1.0 INTRODUCTION

1.1 Automobile Industry Profile

Growth in global automotive production is likely to remain at around +4% per year in 2014 and 2015, with an increase in production in China, India, and Mexico at the expense of Europe. Production is even expected to exceed 100 million vehicles by 2017. The major component manufacturers, which are essential for auto makers, have relocated to follow production and register healthy levels of profitability.

On the other hand, car sales by market reflect the economic difficulties facing various countries. The recovery is sluggish in Europe, in United States it is more pronounced, but, jobless; In Japan it is underpinned by public policies; in emerging countries it is lagging behind, despite high expectations.

How are the industry and the market evolving?

Globally, the automotive industry has recovered from the economic crisis. Industry profits in 2012 (EUR 54 billion) were much higher than in 2007 (EUR 41 billion), the last pre crisis year, and the prognosis for future growth is even better. By 2020, global profits could increase by another EUR 25 billion, to EUR 79 billion. That is good news, but the benefits will not be distributed equally across all geographies or all types of cars. Instead, some regions and segments will do much better than others. What is most striking about the recent past is how profoundly the source of profits has shifted. In 2007, the BRICs (Brazil, Russia, India and China) and RoW (Rest of the World) accounted for 30 percent of global profits (or EUR 12 billion). In 2012, that share rose to nearly 60 percent (EUR 31 billion), as sales in these regions rose 65 percent and outpaced growth in Europe, North America, Japan, and South Korea (Figure 1.0). More than half of this growth came from China (EUR 18 billion).

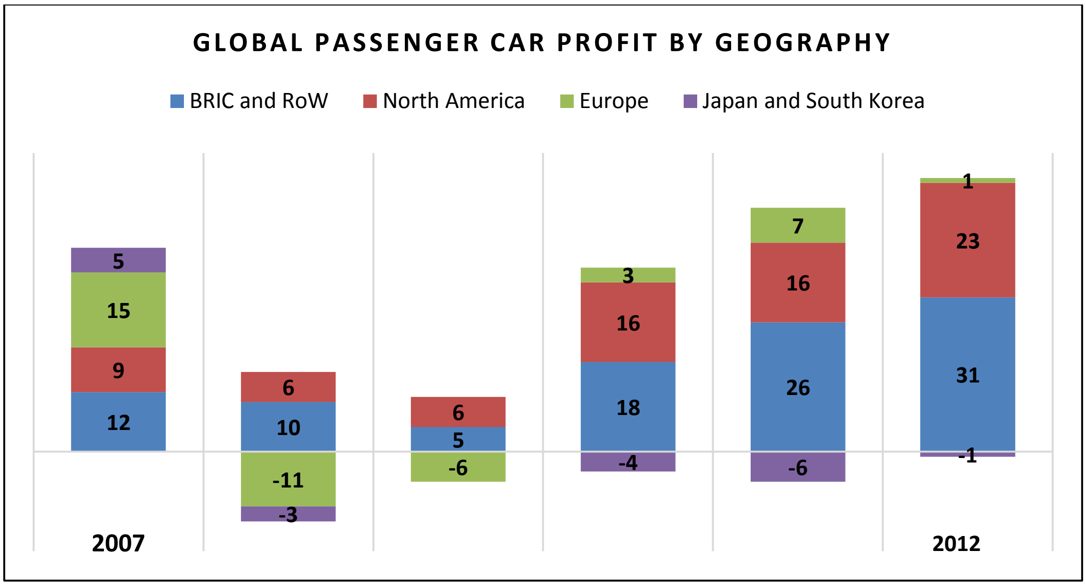

Figure-1.0 – Global passenger car profit by geography

Europe went in the other direction: in 2007, its automotive industry recorded profits of EUR 15 billion. By 2012, that profit had become a loss of EUR 1 billion. There are two main reasons for the decline. First, fewer people bought new cars. Across the region, the number of new registrations declined by more than four million units over this period, and car sales today are at levels last seen in the early 1990s. Second, Europe's well-developed automotive industry suffers from overcapacity; fierce competition is keeping prices (and therefore profits) down. Japan and South Korea are also looking far from robust. Both markets suffered from the economic crisis, and Japan endured another hit in 2011, with the tsunami-earthquake disasters in March. But in 2012, both countries saw their first profitable year since 2008. The road to 2020 and beyond - What's driving the global automotive industry?

In Japan, exports and production rose and domestic sales also increased sharply. But this trend does not look likely to be sustained, as car purchase subsidy programs expire. Sales in Japan have fallen so far in 2013, and projections indicate a continued drop. By contrast, North America is in good shape: profits improved from EUR 9 billion in 2007 to EUR 23 billion in 2012. Sales in North America reached 17 million units in 2012 – the most in five years – and are rising again this year. The product mix has also started to shift to higher-value pickups and SUVs. Finally, following some painful balance sheets and labor and non-cost restructurings, the cost structure of leading OEMs has significantly improved, providing a basis for enhanced profitability. Not only did emerging markets (the BRICs and RoW) account for almost 60 percent of worldwide automotive profits in 2012, these regions are poised to significantly outpace growth in established markets over the next seven years. Profit in the BRICs and RoW is projected to grow more than three times as fast as in established markets. By 2020, emerging markets will account for approximately two-thirds of the total automotive profit, and China will be the driving force (Exhibit 2). The vast majority of the estimated additional profits (EUR 25 billion) will come from steady sales growth (an estimated 3.8 percent a year, including 4.4 percent for the premium segment). The sources of those profits, however, will be rather lopsided. McKinsey's research indicates that China will account for a little more than half – EUR 13 billion, including EUR 9 billion from the premium segment alone. Other emerging markets will add about EUR 6 billion, while established markets will likely contribute only EUR 4 billion in additional profits, almost all of that from North America. Additional challenges and opportunities could add EUR 2 billion to total profit.

What are the future challenges and opportunities?

Apart from sales volume growth, four challenges will shape the near and medium-term future. The industry response to these challenges could raise profitability by EUR 2 billion in a base case scenario. These challenges will matter much more for established markets than for emerging ones.

Complexity and cost pressure - The increase in regulations with respect to environmental and safety standards will raise costs but also increase complexity, as they need to be managed apart from domestic markets. The growing number of derivatives serving different vehicle segments and markets based on a single platform also raises complexity. At the same time, OEMs will have to develop alternative powertrain technologies for lower-emission vehicles without knowing what will end up being the prevailing technology of the future. This will require significant investment. Given all these pressures, plus flat net price development due to less budget available for new features, it will be more difficult for OEMs to differentiate themselves with new features while extracting economic value from these forces.

Diverging markets - Emerging markets' share of global sales will rise from 50 percent in 2012 to 60 percent by 2020, while their share of global profits is also set to rise by 10 percentage points. However, the location of current production and supply bases is not sufficiently aligned to future sales. Moreover, there is potential for "portfolio mismatch," as smaller vehicle classes are growing more strongly than others, particularly in fast-growing emerging markets. Finally, OEMs need to prepare for the Chinese aftersales market, which will grow an estimated 20 percent per year.

Digital demands -When it comes to buying a car, research shows that digital channels are already the primary information source for customers. For many, the next step could be online purchasing. This might be an opportunity for OEMs, but it also means the potential threat of competition from online retailers and puts pressure on the existing dealership structure. The growing role of digital also applies to the driving experience. Consumers want to combine mobility with communication. This could be an opportunity for OEMs, but only if they can figure out how to make money from this desire.

Shifting industry landscape- As OEMs seek to develop alternative powertrain technologies, suppliers will likely provide more of the value-added content per car. In addition, OEMs need to ensure that their suppliers' production footprints – especially in emerging markets – match future market demands and their own production plans. OEMs in Europe have one unique challenge: managing the restructuring that is clearly required. And everyone will have to deal with emerging Chinese players entering new segments and markets. Beyond base case assumptions, these challenges could give rise to further risks to automotive profits. Recent restrictions on China's pharma and dairy industries could foreshadow a tightening of regulations to the automotive industry. Therefore, assuming a negative scenario, which might induce a 50-percent margin drop, a negative profit impact of up to EUR 15 billion is possible. 10 Moreover, OEMs would have to pass on the expense of developing new powertrains. However, market constraints in a less positive scenario could lead to lower markups. Assuming a 5-percentage-point drop in markup for electric vehicles (EVs) and a 2-percentage-point decline in markup for hybrids (HEVs), this could add up to EUR 4 billion less in future profits. These two examples indicate the necessity for defining appropriate strategies, as business as usual would probably not be sufficient to tackle those risks from the overarching challenges. Similar penetration and pricing scenarios need to be modeled and understood for the adoption of new features in active safety and the wide range of connectivity offerings for customers.

How can OEMs benefit from these new challenges and opportunities?

The lion's share of profit growth will come from higher sales. But beyond selling more cars, the industry is changing in more fundamental ways. The research points to nine major imperatives for the automotive industry, especially for OEMs.

