team members to endure a stressful process with suppliers to determine the root cause of the problem. Commodity managers tend to dual-source high lead-time and complex components in order to execute the best sourcing strategy for the project. However, this strategy also serves as an insurance plan in case one supplier's technological capability unravels during the Prototype Phase. Familiarizing multiple suppliers with a complex new technology demand is an intelligent way to prevent quality issues from drastically delaying a project. If powertrain components lack acceptable quality, prototype engineers cannot assess the functionality of the machine, thus causing major delays in project schedules. As the quality engineering team confirms approval for all components in the prototype machine, the bill of materials is finalized and the component revision process is no longer permitted. Team members consider the engineering design portion of the process complete, and the focus shifts to preparing for the next stage of the process.

Throughout the duration of the prototype build, commodity managers and buyers simultaneously prepare purchase orders for the Pilot Phase. Similar to the Prototype Phase, buyers procure high lead-time components well in advance to guarantee alignment with the project schedule. The Pilot Phase is widely considered an amplified prototype manufacturing process, as engineers construct an increased number of machines. The purpose of the Pilot Phase of the new product development process is to simulate the production setting to ensure the organization generates a standard manufacturing procedure for the new product with high scale volumes. The Pilot Phase's production simulation also serves as a method to monitor the supplier's potential performance in delivery and quality facing production scaled volumes. Although the Pilot Phase represents a seemingly ideal scenario, one should note the subjectivity involved with this stage of the process. Depending on the success of the prototype build and similarity in manufacturing processes to those of current products, the management team may deem the phase unnecessary and skip the production simulation to reach the market at a faster pace. Traditionally, the Pilot Phase remains flexible, but the implementation of the Pilot Phase may be integrated at a smaller scale during the Prototype Phase to save time and cost. Upon completion of the Pilot Phase, commodity managers may schedule 'supplier conferences' to outline the expectations for start of production. Commodity managers and buyers remain in constant communication with the supply base until the start of production date. Once official production begins, supplier management responsibilities transfer from the new product development procurement team to the tactical procurement team in terms of managing purchase orders; however, commodity managers maintain connections with suppliers throughout the duration of the product's contract.

Overall, recognizing the inputs and outputs of a standard process for new product development is crucial to gain insight into strategic sourcing decisions (see Figure 4). Commodity managers make difficult sourcing decisions during the Concept and Design stages with an understanding of the project's unique demands for delivery, cost, and quality. Commodity managers carefully manage a component's network of suppliers throughout every new product development project. Over the course of managing a component and its network of suppliers in industry setting involving complex engineering, commodity managers may discover a sourcing methodology involving different types of suppliers for different stages of a new product development process.

