SINGLE SOURCING VS. DOUBLE SOURCING: A SIMULATION APPROACH TO SUPPLIER SELECTION

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ABSTRACT

The paper presents a simulation approach to the supplier selection problem. Specifically, the aim of the model is to compare a scenario where a company exploits only one supplier (single sourcing) with a double sourcing option. In the case of double sourcing, the second supplier has a higher reliability compared to the first one, meaning that it is always able to deliver the product required within a defined lead time; however, products are supplied at a higher price, thus generating higher costs for the company. Under both scenarios, it is hypothesized that the company adopts an Economic Order Interval (EOI) reorder policy. Overall, the study is articulate into two steps and has the final aim to compare the single sourcing and double sourcing strategies, to assess the economic profitability of those solutions depending on the operating conditions of the company. Related results will provide companies with some economic benchmark for pondering purchasing options.

Keywords: supplier selection, single sourcing, multiple sourcing, simulation, economic analysis, benchmark.

1. INTRODUCTION

A supply chain is a network of suppliers, manufacturers, distributors and retailers, connected by transport infrastructures and information sharing mechanisms. Currently, supply chains include many potentially suppliers, serving one or more manufacturers and/or assemblers, who often use various distributors to send products to the different retailers. A supply chain must ensure an adequate service level to the customers, at the same time minimizing its total cost, including, among others, stock-out cost, cost of holding stocks, order, transport and purchasing.

Purchasing decisions play a main role both to ensure the quality of the final product and to control the cost of procurement (Monczka et al., 2011). Traditionally, purchasing decisions have mainly been made based on cost considerations; currently, many other characteristics are considered for the selection of suppliers, including quality, reliability, flexibility and so on. Weber at al. (1991) review 47 articles, where more than one criterion was exploited for supplier selection. Many other authors (e.g., Roa and Kise 1980, Ellram 1990, Stamm and Golhar 1993, Bottani and Rizzi, 2005) propose detailed lists of criteria for the selection of suppliers.

Besides those selection criteria, some particular procurement strategies also require specific selection procedures for suppliers. For instance, just in time (JIT) strategies ground on the principles of improving quality of the final product, flexibility of the supply chain and service level delivered to customers. A practical way to achieve the objectives above is to decrease the lot size, thus reducing the amount of waste, the cost of inspections and quality checking. With the decrease of the lot size, the number of suppliers decreases too.

The most common procurement strategies are single sourcing, dual sourcing and multiple-sourcing (Yu et al., 2009). Single sourcing means that a company selects one single supplier, starting from a set of suppliers and evaluating them based on relevant selection criteria (Newman, 1989). The second strategy, i.e. the dual sourcing, refers to the case where the buyer uses two suppliers, with different characteristics in terms of market share, price, reliability, or other aspects (Tomlin and Wang, 2005). In the last strategy, i.e. the multiple-sourcing, the buyer works with several suppliers and encourages competition among them, to keep advantage of the better procurement conditions.

The strategic importance of selecting among single sourcing or dual sourcing has been widely debated in literature. A wide branch of studies discusses the advantages and disadvantages of adopting single sourcing vs. double/multiple sourcing. For instance, Costantino and Pellegrino (2010) summarize the main pros and cons of multiple sourcing against single sourcing, as follows:

- Single sourcing allows establishing a long-term partnership between company and supplier. On the other hand, however, the company is more dependent on the supplier, and, therefore, the supply channel is more vulnerable;
- Multiple sourcing allows reducing the risk of unexpected interruption of furniture, and, at the same time, it increases competition among suppliers. Hence, lower price of the products can be obtained. However, the overall cost of the purchasing process could be higher than in the case of single sourcing, because of the need for managing more suppliers.

