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An Integrated Model for Sourcing Strategies in Global Outsourcing

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ABSTRACT
The current globalization of the economy is forcing enterprises to design and manage their supply chains efficiently on a worldwide basis. Sourcing strategy design in supply chain management is vital to gain competitive advantages. Under competitive environment the ability to make fast and accurate decisions constitute an important advantage. Successful supply chain management applications necessitate an effective sourcing strategy to deal with uncertainties both in sourcing decision making and order allocation among selected suppliers. This study presents an empirical approach with two different (but not independent) parts. The first part includes the evaluation of sourcing strategy and the second part includes the order allocation model based on the evaluation results of the sourcing strategy. The proposed model offers an innovative approach by integrating the decision making process over sourcing strategy decisions and order allocation.
Keywords: Decision making, Fuzzy logic, Linear programming, Order allocation, Sourcing strategies

I. INTRODUCTION

Today growing international competition forces enterprises to remain ahead of the competition.Nowadays customers are becoming more conscious and tend to demand a particular number of customised products at a particular speed and very few manufacturers have owned all of the activities along the supply chain. Global outsourcing can be defined as the forwarding of specific business to a global supplier. Stare and Rubalcaba (2009) described global outsourcing as the relocation of production from countries with higher labour costs to countries with lower labour costs.

Global outsourcing allows firms to develop their core competencies and expand their flexibility. In global outsourcing decision process environment, many manufacturers have forwarded the production to low cost countries (LCC) and prefer low cost country sourcing (LCCS) to purchase of semi-finished or finished products (Kotabe and Murray 2004, Masso et al. 2008). LCCS refers to the process of procuring products, parts and services from suppliers in countries with lower labor and materials costs (Carter et al. 2008). LCCS has become a target of opportunity for procurement managers in supply chain management strategy. Decisions about LCCS strategies and operations are the primary determinants of profitability in global outsourcing.

This study presents a new system to integrate the sourcing strategy decisions and order allocation. This system consists of two components, the sourcing strategy evaluation component (including LCCS), and order allocation component. To the best of our knowledge, there has not been adequate number of studies integrating sourcing strategy decision making process and order allocation. Therefore, this study focused on integrating these two systems. The reminder of the paper is organized as follows: Section 2 includes the literature review. Section 3 presents the proposed fuzzy logic based sourcing strategy evaluation model and order allocation component. The application examples and results are provided in Section 4. Finally, conclusions are presented in Section 5.

II. LITERATURE REVIEW

Sourcing strategy design in a supply chain involves the selection of suppliers, design of supplier contracts, product design collaboration, procurement of materials, and evaluation of supplier performance (Chopra and Meindl 2005). Yu et al. (2009) stated that, successful supply chain managementnecessitates an effective sourcing strategy to combat unreliable supply and stochastic demand. Since suppliers represent a critical resource to a firm, the perceptions of the buying organization regarding the sourcing strategy affect the performance of the buying firm directly and indirectly (Su 2013). Sourcing strategies are divided into three types by Yu et al. (2009): In the first type single sourcing, a buyer chooses a single supplier even though other suppliers exist in the supplier base (Newman 1989). Single-sourcing strategies strive for partnerships between

buyers and suppliers to foster cooperation and achieve shared benefits (Burke et al. 2007). The second sourcing strategy, dual sourcing, indicates that a buyer employs two suppliers, one of which may dominate the other in terms of business share, price, reliability, and others. In the last sourcing model, multiple sourcing, a buyer does business with several suppliers and plays one supplier against the other to achieve the best price advantage.
Multiple sourcing is also considered a better mechanism to avoid source dependency and price disruption and to provide a buffer against uncertainties such as strikes, fires, and bankruptcies (Newman 1989). However, the literature has advocated single sourcing policies that emphasize economies of scale, trust, and improved quality (Shin et al. 2009). The documented benefits of single-sourcing are quantity discounts from order consolidation, reduced order lead times, and logistical cost reductions as a result of a scaled down supplier base (Bozarth et al. 1998). Although, managing more than one source is obviously more impracticable than dealing with a single source, single-sourcing dependency may also expose the buying firm to a greater risk of supply interruption (Burke et al. 2007). Another shortcoming of single sourcing is that it exposes the buying firm to hold-up risk. The identification of the correct strategy for mitigating risks and coping with the uncertainty that affects the current economy is a key factor for the success of firms (Costantino and Pellegrino 2010). Concepts such as Just-In-Time, Lean Manufacturing, and Total Quality Management often suggest reducing the sourcing base and building long-term relationships with important sources (Sajadieh and Thorstenson 2014).

