LOGISTICS OUTSOURCING AND 3PL SELECTION: A CASE STUDY IN AN AUTOMOTIVE SUPPLY CHAIN

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ABSTRACT

Outsourcing logistics functions to third-party logistics (3PL) providers has been a source of competitive advantage for most companies. Companies cite greater flexibility, operational efficiency, improved customer service levels, and a better focus on their core businesses as part of the advantages of engaging the services of 3PL providers. There are few complete and structured methodologies for selecting a 3PL provider. This paper discusses how one such methodology, namely the Analytic Hierarchy Process (AHP), is used in an automotive supply chain for export parts to redesign the logistics operations and to select a global logistics service provider.

Keywords: Outsourcing, Third-Party Logistics, 3PL, Analytic Hierarchy Process, AHP, Multiple-Criteria Decision-Making

1. INTRODUCTION

There is a fundamental paradigm shift exhibited by many firms as they transform their supply chain capabilities from an industrial to an information technology driven society. Substantial change is foreseen in logistics practices between supply chain partners as they struggle to establish efficient, effective, and relevant product or service solutions for end customers and emphasize the "vertical to virtual integration trend" with a high implementation potential in the ten mega-trends of the new millennium. The problem with the vertical integration is that it requires significant capital investment and complex organizational structure. Companies must tie the expertise and synergy of external supply chain partners together to achieve success. Virtually integrating operations with material and service suppliers to form a seamless flow of internal and external work overcomes the financial barriers of vertical ownership while retaining many of the benefits [3].

Outsourcing logistics functions to third-party logistics (3PL) providers has been a source of competitive advantage for most companies. Companies cite greater flexibility, operational efficiency, improved customer service levels, and a better focus on their core businesses as part of the advantages of engaging the services of 3PL providers. 3PL alliances began with companies outsourcing some or all of their transportation and distribution functions. In recent times, most 3PLs have gone from offering a single function to integrated logistics provision, offering two or more functions at the same time. Among typical logistics services offered by 3PL providers are inventory management, IT services, such as tracking and tracing, value added activities, such as secondary assembly and installation of products, in addition to transportation and distribution services [2]. This paper aims at reporting the efforts of Tofas-Fiat, a leading Turkish automotive company, to restructure its supply chain for export parts and presents the methodology it adopted to select a 3PL provide, namely the analytic hierarchy process (AHP).

The remainder of the paper is organized as follows: Section 2 reviews the literature on logistics service provider selection. Section 3 introduces Tofas-Fiat automotive company and provides an overview of its supply chain. The AHP implementation is discussed in Section 4 and finally, concluding remarks are given in the last section.

2. LITERATURE REVIEW

There exist few analytical models which provide strategic decision support for selecting 3PL providers. Literature includes the changing emphasis in the selection process, the criteria that can be used, and conceptual models. In their exploratory study, Menon *et al.* [12] examined the selection criteria for 3PL providers and how these are affected by the firm's organizational strategy, competitive responses and external environment. The study points out two dimensions for the selection criteria: supplier's perceived performance and perceived capability. The first is comprised of operational issues which are on-time shipments and deliveries, ability to meet promises, availability of top management, and superior error rates. The latter includes creative management and financial stability. In addition to two factors it is found that responsiveness is also important; however, it did not load on either factor. Finally, the relatively low importance of prices suggests that price rates are not considered per se.

Ackerman [1] also provides a list of criteria and recommends corresponding rating scales for evaluating 3PL providers. Most of the criteria are operational and are listed as: multiple warehouse facilities nationwide, inventory management and control, order acceptance and

processing, pick-and-pack operations, order fulfillment, assembly/packaging/value-added activities, credit card verification, invoicing, credit and collection, pre-sort capabilities, returns handling, manifesting, operational management structure, organizational strategic direction, and financial stability.

Sink and Langley [18] provides a managerial framework for the acquisition of 3PL services. The steps of the conceptual model provided for 3PL buying process are as follows: identify the need to outsource logistics, develop feasible alternatives, evaluate and select supplier, implement service, and ongoing service assessment. In the evaluation and selection step criteria like references provided by current customers, cultural compatibility, financial strength, the depth of management expertise, operating and pricing flexibility, and information system capabilities are stated besides the traditional criteria such as quality, cost, capacity, and delivery capability.

Foster [5] reflects the shift in the selection paradigm. Viewing outsourcing as a strategic process, companies are focusing more on technology, operations, finances, and management skills than on cost in their selection process. The ten steps in the engineered process are important for the strategic point of view of the selection issue. The process steps are defining company's strategy, establishing centralized control, verifying operational excellence, leveraging technology, ensuring compatibility, researching bench strength, setting a trust threshold, ascertaining cultural similarities, seeking support for continuous improvement, and making cost a lower priority.

Meade and Sarkis [11] discuss the factors that provide an important role in evaluating a third-party reverse logistics provider and model a decision support framework for selection. They differentiate the characteristics of a forward and a reverse 3PL provider. The multi-attribute utility theory decision support tool employed is analytic network process (ANP) which incorporates interdependencies and feedbacks among clusters or groups of selection factors. The ANP model developed puts quantitative, qualitative, strategic, and operational factors into the decision framework.