On the basis of the above considerations, many researchers have tried to define the optimal procurement strategy of the company, by identifying the optimal number of suppliers (e.g., Agrawal and Nahmias 1997; Zeng 2001; Burke et al. 2007). Others studies propose the evaluation of supply contracts as a function of the level of uncertainty where the company operates (Kamrad and Siddique 2001). Costantino and Pellegrino (2010) propose a Real Options approach for evaluating, through a probabilistic model, the benefits of multiple sourcing in managing the supplier default risk, compared to the single sourcing strategy. Sajadieh and Thorstenson (2014) investigate four different sourcing models, including sole sourcing and dual sourcing, in a two-echelon supply chain. The sourcing strategies are compared with respect to the total cost they generate, including inventory holding cost, backorder cost, order cost and setup costs for the vendors. The authors found that there is not a strategy that dominates the remaining ones; therefore, they conclude that the selection of the sourcing strategy needs a careful evaluation. A similar work is carried out by Chung et al. (2010). These authors study a decentralized supply chain composed of two suppliers and one buyer. One supplier has more flexibility in terms of quantity, while the second one offers lower purchasing price of items. The purchasing problem is faced from the buyer's perspective, to identify the optimal decision. Yu et al. (2009) evaluate the single sourcing vs. dual sourcing methods in presence of supply disruption risks. They examine a two-stage supply chain with a non-stationary and price-sensitive demand, and derive the expected profit functions of the two sourcing modes for the supply chain. Similarly, Sawik (2014) presents a stochastic mixed integer programming model to selecting suppliers in the presence of supply chain disruption risks, both in the case of single and dual sourcing strategies. Glock (2012) examines the case of a buyer who has to decide between single or dual sourcing for a homogeneous product. In the scenario examined, the production process of the suppliers is subject to learning effects, meaning that the production cost can progressively decrease and the production capacities of the suppliers can increase correspondingly.

The brief discussion of the literature proposed above suggests that, in general, researchers compare single sourcing and dual sourcing policy with the purpose of identifying the optimal purchasing strategy, in terms of total cost. Another finding from the literature is that dual sourcing is a preferred strategy when there is the risk of interruptions of furniture.

Starting from the considerations above, in this paper we compare the single sourcing strategy and the dual sourcing one, in terms of their total cost. A simulation model is developed to reproduce the sourcing strategy of a buyer, under two different scenarios. For each scenario, the total cost of sourcing is evaluated, with the purpose of identifying the optimal purchasing strategy of the buyer.

The remainder of the paper is organized as follows. Section 2 describes the simulation model developed and the scenarios examined. Section 3 provides the results of the simulation runs. Section 4 discusses the main findings of the study, the related limitations and implications, and highlights future research directions.

2. MODELLING FRAMEWORK

2.1. The scenarios examined

As mentioned, a simulation approach has been chosen in this paper, to study the behavior of single sourcing and dual sourcing systems.

Two different scenarios have been modelled and evaluated. The first one reflects the single sourcing strategy, and considers only one supplier who is characterized by a defined level of reliability. Several simulation runs have been launched varying the degree of reliability, from 100% (i.e., the supplier always delivers the product on the right quantity and on time) to 80% (reflecting the percentage of times the supplier is able to satisfy the customer's request). Obviously, in general a more reliable seller is preferred. Nonetheless, a company could accept a lower level of reliability in the case this corresponds to a lower cost of purchasing. In this respect, simulation is a valuable tool to evaluate the trade-off between cost and reliability, and to assess the impact of reliability on the total cost of the system. By means of simulation, for each level of reliability (from 100% to 80%, step 1%), the optimal combination of the operating leverage of the reorder policy (i.e., ΔT and OUTL) is determined. By optimal, we mean the combination that minimizes the total cost of the system, as described in section 3.

The second scenario reflects the dual sourcing option; therefore, two different suppliers are considered. The first one has the same characteristics of the supplier described in the previous scenario. The second one, instead, is characterized by 100% reliability; however, compared to the first vendor, it sells its product at a higher price. For this reason, the buyer will place an order to the second vendor only when the first one is not able to deliver the right quantity of product in the required time. Again, several scenarios are considered, with the reliability of the first vendor varying in a defined interval, as per the first scenario.

The aim of this work is to determine the optimal (in terms of total cost) level of reliability for the scenarios described. Moreover, the single sourcing and dual sourcing options are also compared, to identify the positive and negative aspects of both solutions.

