VENDOR SELECTION- AN INSIGHT OF METHODS

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Abstract

The objective of a collaborative supply chain is to gain competitive advantage, by improving overall performance through taking a holistic perspective of the supply chain. Modeling the constituents of a collaborative supply chain, the key parameters they influence, and the appropriate performance measures in a decision support environment enables prior understanding of the impact on the performance of a collaborative supply chain as a result of changes in the constituents and key parameters. In turn, this allows pinpointing of those areas where the actual supply chain can be improved and hence manage the chain's performance. This research proposal aims at reviewing the different criteria in supplier selection. The various methodologies are studied here. Further the research methodology of developing a collaborative framework is proposed.

Index Terms: Supply Chain Management, Supplier Selection, Supplier Performance.

I. INTRODUCTION

Supplier selection is a fundamental issue in the supply chain which heavily contributes to the overall supply chain performance. Companies who spend a high percentage of their sales revenue on parts and material supplies, and whose material costs represent a larger portion of total costs, savings from supplies are of particular importance. These situations require more systematic and transparent approach to purchase decision making, especially regarding the area of supplier selection. Carefully selecting the suppliers significantly reduces the purchasing cost and improves corporate competitiveness which is why many experts believe that supplier selection is the most important activity of a purchasing department. Supplier selection is the process by which suppliers are reviewed, evaluated and chosen to become part of the company's supply chain.

The contemporary supply management is to maintain long term partnership with suppliers, and use fewer but reliable suppliers. Therefore, choosing the right suppliers involves much more than scanning a series of price list and choices, will depend on a wide range of factors which involve both quantitative and qualitative. Extensive multi-criteria decision making approaches have been proposed for supplier selection, such as the analytic hierarchy process (AHP), analytic network process (ANP), case-based reasoning (CBR), data envelopment analysis (DEA), fuzzy set theory, genetic algorithm (GA), mathematical programming, simple multi-attribute rating technique (SMART), and their hybrids.

In a globalized and outsourced environment, managing the performance of suppliers has taken a new sense of urgency. As companies focus on their core competencies and outsource their non-core operations, this percentage has increased, leading to an increased dependency on suppliers. In certain industries such as technology and automotive, purchases from external suppliers can be over half of the total cost of new products. Increased dependency on suppliers not only significantly increases an organization's supply and pricing risk, but it also increases exposure to adverse scenarios such as a safety issues or lack of regulatory compliance. To continually improve operation performance, manage costs and reduce regulatory risks, a

company must be able to not only select the appropriate suppliers, but also to monitor and manage performance of these partners over time.

Recent analyst reports have shown that often less than half of enterprises have formal procedures or systems in place for consistently measuring supplier performance. The monitoring is based on tracking the performance with previously agreed norms of the agreement or predefined Key Performance Indicators (KPI's). Often suppliers cannot conform to the predefined norms due to many reasons. Non-conformance by the supplier adversely affects the supply chain. But if the risk at every stage is analysed previously and behavior of the supplier predicted, the failure could be averted. This research proposes to develop a framework to monitor supplier performance by constantly tracking supplier activities, analyzing the outcomes and risks at each stage, predicting the supplier performance. The research includes the study of different KPI's and the possible risks involved. The effects of these risks on the KPI's will also be studied. The proposed framework will help to select an appropriate supplier for any buyer and track the performance. It will recommend a risk free solution for the supplier.

II. LITERATURE SURVEY

Weber, C. A. 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, Z. 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 micro-economic theory were developed. 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. Zeng, A. Z. [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, F. 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.

Burton, T.T. [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. Abratt [9] analyzed the buying behavior of purchasers of high technology laboratory instrumentation process and identifies and determines the relative importance of the factors influencing supplier selection. Research was undertaken with 54 organizations.

Sharland et al. [10] empirically examined the impact of cycle time on supplier selection and on the effectiveness of long-term relationships with suppliers, as reflected in the commitment and trust developed. Authors observed that initial cycle time is not a significant predictor of trust and commitment in the context of supplier-buyer long-term relationships. However, cycle time reduction along with consistently high quality were found to be significant predictors of trust and commitment in long-term relationships

Lin et al. [11] 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.

Gonzalez et al. [12] developed a methodology to analyze 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 Nine variables related to the supplier selection process were analyzed. 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. [13] presented a framework for integrating environmental factors into the supplier selection process. Traditionally, companies consider factors like quality, flexibility, etc. when evaluating supplier performance. Authors developed a decision support tool which should help companies to integrate environmental criteria into their supplier selection process. Yan and Wei [14] described a mini-max principle based procedure of preference adjustments with a finite number of steps to find compromise weights. Finally it is proved that compromise weights can be achieved within a finite number of adjustments on preference orders.