1. **The price-cost gap narrows -** Price and regulatory pressures mean that OEMs in the established markets of Europe, North America, Japan, and South Korea have little margin of error when it comes to making the right decisions on how to differentiate themselves. An analysis of 76 vehicle models shows that prices have been almost flat in real terms since 1998, while more and more features and improvements have been added due to competition, customer demands, and regulation. The net effect has been a decline in profit per vehicle (Exhibit 3), but OEMs have been able to manage this so far because they have been able to make efficiency and quality gains of 3 to 4 percent a year. However, tighter regulations for emissions or safety will add further costs to the average vehicle. Evidence suggests that the share of this regulation-driven content will increase to 60 percent in these markets (up from 40 percent). This will narrow the price-cost gap, and OEMs will face difficulties in prioritizing among differentiating features and basic customer demands. Therefore, OEMs need to find ways to impose markups for mandated content and to tighten annual cost improvement beyond 3 to 4 percent

2. **Rising complexity encourages more platforming**- Well into the 1990s, major brands would build four or five different models off a single platform. But car buyers worldwide continue to be more and more demanding, seeking region-specific features, performance, and styling as well as an element of uniqueness even in mass market products as a way of differentiating and emphasizing individual taste and status. Most automakers respond to this demand with an increasing number of derivatives subject to markups compared with standard models. It is not uncommon to have 20 or even more such "derivatives," as companies seek to profit from different market niches. In effect, derivatives share common non-consumer facing product elements (e.g., common chassis underpinning, body structures, core components) in order to make differentiation of consumer-facing features profitable. In the entry and value segments, the pace of introduction of new derivatives will likely peak, and the number of new models will level off. Continuing to create even

more derivatives will simply exert pressure on profitability. Just in the premium segment, there are some remaining market niches that offer opportunities. For non-premium players, the key to profit is to produce higher volumes on fewer platforms. But running more derivatives per platform also increases complexity. To manage this complexity, control costs, prevent cannibalization, and ensure that differentiation is aligned with consumer preference, OEMs need to develop new global platform strategies, including modular concepts. They would have to thoroughly analyze niches where derivatives still might create additional value. However, this would require more sophisticated research on customer preferences and diligent assessments of customer trade-offs and cannibalization effects. Moreover, OEMs need to balance global scale, complexity, and local or segment-specific customer demand. Specifically, they should consider ways to cooperate with other OEMs and how to enhance platform usage across segments, regions, and price levels.

3. **Greening gets more expensive** - Carbon dioxide regulation is likely to continue to tighten, and not just in Europe. China, the US, and Japan have also enacted laws to reduce emissions. One immediate result will be higher costs. Because the easy things have already been done, the price of cutting future emissions is rising. In Europe, the 2020 target might be reached with the help of advanced conventional technologies, but to meet the overall fleet targets, more electrification could be necessary (especially for premium players). This will push OEMs to invest more in e-mobility, meaning electrical/hybrid powertrains, including batteries, as well as in lightweight and aerodynamic drag-reducing technologies. Ultimately, electric vehicles may be the answer, though the transition will not happen fast, or soon. In 2020, conventional internal combustion engines (ICEs) will still account for more than 90 percent of cars. OEMs will have to continue developing more advanced ICEs, including cylinder deactivation or variable valve timing and lift. On the other hand, they need to invest in alternative powertrain technologies to meet future emissions targets – without knowing which kind will prevail. Managing these pressures will be a fact of OEM life to 2025 and beyond. One way to lower investment outlays and to drive innovation is to create strategic alliances with other OEMs and preferred suppliers. OEMs could also experiment with alliances with car sharing companies as a way to push EVs into the market, and thus help customers get used to them. Finally,

OEMs need to build up their capabilities to anticipate – or at least be prepared for – foreign regulations, especially regarding imports.

4. **The aftersales market in China becomes more important** - China is already the world's largest automobile market, with 19 million vehicles sold in 2012. But new car sales growth is slowing, from 18 percent a year between 2006 and 2012 to a projected 6 percent a year between 2012 and 2020. That is still a lot of cars, but an even more promising, and less obvious, opportunity is the aftersales market, including spare parts, service, used car sales, and financing, which serves as an integral component of brand building and sales funnel management. Aftersales automotive parts revenues on its own could grow from approximately EUR 20 billion in 2012 by 20 percent a year and reach nearly EUR 100 billion by 2020. A strong aftersales network could also enable OEMs to build brand loyalty. To capture this opportunity, OEMs need to enhance their dealer capabilities, as today the dealership is mainly focused on new car sales.

5. **Growth continues to shift** -The automotive industry's economic center of gravity will continue to shift, as sales volumes and market share keep moving toward emerging markets. The global sales share of established markets will decline from 50 percent in 2012 to 40 percent in 2020; these will account for only about 25 percent of future volume growth. The premium segment will account for more than half of future profit growth. One major growth opportunity is in smaller vehicles (subcompacts, micro cars, and superminis); these already account for more than 30 percent of global sales and could reach more than 30 million vehicles in 2020. More than 60 percent of this market is located in emerging economies, where sales are set to grow 5 to 6 percent a year until 2020. The majority of this growth will be in urban areas, offering OEMs the opportunity to address a large share of growth with relatively few, and focused footprint adjustments. Competition in this segment, however, will be intense, as many emerging market players are expanding. Success requires a low-cost business model, such as a limited number of body types based on one platform and a lean sales approach with a limited offer range due to despecification. In addition, OEMs would have to think about differentiating their brand perception

6. **Connectivity becomes more important** - Just as phones got smart, so will cars. They won't quite think, but they will respond and remind. Cars on the road are being equipped with danger-warning applications, traffic information services, and a host of infotainment features and increasingly active safety features as well. The number of networked cars will rise 30 percent a year for the next several years; by 2020, one in five cars will be connected to the Internet. These cars will be in the premium segment (approximately 50 percent) and increasingly in the value segment as well, where many of them will have network solutions by 2020 (compared to 3 percent in 2011). Delivering services through the car – Internet radio, smartphone capabilities, information/entertainment services, driver-assistance apps, tourism information, and the like – is a promising area for future profits and differentiation. So is the creation of new technical features for safe, comfortable, and eventually, autonomous driving. To deliver on this, OEMs will have to manage shorter product and service development cycles, such as software and other technology updates. They will also need to build relationships with affiliated firms that build apps tailored to the car. Given that car owners spend about 50 minutes a day in their vehicles, there is a real opportunity to monetize digital media revenues and generate additional, highly profitable revenue streams. But again, the competition will be intense, particularly if new players from the non-automotive "digital arena" enter the market. Ultimately, end consumers will seek applications that make driving more convenient and a seamless element of their daily routines and lifestyles. This entire space is still in the early stages of development, both from a technology/service offerings perspective as well as from the perspective of the dominating players.

7. **Retail of the future comes closer** - With a few clicks, potential car buyers can already access a tremendous amount of information, and the volume and breadth of the material available on the Internet will only increase. In 2012, 70 percent of buyers stated the Internet as a major source for information gathering, displacing brochures, ads, and test reports. Five years ago, customers visited dealers an average of five times before purchasing a car; now they enter the showroom well-informed, giving the dealer one chance to turn the browser into a buyer. Dealerships are still important in decision making and in the customer's overall experiences but less so in the research and product comparison phases. This presents OEMs with contrasting challenges. On the one hand, they need to create a state-of-the-art Web presence that

provides customers with a digitally supported purchasing experience based on, for example, comparison tools, car configurators, and other online tools. On the other hand, they need to provide an engaging interaction and compelling experience across all touch points on the customer decision making journey and in the post-purchase experience. The path to purchase and the post-purchase experience are comprised of multiple touch points and are two of the most innovation-ripe areas for a truly superior customer experience. Innovative retail concepts, such as brand experience centers that feature high-tech digital, personalized visualization tools or “pop up” stores that advertise a specific product to create buzz, could help. This development would require joint investment from dealers and OEMs and intense cooperation to create a seamless experience for the customer throughout the pure online and digitally supported offline channels. Another cost-efficient strategy would be to establish an online presence to foster direct sales. Half of car buyers say they would make the transaction online as long as they got a test drive opportunity or an equivalent experience. OEMs will need to determine the best combination of online and offline touch points to shape the customer’s decision making and experience along the purchase journey. The rewards are great for those that get it right.