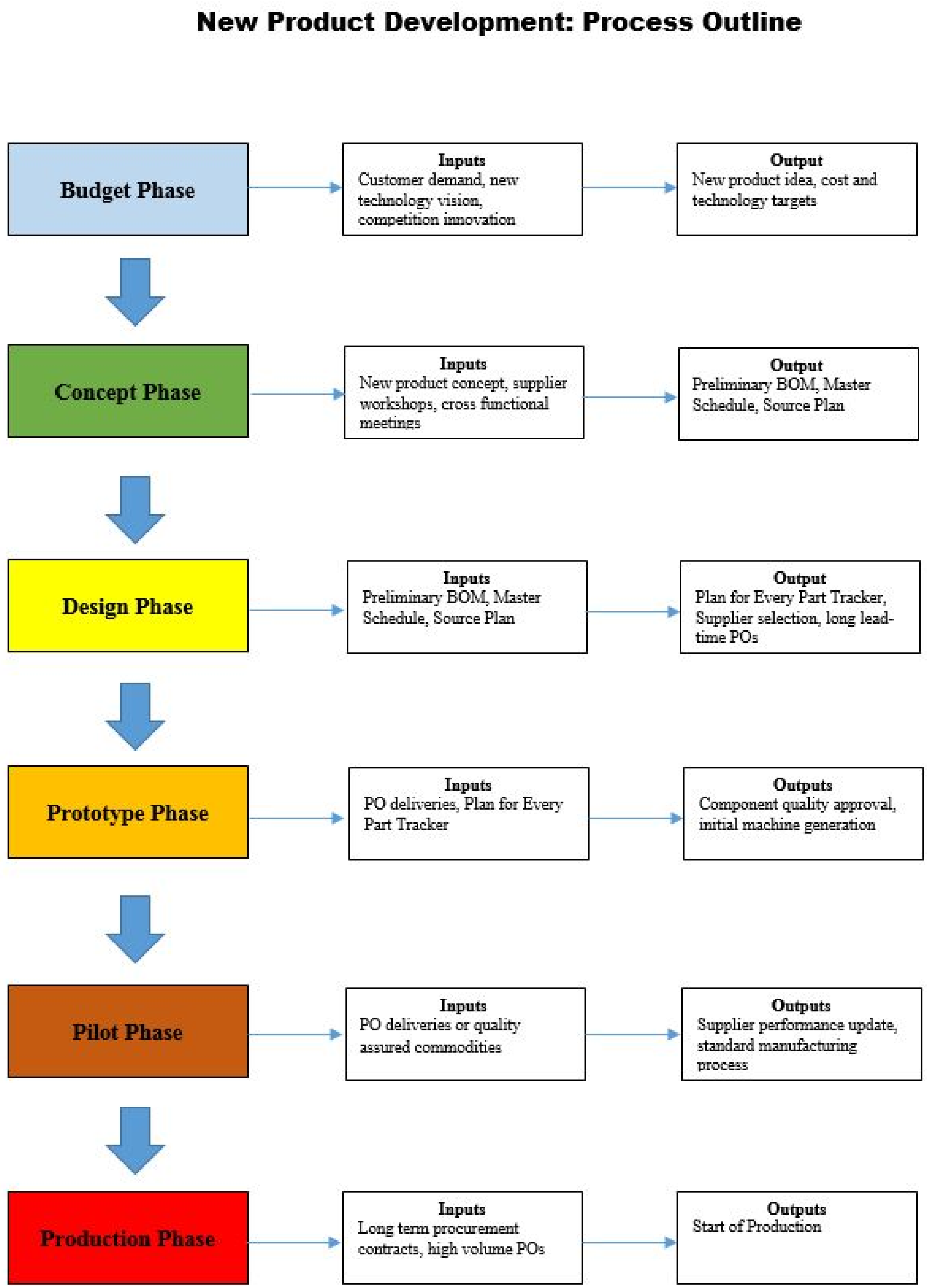

Figure 4: Process Inputs and Output

Chapter 3

Introduction to Best Practices for Powertrain Component Management

The nature of powertrain components presents a unique challenge to business units dependent on supply chain performance. Supply chain performance may be measured in a variety of ways, but in general, cost, quality, and delivery represent a simplistic overview of key parameters. Although the management of every component on a bill of material is crucial to a project's success, a powertrain system represents a group of components demanding an even greater organizational focus. The powertrain system comprises the base for the entire machine, and typically maintains the highest totals in terms of cost, lead-time, and engineering complexity. Therefore, the impact of powertrain component management on overall supply chain performance is greater than the influence of other components, and critical for supply chain success. The nature of a new product development process forces powertrain commodity managers to carefully manage the business in a strategic fashion from the very beginning of a project. Commodity managers develop a business strategy focused on supplier negotiations and integration prior to the quotation process to guarantee a successful approach to a new project. If managers effectively communicate and establish relationships with suppliers during the new product development process the opportunity for long-term optimal delivery, quality, and cost increases dramatically.

As the new product development process moves forward, commodity managers begin to develop a substantial role during the Concept Phase as overall component and project strategies start to formulate. From the Concept Phase to the Production Phase, commodity managers constantly consider the cause and effect of specific decisions in relation to the supply base. This research outlines several key considerations for powertrain commodity managers during the new product development phase under two overarching concepts: supplier integration and supplier network management. Supplier integration encompasses a breadth of ideas including design transparency, cost transparency, and supplier embeddedness. On the other hand, supplier network management focuses on sourcing strategy including the concept of leveraging the supply base and selecting a supplier based on a strategic set of parameters. Collectively, these initiatives outline best practices in new product development commodity management for managers responsible for the powertrain portion of the bill of material.

Supplier Integration Concepts

Over the past decade, business units involved in technology and engineering related industries adopted business strategies related to the idea of ‘focusing on core competencies’ by shifting resources away from manufacturing complex commodities to outsourcing highly engineered components. By definition, a core competency is the profound expertise that enables an organization to deliver distinctive value to customers. It represents a business unit’s ability to aggregate knowledge and integrate productions skills with engineering designs and final product ideas (Rigby, 2015). This initiative is possible through an original equipment manufacturer’s trust in outsourcing highly engineered components, such as powertrain components, to suppliers. One could argue the higher level of sophistication a new product development project requires, the more an original equipment manufacturer should collaborate with the supply base. If an organization fails to outsource a portion of complex components to suppliers, problems may arise in operations; controlling the manufacturing of all relevant technologies is nearly impossible to execute in an efficient manner (Yoo, 2015). As a result, companies often plan to decentralize their supply chain during the initial Budget Phase of a new product development process.

For organizations manufacturing complex final products or machines, outsourcing the production of powertrain components enables an organization to focus on their core competencies, such as the overall final product design and assembly. Outsourcing critical components often causes discomfort amongst organizational stakeholders due to an inherent loss of control. Therefore, the process and concepts surrounding supplier integration grows in importance as original equipment manufacturers outsource powertrain components to suppliers. Supplier integration is defined as the process of sharing expertise, expectations, and processes with a business partner so both the buyer and supplier maintain the ability to act collaboratively and meet business expectations. In simple terms, integration aims to create seamless supply chains by coordinating information flows (Danese, 2013). During the integration or onboarding process, the buyer works with the supplier to share relevant component information and introduce information systems necessary for a functional relationship. When integrating suppliers of complex powertrain components, information transparency regarding engineering design and detailed cost data is fundamental to successful new product development. Research shows that joint buyer-supplier efforts regarding technical and business goal setting is positively correlated with successful new product development performance (Petersen, 2005). Engineering design transparency and cost data sharing is crucial for the buyer and supplier to develop technical goals related to component quality and final product performance, and business goals of operating at the lowest cost possible in order to achieve the highest level of profit margin possible. Information systems enable both organizations to share design and cost information. Commodity managers and buyers also work collectively to integrate suppliers with information systems tracking purchase orders and the delivery of prototype components. A supplier's ability to update the buyer through information systems provides firms with the capability to manage logistics involved with prototype deliveries.

The process of supplier integration continues throughout the duration of new product development, especially for new suppliers. However, current suppliers from other projects still need to integrate with the specific demands of the new project, specifically within new component design. Supplier integration officially begins in the Concept Phase of a new product development process, as commodity managers begin to collaborate with project managers and design engineers to gain an understanding necessary to develop a preliminary sourcing plan. During this phase, commodity managers reach out to the supply base to schedule supplier workshops, arguably the first step of supplier integration. Supplier workshops are crucial for commodity managers to begin to share information relevant to the new project, and filter out members of the supply base incapable of meeting basic business expectations. After evaluating the supply base's initial response to the new project concept, a source plan begins to develop for strategic purposes. The project moves into the Design Phase as the engineering team develops the preliminary bill of materials. Several components will experience 'component revisions' as the design team updates a component to fit the needs of the project over time. However, with engineering drawings available, buyers are capable of sending RFQ packages to suppliers aligned with the commodity manager's sourcing plan. At this stage of the new product development process, one begins to notice another aspect of supplier integration through cost data sharing. Buyers and commodity managers review quotation packages and cost data to begin to formulate a plan for supplier selection. Upon awarding business to a supplier, the team works to integrate the supplier with information systems necessary to execute and track purchase orders. This onboarding process is another key aspect of supplier integration. As the new product development process advances into the later stages, commodity managers should continue to share necessary information with the selected supplier in order to prepare for start of production.

After highlighting the key supplier integration points within the new product development process, a few concepts stand out as key practices to focus on in order to best manage powertrain components. One aspect of the supplier integration process for optimal management practices is the transparency of engineering design. Original equipment manufacturers (industries utilizing powertrain components) are shifting their operations away from manufacturing highly engineered components and focusing on the core competency of final product innovation and assembly. This generates several implications for engineering design sharing between an organization and their powertrain components suppliers. One of the first decisions powertrain commodity managers contemplate relates to the amount of engineering information to relay during specific stages of the new product development process. Generally, organizations treat new product information sensitively, and sharing the minimum amount of information possible is common practice. As a firm enters the Concept Phase, supplier workshops are necessary to determine the supply base’s capability. Commodity managers and design engineers remain hesitant to fully disclose information regarding the details of the overall product design. However, as the new product development project progresses to the quotation process, engineering drawing disclosure is necessary to fully evaluate a supplier based on cost and capability. One question many commodity managers debate is the level of transparency in terms of the overall final product design and performance expectation to reveal to the supplier.