In such a competitive business environment, enterprises should use worldwide resources to upgrade their own core-value and to obtain differential competitive edge (Chen et al. 2013). Global outsourcing may also be perceived as a way to reduce firm risk by sharing it with suppliers (Kremic et al. 2006) andit is an expected response to competition (Zeng 2000, Rossini 2005). However, the choice of the location and/or the speciality of the serviceis subject to continual re-evaluation (Carter et al. 2008). An effective global sourcing strategy requires continual efforts to streamline manufacturing without sacrificing marketing flexibility (Kotabe and Murray 2004). Kotabe et al. (2008) presented an inverted-U shaped curve to define the relationship between profitability and the degree of global outsourcing and they suggested an optimal degree of outsourcing for a firm. If the firm moves away from this optimal point, profitability decreases dramatically. Grössler et al. (2013) suggest that globally outsourcing companies focus on achieving cost benefits, while companies domestically outsourcing companies focus on achieving capacity flexibility.

Determination of the order allocation is a strategic purchasing decision that will also impact the firm's relationship with suppliers. Since the purchasing decision is based on multiple suppliers, the buying firm can split its orders among suppliers to weaken the supplier's power over the buyer (Tsai and Wang, 2010). To focus on relationship management, firms need to split order quantities to all the selected suppliers to keep secure working relationship with suppliers (Kawtummachai and Hop, 2005). Kawtummachai and Hop (2005) studied the effects of an order allocation procedure in a supply chain. They have constructed an algorithm to determine the orderquantities with regarding the purchasing costs of products for multiple suppliers. Demirtaş and Üstün (2008) presented an integrated approach of analytic network process (ANP) and multi-objective mixed integer linear programming (MOMILP). They proposed to consider both tangible and intangible factors in choosing the best suppliers and determined the optimum quantities among selected suppliers to maximize the total value of purchasing and minimize the budget and defect rate. Lin (2009) combined ANP with Fuzzy Preference Programming (FPP) to select suppliers and used multi objective linear programming model to achieve order quantities among the selected suppliers. Kirytopoulos et al. (2010) presented a meta-model for supplier evaluation and order allocation. Venkatesan and Kumanan (2012) proposed a multi- objective binary particle swarm algorithm to select the supply chain sourcing strategy and modeled the selected scenarios by using simulation software. Wu et al. (2012) developed a bi-objective genetic algorithm (boGA) for solving the outsourcing order allocation problem with multiple objectives and nonlinear cost structure. Guo et al. (2013) presented a multi objective order allocation planning model for make-to-order production environment. Jadidi et al. (2014) presented a multi objective optimization model for the problem of supplier selection and order allocation.

III. PROPOSED MODEL

In this paper sourcing strategy evaluation process is formulated as a multi criteria decision making problem and order allocation among global suppliers is formulated as a mixed integer linear programming model. The proposed framework depicted in Figure 1 is divided into two distinct but dependent components, fuzzy logic based sourcing strategy evaluation model (FLB_SSEM) and order allocation component (OAC).