2.2. Software implementation under MS Excel™

The simulation model consists of a MS Excel™ file which reproduces the flow of orders, under an EOI reorder policy. The simulation duration was set at 100,000 days.

The customer's demand is generated as a sequence of random numbers, whose statistical distribution is uniform between 0 and 200 items/day.

According to the EOI policy, the buyer places an order to the vendor at fixed periodic interval (designated as ΔT), regardless of the current inventory position. The amount of product ordered can vary, as it should allow raising the current stock to the order-up-to level (OUTL) threshold. This latter reflects the amount of stock to recover. Therefore, the reorder policy simulated is characterized by 2 operating leverages, such as ΔT and OUTL.

During the simulation, the model was exploited to examine different settings of the operating leverages, with the purpose of identifying the combination of ΔT and OUTL which generates the minimum total cost. To this extent, ΔT was varied from 20 and 40 days while OUTL from 3000 to 4000 items.

The total cost, that the simulation model minimizes, includes the inventory holding cost (C_h), the stock-out cost (C_{so}) and order cost (C_o). All contributions are expressed in [€/day], and their amount is derived as the average cost over the simulation duration.

The holding cost considers only one variable, i.e. the level of the inventory at the buyer's site. The stock out cost results from the number of items the buyer is not able to deliver to the customer (which is a direct outcome of the simulation). The economic loss for those items is assumed to be very high, accounting for 100 times the unitary cost of holding stocks. Such a value should highlight the need for avoiding out-of-stock situations. Finally, the order cost covers the administrative aspects that a company has to consider when it places an order (e.g., the cost of personnel). It unitary amount is expressed as a fixed cost per order, i.e. [€/order]

On the basis of the description above, it can be easily deduced that, in scenario 1, the total cost C_{tot} is computed as:

$$C_{tot} = C_h + C_{so} + C_o \qquad [€/day] \qquad (1)$$

In scenario 2, two additional cost components are included in the total cost, i.e.:

- a difference in the purchasing cost (ΔC_p) between vendor 1 and 2. This contribution reflects the fact that vendor 2 delivers the product at a higher price;
- a fixed additional cost component, which consider the fixed cost of managing the order (and, more in general, the relationship) with the second supplier (ΔC_m). This cost contribution is computed each day.

Moreover, as already mentioned, in scenario 2 the order cost is different for seller 1 and 2. Overall, the total cost in scenario 2 can be calculated as:

$$C_{tot} = C_h + C_{so} + C_{o1} + C_{o2} + \Delta C_p + \Delta C_m \qquad [€/day] \qquad (2)$$

Table 1 shows the input data set in the simulation for the 2 different sellers. As already explained, scenario 1 considers only one supplier, with not perfect reliability (vendor 1). Conversely, scenario 2 includes 2 suppliers, i.e. vendor 1, with the same characteristics described above, and vendor 2, this latter being more expensive but perfectly reliable.

Table 1: Input data of the simulation

	Vendor 1	Vendor 2
Procurement lead time [days]	3	3
Cost of holding stock [€/unit/day]	0,001	0,001
Stock-out cost [€/unit/day]	0,1	0,1
Order cost [€/order]	50	100
Δ purchase cost [€/unit]	-	0,05
Seller management [€/unit]	-	1,8
Reliability	80-100%	100%

3. RESULTS

At the end of the simulation process, the results have been collected, to study the behavior of the system as a function of the different operating conditions. Results are discussed below for the two scenarios simulated.

3.1. Results under scenario 1

The optimal combination of ΔT and OUTL (i.e. the combination which minimize the total cost), as a function of the reliability of the supplier, has been first investigated. Results are reported in Table 2.

Table 2: Scenario 1 – total cost, ΔT and OUTL as a function of the supplier's reliabiliy.