For powertrain components, the engineering design team will generally design components to fit the size and weight relevant to overall final product scheme. Within an engineering design, performance expectations for specific powertrain components are commonly outlined as part of the drawing specifications so a supplier reading an engineering drawing from a quotation package (or updated component revision delivered during the Design or Prototype Phases) will recognize performance standards required for the component. For example, an axle component would contain information regarding the necessary planetary gear ratio specifications in the drawing. However, these performance metrics are component specific and do not reveal the overall goal of the entire project. If a commodity manager and design engineer were to share the overall project scheme with the supplier, they may access a higher level of innovation and expertise from the supplier. Transparency with the supply base, in regards the overall project concept, presents the supplier with an opportunity to offer an alternative powertrain component design that delivers higher quality than originally proposed. Overall project design transparency also offers an opportunity for the supplier to understand how the original equipment manufacturer plans to assemble the final product, leading to a conscious effort to increase manufacturability and ease of assembly. In order for early supplier involvement in engineering design to be effective, both the buyer and supplier organizations must adopt a culture that facilitates and encourages joint-problem solving. Traditional barriers of transparency must be removed in order to obtain the stated benefits of supplier expertise within their components. (McIvor, Humphreys, 2004). Although overall design transparency presents multiple benefits, one should be aware of the potential negative aspects of high integration. One of the biggest fears in allowing the supply base to become highly innovative and offer alternative solutions is the prospect of engineering dependency. Original equipment manufacturers are hesitant to offer this transparency and opportunity in fear that the organization will depend on external sources for innovation rather than internal design generation. Providing opportunity to offer alternative powertrain solutions also incentivizes the supplier to develop a more expensive component. The supplier's best interest is to offer a higher performing product, especially if the market is willing to pay a premium for it, even though the component may be higher performing than necessary for the product. In conclusion, determining which design information is necessary for the supplier is challenging for a manufacturing company. Transferring large quantities of information may present both opportunity and risk. Information transferred should be cautiously tailored to the specific needs of the supplier. (Bruch, Bellgran, 2012). Both global procurement and design engineering teams need to determine how early in a process the firm should share detailed design and final product innovation data. The teams should also contemplate the degree of freedom the organization gives to the supply base to innovate in design, as several risks arise from design dependency.

Another point of emphasis derived from reviewing supplier integration within the new product development process is the concept of cost data transparency. As discussed in Chapter 2, an organization should include a cost data section in a quotation package that outlines the "five buckets of money" including raw materials, labor, burden, sales and general administrative expenses, and profit. Powertrain components, specifically axles and engines, maintain extremely high costs and represent a significant portion of the overall machine cost. Therefore, obtaining cost data from the supplier is crucial in evaluating a supplier for powertrain components. If a commodity manager acquires access to detailed cost data, several benefits are possible for both the supplier and buyer. During the quotation process, buyers receive cost data from a number of suppliers. If the returned quotation package contains detailed cost data, commodity managers communicate with the supplier about their level of competitiveness in relation to the rest of the supply base. If quotation packages lacks detailed cost data, commodity managers face difficulty in communicating a specific area of cost suppliers need to work on to become competitive. Detailed cost data provides the opportunity for the supplier to re-evaluate a proposed price, and if necessary lower the unit price in order to increase the probability of winning the new project's volume. Transparent cost data also offers the prospect for the supplier and commodity manager to recognize opportunity for collaborative cost savings initiatives. For example, if the supplier experiences an extremely high material cost, the commodity manager may relay this information to the engineering team to inquire about the possibility of re-designing the component to contain less material, thus reducing unit cost. Utilizing cost transparency enables the supplier and buyer to work together to achieve mutual cost savings opportunities. However, one may find receiving detailed cost data in the form of the 'five buckets of money' to be extremely challenging due to a supplier's reluctance to reveal internal data. Many suppliers fear the buyer acquires a competitive advantage from transparent cost data. Commodity managers in new product development projects face a challenge in determining the degree of importance in regards to receiving cost data from the supplier. Commodity managers fundamentally desire this information, but need to determine if a suppliers reluctance to share cost data is worth eliminating a supplier from the selection process altogether. Although it may be difficult to attain cost transparency for all five buckets of money, a commodity manager for powertrain components needs to focus specifically on the bucket related to material cost. This desire relates to the concept of supplier embeddedness: the importance of observing suppliers as being embedded in, or part of, an overall supply network rather than in isolation. The performance of a supplier is dependent on its own supply network, and analyzing this network reveals a more detailed explanation of a supplier's performance and material costs (Choi, Kim, 2008). Powertrain commodity managers should demand information about the supplier's internal supply base in order to identify the root cause of unsatisfactory total unit costs. Access to raw material data relevant to the supply base's country of origin offers an opportunity for commodity managers to understand and track raw material indices for specific locations. Each country possesses different material indices based on domestic economies and resource levels, resulting in material price volatility over time. These raw material fluctuations may help a commodity manager detect a natural reduction or increase in total unit cost stemming from a change in a material index. Powertrain commodity managers should work to understand the supplier's supply base for steel and iron materials in order to receive an accurate and honest total unit cost from a supplier. Powertrain commodity managers need to develop a level of accountability with suppliers through cost transparency. Cost transparency provides opportunity for an original equipment manufacturer to communicate competitiveness with the supply base and utilize cost data to negotiate with individual suppliers. Transparency also offers the opportunity for both parties to identify mutually benefiting cost savings opportunities and build a collaborative relationship. Although cost data is difficult to obtain commodity managers should maintain a strong stance on demanding raw material supplier information in order to ensure accountability and track the country of origin data's impact on price over time.

Supplier Network Management

Integrating and developing a collaborative relationship with an individual supplier is a key aspect of the new product development process for powertrain components. However, in terms of understanding the overall best practices for powertrain commodity management, focusing on the concept of supplier network management is crucial to devising an optimal overall strategy. Commodity managers begin to develop a sourcing strategy during the Concept Phase in reaction to performance requirements communicated by the design engineering team and supplier workshops to convey basic project requirements to the supply base. Although supplier workshops provide an excellent preliminary step to generating a decision for supplier selection, commodity managers often experience a more complex process to make a final decision.

One methodology common in supplier selection decisions is the utilization of a supplier scorecard. A supplier scorecard is a tool containing a weighted score based on categories relevant to an individual original equipment manufacturer's overall strategy for a component. Each category receives a percentage (weight), determining how much the organization values the parameter in comparison to other categories. An example from research related to strategic scorecards in a manufacturing environment is displayed below (Kumar, Clemens, Keller, 2014).