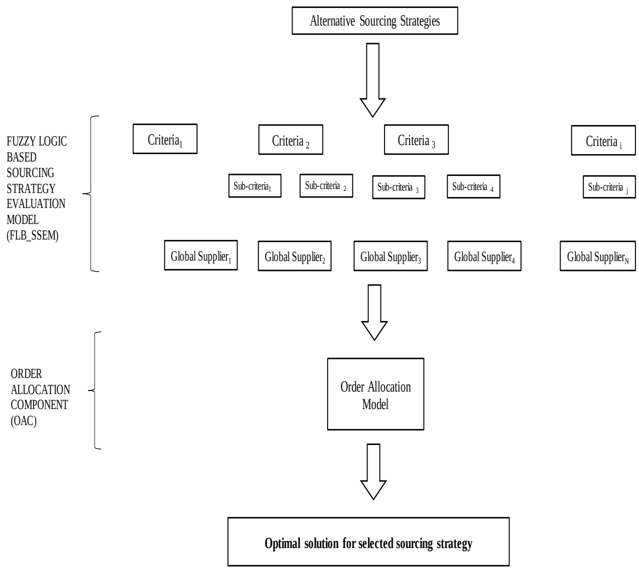

Figure 1. The structure of the proposed framework

Interviews with individuals and a review of the related literature indicated that the decision making process for sourcing strategies evaluation is a critical stage in the strategic development of the business organization (Kotabe and Murray 2004, Jain and Swarup 2011, Rao 2013). However, business organizations do not have an appropriate method to use to make this decision. The contribution of this study is multiple. Initially, in this study FLB_SSEM is presented. To develop a fuzzy inference system, the input and output criteria were first determined. Alternative global suppliers are evaluated by considering determined criteria using fuzzy logic. The output of the FLB_SSEM includes numerical evaluation results of each global supplier. Secondly, mixed integer linear programming model is presented for order allocation. Even though the order allocation component seems to be an independent component, it can be included in the decision process when the capacity of the best global supplier is insufficient for product demand or there can be simultaneous multi-product demand. In this situation the decision maker needs an optimization model which considers the global suppliers' numerical evaluation results, global suppliers' capacities and product demand.

3.1 Sourcing strategy evaluation model

The first part of this study includes FLB_SSEM application was developed using the Matlab Fuzzy Logic Toolbox. The ability to determine the right criteria for analysis is closely related to the performance of the fuzzy system. The determined criteria should represent the entire decision process. In this study defined eight main criteria and 19 sub-criteria dependent on the five main criteria are determined. One output is defined for the FLB_SSEM. This output represents the relevant evaluation decision with the relevant global suppliers for the product in question. The general structure of the system including the main criteria and sub-criteria is shown in Figure 2.

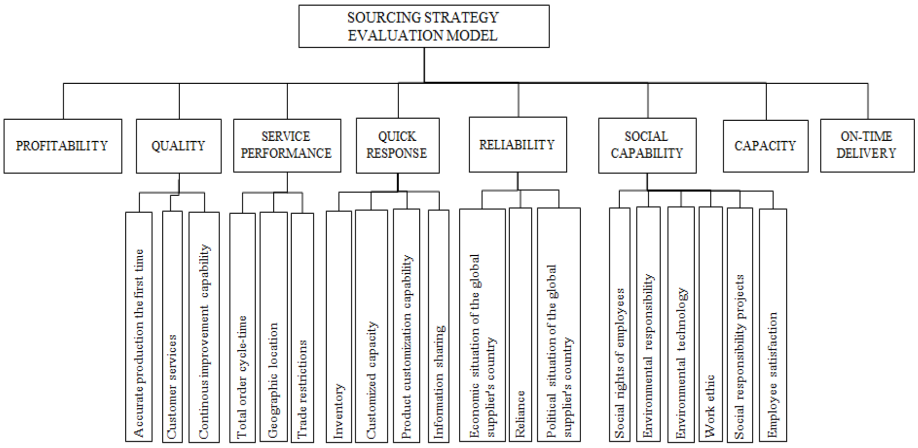

Figure 2. Criteria of the sourcing strategy evaluation model

The numerical ranges of the linguistic labels of the input and output criteria determined for the FLB_SSEM are presented in Table 1. A total of 1296 "IF-THEN" rules were defined for the fuzzy inference system, which had eight inputs and one output.

Table 1. Numerical ranges of the linguistic labels of the input and output criteria for the FLB_SSEM

Criteria		Linguistic Labels	Numerical Range
INPUT	Profitability	Low Medium High	[0 – 0.4] [0.3 – 0.6] [0.5 – 1]
	Quality	Bad Average Good	[0 – 0.4] [0.3 – 0.6] [0.5 – 1]
	Service Performance	Bad Average Good	[0 – 0.4] [0.3 – 0.6] [0.5 – 1]
	Quick Response	Bad Average Good	[0 – 0.4] [0.3 – 0.6] [0.5 – 1]
	Reliability	Satisfactory Unsatisfactory	[0 – 0.5] [0.4 – 1]
	Social Capability	Satisfactory Unsatisfactory	[0 – 0.5] [0.4 – 1]
	Capacity	Sufficient Insufficient	[0 – 0.95] [0.4 – 1]
	On-time Delivery	Sufficient Insufficient	[0 – 0.5] [0.9 – 1]
OUTPUT	Decision	Very Bad Bad Below Average Average Above Average Good Very Good	[0 – 15] [10 – 30] [25 – 45] [40 – 65] [60 – 80] [75 – 90] [85 – 100]

3.2. Order Allocation Component

The second component of the proposed system consists of a single buyer supplied by N candidate global suppliers. The decision maker (buyer), evaluate global suppliers with FLB_SSEMand obtained numerical evaluation results for candidate global suppliers. The decision maker aims to maximize the buyers profit when deciding the order allocation among global suppliers which have higher scores. If the capacity of the global supplier which has the highest score is sufficient for all product demand, the decision maker allocates the orders to the global supplier, and the decision maker doesn't need to have an order allocation model.