8. Suppliers add more value - *OEMs will have to manage rising production volumes – up to 70 percent in Asia by 2020. That means building a local supplier base, designing an enhanced supply chain, and bolstering supplier capacities. This is particularly important because the imperative to improve green mobility means that suppliers will become more important in terms of how much value they add, especially for the constantly improving ICE but also for the various electrified powertrain alternatives. On the one hand, conventional ICE-powered vehicles have to be optimized with the help of engine control systems, downsizing, and lightweight or automatic transmissions. On the other hand, there are the long-term possibilities of the various electric powertrain alternatives – and these have not been core competencies of most OEMs. They will need technological and logistical support to manage the long-term transition from ICEs to EVs or augmentation of ICE-based vehicles with electrified powertrain solutions, with increasing adoption to be expected beyond 2020, given tighter regulation requirements and continued technological progress. But OEMs could consider positioning themselves long-term in the areas of e-motor design and/or manufacturing, battery packaging, and* *integration. In addition, electronics and software will play a dominant role in vehicle innovation. Approximately 90 percent of automotive innovations in 2012 featured electronics and software, especially in active safety and infotainment options. Since those capabilities will be crucial, OEMs should consider solutions like developing "vertical partnerships" with their preferred suppliers. These would allow OEMs to cut R&D costs while also developing and implementing new features faster.*

9. The OEM battle intensifies - Europe is in a particularly difficult position because it is maintaining significant overcapacity, according to the European Automobile Manufacturers Association (EAMA). Moreover, a number of lower-cost brands have recently entered the market, heightening competition further. European OEMs have announced capacity reductions of 750,000 vehicles by 2015. But with regard to how the market is likely to develop, that may not be enough. If OEMs in Europe do not revise their production footprint beyond the announced capacity adjustments, it could be five years before the industry gets back to its precise utilization rate and related profitability levels. Similar challenges apply to OEMs in Japan and South Korea, where capacity adjustments have already been initiated. Closing a plant poses severe challenges on the people side, particularly given Europe's high and prolonged rates of unemployment. The recent history in North America, however, shows the possibilities of restructuring and its ultimate benefits. Though restructuring the industry was painful, sales and profits have rebounded. Capacity is running higher than before the crisis, and almost double that of 2009. Therefore, OEMs in Europe ought to revise their production footprint beyond the announced capacity adjustments.

1.2 Objective of the Study

The objective is to Develop and Analysis of a Model for Supplier Selection using Analytical Hierarchical Process: A Case of Automobile Industry"

Analytical Hierarchical Process (AHP) is one of the Multi Criteria Decision Making Techniques (MCDM) developed for prioritizing alternatives when multiple criteria must be considered and allows the decision maker to structure complex problems in the form of a hierarchy, or a set of integrated levels. This method incorporates qualitative and quantitative criteria. The hierarchy usually consists of three different levels, which include goals, criteria, and alternatives. Because AHP utilizes a ratio scale for human judgments, the alternatives weights reflect the relative importance of the criteria in achieving the goal of the hierarchy [13], [14].

One advantage of AHP is that it illustrates how possible changes in priority at upper levels have an effect on the priority of criteria at lower levels. Moreover, it provides the buyer with an overview of criteria, their function at the lower levels and goals as at the higher levels.

A further advantage of AHP is its stability and flexibility regarding changes within and additions to the hierarchy. In addition, the method is able to rank criteria according to the needs of the buyer which also leads to more precise decisions concerning supplier selection. The main advantage of AHP is that the buyer is able to get a reasonable idea of the supplier's performance by using the hierarchy of the criteria.

2.0 LITERATURE REVIEW

In most industries, the cost of raw materials and component parts represents the largest percentage of the total product cost. For instance, in high technology firms, purchased materials and services account for up to 80% of the total product cost. Therefore, selecting the right suppliers is the key to procurement process and represents a major opportunity for companies to reduce costs across its entire supply chain. Choosing the right method for supplier selection effectively leads to a reduction in purchase risk and increases the number of JIT suppliers and TQM production. Supplier selection problem has become one of the most important issues for establishing an effective supply chain system. For many years, the traditional approach to supplier selection has been to select suppliers solely on the basis of price. However, as companies have learned that the sole emphasis on price as a single criterion for supplier selection is not efficient, they have turned into to a more comprehensive multi-criteria approach. Recently, these criteria have become increasingly complex as environmental, social, political, and customer satisfaction concerns have been added to the traditional factors of quality, delivery, cost, and service. The realization that a well-selected set of suppliers can make a strategic difference to an organization's ability to provide continuous improvement in customer satisfaction drives the search for new and better ways to evaluate and select suppliers. The use of multiple suppliers provides greater flexibility due to the diversification of the firm's total requirements and fosters competitiveness among alternative suppliers. Keeping in view the strategic importance of the supplier's role in the functioning of supply chains the researchers have developed number of criteria, methods and models for supplier selection. The relevant literature has been thoroughly reviewed and presented below.

Weber et al. [1] reviewed, annotated, and classified 74 related articles which have appeared since 1966. Specific attention was given to the criteria and analytical methods used in the vendor selection process. In response to the increased interest in Just-In-Time (JIT) manufacturing strategies, and analysis of JIT's impact on vendor selection was also discussed by the authors.

Degraeve et al. [2] focused on a combinatorial auction where a bidder can express his preferences by means of a so called ordered matrix bid. Authors gave an overview of how this auction works and elaborated on the relevance of the matrix bid auction. The methods to verify whether a given matrix bid satisfies a number of properties related to microeconomic theory were developed. Finally, authors investigated how a collection of arbitrary bids can be represented as a matrix bid.

Tung and Torng [3] presented a fuzzy decision-making approach to deal with the supplier selection problem in supply chain system. In this work linguistic values are used to assess the ratings and weights for various factors. These linguistic ratings can be expressed in trapezoidal or triangular fuzzy numbers.

Then, a hierarchy multiple criteria decision-making (MCDM) model based on fuzzy-sets theory is proposed to deal with the supplier selection problems in the supply chain system. According to the concept of the TOPSIS, a closeness coefficient is defined to determine the ranking order of all suppliers by calculating the distances to the both fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) simultaneously.

Lewis [4] suggested that of all the responsibilities that related to purchasing, none was more important than the selection of a proper source. As long as supplier relationship management (SRM) concept is concerned, Companies are trying to build long-term and profitable relationships with suppliers. There has been an evolution in the role and structure of the purchasing function through the nineties. The purchasing function has gained great importance in the supply chain management due to factors such as globalization, increased value added in supply, and accelerated technological change.

Zeng [5] developed an integrated optimization framework for joint decisions of sourcing and lot sizing for sustaining time-based competitiveness. Author developed an optimization procedure that can be conveniently implemented on a spreadsheet to determine the optimal number of sources and the lot size and the sensitivity analysis shows that the impact of transportation on the sourcing and lot sizing decisions is significant.

Aissaoui, et al. [6] extended previous survey papers by presenting a literature review that covers the entire purchasing process, considers both parts and services outsourcing activities, and covers internet-based procurement environments such as electronic marketplaces auctions. In view of its complexity, authors focused especially on the final selection stage that consists of determining the best mixture of vendors and allocating orders among them so as to satisfy different purchasing requirements.

Tahriri et al. [7] state that in today's highly competitive environment, an effective supplier selection process is very important to the success of any manufacturing organization. Supplier selection is a multi-criterion problem which includes both qualitative and quantitative factors (criteria). A trade-off between these tangible and intangible factors is essential in selecting the best supplier. Authors further discussed and compared the advantages and disadvantages of different selection methods concerning supplier selection especially the Analytic Hierarchy Process (AHP).

Burton et al. [8] states that for many firms, purchases from outside vendors account for a large percentage of their total operating costs. The raw material purchased for most U.S. firms constitutes 40-60% of the unit cost of a product. For large automotive manufacturers, the cost of components and parts purchased from outside vendors may total more than 50% of sales. Purchased material and services represent up to 80% of total product costs for high technology firms.

Abrat at el. [9] analysed the buying behaviour of purchasers of high technology laboratory instrumentation process and identifies and determines the relative importance of the factors influencing supplier selection.

Lin et al. [10] identified the factors affecting the supply chain quality management. Authors observed that Quality Management (QM) practices are significantly correlated with the supplier participation strategy and this influences tangible business results, and customer satisfaction levels. It is further observed that QM practices are significantly correlated with the supplier selection strategy.

Gonzalez et al. [11] developed a methodology to analyse the variables involved in the supplier management process and it is illustrated with a case study of the chair manufacturing industry. The results indicate that the supplier selection process appears to be the most significant variable as it helps in achieving high quality products and customer satisfaction. Total four variables related to the supplier selection process were analysed. Each of these variables was then evaluated through an experimental design using statistical information based on three factors, namely, quality, cost and productivity.

Humphreys et al. [12] presented a framework for integrating environmental factors into the supplier selection process. Traditionally, companies consider factors like quality, flexibility, etc. when evaluating supplier performance. However, environmental pressure is increasing, resulting in many companies beginning to consider environmental issues and the measurement of their suppliers' environmental Performance. Authors developed a decision support tool which should help companies to integrate environmental criteria into their supplier selection process. Finally, a knowledge-based system is constructed based on the proposed framework.