The important aspect of 3PL is that 3PL services are offered in an integrated way, not on a stand-alone basis. The cooperation between the shipper and the external company is an intended continuous relationship. Berglund *et al.* [2] argue that in a 3PL relationship the contract should contain some management, analytical or design activities, and the length of the cooperation between the shipper and the provider should be at least one year, to distinguish 3PL from "arm's length" sourcing of transportation and/or warehousing.

While outsourcing of logistics continues to grow, the level and type of outsourcing vary significantly across time, sectors, and companies. Some use 3PL providers simply as a source of lower cost labor while others entrust 3PL providers with vast responsibility over their logistics network. Such differences reflect a range of motivations for outsourcing logistics that can be best described as "waves" of outsourcing [7].

3. OVERVIEW OF TOFAS-FIAT SUPPLY CHAIN

Turkish automotive industry has become one of the major contributors to the Turkish economy, being one of the fastest growing sectors over the past ten years. The export of vehicles has roared to $6.875 billions from $200 millions between 1994 and 2004, showing a drastic average growth rate of 42% per year. In the same period, the exports of automotive parts and components have increased from $594 millions to $3.031 billions, averaging an annual growth rate of %18. This

significant performance forces Turkish automotive companies to improve the effectiveness of their logistics functions, against foreign competitors in particular. Recent studies show that the primary aim of the industry is to decrease the unit cost of manufacturing. Car makers claim that the material cost component corresponds to 87% of the total manufacturing cost [19]. This high share confirms the importance of logistics function for companies trying to reduce their unit cost of manufacturing. Among those, Tofas-Fiat Turkish Automobile Plant, Inc., an affiliate of Fiat/Italy, is one of the leading automotive manufacturers in Turkey with a 17% market share (in 2004). The company manufactured over 147,000 passenger cars and light commercial vehicles and realized $1.9 billion in total sales in 2004.

There are three main product flows in Tofas-Fiat supply chain: Complete Built-Up (CBU) units flow, Spare Parts flow, and Inter-Company/Complete Knocked Down (IC/CKD) flow. The company is planning to restructure its logistics activities related with IC/CKD flow. There are two types of customers in these export parts flow: IC and CKD. ICs are the main manufacturing centers of Fiat joint venture company, namely Italy, Poland, Brazil, and China. ICs (including Tofas-Fiat) buy and sell parts from each other except China which only buys parts from ICs. These ICs are able to manage the bill of materials (BOM), in other words they are able to boom the BOM and create orders according to their requirements. CKDs are the other manufacturing centers of Fiat joint venture company: Egypt (Nasco), South Africa, Vietnam, North Korea, Morocco, and India. They do not have the ability to manage the BOM. The existing material and information flow in the IC/CKD supply chain is illustrated in Figure 1. After customers give their orders to the Fiat, it sends these to the predetermined suppliers via the world material flow system. Every supplier gets the parts manufactured and ready to be picked up by the 3PL company in the designated time-window.

Insert Figure 1 about here

Tofas-Fiat initiated the Customized Milk Run Project for Export Parts in an attempt to gain competitive advantages in terms of cost and time among other Fiat subsidiaries. The customers are the IC customers –Italy, Poland, Brazil, and China– and the CKD customers – Egypt (Nasco), South Africa, Vietnam, North Korea, Morocco, and India.

Existing Material Handling

In the current practice the supplier clusters are determined by the Direct Material Logistics Department at Tofas-Fiat. According to these clusters, route planning and load optimization are performed taking into consideration the frequency of shipments from suppliers. Frequencies are changed if needed. The 3PL receives the daily shipment information from and collects the parts from the suppliers in the required time-window.

The export parts are unloaded in the export parts warehouse. A minimum of 80% truck utilization is desired. If the utilization is below 80%, then weekly shipment, loading, timing, and routing data are investigated and the plans are revised if necessary. The majority (nearly 60%) of the export parts are packaged at the export parts warehouse. The remaining 40% are packaged at the supplier sites. The export parts are grouped according to customer orders and wait nearly 3 days in the warehouse for packaging, documentation, and consolidation. If the customer is an overseas country, the parts are loaded into a container rented from the line selected by the customer and shipped as soon as the order gets ready. The orders of the European customers (Italy, Poland) are shipped by trucks.

In the project, China is selected as the pilot customer for implementation. The Chinese market corresponds to nearly 10% of the total export parts market and has no packaging or transport mode constraints. 12 suppliers are determined; their exports constitute 88% of the total exports to China. Our analysis has revealed that the logistics costs of the 52 export parts correspond to the 4.9% of total sales value. 54% of these logistics costs stem from outbound transportation, 29% from inbound transportation, 15% from inventory holding, and 2% from warehouse costs. Packaging costs are excluded in our analysis since the customer ensures that these costs will not be incurred by Tofas-Fiat. The inbound transportation costs is deducted from the supplier as a percentage of the unit purchasing cost according to the contracts made when initiating the project.

Insert Figure 2 about here

Customized Milk Run Material Handling

In the proposed Customized Milk Run for Export Parts, the orders are customized with respect to individual customers. The orders are collected from suppliers by containers and shipped to each individual customer via the same container without any additional material handling operations at Tofas-Fiat warehouse. The proposed material handling and information flow for export parts to China is depicted in Figure 2.