Reliability	Total cost	ΔT	OUTL
99%	4.53	23	3050
98%	5.03	19	3125
97%	5.24	19	3475
96%	5.39	19	3650
95%	5.5	18	3500
94%	5.61	17	3575
93%	5.74	16	3375
92%	5.84	16	3550
91%	5.96	15	3400
90%	6.08	15	3625

89%	6.18	15	3675
88%	6.27	14	3550
87%	6.36	14	3775
86%	6.41	14	3900
85%	6.49	13	3700
84%	6.57	13	3775
83%	6.62	13	3850
82%	6.71	12	3900
81%	6.77	12	3700
80%	6.8	12	3957

The trend of ΔT as a function of the reliability level for this scenario is shown in Figure 1.

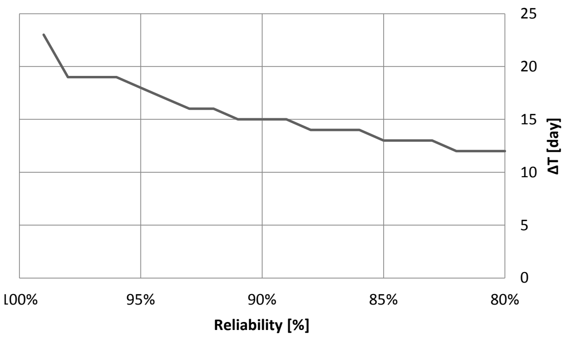


Figure 1: Scenario 1 – trend of ΔT as a function of the supplier's reliability.

From Figure 1, it is easy to see that that there is a significant decrease in the optimal ΔT when the supplier's reliability decreases. This means that, if the supplier is less reliable, the company will increase the order frequency (i.e., will decrease the reorder interval), to protect itself from possible delays and avoid stock-out situations.

Conversely, the trend of the OUTL as a function of the supplier's reliability is opposite (Figure 2): this parameter increases when the reliability decreases. Indeed, a company should set a high safety stock level in order to face a potential lack of product ordered.

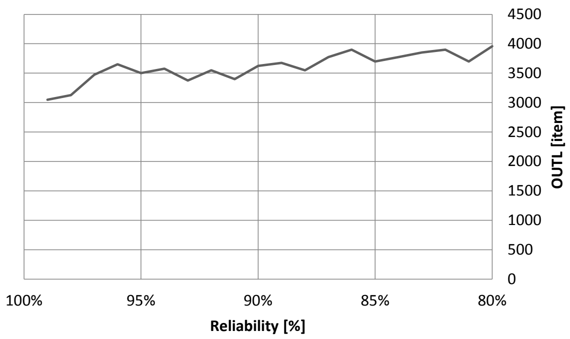


Figure 2: Scenario 1 – trend of OUTL as a function of the supplier's reliability.

With respect to the total cost of this scenario, it increases with the supplier's reliability, with a logarithmic trend (Figure 3). Indeed, if a supplier is 100% reliable, the company could work at optimal level of ΔT and OUTL minimizing the total cost. Otherwise, if the supplier's reliability decreases (meaning that it is not always able to deliver the product), the company should adapt the parameters of its reorder policy to the supplier's reliability, resulting in an increased total cost.

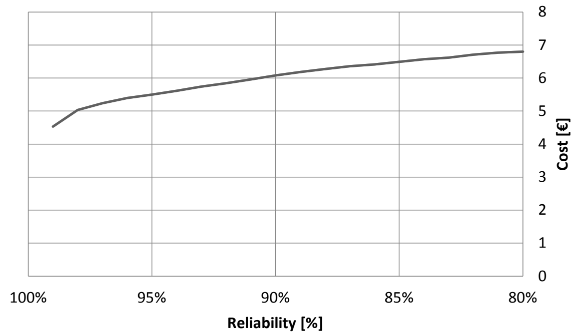


Figure 3: Scenario 1 – trend of the total cost as a function of the supplier's reliability.

3.2. Results under scenario 2

As per the previous case, the trend of the two main parameters was analyzed also in scenario 2. In this case, however, the reliability of the first supplier was varied from 80% to 100%, while and the second vendor owns a perfect (100%) reliability.

The optimal combination of ΔT and OUTL, as a function of the reliability of the first supplier, is reported in Table 3.