3.0 RESEARCH METHODOLOGY

3.1 Introduction

As the stated objective of this project is to "Development and Analysis of a Model for Supplier Selection using Analytical Hierarchical Process: A Case of Automobile Industry"

Supplier Selection Criteria: Supplier selection process primarily is largely driven by the organizations sourcing strategy which in turn is a function of the overall final Product strategy of the organization (the Vehicle). The product strategy generally adopted in Indian automobile Industry:

1. Lowest Cost High Volume product: Tata Nano, Entry level compact cars and motorcycles. The cost is the key driver of these vehicles and among other criteria.
2. Low Cost and better quality product (Best value for money) product – Cars for middle class as target segment. These are loaded with adequate features and fits a range of pocket form Rs. 3 lacs to Rs.10 Lacs. Maruti is the leader in this segment with 41% of total car market share followed by Hyundai at 15%. Cost and quality becomes important for such vehicles
3. High quality high cost product – Under this strategy the organizations tries to woo the customer by cutting edge technology and quality. These are expensive products and generally contributes to around 2% of the overall Indian market

This project is based first two type of product strategies as with a car penetration of 4-5 cars per 1000 of people in India most of the automobile OEMs in India operate to satisfy the needs of the customers looking for such vehicles.

Automobile industry is a relative more organized industry in terms of best manufacturing practices, marketing practices, the one confronted with huge global challenges.

To arrive at the main criteria for supplier selection following method was used:

1. Literature review
2. Interviews with industry experts and best sourcing practices followed by them:

During the interactions with the experts who have worked with various reputed automobile OEMs the RFX* management process of three multinational Automobile OEMs (Original Equipment Manufacturers) were studied (OEMs have requested to maintain their confidentiality and also of the suppliers). The study of RFXs were in line with the literature review as described above. The various significant main criteria of supplier selection were found to be Cost, Quality, Delivery and Management which are considered in this study.

*NOTE – RFX is a group collection of documents used by OEM Purchasing teams to identify, evaluate and select suppliers. The documents mainly used are – Request For Information (RFI), Request For Proposal (RFP) and Request for Quotation (RFQ)

The data collection from the experts was in form of informal interviews over phone and personal visits. The informal set up of the interview and the condition of confidentiality gave the experts open up and their views along with examples from their day to day work and the rich experience they possessed.

Flow Chart for Research Methodology followed for the study

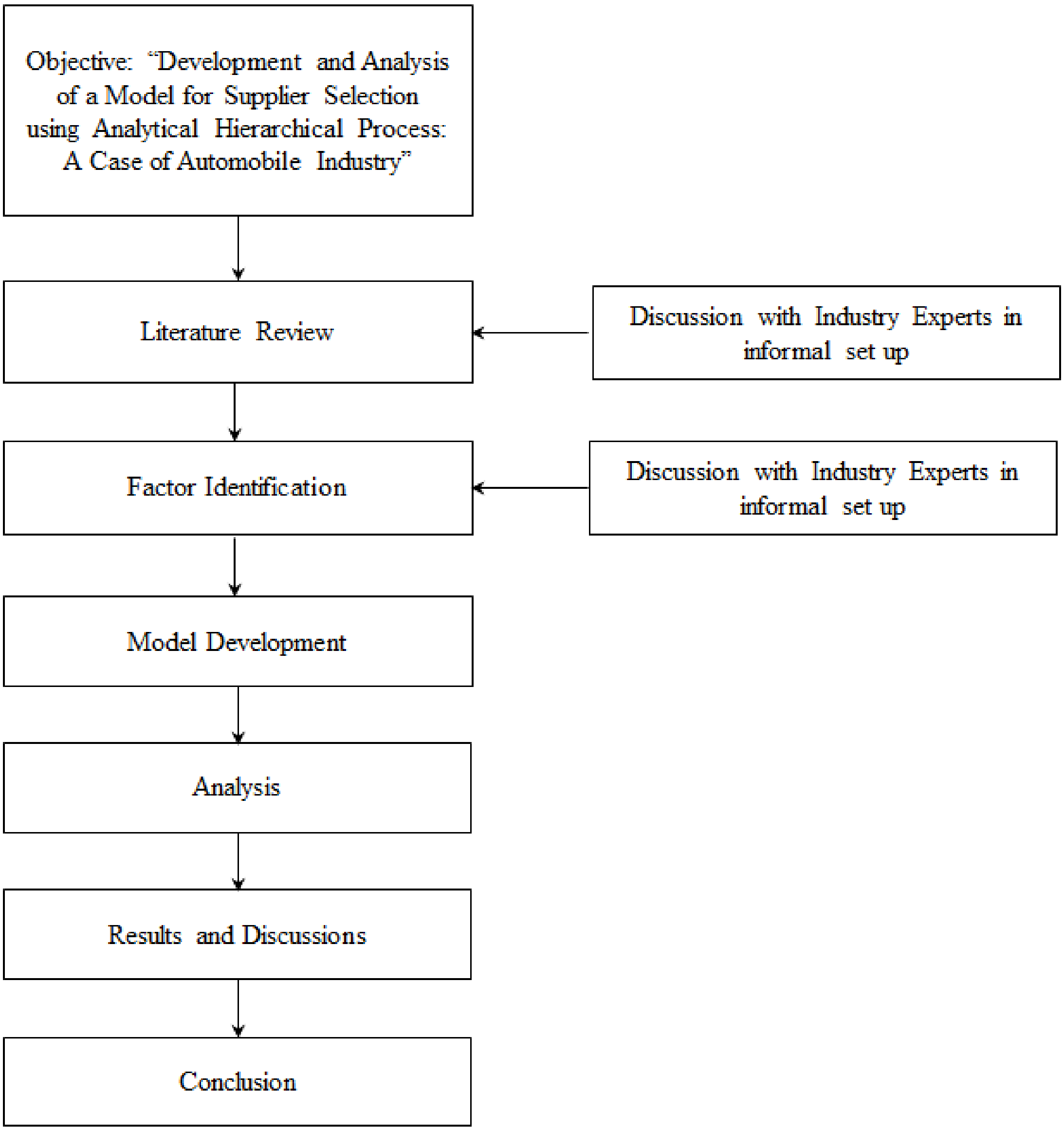

Figure -3.0 – Flow Chart

3.2 Analytical Hierarchical Process (AHP)

AHP, developed by Saaty, addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. The process makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria. The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities.

In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi criteria decision-making problem into a hierarchy of interrelated decision criteria, decision alternatives. With the AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure similar to a family tree. A hierarchy has at least three levels: overall goal of the problem at the top, multiple criteria that define alternatives in the middle, and decision alternatives at the bottom.

The second step is the comparison of the alternatives and the criteria. Once the problem has been decomposed and the hierarchy is constructed, prioritization procedure starts in order to determine the relative importance of the criteria within each level. The pairwise judgment starts from the second level and finishes in the lowest level, alternatives. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level. In AHP, multiple pairwise comparisons are based on a standardized comparison scale of nine levels. Table 1 shows the comparison scale.

Let C = {Cj |j = 1, 2,...., n} be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in an (n_n) evaluation matrix A in which every element aij (i,j = 1,2,..., n) is the quotient of weights of the criteria, as shown below in Figure-2.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ \vdots & \vdots & \vdots \\ a_{21} & a_{22} & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{nn} \end{bmatrix} \quad \text{such that, } a_{ii} = 1,\ a_{ji} = 1/\,a_{ij} \text{ and } a_{ij} \neq 0$$

Figure-3.1- Evaluation Matrix

At the last step, the mathematical process commences to normalize and find the relative weights for each matrix. The relative weights are given by the right eigenvector (w) corresponding to the largest Eigen value λmax as: Aw =λmax W.

If the pairwise comparisons are completely consistent, the matrix A has rank 1 and λmax = n. In this case; weights can be obtained by normalizing any of the rows or columns of A. It should be noted that the quality of the output of the AHP is strictly related to the consistency of the pairwise comparison judgments. The consistency is defined by the relation between the entries of A : aij*ajk = aik. The consistency index CI is: CI = (λmax – n)/(n-1)

The final consistency ratio (CR), usage of which let someone to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI) CR=CI/RI. The consistency ratio should be less than 0.1.

Definition	**Intensity of Importance**
Equally Important	1
Moderately more important	3
Strongly more important	5
Very strong more important	7
Extremely more important	9
Intermediate values	2,4,6,8

Table-3.1 Saaty’s scale of relative importance

4.0 MODEL DEVELOPMENT AND ANALYSIS

4.1 Steps for Model development

In order to select the right supplier, the model is needed to develop the AHP approach. The methodology has been adopted from approaches mentioned in the literature review. The following steps could be applied by any Automotive OEM in order to choose the supplier that is more appropriate than others after collecting quantitative and qualitative data for the AHP supplier selection model:

STEP-1 – DEFINE CRITERIA FOR SUPPLIER SELECTION

The first step in any supplier rating procedure is to find the appropriate criteria to be used for assessing the supplier. To comply with the criteria for supplier selection and their importance, required data were collected based on the consideration of literature. Based on considering the studies Tahriri [7] and Industry best practices Four important criteria were selected. The criteria were selected are the most criteria used mostly in the Automobile Industry.