There are three major requirements of the proposed application: (i) partnership with the suppliers, (ii) synchronized custom operations, and (iii) partnership with a global logistics service provider. The first step in creating and maintaining a successful relationship with a 3PL provider is to define the logistics objectives. These defined objectives will help establishing criteria for 3PL selection. The components of the service that Tofas-Fiat expects from the 3PL provider may be summarized as follows:

- *Integration*: partnership & collaboration, IT integration with Tofas-Fiat supply chain, dedicated 3PL resources to Tofas-Fiat, confirming daily material procurement programs with suppliers/Tofas-Fiat, tracking.
- *Optimization*: optimum daily vehicle planning, fixed/variable route planning, load optimization assuring high saturation.
- *Operations*: on-time shipment, synchronization in customs documentation, transportation of returnable containers (including customs clearance), urgency planning, minimum transportation cycle time.
- *Performance/Quality*: reliability of shipments, quality assurance in loading, documentation and transportation, measurement of logistics performance, accepting penalty in case of low performance, reporting continuous improvement plans.

The company aims at achieving the following major quantitative and qualitative gains through logistics outsourcing: (i) Reduction in costs: decrease in warehousing cost (through reduced area and equipment requirements), in material handling cost, and in inventory carrying cost; (ii) Decrease in cycle time (nearly 3 days); (iii) Improved delivery frequency; and (iv) Increased supplier integration (through improved EDI and supplier packages parts). Tofas-Fiat considers five 3PL companies which are equipped with the desired capabilities. In the next section we discuss the implementation of AHP as the 3PL selection methodology.

4. 3PL SELECTION METHODOLOGY

An appropriate 3PL partner selection process involves multiple criteria and multiple alternatives. The analytic hierarchy process (AHP) method is adopted in Tofas-Fiat's selection process. It is a well-known technique for integrating qualitative and quantitative criteria in decision making. It has been widely applied to decision problems in areas such as economics and planning, energy policy, material handling and purchasing, project selection, vendor selection, budget allocations, etc. [6],[14]. The interested reader is referred to [14],[15],[16], and [17] for details about the technique. We utilized AHP to cope with both the rational and the intuitive to select the best "fit" from five 3PL providers evaluated.

The implementation was carried out using Expert Choice software [4]. We first developed the criteria and the related decision hierarchy. Then, we carried out simple pair-wise comparison judgments which were used to develop overall priorities for ranking the 3PL providers. The performances of 3PL providers according to the criteria were evaluated using utility curves, ratings, and step functions with respect to each criterion. The necessary data and information were obtained through requests for quotations (RFQs) and requests for information (RFIs). The performance evaluations and the priorities were synthesized according to the overarching goal of selecting the appropriate 3PL provider for the export parts supply chain. Finally, sensitivity analysis was performed to examine the robustness of the provisional decision to changes in the ratings of importance. In what follows is the description of each stage of the methodology.

Stage 1: Set-up the Decision Hierarchy

The decision hierarchy is depicted in Figure 3 and the details of the selection criteria are provided in the Appendix. These criteria and hierarchy are established with the assistance of practices and surveys in the American and European logistics market as well as the industrial experiences of Tofas-Fiat. Saaty [16] claims that human minds structure complex reality into its constituent parts, and these in turn into their parts, and so on hierarchically. The number of parts usually ranges between five and nine. Thus, when building the decision hierarchy, we tried not to include more than nine elements in any cluster since it would be cognitively challenging for human beings to deal with more than nine factors at one time and this can result in less accurate priorities. We also attempted to cluster elements such that they include elements that are "comparable" or do not differ by orders of magnitude. The details of the criteria are derived from the quotations and the additional information received from the 3PLs. For instance, Liquidity, Operating, Profitability, and Leverage ratios are derived from the balance sheets and income statements of the 3PLs to evaluate "Financial Considerations" criterion; the information about the software used for optimization in route, load, and vehicle/container planning is requested from 3PLs to make an assessment "Optimization Capabilities" criterion.

Stages 2 & 3: Make Pairwise Comparisons and Transform Comparisons into Weights

In order to determine the weights of the criteria used in the 3PL selection process, pairwise comparisons are made for each level of criteria. Paired comparison judgments in the AHP are applied to pairs of homogeneous elements. The fundamental scale of values to represent the intensities of judgments is used for the comparisons where 1 indicates that the criteria are

indifferent in terms of importance and 9 indicates that the former is 9 times more important (extreme importance) than the latter. This scale has been validated for effectiveness, not only in many applications, but also through theoretical justification of what scale one must use in comparison of homogeneous elements [10].

Insert Table 1 about here

Table 1 shows the comparison made for the level 1 criteria for the overall goal of selecting the appropriate 3PL partner. The first entry "6" means that the criterion General Company Considerations is 6 times more important (with an intensity of strong plus) than the criterion Capabilities. In the same manner, all entries written as an integer show how many times the row criterion is more important than the column criterion. On the other hand, all entries written as a simple fraction show how many times the column criterion is more important than the row criterion.

The left bottom cell named Inconsistency Ratio is an indicator that shows the inconsistency of the decision makers when making the comparisons. This ratio is recommended to be below a certain value which varies according to the number of criteria compared. For level 1, this ratio is 0.08 which is below the threshold value of 0.11 for five criteria. The interested reader is referred to [16] for threshold values for different number of criteria.