Svensson [15] investigated the models of supplier segmentation and supplier selection criteria. Empirical illustrations of supplier segmentation based on the perspectives of a VM and its suppliers are presented. It consists of four relationship strategies towards suppliers in the automotive industry, such as family, business partner, friendly, and transactional. Lee et al. [16] proposes a methodology which identifies the managerial criteria using information derived from the supplier selection processes and makes use of them in the supplier management process. For this methodology, authors propose the supplier selection and management system (SSMS) that includes purchasing strategy system, supplier selection system, and supplier management system, and explained how the SSMS is applied to a real supply chain. Pearson and Ellram [17] states that one important domain of management is the selection and evaluation of suppliers. Authors examined and explore the techniques currently used to select and evaluate suppliers by studying a sample of small and large firms in the electronics industry.

Verma and Pullman [18] examines the difference between managers' rating of the perceived importance of different supplier attributes and their actual choice of suppliers in an experimental setting. Authors use two methods: a Likert scale set of questions, to determine the importance of supplier attributes; and a discrete choice analysis (DCA) experiment, to examine the choice of suppliers. The results indicate that although managers say that quality is the most important attribute for a supplier, they actually choose suppliers based largely on cost and delivery performance.

Dulmin and Mininno [19] made the effort to highlight those aspects that are crucial to process qualitative and quantitative performance measures. The contribution of a multi-criteria decision aid method to such problems is investigated, together with how to allow for a simultaneous change of the weights, generating results that can be easily analyzed statistically, performing an innovative sensitivity analysis.

Monczka et al. [20] suggested seven step methodology for supplier selection and evaluation process. These steps are: Recognition of Need for Supplier Selection, Identify Key Sourcing Requirements and Criteria, Determine Sourcing Strategy, Identify Potential Supply Sources, Pre-qualification of Potential Suppliers, Determine Method for Final Selection and Select Suppliers and Reach Agreement. De Boer, L. [21] stated that so far the application of outranking methods in purchasing decisions has not been suggested in purchasing or operations research literature. Authors have shown by means of a supplier selection example, that an outranking approach may be very well suited as a decision making tool for initial purchasing decisions.

Weber, C.A. [22] reviews, annotates, and classifies 74 related articles which have appeared since 1966. Specific attention is 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 is also presented. Li and Fun [23] proposed a supplier performance measure using the concept of dimensional analysis to obtain an index called the VPI (Vendor Performance Index). Usually the performance criteria used in supplier performance evaluation include quantitative and qualitative criteria. Here a new supplier performance measure is proposed as an alternative to the VPI. For qualitative criteria, a two-directional consideration is used instead of a one-directional approach, which results in only a single score. The fuzzy bag method is used to compensate for blindness in human judgment. Then all scores for quantitative and qualitative criteria are combined in an intuitive sum of weighted averages called the SUR.

Weber, C.A. et al. [24] describe three approaches for the selection and negotiation with vendors who were not selected. Furthermore, it describes how in certain situations two multi-criteria analysis tools, multi-objective programming and data envelopment analysis, can be used together for this selection and negotiation process. The paper describes non-cooperative vendor negotiation strategies where the selection of one vendor results in another being left out of the solution. Weber and Desai [25] demonstrated the use of data envelopment analysis for measuring vendor performance and efficiency. An algorithm is employed for determining points of vendor efficiency on multiple criteria. This study then demonstrates how parallel coordinates graphical representation can be used to display the efficiency of vendors on multiple criteria, and, in so doing, visually identify benchmark values on these criteria for negotiating with inefficient vendors.

Weber and Ellram [26] explore the use of a multi-objective programming approach as a method for supplier selection in a just-in-time (JIT) setting. Maggie and Tummala [28] formulated an AHP-based model and applied it to a real case study to examine its feasibility in selecting a vendor for a telecommunications system. The use of the proposed model indicates that it can be applied to improve the group decision making in selecting a vendor that satisfies customer specifications. Also, it is found that the decision process is systematic and that using the proposed AHP model can reduce the time taken to select a vendor.