Table 3: Scenario 2 – total cost, ΔT and OUTL as a function of the supplier's reliability.

Reliability	Total cost	ΔT	OUTL
0.99	5.47	30	3550
0.98	5.54	30	3575
0.97	5.61	30	3525
0.96	5.67	30	3525
0.95	5.74	30	3575
0.94	5.8	31	3650
0.93	5.87	31	3675
0.92	5.93	31	3650
0.91	6.00	32	3775
0.90	6.07	32	3775
0.89	6.13	32	3700
0.88	6.19	32	3775
0.87	6.26	33	3875
0.86	6.32	33	3825
0.85	6.39	33	3825
0.84	6.46	33	3825
0.83	6.52	33	3875
0.82	6.59	33	3850
0.81	6.65	33	3875
0.80	6.71	34	3975

Compared to scenario 1, the trend of ΔT as a function of the supplier's reliability is opposite (Figure 4). Specifically, the optimal ΔT increases slightly, and the optimal value varies in a range of only 4 days. This result is justified by the fact that, if the first supplier is not able to deliver the product, the company will place an order to the second one, whose order cost, however, is higher. For this reason, less frequent orders are preferable.

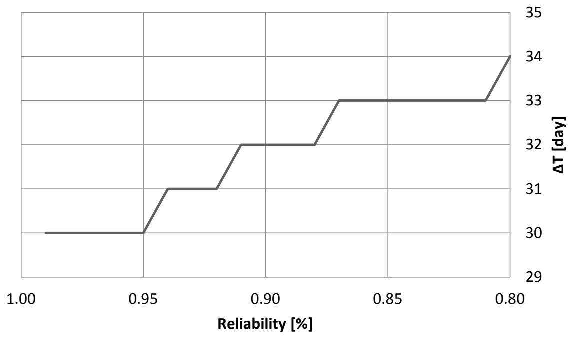


Figure 4: Scenario 2 – trend of ΔT as a function of the reliability of the first supplier.

Conversely, from Figure 5 one can observe that the OUTL trend is the same as that of the previous scenario, even though the increase is less appreciable, as can be seen from the lower slope of the curve.

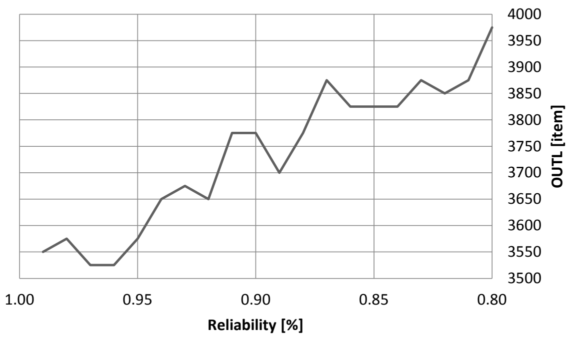


Figure 5: Scenario 2 – trend of OUTL as a function of the reliability of the first supplier.

As already mentioned, the total cost of scenario 2 includes more cost components than scenario 1. Nonetheless, even in this scenario, the cost increases if the reliability decreases, but with a different (linear) trend.

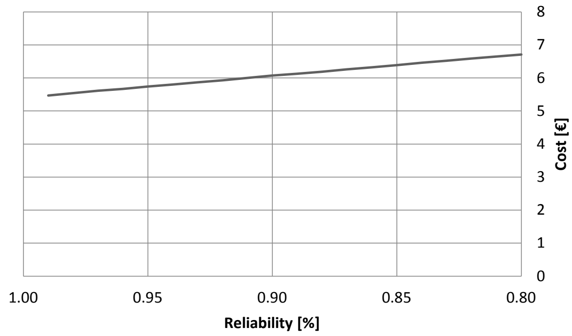
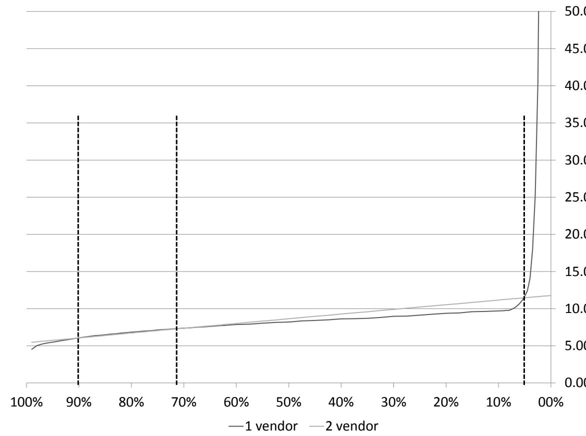