Insert Figure 4 about here

Moving bottom-up, global priority, which means how much the specific criterion contributes to the overall decision, is calculated for each criterion. The weights of the global priorities are depicted in Figure 4.

Stage 4: Decide How Well the Alternatives Perform on Different Criteria

This stage is executed by evaluating each 3PL provider by how it performs under each criterion as shown in Table 2. The 3PLs are represented as A, B, C, D, and E[1]. The performances are entered in the specified measurement units (for example Euro for Price). Then the entries are transformed to utility values varying between 0 and 1 in order to be able to compare both the quantitative criteria (for the hard data like price) and qualitative criteria (for subjective judgment like reputation). The transformation methodology is detailed for each criterion in Table 3.

Insert Table 2 and 3 about here

These performance evaluations are based on the quotations and additional information obtained from the 3PL providers. The evaluations can be made using four tools: utility curves, rating functions, step functions, or direct entry. The intensities of the rating functions are determined by pairwise comparisons. The intensities for excellent, very good, good, fair, and poor are 1.000, 0.842, 0.632, 0.421, and 0.158, respectively.

[1] 3PLs are not disclosed because of confidentiality.

Stage 5: Combine the Criteria Weights and Alternative Performances

The global priorities of the criteria and the performances of the 3PL providers are multiplied in order to get a synthesized result. The total score each 3PL provider gets is depicted in Figure 5. As a result, a ranking of the 3PLs is obtained, indicating the best fit score-wise. The scores are 0.515, 0.415, 0.412, 0.398, and 0.169, respectively, over a scale of 1.000 for 3PLs B, C, A, D, and E, respectively. These results show that 3PL provider B is the best performing among all alternatives.

Insert Figure 5 about here

Stage 6: Perform Sensitivity Analysis

This stage enables us to examine how robust the provisional decision is to changes in the ratings of importance determined. Performance sensitivity analysis is used to show how the alternatives were prioritized relative to other alternatives with respect to each objective as well as overall. The original Performance graph for level 1 is depicted in Figure 6.

Insert Figure 6 about here

Head-to-head sensitivity analysis is used to show how two alternatives are compared against the criteria in a decision. If the left-hand side alternative is preferred to the right-hand side alternative with respect to a criterion, the horizontal bar will be on the left. If the choices are equal no bars will be displayed. The overall result is displayed at the bottom of the graph and shows the overall percentage of one alternative being better than the other. The overall is derived by weighted averages and may differ from the total scores in the sensitivity analysis. The head-to-head graph of B versus C is illustrated in Figure 7.

Insert Figure 7 about here

5. CONCLUDING REMARKS

This paper presents 3PL provider selection in an automotive company that attempts to streamline and efficiently run its supply chain through logistics outsourcing. The study is valuable for the company in terms of understanding the 3PL concept and practice and realizing the importance of the selection process. Proper care and managerial support is required for defining the objectives and 3PL requirements of the company, having an efficient implementation plan for the integration process, and consistently evaluating and monitoring the 3PL provider.

The study has revealed that the 3PL industry in Turkey will go through an evolutionary change because not only are the providers and their capabilities changing, but the expectations of

the companies from 3PL providers and their services are changing as well. The following highlights some of the changes that are likely in the industry:

- More demanding customer expectations of 3PL services and increasingly sophisticated requirements for technology based and strategic supply chains.
- Advanced technology offerings around strategy, planning, collaboration, supplier management, data management, decision support, and integration.
- Continued pressure to improve relationship skills in an effort to exceed customer expectations.
- Ongoing shifts in relationship models and deal structure in an effort to provide advanced services structured around mutual incentives.
- Improved measurement processes that address broader supply chain requirements, international trade, and partner integration.
- Further evidence for a need for 3PL providers or system integrators to assume a lead logistics manager role to more strategically serve the clients.

In the 3PL provider selection process, we considered 27 criteria with respect to the general company considerations, capabilities, quality, client relationship, and labor relations of the 3PL providers. The analysis helped the company to structure the problem with its differing aspects rather than only financial considerations, to reflect the common mind of the team, to resolve conflicts between different departmental goals, and to bring objectivity to decisions via an analytical approach. AHP technique is utilized since it facilitates accurate judgments, provides the management with information about criteria's implicit weights, and allows performing sensitivity analysis easily. AHP provides a ranking of the 3PL providers, indicating the best performing 3PL score-wise. However, an appropriate selection could have only been made after an extensive sensitivity analysis and negotiation process. Consequently, the company selected some 3PL providers based on the AHP results and carried out further negotiations. At the end of this process, the final decision of the management had been in favor of maintaining the existing logistics practice and postponing the decision for the new outsourcing strategy.