Variable	Weight (%)
TCO	30
Quality	25
Delivery	20
Financial security	15
Innovation/communication	10

Figure 5: Supplier Scorecard

As one can see, the category listed with the highest weight is total cost of ownership (TCO). As mentioned in Chapter 1, powertrain components demand the highest cost of any component in a product in the automobile or access equipment industries. Therefore, the cost consideration for powertrain components carries significant weight in a supplier scorecard. Quality is another significant consideration for powertrain components, arguably deserving the highest weight for supplier selection. Powertrain components are essential to the machine's performance, and any small miscue in quality causes major disruptions in a new product development process. In order to fully assess quality, original equipment manufacturers may send commodity managers and a member from the quality engineering team to perform a supplier quality evaluation at a supplier's production plant during the Concept Phase. Delivery remains a common parameter on any organization's supplier scorecard, as companies continue to recognize the importance of on-time delivery. Prototype building runs on a strict schedule, and powertrain components are considered the building blocks of any original equipment manufacturer's products. Commodity managers will review the supplier's freight terms and facilities locations to generate a weighted score for the delivery category. Financial security remains part of a necessary background check process for any supplier selection decision. Commodity managers often request access to a supplier's financial statements (if the supplier is a private organization) and communicate the results to the finance and accounting departments to generate a score for this parameter. Innovation and communication is a supplier scorecard category growing in popularity in industry today. For any new product development project, communication amongst the supplier's design engineering team and the original equipment manufacturers engineering team is crucial. Powertrain components present a high level of complexity, encouraging commodity managers to value communication with suppliers more than other industries. Current and past supplier's score for communication should include feedback from the design engineering team in consideration of the supplier's compatibility in design engineering formulation in past new product development projects. However, this parameter is difficult to measure for new suppliers and commodity managers should adjust the score for a scenario with suppliers lacking historical reference.

Although supplier selection remains a large factor in overall supplier network management, commodity managers need to consider a concept known as leveraging to execute optimal business decisions in new product development. Leveraging considers the best practices for distributing portions of the total business volume to a specific number of suppliers. A leveraged component supply base contains a small group of suppliers, each managing a large portion of an original equipment manufacturer's component business. An unleveraged component supply base contains a wide range of suppliers encompassing a variety of expertise, each managing a small portion of the original equipment manufacturers overall business. Research shows a wide range of benefits and risks for each variation of supplier leveraging. In leveraged component supply bases, original equipment manufacturers often benefit from increased dedication from each of the few suppliers. For example, if suppliers recognize they supply a significant portion of a manufacturer's business, a supplier is likely to make a direct investment in an original equipment manufacturer, such as dedicated capacity, exclusive technology, generating mutual cost savings initiatives, or assigning top design engineers to work on projects (Rudzki, 2010). However, researchers in support of an unleveraged supply base argue presenting too much power to a supplier may present inherent risks. If a supplier recognizes the amount of power it possesses over an original equipment manufacturer, the supplier may take advantage of the relationship by unjustifiably increasing costs. Unleveraged component supply bases present security in the form of higher levels of interchangeability and substitution in case of a failing supplier relationship.

In conclusion, commodity managers optimally observe the supplier selection process from a high level, noticing the opportunities new product development products offer to assess the overall supply base. A new product development project directly changes the positions of power, in terms of component volume, each member of the supply base possesses. Before awarding new powertrain component volume, a commodity manager should consider the current scorecard results for each supplier and the current leveraging status of the supply base. Although accounting for a supplier scorecard's results is pivotal to any sourcing decision, commodity managers consider the amount of volume each supplier possesses when making business decisions.

Chapter 4

Interview Process Results

After reviewing the dynamics of powertrain components and new product development processes, this research outlines the opinions and conclusions of industry professionals about the concepts surrounding best practices for powertrain components during a new product development project. To gather necessary information to present conclusions, an interview process collected data from industry professionals by asking questions related to the topics of engineering design transparency, cost data transparency, supplier embeddedness, and supplier network management. The group of industry professionals consisted of experts within a multitude of positions including project managers, commodity managers, and buyers. The group of professionals interviewed represent three different companies, and all of the professionals have experience in either the automobile, access equipment, or industrial services fields.

Engineering Design Transparency

As discussed in Chapter 3, engineering design transparency presents many challenges for the global procurement and engineering design teams for an original equipment manufacturing firm. Both global procurement and design engineering teams need to determine how early in a process the firm should share detailed design and final product innovation data. When asked questions related to the timing of design transparency, industry professionals shared similar ideas. As original equipment manufacturers gravitate towards the strategic initiative of focusing on core competencies, firms become dependent on suppliers to manufacture highly engineered components as the firm places emphasis on final product innovation and ease of assembly. One of the industry professionals pointed out the distinction between the design transparency of powertrain components versus other components on the bill of materials. When communicating design specifications the original equipment manufacturing engineering team relays detailed parameters for a component, rather than a completely unique design. The design engineering team seeks to outline the needs for the powertrain components in design, instead of a drawing specification. For example, in the case of engine components an original equipment manufacturers design will include information about the allotted space for the component within the overall machine, temperature levels the engine will need to operate in, the horsepower levels required for the machine's performance, and the fuel type the organization plans to utilize. As one industry professional pointed out, design transparency for powertrain components is crucial in outlining the parameters for the component, allowing the supply base to see if they maintain a component in their product portfolio capable of meeting the needs of the new product development project. In the case of powertrain components for many access equipment and automobile companies, the supplier officially owns the design, and the process of a new product development project seeks to execute modifications to an existing component. In terms of a specific timeline, industry professionals recommended sharing the basic parameters for the component during the supplier workshops held during the Concept Phase of a new product development project. At this time, the supply base may review the required parameters for the component and relate the metrics to their existing products to see if manufacturing is possible. If the supplier maintains a component capable of meeting the demands of the original equipment manufacturer's design specifications, they may be included in the RFQ process. Industry professionals stressed the importance in providing as much information about the parameters for powertrain components as early as possible in the process. One of the major areas of conflict in relation to engineering design transparency is the cross functionality between powertrain engineering design teams and other engineering design teams. In the example regarding engines components, one of crucial basic parameters is the space allotment for the component. Essentially, suppliers use this information to recognize if their component is size compatible, or if a slight modification in their component's size is possible. The engineering team directly responsible for space allotment data is not the powertrain engineering team, but the team responsible for designing the frame. One industry professional pointed out the high cost consequences if the supplier is unaware of size allotment. Although the supplier's engine may operate at necessary temperatures and capable power performance, if the component is too big the supplier and engineering team faces major re-design implications, extending the project timeline, thus increasing the overall new product development cost. Industry professionals stressed the importance of collecting necessary detailed parameters, such as size allotment, early in a new project timeline to effectively deliver the transparency required for the supplier to recognize necessary modifications quickly.