In addition, the presence of too many criteria makes the pair-wise comparisons in Evaluating suppliers a difficult and time consuming process. To overcome these Problems, the cut-off value to reduce the number of criteria to a few is desirable finally, the four important criteria were selected are:

1. Quality
2. Cost
3. Delivery
4. Management

They were selected at level (2) in supplier selection model (The goals main criteria in Level (1) for supplier selection model is to select the best overall supplier).

STEP-2 – DEFINE SUB CRITERIA FOR SUPPLIER SELECTION

In this step, the definition of the sub-criteria has been done for supplier selection based on the four important criteria selected as the results of the previous step with the consideration of literature.

After discussions with Industry experts a chunk of various significant criteria and sub-criteria were selected. The sub criteria along with a brief description if each is mentioned below:

1. Cost
   1.1 Net Price
   1.2 Delivery Cost
   1.3 Ordering Cost
   1.4 Overheads
2. Quality
   2.1 Customer Rejections
   2.2 Field returns
   2.3 Quality Certifications
   2.4 Overall standard deviation (Process)
3. Delivery
   3.1 Delivery lead time
   3.2 Percentage of late delivery
   3.3 Percentage order quantity fulfilment
   3.4 Network nodes
4. Management
   4.1 Professionally managed
   4.2 Responsiveness
   4.3 Strategic alliance
   4.4 Procedural compliance

Brief description of the sub—criteria

1.1 Net Price:

Automobile Industry today is one of the most competitive industries in the world today. The OEMs are fighting to hold on to their positions in the market place by keeping a check on the increasing input costs. Supplier community is the one that is affected the most by this and is under tremendous pressure to contain price of their products. The OEM Purchasing teams are always on a lookout for suppliers to identify opportunities for cost reduction and this in return pushes suppliers to innovate. Innovate to bring the net price down or counter the price increase due to increasing input costs. This cost sensitivity leads to make Net Price as one of the important factors of supplier selection.

1.2 Delivery Cost

The Net price is the Ex-works price that does not include the logistics cost which comprises of packaging cost, transportation cost, warehousing cost. These costs build up on the Net price so for a simple product the net prices of 2 suppliers may be exactly the same, it is the delivery cost that makes a difference between award of business to one of the suppliers. The OEM is equally concerned about the Delivery cost as it is about the Net price since it is supposed the bear the delivery cost as well (the OEM pays for the landed cost) if the delivery is in OEM’s scope of contract. It is because of this that the OEMs prefers to buy from the supplier with less delivery cost even if the Net price from two suppliers is the same.

1.3 Ordering Cost

Ordering costs are costs of ordering a new batch of raw materials. These include cost of placing a purchase order, costs of inspection of received batches, documentation costs, etc. It is desirable to deal with a supplier with low ordering costs.

1.4 Overheads

Like delivery cost, total cost structure of different suppliers vary. The direct costs may be close but the indirect costs could be very different. A supplier with leaner organizational set up is more likely to have lower overhead cost as compared to the supplier with a heavier organizational set up. The later would have higher overhead cost which will ultimately be built in part cost and shall make the part price higher or less competitive. Some organizations have a policy to charge a fixed percentage of the sales as the overhead cost. This situation may need intervention from the top management of the supplier organization.

2.1 Customer Rejections:

Quality assessment is a key factor of suppliers by which they can improve and maintain quality and delivery performance. It is very important for the company and suppliers. Quality and availability of product depends on this criterion. This factor has been measured on the basis of the importance of the following quality dimensions: management commitment, product development of suppliers, process improvement of suppliers, quality planning and quality assurance in supply chain, quality assessment in production, inspection and experimentation and quality staff of supplier. The rejection rate of the product is defined in the terms of the number of parts rejected by the customers in fixed time period because of some quality problems. It also includes the defective parts detected in the incoming products. This encounters the issues like whether or not the frequent quality assessment of the parts has been done by the Supplier

2.2 Field Returns

Field returns and warranty issues not only is a big cost to the OEM but also it hampers the reputation of the organization. The end user becomes sceptical for early field failures with regards to the performance of the product. Hence, this assumes a greater role in supplier selection criteria primarily for proprietary parts.

2.3 Quality Certifications

Although quality is a practice that needs to be built in every single thing that an organization does. Quality not only in manufacturing of the product but also in design, its processes and allied processes. The supplier organization also needs to be responsible towards the quality of the environment it operates. It is important for the supplier organization to be certified for Process quality, standards and environment. In case of automotive supplier it is required to have the following certifications atleast like – ISO 9001:2000, TS 16949, ISO 14001, OHSAS. The other desirable certifications are TPM, Deming Award

(ISO- International Organization of Standards; TS – Technical Standards, OHSAS- Organizational Health and Safety Assessment Series)

2.4 Overall Standard Deviation

It is desirable that the supplier organization is competent enough to build parts to the required quality as per the OEM. It is also required that the quality is met without much emphasis on the Finish goods inspection. It is not a healthy situation where the supplier FG rejection are very high even if the supplier is managing to supply 100% OK parts to the customer. The customer sees this as a huge risk hence demands the manufacturing processes should be so designed to produce high quality parts accurately and consistently. It is therefore important to have the processes robust enough that does not demand FG inspection. Today, the OEMs wants that the processes responsible for Critical to quality dimension of parameter should operate at 6 sigma levels hence the standard deviation of the processes should be at least be 6 times the difference between the process mean and the specification limits.

3.1 Delivery lead time:

This is the time between order and placement of material and the actual delivery. The shorter the lead time, the better the supplier. Every purchasing firm will be comfortable when the lead time is shortest possible. Long lead time has the impression that the specific supplier is less efficient or he just has more customers than he can serve thus delaying deliveries.

3.2 Percentage of late deliveries (Delivery Performance)

Delivery performance is a key criteria to measure supplier’s service levels, this gains more importance in the current environment of high demand volatility. Therefore, it is important for an OEM to have a supplier partner who can align to market demand and adjust delivery service levels as per the OEM’s requirement 100% of the time. Any missed delivery has the potential to cause manufacturing line stoppage at OEM causing huge operational and market loss.

3.3 Percentage order fulfillment

Customer requirement doesn't get fulfilled by just meting the delivery date as per the purchase order, the order quantity also needs to be met in full to ensure the OEM doesn't suffer any loss due to material unavailability.

3.4 Network nodes

Assembly line stoppage at OEM due to any reason is an acceptable situation to be in. While some of the reasons are beyond immediate control some can be take care off during the supplier section stage. As bulk of the volumes of material is transported via road transport within India, higher network nodes is considered as potential risk to the supplies. Hence an OEM would like to have a supplier Warehouse near to the OEM wherein the safety stocks are maintained to insulate the supplier from rad disruptions caused by poor road conditions, transporters strikes etc.

4.1 Professionally managed

Indian Tier-1 supplier organizations started as family owned and managed businesses. As the integration between the supplier and OEM increased a need was felt to have professionals manage the supplier firms. This transition primarilily happened to separate ownership from the organization so that corporate governance principles can be implemented and professionals from automotive industry can lead the supplier firms as they have a better hang of automotive businesses, future outlook, processes etc. Therefore the OEMs prefer to deal with supplier firms which are professionally managed.

4.2 Responsiveness

Time is of the essence and with supply chain chains getting complex by each passing day the chances of errors are also increasing. The reasons could be any from the listed ones like – Human errors, communications failure, IT system breakdown etc. What is important is how quickly the normalcy is attained. This depends upon the responsiveness of the supplier organization to play their part in fixing up the issues in a highly responsive way. This could be personal visits, video conferencing, raw material expediting. The OEMs prefers to work with responsive suppliers so that the failure of any kind can be fixed in the shortest possible time and the normalcy be restored.

4.3 Strategic Alliances

LCC sourcing (Low Cost Country) comes up with a challenge of supplier maturity in terms of technological limitations. The local suppliers of these developing economies have a reasonable command over manufacturing the product through "build to print" which mean they will be able to manufacture the parts as per the drawing however, if any input on the design of functionality of the part is required they generally have limitations in this context. The OEMs these days look for suppliers who are expert of the product technology not just manufacturing and they want system suppliers who they can collaborate with in the early stages of vehicle idea conception and develop a product as per the required needs. For this, the local suppliers borrows technological capabilities by forming strategic alliances with global leaders of technology. This provides them with the advantage of getting in engaged with the OEM during early stages of the product development a few examples in this regards are – Shriram Pistons and Rings Limited a leading Indian automotive Tier-1 has formed strategic alliances with Kolbenschmidt of Germany for Pistons and Riken Corporation of Japan for Piston Rings. RICO and Indian Tier-1 has formed a Strategic alliance with FCC for clutches. FCC is a leader in Clutch technology. Sona Steering Limited a leading Tier-1 in steering systems has a strategic alliance with Koyo of Japan,

4.4 Procedural Compliances

The OEM wants the suppliers to have all procedural compliances well in place so that there are no supply disruptions due to non-compliances on the part of the supplier be it commercial, legal, environmental, human resource etc.