APENDIX: 3PL SELECTION CRITERIA

GENERAL COMPANY CONSIDERATIONS (GCC)	
Price **(Pri)**	Competitive pricing which will be derived from the quotations.
Financial Considerations **(Fin)**	Liquidity, Operating, Profitability, and Leverage Ratios are the selected ratios for measuring the financial situation of the 3PL providers. These will be derived from the balance sheets and income statements.
Experience in the Same Industry **(Ind)**	The provider's automotive industry expertise will be taken into consideration. The references and the previous experiences may give an idea about the logistics company's automotive industry experience.
Location **(Loc)**	The geographic area served by the provider is an important issue. The distribution of the offices/branches/warehouses of the service provider according to the suppliers of the Company will be considered.
Asset Ownership **(Ass)**	The percentage of the asset ownership is also an important indicator among company considerations.
International Scope **(Int)**	The provider's revenues generated from foreign sales will show how intensive and broader the provider has an international scope.
Growth Forecasts **(Gro)**	How many days it takes the 3PL to respond a capacity increase of 20% shows the sensitivity of the 3PL providers' growth capability.
Yearly Efficiency **(Eff)**	It is a measure for continuous improvement for reducing total costs.
CAPABILITIES (CAP)	
Optimization Capabilities **(Opt)**	The software names used for optimization in route planning, load planning, vehicle/container planning, and returnable container plans.
Information Tech. Systems **(Its)**	The names or description of the computer systems used for tracking, tracing, and confirmation.
Customer Service **(Cus)**	This criterion is a sign for dedicated resources for the Company. These resources should be full-time employed. The selected indicators for customer service are management human resource as hour/month reserved and the number of trucks dedicated to the Company.
SC Vision **(Scv)**	(Capacity to Accommodate and Grow the Client's Business) Supply Chain Vision of the 3PL provider is vital since it adds value to the chain by service offering migrations.
Creative Management **(Cre)**	(Flexibility and Capability to Handle Specific Business Requirements) Transportation with containers in Customized Milk Run Project for Export Parts is an example for specific business requirements. The flexibility and capability to handle these is an important consideration.
Responsiveness **(Res)**	(to Unforeseen Problems or Unexpected Events) Ability to do Urgency Planning and ability to perform hot shipments indicates the responsiveness to the unexpected events.
QUALITY (QUA)	
Service Quality **(Ser)**	The quality management systems that the service provider exploits, e.g. six Sigma, ISO 9000, give an idea about the service quality and performance of the 3PL provider.

Continuous Improvement **(Imp)**	Reputation for continuous problem solving can be realized from the ideas taken from the references of the 3PL provider.
Key Performance Indicator (KPI) Measurement and Reporting **(Kpi)**	The KPIs proposed by the 3PL provider or the ability to measure the KPIs desired by the Company and the forms of reports proposed by the 3PLprovider is vital even in the selection process for the future quality of the service.
CLIENT RELATIONSHIP (CLI)	
Availability of Top Management **(Top)**	The accessibility of contact persons from top management is important in case of a necessity for an essential decision to be made in urgency.
Cultural Fit **(Cul)**	Capability with company culture and policies is derived from subjective "feel".
Service Cancellation **(Can)**	The durations of the contacts and the reasons of cancellations of contracts for the past five years illustrate the 3PL's client relationships.
General Reputation **(Rep)**	The subjective "feel" derived from the industry for the 3PL provider shows its image and general reputation of the 3PL provider.
LABOR RELATIONS (LAB)	
Human Resource Policies **(Hrp)**	The organizational structure and the titles for the positions indicate 3PL provider' HR policies.
Availability of Qualified Talent **(Aqt)**	The occupations of the employers and their automotive experience and logistics experience in terms of years will demonstrate the quality of the talent that the 3PL provider employs.

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TABLE 1 Level 1 Pairwise Comparisons

	GCC	CAP	QUA	CLI	LAB
GCC		6	6	8	7
CAP			2	6	3
QUA				5	2
CLI					¼
LAB					
Inconsistency Ratio: 0.08					

TABLE 2 Performance Evaluation of 3PL Providers

	A	B	C	D	E
Pri	118,513	87,487	123,367	103,365	490,065
Fin / Liq	0.325	1.195	1.113	2.600	--
Fin / Ope	0.880	3.617	0.743	2.152	--
Fin / Pro	0.093	0.492	11.223	18.128	--
Fin /Lev	2.934	28.800	3.368	1.665	--
Ind	Good	Good	Very Good	Very Good	Poor
Loc	26	45	20	13	--
Ass	65	40	92	100	--
Int	963,708	1,287,951	3,686,236	1,952,423	--
Gro	2	1	1	1	5
Eff	3	3	3	3	7
Opt	Legacy	0.5	Legacy	Low Quality	Low Quality
Its	0.7	0.6	Medium Quality	Low Quality	Low Quality
Cus / Tru	6	7	10	0	--
Cus / Man	240	240	480	240	240
Scv	Good	Good	Fair	Poor	Poor
Cre	Fair	Fair	Good	Good	Fair
Res	Good	Fair	Good	Good	Poor
Ser	Excellent	Good	Fair	Fair	Good
Imp	Fair	Fair	Fair	Poor	Fair
Kpi	Good	Good	Good	Poor	Poor
Top	Good	Good	Good	Good	Good
Cul	Fair	Fair	Excellent	Excellent	Poor
Can	Good	Good	Good	Good	Good
Rep	Very Good	0.75	Very Good	Fair	Poor
Hrp	Excellent	Very Good	Fair	Poor	Poor
Aqt	Excellent	Very Good	Fair	Fair	Fair