Hill and Nydick [29] have shown how AHP can be used to structure the supplier selection process. This method of selection is described, and a detailed, hypothetical example of how AHP can be used also is provided. Liu and Hai [30] compared the weighted sum of the selection number of rank vote, after determining the weights in a selected rank in order to decide the total ranking of the suppliers. This investigation presents a novel weighting procedure in place of AHP's paired comparison for selecting suppliers. It provides a simpler method than AHP that is called voting analytic hierarchy process, but which does not lose the systematic approach of

deriving the weights to be used and for scoring the performance of suppliers.

Ellram, L. M. [33] examines case studies of 11 firms which use total cost of ownership concepts in purchasing. Based on the case study data and the literature, barriers and benefits associated with the total cost of ownership approach are discussed. The total cost of ownership models used by the case study firms are classified by type as dollar-based or value-based. Elanchezhian, C. [34] used a versatile technique namely multi criteria decision making (MCDM) technique which involves the analytical network process (ANP) and technique for order performance by similarity to ideal solution (TOPSIS) method to select the best vendor. Authors developed standard software in a suitable platform such as VB, .NET and MS access.

Min, H. [35] proposes multiple attribute utility theory which can help purchasing professionals to formulate viable sourcing strategies in the changing world marketplace particularly for international supplier selection. Authors considered the factors including political situations, tariff barriers, cultural and communication barriers, trade regulations and agreements, currency exchange rates, cultural differences, ethical standards, quality standards and so forth.

Sanayei, A. et al. [39] proposed an integrated approach of multi-attribute utility theory (MAUT) and linear programming (LP) for rating and choosing the best suppliers and defining the optimum order quantities among selected ones in order to maximize total additive utility.

Shyur and Shih [40] proposed a hybrid model for supporting the vendor selection process. First, the vendor evaluation problem is formulated by the combined use of the multi-criteria decision-making (MCDM) approach and a proposed five-step hybrid process, which incorporates the technique of an analytic network process (ANP). Then the modified TOPSIS is adopted to rank competing products in terms of their overall performances. The newly developed ANP will eventually yield the relative weights of the multiple evaluation criteria, which are obtained from the nominal group technique (NGT) with interdependence.

A. Criteria for Supplier Selection

On the basis of the literature reviewed above it has been observed that the basic criteria typically utilized for selecting the suppliers are pricing structure, delivery, product quality, and service etc. While most buyers still consider cost to be their primary concern, few more interactive and interdependent selection criteria are increasingly being used by the manufacturers. The various important criteria for the supplier selection as observed from the literature reviewed above are:

- Price
- Quality
- Delivery
- Performance History
- Warranties & Claims Policies
- Production Facilities and Capacity
- Technical Capability
- Financial Position
- Procedural Compliance
- Reputation and Position in Industry
- Desire for Business
- Repair Service
- Attitude
- Packaging Ability
- Labor Relations Record
- Geographical Location
- Amount of Past Business
- Reciprocal Arrangement

It has been observed from the literature that the price, delivery, and quality continued to be considered most important criteria by most of the researchers. With economic globalization, companies choose suppliers globally from anywhere in the world. For instance , developing countries are becoming more competitive because of their low labor and operating costs.

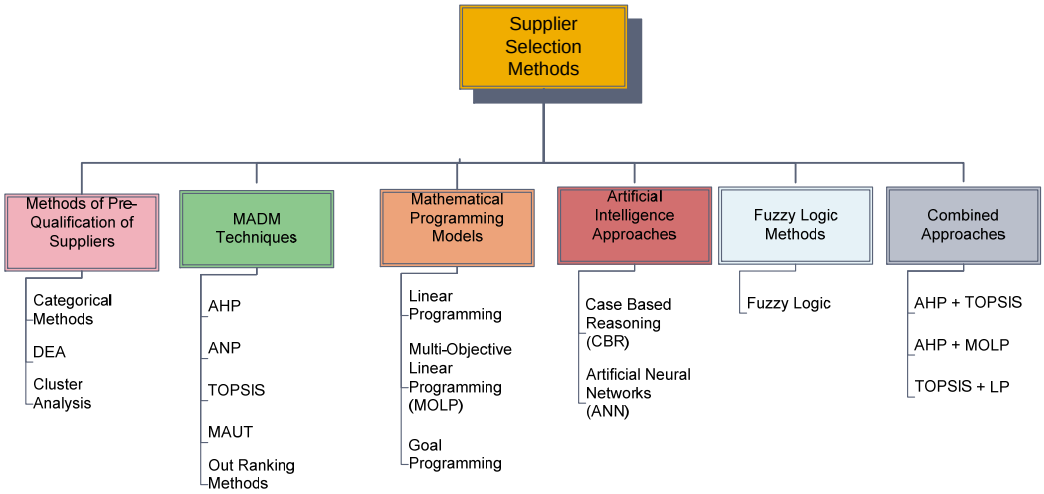

Fig. 1 Vendor Selection Methods

A. *Supplier Selection Methods*

Various supplier selection methods as observed in the literature have been classified in to a number of broader categories. Fig. 1 presents various supplier selection methods as discussed in the literature. Some of the most commonly used methods for supplier selection are discussed briefly here.