4.2 Hierarchy based model for supplier selection

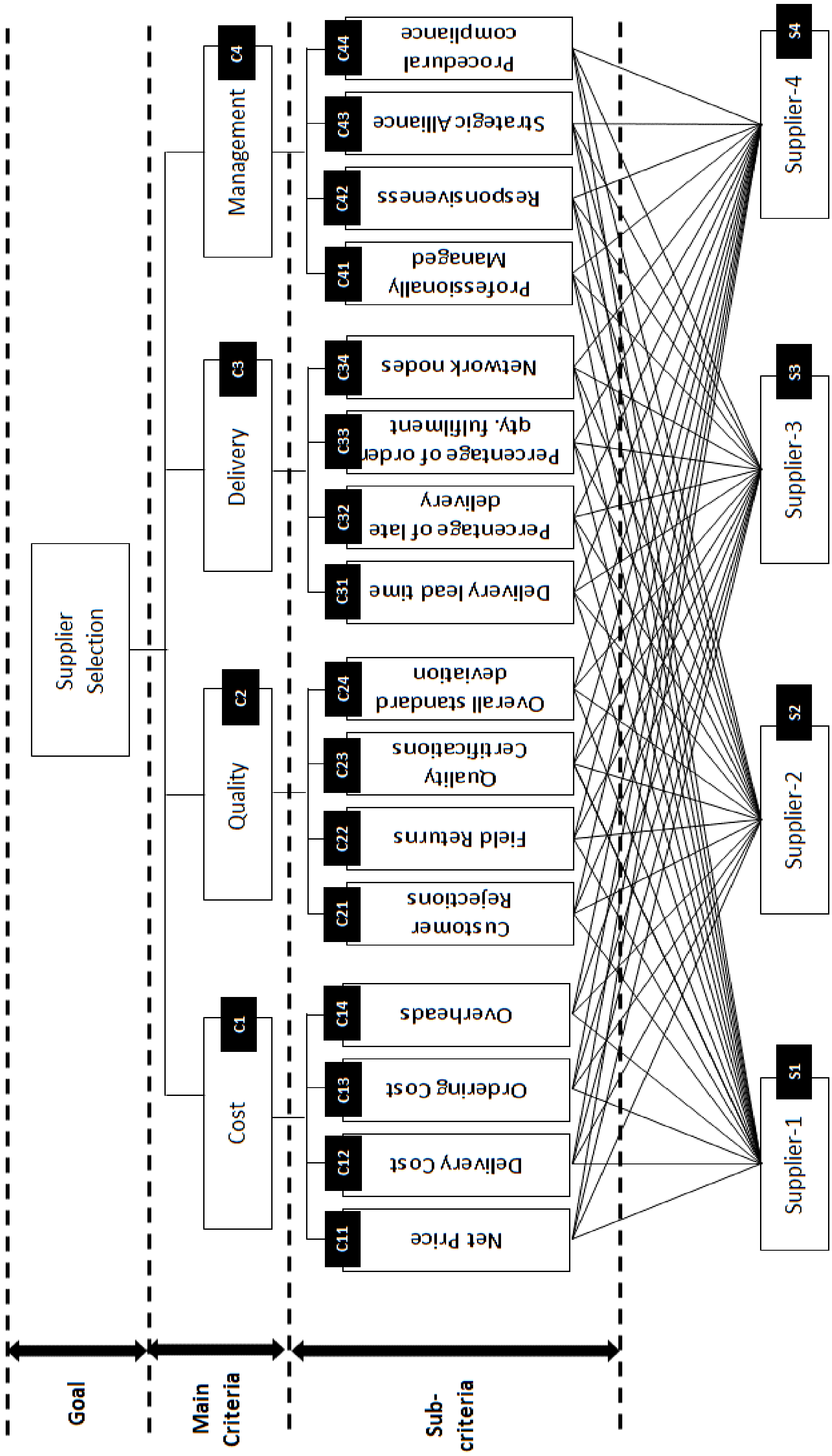

Figure-4.1– Hierarchy based model for Supplier Selection

To complete the model at this stage, the priority weight of each criterion in each level was determined. A second structure, an interview consisting of all factors in each level of the AHP model is used to collect the pair-wise comparison judgments from all evaluation team members. This approach is found to be very useful in collecting data. This determination is performed through using pair-wise comparisons. The function of the pair-wise comparisons is by finding the relative importance of the criteria and sub criteria which is rated by the five-point scale proposed by Saaty (1980), as shown in Table 3.1, which indicates the level of relative importance from equal, moderate, strong, very strong, to extreme level by 1, 2, 3, 4, and 5, respectively.

Sample of pair-wise comparison matrix shows that the entry for the fourth row and the fourth column gives the importance of that row's criterion relative to the column's criterion as shown in Table 2.

Table -4.1 Pair-wise comparison matrix for criteria

Criteria for supplier selection	C1	C2	C3	C4
Quality (C1)	1	2	3	4
Cost (C2)	1/2	1	2	1
Delivery (C3)	1/3	1/2	1	2
Management (C4)	1/4	1	1/2	1

Table-4.2 Paired comparison matrix in decimal for with priority weights

	C1	**C2**	**C3**	**C4**	**GMj**	**WEIGHT**
C1	1.00	2.00	3.00	4.00	2.2134	0.4848
C2	0.50	1.00	2.00	1.00	1.0000	0.2190
C3	0.33	0.50	1.00	2.00	0.7579	0.1660
C4	0.25	1.00	0.50	1.00	0.5946	0.1302
				SUM	4.5659	1.0000

Consistency Index (C.I) – 0.0554

Consistency Ratio (C.R.) – 0.0616

The consistency ratio (C.R.) for the comparison above is calculated to determine the acceptance of the priority weighting. The consistency test is one of the essential features of the AHP method which aims to eliminate the possible inconsistency revealed in the criteria weights, through the computation of consistency level of each matrix. The software system called Expert Choice is used to determine the normalized priority weights. The consistency ratio (CR) was used to determine and justify the inconsistency in the pair-wise comparison made by the respondents. Based on Saaty's (1980) empirical suggestion that a C.R. = 0.10 is acceptable, it is concluded that the foregoing pair-wise comparisons to obtain attribute weights are reasonably consistent.

If the CR value is lower than the acceptable value, the weight results are valid and consistent. In contrast, if the CR value is larger than the acceptable value, the matrix results are inconsistent and are exempted for the further analysis. The pairwise comparisons were done to establish hierarchical relationships.

4.3 Numerical Illustration and Analysis

Table-4.3 Pairwise comparison of sub criteria of C1

C1	C11	C12	C13	C14	GMj	WEIGHT
C11	1.00	5.00	4.00	0.50	1.7783	0.3628
C12	0.20	1.00	0.50	0.33	0.4262	0.0870
C13	0.25	2.00	1.00	0.33	0.6373	0.1300
C14	2.00	3.00	3.00	1.00	2.0598	0.4202
				SUM	4.9016	1.0000

Consistency Index (C.I) – 0.0638

Consistency Ratio (C.R.) – 0.0709

Table-4.4 Pairwise comparison of sub criteria of C2

C2	C21	C22	C23	C24	WEIGHT
C21	1.00	2.00	5.00	4.00	0.4943
C22	0.50	1.00	3.00	3.00	0.2863
C23	0.20	0.33	1.00	0.25	0.0704
C24	0.25	0.33	4.00	1.00	0.1490
				SUM	1.0000

Consistency Index (C.I) – 0.0723

Consistency Ratio (C.R.) – 0.0803

Table-4.5 Pairwise comparison of sub criteria of C3

C3	C31	C32	C33	C34	WEIGHT
C31	1.00	0.33	0.33	5.00	0.1959
C32	3.00	1.00	0.25	2.00	0.2524
C33	2.00	3.00	1.00	3.00	0.4699
C34	0.20	0.25	0.33	1.00	0.0818
				SUM	1.0000

Consistency Index (C.I) – 0.0717

Consistency Ratio (C.R.) – 0.0796

Table-4.6 Pairwise comparison of sub criteria of C4

C4	C41	C42	C43	C44	WEIGHT
C41	1.00	0.20	3.00	0.33	0.1348
C42	5.00	1.00	4.00	2.00	0.5082
C43	0.33	0.25	1.00	0.50	0.0911
C44	3.00	0.50	2.00	1.00	0.2659
				SUM	1.0000

Consistency Index (C.I) – 0.0855

Consistency Ratio (C.R.) – 0.0950

Table-4.7 Pairwise comparison of Suppliers with respect to sub criteria C11

C11	S1	S2	S3	S4	WEIGHT
S1	1.00	5.00	3.00	4.00	0.6020
S2	0.20	1.00	2.00	3.00	0.1798
S3	0.33	0.50	1.00	2.00	0.1339
S4	0.25	0.33	0.50	1.00	0.0843
				SUM	1.0000