Figure 6: Scenario 2 – trend of the total cost as a function of the reliability of the first supplier.

3.3. Cost comparison

On the basis of the outcomes of the scenarios 1 and 2, a trade-off between cost and supplier's reliability can be investigated, by varying the reliability of the first vendor between 0% and 100%. The corresponding outcomes are reported in Figure 7.

Figure 7: scenario 1 vs. scenario 2 - total cost comparison.



The comparison of cost shows that the economic profitability of single sourcing vs. dual sourcing chiefly depends on the reliability of the first vendor. Specifically:

- in the case vendor 1 has a high reliability (approx. ranging from 100% to 90%), there is actually no economic profitability in exploiting the dual sourcing strategy. Indeed, under that circumstance the stock-out experienced by the buyer is limited, and the related cost is not balanced by the additional cost of purchasing items from vendor 2;
- in the case the reliability of vendor 1 is lower (approx. from 90% to 70%), dual sourcing becomes the most profitable strategy. This suggests that, under this scenario, the additional cost of sourcing at vendor 2 is counterbalanced by the avoidance of out-of-stock situations, resulting in a lower total cost;
- if the reliability of vendor 1 decreases (from 70% to 7% approximately), dual sourcing is no longer profitable. Indeed, despite the low reliability, the optimal cost configuration is obtained with single sourcing at vendor 1. The rationale for this outcome, that could sound strange, is that, under this scenario, if multiple sourcing was allowed, the buyer would always place order to vendor 2, generating higher total cost;
- finally, in the case the reliability of vendor 1 is lower than 7%, the optimal sourcing strategy becomes single sourcing with vendor 2. This means that, with this low reliability, placing orders to vendor 1 would always generate out-of-stock situations. Therefore, the optimal situation is sourcing only at vendor 2, to avoid out-of-stock occurrence.

4. DISCUSSION AND CONCLUSIONS

This paper has proposed a simulation approach to a well-known problem of supplier selection literature, i.e. the choice between single sourcing and dual sourcing. A simulation model has been built under MS Excel™ to reproduce the order process of a buyer, under two scenarios, i.e.:

- The single sourcing scenario, where the buyer can place orders only to one vendor;
- The dual sourcing scenario, where the buyer can exceptionally place orders to a second vendor. This latter has higher reliability compared to the first vendor, and therefore is always able to send products to the buyer, but at higher price.

The economic profitability of the two scenarios has been analyzed as a function of the reliability of the first supplier, as well as the trend of the reorder policy (i.e., EOI) parameters, namely the reorder interval and the order-up-to level.

Although the numerical outcomes of our study can be affected by the specific input data we set, the considerations related to the economic profitability of the two scenarios can be useful to a company wishing to ponder different purchasing decisions. This is an interesting practical contribution of this study.

From the theoretical perspective, we have mentioned that single sourcing and dual sourcing are quite debated topics of supply chain management literature. Nonetheless, to our knowledge, there are very few studies that propose a simulation approach to solve this problem. This paper, therefore, demonstrates the usefulness of a simulation approach to this kind of managerial decisions. Simulation is also useful to vary the problem settings (as done also in this paper), in terms, for instance, of the EOI parameters, the supplier's reliability or the economic parameters.

Starting from this paper, future research activities can be carried out to investigate in further detail the sensitivity of the results to the input data set. A formal design of experiments (DOE) procedure could be useful to this extent. Moreover, applying the approach developed to a real case example could be another suitable research to be undertaken in the future.

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