When questioned about the freedom of the supply base to innovate and offer an alternative component than the one proposed, industry professionals reacted differently. One industry professional argued in support of the increased value in allowing the supply base to observe the new project and offer an idea for alternative design specifications. As the overall business strategy for original equipment manufacturers strategy shifts to focus on core competencies, the expertise of suppliers grows in importance. However, other industry professionals argued powertrain commodity managers and design engineers should carefully ensure the supply base does not attempt to propose alternative specifications for their own benefit. For example, if the supplier notices their powertrain components lack the design specifications communicated by the design engineering team, the supplier may propose a different design solely to meet their product portfolio. In some cases industry professionals pointed out the mutual benefit of investing in a joint new powertrain component project with a specific supplier. In other words, the manufacturer and supplier work to design and manufacture an entirely new powertrain component specifically for original design manufacturer's products in the future. This innovative initiative may take place alongside a new product development project, but the initiative would drastically increase the project timeline, as the time required to design an entirely new powertrain component is much longer than modifying an existing component to meet a new product's standards. Sometimes this level of innovation does not directly originate with a new product development project, but as part of a long-term initiative seeking to coincide with a new project in the future. Industry professionals agreed this level of design innovation with the supply base should only take place with experienced and trusted suppliers. By increasing design transparency in this fashion, original equipment manufacturers generate a feeling of inclusiveness and commitment within the supplier, resulting in a successful long-term relationship.

One last area the interview process discussed in relation to engineering design transparency is the idea of sharing overall final project design. Although sharing the detailed parameters directly related to the powertrain components is imperative, sharing the overall new product design is less common. In fact, industry professionals agreed with the common practice of treating final product design sensitively, and sharing little information about the final product design with the supply base during the beginning phases of a new product development process. Suppliers often maintain business relationships with competing firms in the marketplace, incentivizing managers to maintain the minimum level of information flow in regards to the goals of the final product in terms of competitive advantage. However, industry professionals also agreed about the importance of sharing the overall goals of the new product with the selected supplier for the purposes of performance and durability testing. For example, within axle components, relaying the terrain conditions the final product will primarily operate in is crucial for the supplier to understand. With an understanding of the final product, quality testing can simulate the performance requirements of the powertrain component in a realistic environment. Performance and durability testing inquiries are only relevant to the selected supplier; therefore, information regarding final product design is only transparent to the selected supplier during the Design Phase.

Cost Data Transparency

Another point of emphasis when considering the best practices for the management of powertrain components during a new product development process is the concept of cost data transparency. As discussed in Chapter 2, an organization often includes a cost data section in a quotation package standardly outlining the “five buckets of money” including raw materials, labor, burden, sales and general administrative expenses, and profit. The interview process questioned the industry professionals about their experiences with cost data transparency and the importance of the five buckets of money.

Many of the industry professionals agreed cost data transparency for powertrain components is extremely valuable and important for negotiations, but obtaining the ‘five buckets of money’ is far less important than acquiring cost data for engineering design specific features. In simpler terms, the design engineering and global procurement teams need to understand the reasoning behind certain aspects or features within an engine, transmission, driveshaft, or axle. Examples of component design features for an engine may include horsepower levels, fuel capability, number of power generators, or cooling fan temperature capability. During the Design Phase the original equipment manufacturer's design engineering team works in unison with the powertrain components engineering team to execute necessary modifications to the supplier's existing design to match the needs of the new product. Sometimes design engineers recognize a different need than originally proposed in the original design specifications. One industry professional pointed out an example relating to increasing horsepower levels or changing fuel capability within an engine. The global procurement and design engineering teams should understand the costs of specific features within the engine to justify the machine's cost and negotiate with relevant information. Therefore, if the design engineering team for the original equipment manufacturer realizes a demand for higher horsepower levels or duel fuel capability, the organization will recognize how much this design modification should cost and evaluate the worthiness and justification for the adjustment in price and design. One industry professional cited the ramifications of failing to access cost feature data. If the original equipment manufacturer were to ask the supplier to modify a component feature, such as increased horsepower capability, and the supplier responds with an extreme cost increase, the original equipment manufacturer experiences increased risk. Due to the complexity of powertrain components, and the amount of time spent during the Design Phase working with the supplier's engineering team, switching suppliers during the middle of the process will inevitably delay the project and increase the overall costs of implementing the project. Consequently, industry professionals believe gaining access to component feature cost data carries the greatest value in terms of managing powertrain components. Although accessing the cost data related to labor, burden, and profit margin assists commodity managers in preliminary negotiations, understanding the cost of the features in the component design delivers long-term value throughout the new product development process.

Another aspect of cost transparency the interview process questioned industry professionals about was the level of requirement original equipment manufacturers should place on cost transparency. Industry professional mutually agreed cost transparency is crucial if the organization is interested in a relationship that extents after the new product development product. This claim is supported through the generation of mutually benefitting cost savings programs stemming from cost transparency. One industry professional credited cost data transparency during the early portions of new product development as the base for a larger initiative known as ‘value analysis, value engineering’ (VAVE). VAVE is a standard process for suppliers and original equipment manufacturers to present ideas for a mutual cost savings. For example, if the design engineering team for an original equipment manufacturer notices an opportunity to offer the supplier more space for an engine or axle, the design engineers may propose the idea to the supplier utilizing VAVE documentation to inquire about a reduction in unit cost. The supplier may respond explaining the cost implications of acquiring more space in the product for the component. In a VAVE program, suppliers and manufacturers typically split the cost savings generated from an idea. Manufacturers and suppliers should be transparent with each other about cost in order to implement successful programs, such as VAVE. If engineers from both the manufacturer and supplier notice a functioning and transparent cost savings initiative, the motivation to collaborate increases dramatically, thus improving the chances of a successful long-term relationship beyond a single new product development process.