Consistency Index (C.I) – 0.0820

Consistency Ratio (C.R.) – 0.0911

Table-4.8 Pairwise comparison of Suppliers with respect to sub criteria C12

C12	S1	S2	S3	S4	WEIGHT
S1	1.00	4.00	3.00	3.00	0.5137
S2	0.25	1.00	2.00	3.00	0.2321
S3	0.33	0.50	1.00	1.00	0.1337
S4	0.33	0.33	1.00	1.00	0.1205
				SUM	1.0000

Consistency Index (C.I) – 0.0620

Consistency Ratio (C.R.) – 0.0689

Table-4.9 Pairwise comparison of Suppliers with respect to sub criteria C13

C13	S1	S2	S3	S4	WEIGHT
S1	1.00	2.00	4.00	3.00	0.4690
S2	0.50	1.00	2.00	3.00	0.2789
S3	0.25	0.50	1.00	2.00	0.1498
S4	0.33	0.33	0.50	1.00	0.1024
				SUM	1.0000

Consistency Index (C.I) – 0.0301

Consistency Ratio (C.R.) – 0.0334

Table-4.10 Pairwise comparison of Suppliers with respect to sub criteria C14

C14	S1	S2	S3	S4	WEIGHT
S1	1.00	3.00	1.00	2.00	0.3465
S2	0.33	1.00	0.33	2.00	0.1513
S3	1.00	3.00	1.00	3.00	0.3835
S4	0.50	0.50	0.33	1.00	0.1187
				SUM	1.0000

Consistency Index (C.I) – 0.0368

Consistency Ratio (C.R.) – 0.0409

Table-4.11 Pairwise comparison of Suppliers with respect to sub criteria C21

C21	S1	S2	S3	S4	WEIGHT
S1	1.00	5.00	3.00	5.00	0.5684
S2	0.20	1.00	2.00	4.00	0.2172
S3	0.33	0.50	1.00	1.00	0.1231
S4	0.20	0.25	1.00	1.00	0.0913
				SUM	1.0000

Consistency Index (C.I) – 0.0865

Consistency Ratio (C.R.) – 0.0961

Table-4.12 Pairwise comparison of Suppliers with respect to sub criteria C22

C22	S1	S2	S3	S4	WEIGHT
S1	1.00	0.50	1.00	3.00	0.2369
S2	2.00	1.00	3.00	4.00	0.4737
S3	1.00	0.33	1.00	2.00	0.1929
S4	0.33	0.25	0.50	1.00	0.0965
				SUM	1.0000

Consistency Index (C.I) – 0.0124

Consistency Ratio (C.R.) – 0.0138

Table-4.13 Pairwise comparison of Suppliers with respect to sub criteria C23

C23	S1	S2	S3	S4	WEIGHT
S1	1.00	0.33	4.00	2.00	0.2762
S2	3.00	1.00	2.00	4.00	0.4795
S3	0.25	0.50	1.00	2.00	0.1532
S4	0.50	0.25	0.25	1.00	0.0911
				SUM	1.0000

Consistency Index (C.I) – 0.0863

Consistency Ratio (C.R.) – 0.0959

Table-4.14 Pairwise comparison of Suppliers with respect to sub criteria C24

C24	S1	S2	S3	S4	WEIGHT
S1	1.00	2.00	4.00	5.00	0.5144
S2	0.50	1.00	1.00	3.00	0.2264
S3	0.25	1.00	1.00	2.00	0.1720
S4	0.20	0.33	0.50	1.00	0.0872
				SUM	1.0000

Consistency Index (C.I) – 0.0181

Consistency Ratio (C.R.) – 0.0959

Table-4.15 Pairwise comparison of Suppliers with respect to sub criteria C31

C31	S1	S2	S3	S4	WEIGHT
S1	1.00	0.20	2.00	4.00	0.2136
S2	5.00	1.00	3.00	5.00	0.5590
S3	0.50	0.33	1.00	3.00	0.1593
S4	0.25	0.20	0.33	1.00	0.0681
				SUM	1.0000

Consistency Index (C.I) – 0.0811

Consistency Ratio (C.R.) – 0.0901

Table-4.16 Pairwise comparison of Suppliers with respect to sub criteria C32

C32	S1	S2	S3	S4	WEIGHT
S1	1.00	0.20	2.00	1.00	0.1664
S2	5.00	1.00	3.00	3.00	0.5418
S3	0.50	0.33	1.00	1.00	0.1333
S4	1.00	0.33	1.00	1.00	0.1585
				SUM	1.0000

Consistency Index (C.I) – 0.0442

Consistency Ratio (C.R.) – 0.0491

Table-4.17 Pairwise comparison of Suppliers with respect to sub criteria C33

C33	S1	S2	S3	S4	WEIGHT
S1	1.00	0.33	3.00	4.00	0.2791
S2	3.00	1.00	5.00	3.00	0.5125
S3	0.33	0.20	1.00	2.00	0.1193
S4	0.25	0.33	0.50	1.00	0.0892
				SUM	1.0000

Consistency Index (C.I) – 0.0800

Consistency Ratio (C.R.) – 0.0889

Table-4.18 Pairwise comparison of Suppliers with respect to sub criteria C34

C34	S1	S2	S3	S4	WEIGHT
S1	1.00	0.50	1.00	3.00	0.2369
S2	2.00	1.00	3.00	4.00	0.4737
S3	1.00	0.33	1.00	2.00	0.1929
S4	0.33	0.25	0.50	1.00	0.0965
				SUM	1.0000

Consistency Index (C.I) – 0.0124

Consistency Ratio (C.R.) – 0.0138

Table-4.19 Pairwise comparison of Suppliers with respect to sub criteria C41

C41	S1	S2	S3	S4	WEIGHT
S1	1.00	0.50	5.00	3.00	0.3214
S2	2.00	1.00	4.00	5.00	0.4884
S3	0.20	0.25	1.00	1.00	0.0918
S4	0.33	0.20	1.00	1.00	0.0984
				SUM	1.0000

Consistency Index (C.I) – 0.0240

Consistency Ratio (C.R.) – 0.0266

Table-4.20 Pairwise comparison of Suppliers with respect to sub criteria C42

C42	S1	S2	S3	S4	WEIGHT
S1	1.00	1.00	4.00	3.00	0.3868
S2	1.00	1.00	3.00	4.00	0.3868
S3	0.25	0.33	1.00	2.00	0.1325
S4	0.33	0.25	0.50	1.00	0.0940
				SUM	1.0000

Consistency Index (C.I) – 0.0267

Consistency Ratio (C.R.) – 0.0296

Table-4.21 Pairwise comparison of Suppliers with respect to sub criteria C43

C43	S1	S2	S3	S4	WEIGHT
S1	1.00	0.25	0.33	1.00	0.1140
S2	4.00	1.00	2.00	3.00	0.4707
S3	3.00	0.50	1.00	2.00	0.2799
S4	1.00	0.33	0.50	1.00	0.1355
					1.0000

Consistency Index (C.I) – 0.0087

Consistency Ratio (C.R.) – 0.0096

Table-4.22 Pairwise comparison of Suppliers with respect to sub criteria C44

C44	S1	S2	S3	S4	WEIGHT
S1	1.00	1.00	2.00	3.00	0.3252
S2	1.00	1.00	4.00	5.00	0.4394
S3	0.50	0.25	1.00	2.00	0.1469
S4	0.33	0.20	0.50	1.00	0.0886
					1.0000

Consistency Index (C.I) – 0.0209

Consistency Ratio (C.R.) – 0.0232

Table-4.23 Priority weight of Suppliers with respect to main criteria C1 (Cost)

C1	C11	C12	C13	C14	PRIORITY VECTOR
	0.3224	0.1848	0.2747	0.2180	
S1	0.3187	0.2716	0.3501	0.2681	0.3076
S2	0.1688	0.2252	0.1645	0.1351	0.1707
S3	0.2143	0.3163	0.2484	0.4549	0.2949
S4	0.2982	0.1869	0.2370	0.1419	0.2267

Similarly we can summarize the priority weights of suppliers with respect to main criteria C2 (Quality), C3 (Delivery) and C4 (Management) as give in Table-25

Table-4.24 Summary of priority weights of suppliers with respect to main criteria C2, C3 and C4

C2,C3 and C4	PRIORITY WEIGHTS		
	C2	C3	C4
S1	0.3818	0.3332	0.3236
S2	0.1176	0.1131	0.2413
S3	0.2349	0.3052	0.2954
S4	0.2658	0.2486	0.1398

Table-4.25 Final Summary

GOAL	C1	C2	C3	C4	PRIORITY VECTOR
	0.4849	0.2140	0.2643	0.0288	
S1	0.3075588	0.3818	0.3332	0.3236	0.3282
S2	0.170678	0.1176	0.1131	0.2413	0.1448
S3	0.2949462	0.2349	0.3052	0.2954	0.2825
S4	0.2267169	0.2658	0.2486	0.1398	0.2365

4.4 Results and Discussions

The Final summary of numerical illustration and analysis in Table-4.25 reveals the Final score of the suppliers as per the model developed. The same is replicated here for ready reference in Table-4.26

Table-4.26 Final Weight

Supplier	Final Weight
S1	0.3282
S2	0.1448
S3	0.2825
S4	0.2365

From the table above it is evident that on the selected and main sub criteria Supplier S1 has the highest priority weights hence, ranked 1st among the 4 suppliers considered. As a result of which it will be appropriate to award business to supplier S1. However, in case the OEM has a multiple supplier sourcing strategy in that case, suppliers S3 and S4 can also be selected. In this case as a de risking strategy the total buy can be split between suppliers S1, S3 and S4 with supplier S1 having the highest share of business.