TABLE 3 Transformation of Performances to Utilities

	Type	Low / I1	High / I2	Curve / I3	I4	I5
Pri	Utility (Dec)	59,537	156,829	Linear		
Fin/Liq	Utility (Inc)	0	2	Linear		
Fin/Ope	Utility (Inc)	0	2	Linear		
Fin/Pro	Utility (Inc)	0	1	Linear		
Fin/Lev	Utility (Dec)	1	4	Linear		
Ind	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Loc	Utility (Inc)	0	50	Concave		
Ass	Step (5)	Excellent (90)	Very Good (70)	Good (50)	Fair (30)	Poor (0)
Int	Utility (Inc)	500000	4000000	Linear		
Gro	Utility (Dec)	0	10	Convex		
Eff	Utility (Inc)	0	10	Convex		
Opt	Ratings (4)	High Quality	Legacy	Medium Quality	Low Quality	
Its	Ratings (3)	High Quality	Medium Quality	Low Quality		
Cus/Tru	Utility (Inc)	3	10	Linear		
Cus/Man	Utility (Inc)	0	500	Concave		
Scv	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Cre	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Res	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Ser	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Imp	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Kpi	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Top	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Cul	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Can	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Rep	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Hrp	Ratings (5)	Excellent	Very Good	Good	Fair	Poor
Aqt	Ratings (5)	Excellent	Very Good	Good	Fair	Poor

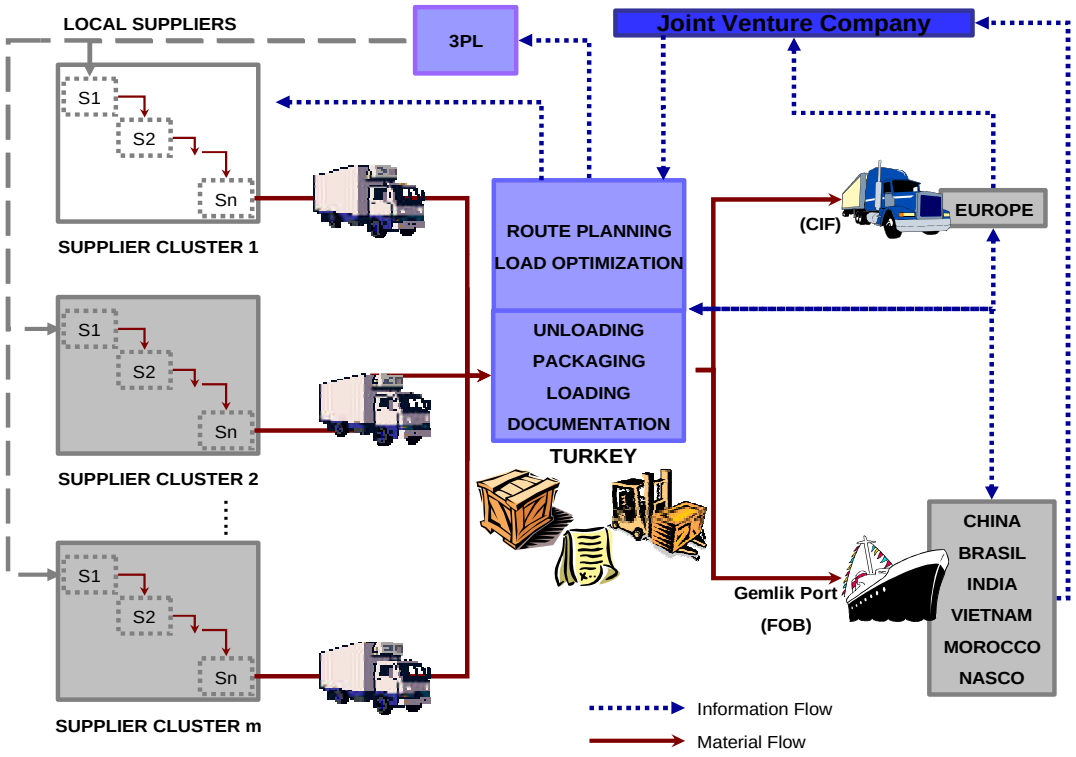

FIGURE 1 Existing Material and Information Flow for Export Parts.