B. *Methods for Prequalification of Suppliers*

Prequalification is the process of reducing the set of all suppliers to a smaller set of acceptable suppliers. The various methods available under this category are:

1) Categorical Methods

Basically, categorical methods are qualitative models. Based on historical data and the buyer's experience, current or familiar suppliers are evaluated on a set of criteria. After a supplier has been rated on all criteria, the buyer gives an overall rating. The primary advantage of the categorical approach is that it helps structure the evaluation process in a clear and systematic way.

2) Data Envelopment Analysis (DEA)

DEA is a classification system that splits suppliers between two categories, 'efficient' or 'inefficient'. Suppliers are judged on two sets of criteria, i.e. outputs and inputs. DEA considers a supplier to have a relative efficiency of 100% if he produces a set of output factors that is not produced by other suppliers with a given set of input factors. Weber et al. [27], [28], and [29] have primarily discussed the application of DEA in supplier selection in several publications.

3) Cluster Analysis (CA)

CA is a basic method from statistics which uses a classification algorithm to group a number of items which are described by a set of numerical attribute scores into a number of clusters such that the differences between items within a cluster are minimal and the differences between items from different clusters are maximal. This classification is used to reduce a larger set of suppliers into smaller more manageable subsets. Hinkle et al. [27] were the first to report this.

C. *Multi Attribute Decision Making (MADM) Techniques*

A vendor selection problem usually involves more than one criterion and these criteria often conflict with each other. So MADM techniques are implemented to solve the problem. Some of the MADM techniques are:

1) Analytical Hierarchical Process (AHP)

Analytical Hierarchical Process (AHP) is a decision-making method 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 [32], [34].

2) Analytic Network Process (ANP)

Analytic Network Process (ANP) [31] is a comprehensive decision-making technique that captures the outcome of the dependence and feedback within and between the clusters of elements. Analytical Hierarchy Process (AHP) serves as a starting point for ANP. Analytical Network Process (ANP) is a more general form of AHP, incorporating feedback and interdependent relationships among decision attributes and alternatives. ANP is a coupling of two parts, where the first consists of a control hierarchy or network of criteria and sub-criteria that controls the interactions, while the second part is a network of influences among the elements and clusters [32].

3) Total Cost of Ownership (TCO) Models

TCO-based models for supplier choice basically consists of summarization and quantification of all or several costs associated with the choice of vendors and subsequently adjusting or penalizing the unit price quoted by the supplier. Total Cost of Ownership (TCO) as stated by Ellram [33] is a methodology and philosophy, which looks beyond the price of a purchase to include many other purchase-related costs.

4) Technique for the Order Performance by Similarity to Ideal Solution (TOPSIS)

Another favorable technique for solving MADM problems is the TOPSIS. According to the concept of the TOPSIS, a closeness coefficient is defined to determine the ranking order of all suppliers and linguistic values are used to assess the ratings and weights of the factors. TOPSIS is based on the concept that the optimal alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) [34].

5) Multiple Attribute Utility Theory (MAUT)

The MAUT proposed by Min, H. [35] is also considered a linear weighting technique. The MAUT method has the advantage that it enables purchasing professionals to formulate viable sourcing strategies and is capable of handling multiple conflicting attributes. However, this method is only used for international supplier selection, where the environment is more complicated and risky [36].

6) Outranking Methods

Outranking methods are useful decision tool to solve multi-criteria problems. These methods are only partially compensatory and are capable of dealing with situations in which imprecision is present. Lot of attention has been paid to outranking models, primarily in Europe. However, there is no evidence of applications of outranking models in purchasing decisions [21].

D. Mathematical Programming (MP) Models

Mathematical programming models often consider only the quantitative criteria. Mathematical programming models allow decision makers to consider different constraints in selecting the best set of suppliers. Most importantly, mathematical programming models are ideal for solving the supplier selection problem because they can optimize results using either single objective models or multiple objective models [6], [20], and [27]. Some of these models are:

1) Multi-Objective Models

These models deal with optimization problems involving two or more coinciding criteria.