Further, the priority weights of sub criteria are represented in Figure-4.1 shows that out of the 16 sub criteria C41 has the highest weightage followed by Delivery lead time, Net Price, Delivery price and cost. This shows that the suppliers with strong management and high customer service levels preferred over price.

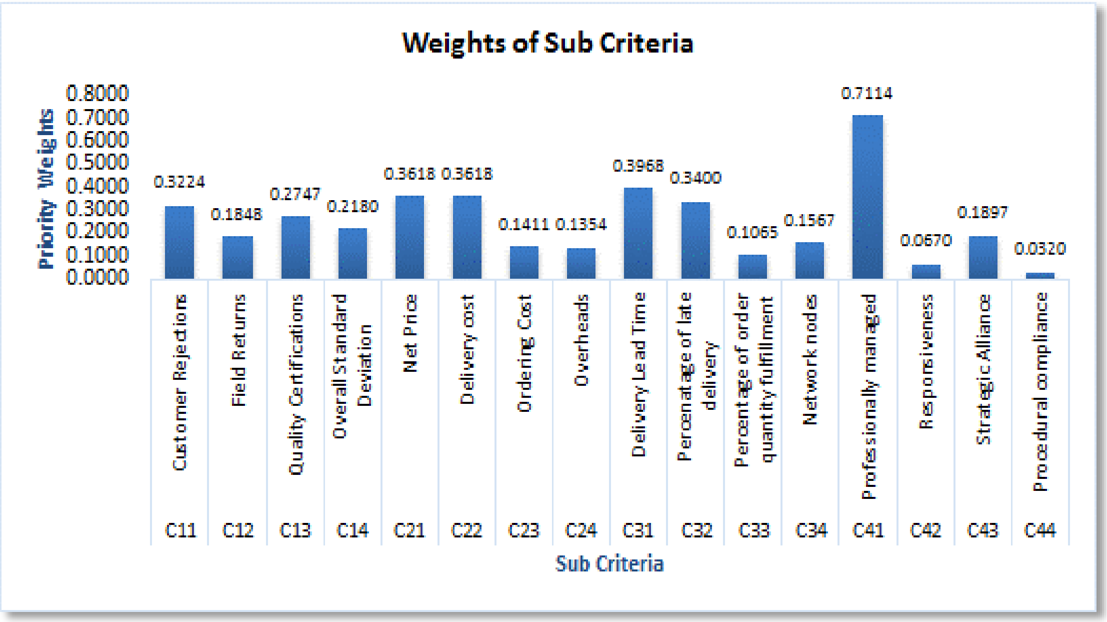

Figure-4.1 Representation of weights of all sub criteria

Final prioritization of considered suppliers S1, S2, S3 and S4 is represented in Figure-4.2, showing S1 has the highest priority weights followed by supplier S3, S4 and S2

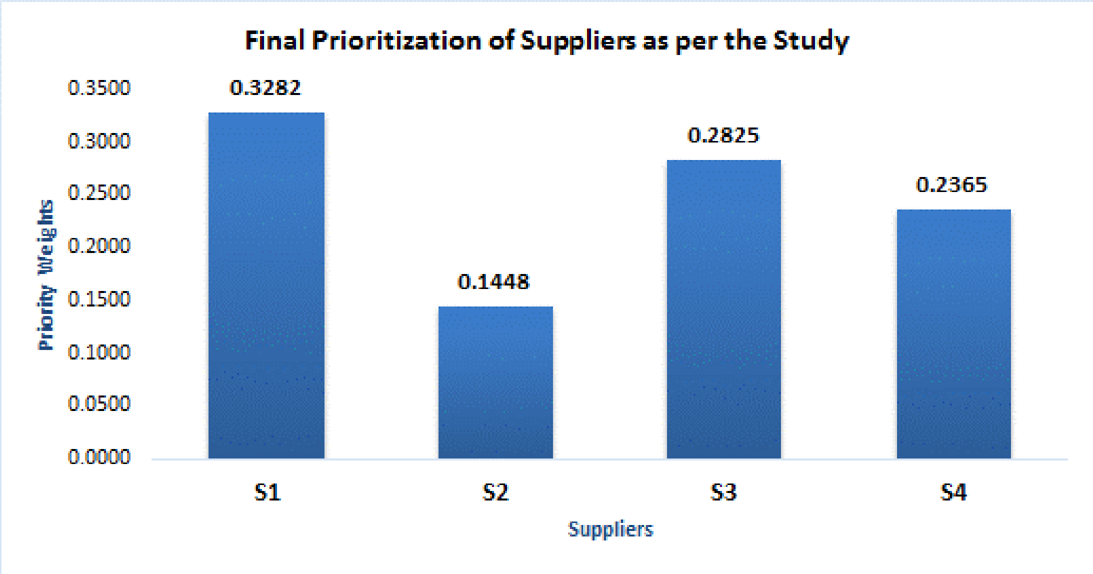

Figure-4.2 Final Prioritization of the suppliers

4.5 Limitations of the study

The study carried out weighs highly on the inputs on the inputs provided by the Industry experts which primarily were form the Strategic sourcing functions of the OEMs. The study lacks the inputs of the operations heads in terms of the challenges that they face with the chosen suppliers. Since the study was limited to the OEMs in India, it may lack representation of global needs and practices as the experts interviewed may have answered to questions relating to the practices they follow and the immediate problems that they face with the supplier base. A global representation of experts may suggest one or two different main criteria than those considered in the study.

The study is limited to automobile industry based on the challenges and practices followed in the automobile industry. The practices and challenges of other industry (s) are different hence it cannot be replicated as it is.

5.0 REFERENCES

[1] Weber, C. A., Current, J. R. and Benton, W. C., "Vendor Selection Criteria and Methods", European Journal of Operational Research, 50 (1991) 2-18.

[2] Degraeve, Z., Labro, E., Roodhooft, F., "An evaluation of supplier selection methods from a Total Cost of Ownership perspective" European Journal of Operational Research 125, 1(2000) 34-59.

[3] Chen-Tung, C. and Ching-Torng, L., "A fuzzy approach for supplier evaluation and selection in supply chain management", Production Economics, 102 (2006) 289 301.

[4] Lewis, H.T., Industrial purchasing principles and practices. Chicago:Richard D. Irwin (1943).

[5] Zeng, A.Z., "Single or multiple sourcing: an integrated optimization framework for sustaining time-based competitiveness", Journal of Marketing Theory and Practice, 6(1998) 10-21.

[6] Aissaoui, N., M. Haouari and E. Hassini, "Supplier selection and order lot sizing modeling: A review", Computers & Operations Research, 34 (2007) 3516-3540.

[7] Tahriri, F., Osman, M.R., Ali,A. and Yusuff, R.M., "A review of supplier selection methods in manufacturing industries", Suranaree J. Sci. Technol., 15(3)(2008) 201-208.

[8] Burton, T.T. "JIT/repetitive sourcing strategies: Tying the knot with your suppliers", Production and Inventory Management Journal (1988) 38-41.

[9] Abratt, R., "Industrial buying in high-tech markets", Industrial Marketing Management, 15(4) (1986) 293-298.

[10] Lin, C., Chow, W. S., Madu, C. N., Kuei, C.-H. and Yu, P. P. , "A structural equation model of supply chain quality management and organizational performance", International Journal of Production Economics, 96(3) (2005) 355-365.

[11] Gonzalez, M. E., Quesada, G. and Monge, C. A. M., "Determining the importance of the supplier selection process in manufacturing: a case study", International Journal of Physical Distribution & Logistics Management, 34(6) (2004) 492-504.

[12] Humphreys, P. K., Wong, Y. K. and Chan, F. T. S., "Integrating environmental criteria into the supplier selection process", Journal of Materials Processing Technology, 138(1-3) (2003) 349-356.

[13] Saaty, T. L., "Fundamentals of Analytical Process", ISAHP 1999, Kobe, Japan, Aug 12 – 14, 1999.

[14] Elanchezhian, C., Vijaya Ramnath, B., and Dr. R. Kesavan, "Vendor Evaluation Using Multi Criteria Decision Making", International Journal of Computer Applications 5 (9) (2010) 0975 – 8887.

[15] Maggie C.Y. Tam, Tummala V.M. Rao, “An application of the AHP in vendor selection of a telecommunications system” International Journal of Management Science