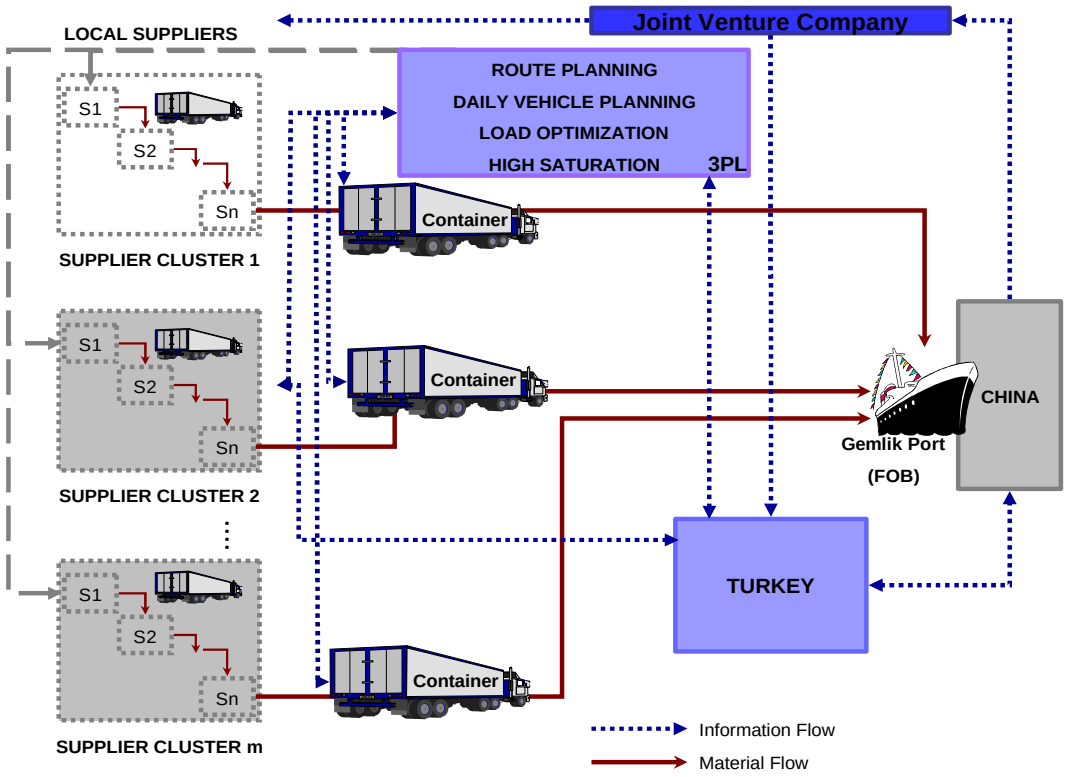

FIGURE 2 Proposed Material and Information Flow for Export Parts to China.

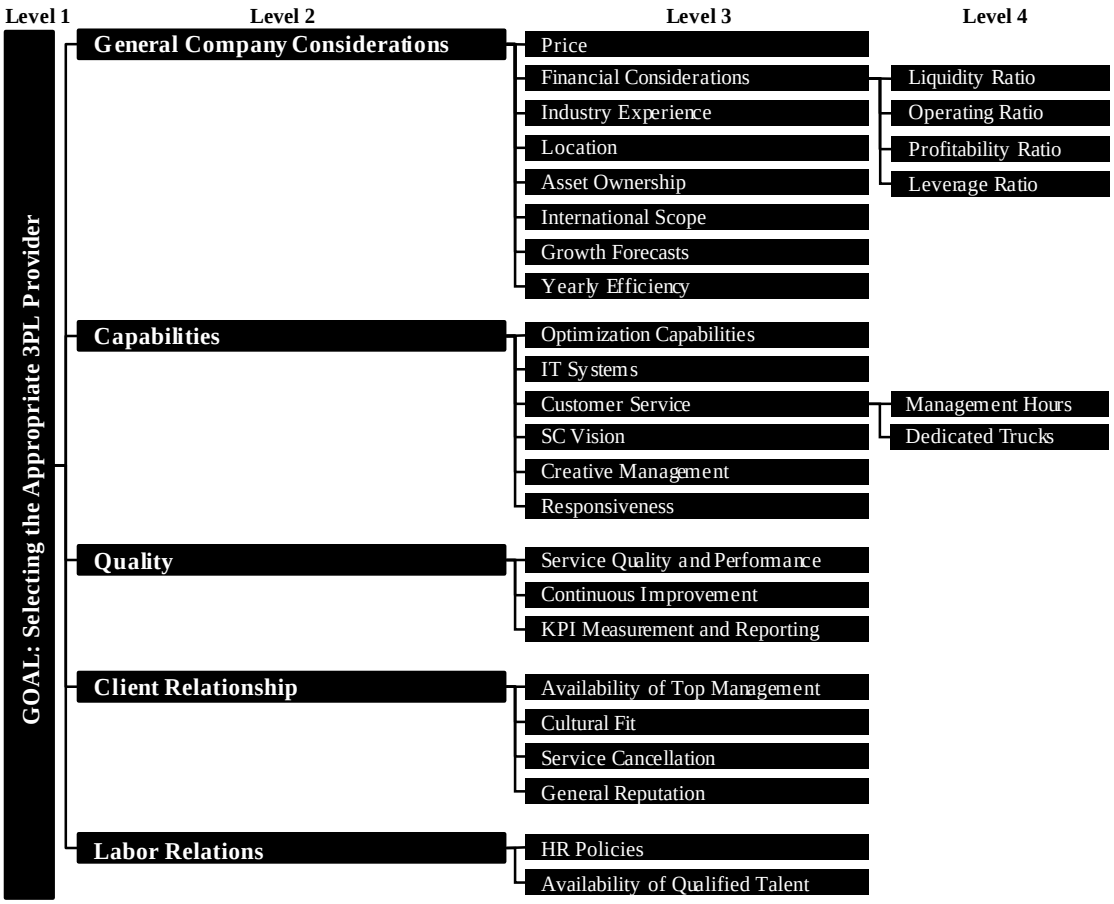

FIGURE 3 Decision Hierarchy.