Supplier Embeddedness

One last aspect of cost data transparency the interview process discussed with industry professionals relates to the concept of supplier embeddedness. Supplier embeddedness is an ideology observing the supplier as part of a larger network of suppliers; the performance of a supplier is dependent on its own supply network, and analyzing this network reveals a more detailed explanation of a supplier's performance and material costs. When asked about the importance of analyzing supplier embeddedness, industry professionals agreed upon two general conclusions. One conclusion related to level of detail the original equipment manufacturer should analyze the internal affairs of the supply base for the powertrain components suppliers. Industry professionals determined analyzing individual second-tier suppliers for powertrain component suppliers is unnecessary, and other initiatives during the new product development process demand a more substantial amount of time and attention. As discussed in Chapter 1, the supply chain for powertrain components begins with raw material suppliers, such as the suppliers of iron, steel, and electrical components. Due to the simplicity of these materials, understanding each individual raw material supplier for a powertrain components supplier is unnecessary. However, the second conclusion the industry professionals cited from the idea of supplier embeddedness is the importance of understanding the necessary raw material indices relevant to the supply base of the powertrain components supplier. A raw material index is a metric measuring the price changes of materials over time in consideration of their perspective location. Therefore, industry professionals cited the importance of understanding the material costs of each supplier in the powertrain component's supply base, and the country of origin for those materials. A raw material adjustment clause should be contractually agreed upon during the end of the Design Phase when the business is officially awarded to the selected supplier. Industry professionals agreed developing a raw materials indices tracker for the selected supplier during the Prototype Phase assists both organizations in holding each other accountable for the duration of the new product development product and overall product life cycle. A raw material index serves the original equipment manufacturer and supplier as a third party resource to ensure fairness in cost and protect each organization's profit margins. Industry professionals agreed a raw materials index tracker documentation should be updated on a semi-annual basis to ensure accurate cost, but not hinder time necessary for other business related activities. One industry professional explained how a failure to adjust raw materials might cause a sudden price increase from the supplier, seemingly unjustifiable to an original equipment manufacturer with a lack of understanding of raw material fluctuations. By accounting for raw material price fluctuations, both organizations spend time focusing on mutually benefitting cost savings opportunities, such as VAVE initiatives. In conclusion, understanding the details of supplier embeddedness lacks importance, but the understanding of the raw material indices relevant to the supply base of the powertrain components providers is crucial for ensuring a fair and healthy relationship.

Supplier Network Management

Supplier network management comprised the last subject area the interview process questioned industry professionals about in terms of a new product development project. Every commonly used component in an original equipment manufacturer's product line maintains a number of potential suppliers. Commodity managers carefully distribute volume to the supply base in order to achieve the business goals of delivery, cost, and quality. This concept looks at a new product development project as a small portion of an overall scheme of managing suppliers effectively. In order to identify the best practices for powertrain component management in new product development, one should understand the global procurement team's decisions and processes in terms of the overall supplier network.

The first area of discussion in regards to the concept of supplier network management relates to best practices for supplier selection. One industry professional outlined a preliminary process directly enhancing a commodity manager's ability to execute a supplier selection decision. In order for the commodity manager to operate effectively, a large-scale request for information process should take place on a yearly basis. Commodity managers should consider a wide range of suppliers through this process, as a request for information process lacks commitment. In this process, the commodity manager reaches out to the global supply base in effort to access and record a variety of information for a specific powertrain component. The goal of the request for information process is to receive data from the global supply base about each supplier's capability. Capability may be defined in a number of ways, but some examples for an engine include power capability, fuel type offerings, and component sizes. If a commodity manager effectively collects this data, a general understanding of the capability differences in supply base increases dramatically. Therefore, as a new product development project moves into the Concept Phase, a commodity manager utilizes information collected during the request for information process to determine a preliminary list of potential suppliers for the sourcing plan. One industry professional noted the practice of keeping a portfolio regarding the global engine component supply base as a key factor in assisting a sensible new product launch. With the request for information data, selecting suppliers for the supplier workshop process becomes efficient and concise based on component capabilities. Industry professionals stressed the importance of a yearly request for information process, as suppliers develop their technological capabilities over time, but not often enough for a commodity manager to spend time on the process for every new product development project.

Industry professionals moved forward in the interview to discuss the actual selection process for powertrain components during a new product development process. From this discussion, the majority of industry professionals agreed upon two conclusions. The first conclusion identified a supplier scorecard initiative as the basis for supplier selection. This process takes into account several factors from the request for quotation process and places a weighted score on perspective categories. Some of the scorecard categories industry professionals identified were price, logistics capability, history of quality, productivity, and product line variability. However, the second conclusion the industry professionals identified places the design engineering team as a key stakeholder in the supplier selection process. As cited previously, the design transparency best practices revolve around the idea of modifying a powertrain supplier's existing product to match the demands of the new product's design. Therefore, despite a weighted scorecard including variables such as price and logistics capability, the design engineering team ultimately makes a directed recommendation for the supplier selection of powertrain components. However, industry professionals pointed out how often times the design engineering team feels comfortable with multiple suppliers, a scenario where the commodity manager accesses ideal negotiation power to discuss lower unit costs and faster delivery commitments. In conclusion, a supplier scorecard generated from the request for quotation process and the recommendation from the design engineering team sway the decision of supplier selection for powertrain components during new product development.

Another concept the interview process discussed was the idea of supplier network leveraging. As discussed in Chapter 3, commodity managers should always account for the total volume or business each powertrain component supplier maintains. Many risks and rewards stem from the dominance, or leveraging power, of one supplier with a powertrain component. Industry professionals offered a variety of opinions about the best practices for dealing with leveraging the supply base, but a general consensus identified the optimal strategy. When asked how many suppliers a specific powertrain component, such as an engine, should maintain, industry professionals agreed the number of suppliers should be relatively low. The reasoning behind this opinion stems from the complexity of powertrain components. Industry professionals argued the relationship development between a supplier's design engineering team and an original equipment manufacturer's engineering team is crucial for successful and timely new product development processes. Therefore, maintaining a smaller group of powertrain component suppliers increases the comfort levels and understanding of operations for each organization. It is important to note this methodology relates to each powertrain component, meaning engine components maintain a small number of suppliers and axle components maintain a separate small number of suppliers. Industry professionals concluded a supplier network with suppliers owning large portions of the overall powertrain component network is acceptable and presents many benefits from a supplier's increased understanding of the original equipment manufacturer's engineering processes and product lines.