On the other hand, if the capacity of the global supplier which has the highest score is insufficient for all products' demand, the decision maker needs to split orders among global suppliers, have higher scores. The complexity of this situation increases as the number of global suppliers and / or products increase as shown in Figure 3.

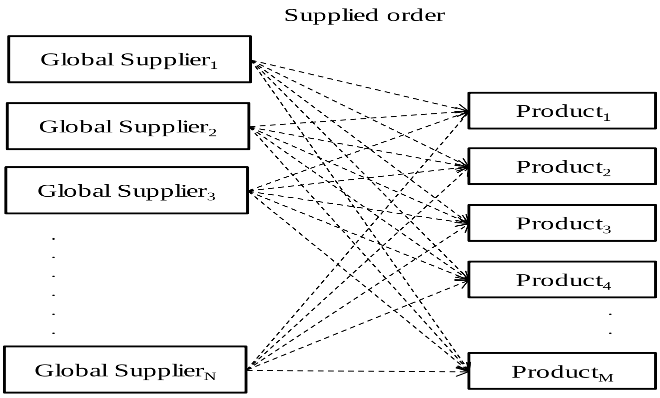

Figure 3. Order allocation among global suppliers

In this section, mixed integer linear programming model is presented, to determine the order quantities among global suppliers. It is assumed that, each global supplier has ability to produce multiple products.

Notations

Indices

$i = 1,2,.....,N$ Set of global suppliers

$j = 1,2,.....,M$ Set of products

Decision variable

Y_{ij} The order quantity of *product*$_j$ from*global supplier*$_i$

Model parameters

W_{ij} Numerical evaluation result for *global supplier*$_i$ and *product*$_j$ obtained from FLB_SSEM

C_i Capacity of *global supplier*$_i$

d_j Demand for the *product*$_j$

l_i Logistics cost of the unit product for *global supplier*$_i$

B Budget

Model

Max $\sum_{i=1}^{N}\sum_{j=1}^{M} W_{ij}Y_{ij}$ (1)

s.t.

$\sum_{j=1}^{M} Y_{ij} \le C_i \qquad i = 1,2,....,N$ (2)

$\sum_{i=1}^{N} Y_{ij} \ge d_j \qquad j = 1,2,....,M$ (3)

$\sum_{i=1}^{N}\sum_{j=1}^{M} l_i Y_{ij} \le B$ (4)

$Y_{ij} \ge 0 \qquad i = 1,2,....,N$ and $j = 1,2,....,M$ (5)

The objective function (1) seeks to maximize the order quantity from global suppliers which have higher numerical evaluation results. Constraints (2) and (3) restrict the order quantity with the capacity and demand, respectively. Constraints (4), ensure the logistics cost smaller than the budget. Constraints (5) ensure Y_{ij} are nonnegative.

IV. THE APPLICATION OF THE PROPOSED SYSTEM

In this paper a numerical example is conducted for the integrated FLB_SSEM and OAC. The application of the FLB_SSEM was developed using the Matlab Fuzzy Logic Toolbox and the OAC includes mixed integer linear programming model for order allocation among selected sourcing strategy is coded in MPL (Mathematical Programming Language) and solved with GUROBI 5.1.0 solver.

Table 2 includes eight application examples regarding FLB_SSEM. The global suppliers might have different evaluation results for different products. These evaluation results are used as coefficients in the objective function of the OAC.