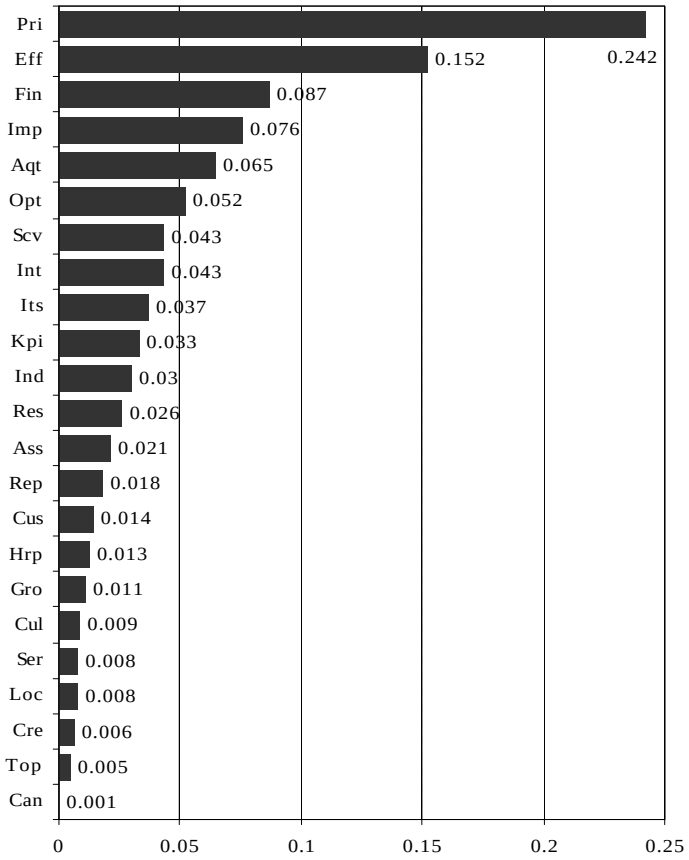

FIGURE 4 Global Priorities for Level 1 Criterion.

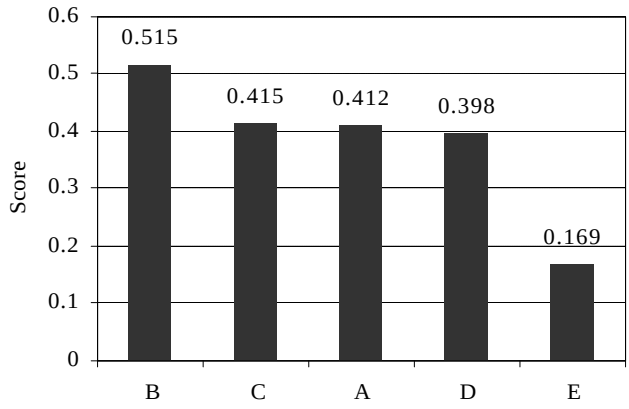

FIGURE 5 Total Scores of the 3PL Providers.

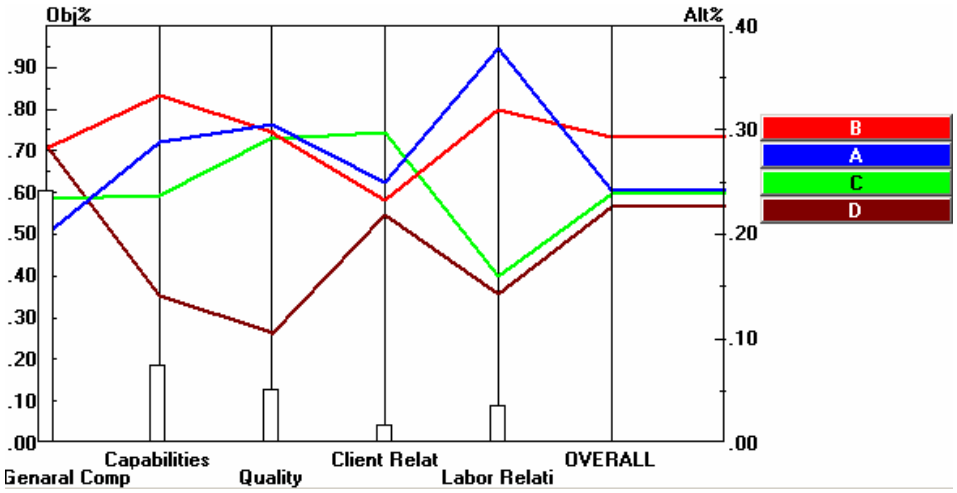

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FIGURE 6 Performance Sensitivity Analysis – Level 1.

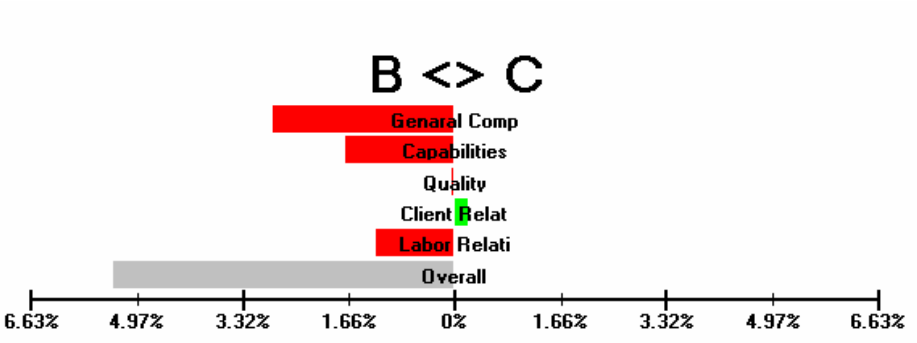

FIGURE 7 Head-To-Head Sensitivity Analysis for B vs. C.