One last concept discussed during the interview process relates to the idea of maintaining negotiation power over the supply base extending past the new product development process. Sometimes in a product's lifecycle, a relationship between a supplier and original equipment manufacturer transforms from a healthy relationship during new product development launching to an unsuccessful relationship during production. Examples of causes for this transformation include a supplier's internal bankruptcy, sudden and unjustified cost increases resulting in tension, or overall poor quality at higher volume expectations. Considering these factors, commodity managers often seek to develop a 'back-up' plan in the case of an unsuccessful relationship, increasing the leverage the organization maintains over the supply base. However, industry professionals from a powertrain commodities perspective stressed the difficulty of implementing a successful back-up plan for a component in this industry. The reason for this difficulty stems from the complexity of powertrain components, and amount of time required for the supplier and original equipment manufacturer engineering teams to collaborate on modifying an acceptable design. In other words, a powertrain component is so complex, it is impossible to onboard a new supplier in the amount of time necessary to ensure acceptable fulfillment of the production schedule. To combat this insecurity in the supplier network, industry professionals stressed the importance of including suppliers with a large product offering in the supply base. If an original equipment manufacturer experiences an extreme turn in a relationship with one supplier, the organization may seek the options of a supplier with a large breadth of product differentiation. Due to a sizable array of product offerings, the ease of modifying a component to match the needs of an original equipment manufacturer's product increases naturally. In conclusion, industry professionals conveyed the importance of selecting suppliers renown for offering a large range of products during new product development projects to cope with the potential difficulties of substituting a new supplier in case of a relationship failure in the future.

Summary of Results

Overall, industry professionals offered a wide range of opinions throughout the interview process, generating a clear picture of the best practices for the management of powertrain components during a new product development process. In terms of engineering design transparency, suppliers often own the component design, and engineering teams must collaborate to adjust an existing component to meet the needs of a new project. During the beginning of a new product development project, commodity managers conduct supplier workshops to communicate the general performance requirements and characteristics of the component. Communicating expectations for design as early as possible assists the fulfillment of supply chain expectations for the new product. Commodity managers should seek to acquire relevant engineering information from design engineering teams outside the powertrain team to ensure the supplier acknowledges all necessary information, such as space allotment from the frame design team. As original equipment manufacturers shift their strategy to focus on core competencies, organizations should rely more on the supply base's expertise and listen to alternative design suggestions from suppliers. Sometimes innovating on a long-term alternative powertrain solutions project in unison with the supplier mutually benefits both organizations and future new product development projects. Overall, new product design concepts should only be shared with the selected supplier to initiate a realistic testing and quality control process during the Design Phase.

In terms of cost data transparency, gaining access to component feature cost data carries the greatest value in terms of managing powertrain components. Although accessing the cost data related to labor, burden, and profit margin assists commodity managers in preliminary negotiations, understanding the cost of the features in the component design delivers long-term value throughout the new product development process. Increased cost transparency within powertrain components is the basis for a mutually benefitting effort, known as 'value analysis, value engineering' (VAVE), that generates a platform for suppliers and original equipment manufacturers to propose cost savings ideas. Therefore, cost transparency is a requirement for all selected suppliers to ensure a successful long-term relationship.

In terms of supplier embeddedness, original equipment manufacturers should not stress to understand the detailed performance of a powertrain component supplier's supply base. However, understanding the raw material indices relevant to the raw material supply base is crucial in developing an agreement that ensures a semi-annual price adjustment. A raw material adjustment clause should be contractually agreed upon during the end of the Design Phase when the business is officially awarded to the selected supplier. Adjusting component pricing based on raw material fluctuations protects both firm's bottom lines, and ensures neither organization creates sudden price demands.

Finally, in terms of supplier network management, commodity managers for powertrain components should manage a yearly 'request for information process' with the global supply base to determine the component capabilities of each supplier. Commodity managers utilize this information when reviewing the engineering design specifications to determine a select number of suppliers for the supplier workshop process. The supplier selection process during the Design Phase considers the results from a weighted supplier scorecard, and more importantly, the recommendation from the design engineering team. During supplier selection, commodity managers recall the difficulty in maintaining a 'backup supplier' due to powertrain component complexity, and value suppliers with a large product portfolio in case of emergency. Overall, commodity managers should manage a network for each powertrain component containing few suppliers due to engineering complexity and the importance of design team collaboration and familiarity. A supplier network with suppliers owning large portions of the overall powertrain component network is acceptable and presents many benefits from a supplier's increased understanding of the original equipment manufacturer's engineering processes and product lines.

Chapter 5

Conclusion

Today, original equipment manufacturers transform their operations towards a strategic initiative of focusing on core competencies. Rather than spending time and resources on manufacturing final product sub-assemblies, original equipment manufacturers source highly engineered components from the supply base. For an organization with powertrain components in the bill of materials, the importance of strategically sourcing these components during new product development is crucial to ensure the profitability and installation of the new product. Powertrain components characteristically maintain longer lead-times, higher costs, and greater complexity in comparison to other components on a bill of materials. Engineering a prototype or final product involving a powertrain system requires the delivery of essential powertrain components prior to other components on the bill of materials, as the powertrain system serves as the base for surrounding sub-assemblies. Therefore, focusing on the management of powertrain components is crucial to ensure the achievement of supply chain goals including the on time delivery of components, acceptable component quality, cost competitiveness, and successful new product launching.

In order to achieve supply chain goals, original equipment manufacturers focus on several key areas during the new product development process. Some of the more important areas this research focused on are the concepts of engineering design transparency, cost data transparency, supplier embeddedness, and supplier network management.

For powertrain components, engineering design transparency is a unique concept with several implications. For original equipment manufacturers focused on core competencies, the supplier often owns the official component design, and the purpose of the new product development project is to execute modifications to the design to match the needs of the original equipment manufacturers new product. Therefore, in order to ensure timeliness and component quality, commodity managers share engineering design performance specifications and characteristics, such as size and power, with the supply base during the preliminary stages of the new product development project. It is important for commodity managers to communicate engineering design performance specifications and characteristics as early in the process as possible to identify which suppliers are capable of supply, and areas in the design the engineering designs teams will need to focus on. If engineering design lacks transparency within the supply base, an original equipment manufacturer may select a supplier unable to meet expectations later in the project, and the delay the project timeline. Another aspect of engineering design transparency this research focused on was the concept of overall new product innovation outside the powertrain system. Research cited the sensitivity of information regarding the final product's competitive advantage goals in the market due to the sharing of suppliers amongst competitors. However, industry professionals concluded the original equipment manufacturer should begin to share the overall new product's concept with the selected supplier once the commodity manager awards the business. Sharing information relevant to overall new product innovation and competitive advantage goals is imperative to ensure the selected supplier will perform powertrain component testing in a realistic environment to predict quality assurance. Suppliers aware of the final product's characteristics become familiar with the original equipment manufacturer's products and relate to the needs of the design engineering team's expectations, thus creating an environment for a smooth transition and successful product launch. Overall, research and the interview process indicated engineering design transparency is crucial when considering the best practices for the management of powertrain components in a new product development product. The better the supplier understands the design engineering team's expectations, the faster the new product can reach production with acceptable quality, thus increasing profitability by beating competitors to the market with an innovative product.