Table 2. Application examples of FLB_SSEM

		GS1	GS2	GS3	GS4	GS5	GS6	GS7	GS8
FLB_SSEM Input	Profitability	0.54	0.72	0.52	0.63	0.81	0.50	0.71	0.50
	Quality	0.52	0.64	0.52	0.62	0.78	0.67	0.62	0.54
	Service Performance	0.57	0.48	0.51	0.50	0.81	0.48	0.54	0.48
	Quick Response	0.19	0.45	0.21	0.47	0.81	0.57	0.58	0.30
	Reliability	0.81	0.53	0.82	0.55	0.24	0.53	0.6	0.76
	Social Capability	0.72	0.48	0.68	0.46	0.27	0.48	0.41	0.80
	Capacity	0.82	0.51	0.84	0.52	0.91	0.45	0.62	0.76
	On-time Delivery	0.95	0.60	0.94	0.64	0.96	0.61	0.54	0.92
FLB_SSEM Output	DECISION	76.12	62.27	72.14	60.34	78.42	64.08	64.22	72.17

Table 3 summarizes the essential information of global suppliers, such as numerical evaluation results with respect to products, unit logistics costs and products' demand.

Table 3. Numerical data for OAC

	Global Suppliers *i*								
Products	1	2	3	4	5	6	7	8	
j	Scores of global suppliers								Demand
1	76.1	62.3	72.1	60.3	78.4	64.1	64.2	72.2	1200
2	90.4	50.2	80.4	80.7	81.6	87.4	80.2	80.7	1800
3	84.2	90.3	40.2	72.4	94.6	58.4	70.3	90.6	3000
4	92.2	80.3	63.4	0.76	92.5	62.6	91.2	76.3	2400
5	78.8	70.7	90.2	81.4	94.7	81.3	67.2	68.2	2600
6	86.3	62.5	80.5	65.5	95.2	72.3	79.3	64.7	1700
7	92.6	66.4	70.2	74.2	83.2	62.5	87.9	75.8	2400
8	95.5	71.9	90.3	80.3	82.3	71.9	75.5	82.7	3200
9	84.5	58.2	51.3	92.3	77.4	81.2	76.3	86.2	4500
10	78.2	64.3	60.4	20.2	68.2	74.2	82.4	94.2	5200
Unit Logistics Cost	2	3	4	4	9	5	2	4	

Each global supplier is assumed to have fixed capacity of 4000 units and the decision maker (buyer) has large budget. OAC is then used to process these parameters and optimal solution is obtained. The details of the optimal solution are given in Table 4.

According to optimal solution, details presented in Table 4, global suppliers S_2, S_3, S_5, S_6 and S_8 fill up their capacities. Total order quantity from global supplier S_1 is 2700, S_4 is 3100, and S_7 is 2200. Different results can be obtained based on the different capacities, logistics costs or budget limit.

Table 4. Optimal solution of the OAC

Global Supplier$_i$	Product$_j$	Order Quantity (Y_{ij})
S_1	P_9	Y_{19}=2700
S_2	P_2	Y_{22}=1800
	P_8	Y_{28}=2200
S_3	P_1	Y_{31}=1200
	P_4	Y_{34}=2400
	P_9	Y_{39}=400
S_4	P_6	Y_{46}=1700
	P_7	Y_{47}=1400
S_5	P_5	Y_{55}=2600
	P_9	Y_{59}=1400
S_6	P_3	Y_{63}=3000
	P_7	Y_{67}=1000
S_7	P_8	Y_{78}=1000
	P_{10}	Y_{710}=1200
S_8	P_{10}	Y_{810}=4000

V. CONCLUSION

The design of global supply chains has been a challenging optimization problem for many years. In a continuing effort to remain competitive, many firms are considering new sources for their raw materials and components, new locations for their production and distribution facilities, and new markets in which to sell their products without regard for national boundaries. The current globalization of the economy is forcing firms to design and manage their supply chains efficiently on a worldwide basis.

This study presents an integrated model for sourcing strategy evaluation considering LCCS and order allocation.The system consists of two components, the sourcing strategy evaluation model, and order allocation component. The decision maker evaluates global suppliers via fuzzy logic based sourcing strategy evaluation model by considering eight main criteria and 19 sub-criteria dependent on the five main criteria (quantitative and qualitative criteria). The output of the first component is numerical evaluation result of the global supplier. This numerical data is one of the inputs of the order allocation component and as coefficient in the objective function of the order allocation model. The decision maker aims to maximize the buyers profit when deciding the order allocation among global suppliers which have higher scores. Mixed integer linear programming model is solved optimally for order allocation component.

According to our knowledge there is not adequate number of studies integrating sourcing strategy evaluation model especially in LCCS and order allocation model in the literature. The proposed model suggests an easy-to-use and effective method for the sourcing strategy evaluation model and optimal model for order allocation among global suppliers, which has been identified in the literature as a complex problem.

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