2) Goal Programming Models

Another important tool is Goal Programming (GP). Unlike most mathematical programming models, goal programming provides the decision maker (DM) with enough flexibility to set target levels on the different criteria and obtain the best compromise solution that comes as close as possible to each one of the defined targets.

E. Artificial Intelligence Methods

Artificial Intelligence (AI) models are computer-based systems trained by the decision maker using historical data and experience. These systems usually cope very well with the complexity and uncertainty involved in the supplier selection process. Some of the AI models are:

1) Case-Based-Reasoning (CBR) Systems

CBR systems fall in the category of the so-called artificial intelligence (AI) approach. Basically, a CBR system is a software-driven

database which provides a decision-maker with useful information and experiences from similar, previous decision situations. CBR is still very new and only few systems have been developed for purchasing decision-making [43].

2) Artificial Neural Network (ANN)

The ANN model saves money and time. The weakness of this model is that it demands specialized software and requires qualified personnel who are expert [42].

F. Fuzzy Logic Approach

In this method, 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. Since human judgments including preferences are often vague and cannot estimate his preference with an exact numerical value. The ratings and weights of the criteria in the problem are assessed by means of linguistic variables. One can convert the decision matrix into a fuzzy decision matrix and construct a weighted-normalized fuzzy decision matrix once the decision-makers' fuzzy ratings have been pooled. Finally a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives [4], [26].

G. Combined Approaches/ Hybrid Methods

Some authors have combined decision models from different steps in the supplier selection process. Degraeve and Roodhoft [37] developed a model combining mathematical programming model and TCO. Ghodsupour and O'Brien [38] had integrated AHP and Linear Programming to consider both tangible and intangible factors in choosing the best suppliers. Sanayei et al. [39] presented an effective model using both MAUT and LP for solving the supplier selection problem. Shyur [40] present an effective model using both ANP and modified TOPSIS, to accommodate the criteria with interdependencies. Boran [41] has proposed a multi criteria group decision making approach using fuzzy TOPSIS, to deal with uncertainty.

III. RESEARCH OBJECTIVES AND APPROACH

This research proposes to develop a framework for a collaborative supplier base. In order to monitor supplier performance, constant tracking of supplier activities is necessary. The research proposes to identify metrics or KPI's for any kind of enterprise. Data from different industries will be analysed to identify the shortfalls in method already develop. The research includes the study of different KPI's and the possible risks involved. The effects of these risks on the KPI's will also be studied. The proposed framework will help to select an appropriate supplier for any buyer and track the performance. It will recommend a risk free solution for the supplier.

The use of collaborative supplier portals that provides this information to suppliers, along with the ability to set priorities helps ensure that nothing falls between the cracks and both parties are on the same page with respect to what is working well and what needs improvement.

A. Methodology

Step 1: Identify metrics, thresholds and targets:

The first step is to capture key performance metrics in the supplier's contracts. This validates key terms and measures to help ensure contract compliance are visible. Secondly, gather input from key relationship managers to understand their supplier performance objectives and use the information to establish metrics and validate that they are aligned with overall strategy.

Step 2: Collect data through various mechanisms:

Collect information to calculate current values on agreed upon set of metrics, thresholds and targets. Various methods that can be used to gather this data include supplier assessment surveys, information from Enterprise Resource Planning (ERP) systems, homegrown operational systems, instant supplier feedback, etc.

Step 3: View and analyze aggregated information:

Once data is collected, it should be aggregated to report on performance versus plan. While spreadsheets and other tools can be used for analysis, supplier performance management systems significantly improve the ability to analyze the information.

Step 4: Identify gaps, prioritize and communicate:

Scorecards, trend reports and alerts help identify gaps between target and actual performance for virtually every supplier.

Step 5: Develop alternatives: The shortfalls in the existing system will be identified new alternatives will be developed.

Step 6: Implement and Test alternatives: The proposed methods will be implemented and tested. The results will be analysed.

IV. CONCLUSION

A supplier performance management initiative provides a critical foundation for improving operational performance, reducing supplier risk, reducing component costs and improving supply chain efficiency. It is not about completing a one-time review with suppliers. To be successful, it must be sustained on an ongoing basis using enabling technology – and ideally implemented globally. With these elements in place, a company's supplier performance management initiative can significantly improve operational performance and competitive advantage

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