The second concept this research focused on was the importance of cost data transparency. After determining the general capability of the supply base, commodity managers conduct the RFQ process to determine the cost transparency of suppliers. Research showed commodity managers request cost data related to materials, labor, burden, and profit margin to assist preliminary negotiations. However, the industry professionals interviewed indicated that understanding the cost of the features in component design delivers the highest long-term value throughout the new product development process. During the supplier selection process, commodity managers seek to understand the impact specific features within the powertrain component has on the unit cost. If commodity managers and design engineers fail to understand the cost implications of specific features on the component, the team may be unprepared for sudden price increases stemming from design modifications following supplier selection. Industry professionals also pointed out the value of sharing component feature cost data as a basis for creating a mutually benefitting cost platform known as 'value analysis, value engineering'. When suppliers and original equipment manufacturers are cost transparent, the ability to focus on generating cost savings modifications in engineering design becomes possible. Therefore, cost transparency is required for commodity managers to establish a relationship with a supplier to collaboratively save cost. Overall, when the original equipment manufacturer understands the cost of features within the powertrain component, the organization is best prepared to understand how possible modifications in new product design impact future final product cost. With this understanding, the organization manages the cost and performance of the new product to access an optimal level of profitability.

The third concept this research focused on was the importance of supplier embeddedness. Research showed the performance of a supplier is dependent on its own supply network, and commodity managers should seek to evaluate second-tier suppliers. However, the industry professionals interviewed claimed evaluating the detailed performance of each second-tier supplier is unnecessary, but understanding the raw material indices relevant to the supply base of the powertrain components supplier is crucial in establishing an accurate unit cost. After the global procurement and engineering design teams agree on a selected supplier, the organization will formulate an official contract for the new product's powertrain component volume. Within this contract commodity managers seek to include a raw material clause, to account for a semi-annual price adjustment based on fluctuation in raw materials. Overall, creating a best practice for tracking the impact of raw material price fluctuations ensures both organizations are treated fairly as the unit cost naturally changes. A semi-annual update secures the profit margins of both firms, and allows the partnership to focus on mutually benefitting cost savings initiatives, rather than innate cost fluctuations.

The final concept this research focused on was the importance of supplier network management. Research showed the supplier selection process for powertrain components involves the input from a weighted supplier scorecard. Industry professionals agreed with this process, but more importantly, focused on the recommendation from the design engineering team for supplier selection. The design engineering teams of the original equipment manufacturer and the supplier constantly work together throughout the new product development project to modify design to match the needs of the new product. Commodity managers must select suppliers the engineering team is comfortable with to ensure efficiency in the product's development. If a commodity manger selects a supplier based solely on the supplier scorecard, they may select a supplier the engineering team is uncomfortable with, thus extending the length of the project, allowing competitors to reach the market first. When executing a supplier selection decision, commodity mangers also consider the concept of leveraging. For powertrain components, industry professionals agreed an original equipment manufacturer should maintain a small supply base for each powertrain component in order to maximize engineering team collaboration and familiarity with the business. Due to the complexity of the engineering design for powertrain components, and the amount of time and resources required to install a substitute supplier, maintaining an unleveraged supply base presents little value. However, industry professionals concluded commodity managers should value suppliers with a large product portfolio in case of a demand for component substitution during production. If the commodity manager maintains a network of suppliers with maximum product variation, the chances of finding a reasonable substitute with a supplier already familiar with the business increases dramatically.

In conclusion, powertrain components present original equipment manufacturers sourcing highly engineered components with a unique challenge. The characteristically high expense and complexity of such components makes the management of engineering design transparency, cost data transparency, supplier embeddedness, and supplier network management crucial for the success of a new product development project. Strategically establishing best practices for these concepts helps an original equipment manufacturer predict the future success and profitability of a new product.

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ACADEMIC VITA
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EDUCATION

The Pennsylvania State University: Smeal College of Business
B.S. Supply Chain and Information Systems
Minor: Information Systems Management

WORK EXPERIENCE

JLG Industries, Oshkosh Corporation – *Supply Chain Intern: Driveline Commodities Management*

- Developed and managed a price matrix to account for raw material and currency fluctuations.
- Created strategy grids for evaluating potential suppliers for axle, driveshaft, and wheel drive business.
- Compiled axle engineering and cost data to identify opportunities to challenge suppliers on pricing.
- Formulated process flow maps for multiple suppliers to track logistics and returnable packaging methodologies.

JLG Industries, Oshkosh Corporation – *Supply Chain Intern: New Product Development*

- Experience in the purchase order process and sending out requests for quotations packages.
- Constructed a data reference for standard lead times (by commodity) for strategic sourcing decisions.
- Developed inventory and pricing reports by navigating through the AS400 ERP system.

LEADERSHIP AND ACTIVITIES

Delta Kappa Epsilon Fraternity
President (December 2014-November 2015)

- Head of a sixty-five member organization; conduct weekly meeting to address all functional updates.
- Liaison between the fraternity and all parties including the University, State College Borough, and International Headquarters.

Penn State IFC/Panhellenic Dance Marathon (THON)
Hospitality Committee Member (September 2013-March 2014)

- THON is the largest student-run philanthropy in the world.
- Volunteers serve a mission to conquer pediatric cancer by providing financial and emotional support to children, families, researchers, and staff members of the Four Diamonds Fund.
- Hospitality Committee members/volunteers are responsible for organizing and staffing the THON 5k fundraiser, managing concessions on THON weekend, and raising money/awareness for THON.

Fresh Start Community Service Program
Team Leader (March 2013-September 2014)/Participant (September 2012)

- Led a group of fifteen freshmen in a day of community service during the first weekend of fall semester.
- Provide freshmen with academic, social, and community service guidance throughout the fall.

CERTIFICATIONS/AWARDS

- Certified Six Sigma Yellow Belt (June 2014)
- United States Army Reserve National Scholar Athlete of the Year Award (Massachusetts 2012)
- Scholar Athlete Award (Football 2011, 2012) (Hockey 2012)
- National Honor Society Member