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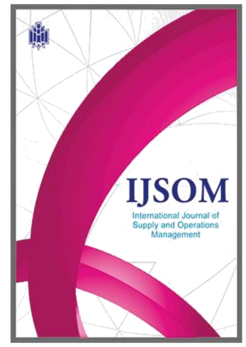

Applying a Safety System Versus the Risky Suppliers

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Abstract

The changing factors of supply chain management include the evolution of technology in market conditions, the transformation of business practices, new expectations of partners in the supply chain, and demand for more value-added from the end-user consumer. Manufacturing organizations require more flexibility to maintain a competitive advantage as well as to operate in a dynamic environment. As the complexity increases, uncertainty and levels also increase in the supply chain. Hence, risk management has become a major issue in the supply chain and plays a significant role in the supply chain performance and the continuity of the organization's dynamics. In the paper, the process of supply chain risk management has been gone through and a risk mitigation model has been presented. The goal of the paper is to expand the proposed model of Kirilmaz & Erol in which the number of commodities increases. In the first step of the suggested method, a procurement plan is provided by a linear planning model, taking into account cost constraints. In the second step, the plan is revised by considering risk criteria for planning. The transition of orders is made to reduce the risk from high risky suppliers to less risky suppliers. The process of supply chain risk management has been performed by an electromotor company in the Middle East. We use the Kirilmaz & Erol model to validate the proposed model.

Keywords: Supply Chain Risk Management; Proactive Approach; Procurement Plan; Multi-Commodity.

1-Introduction

A supply chain (SC) is a network that is geographically composed of dispersed facilities (suppliers, manufacturers, warehouses or distribution centers, customers) (Mohajeri et al., 2011). Today, factors such as globalization, outsourcing, and increasing the variety of products and services lead to increased complexity in the SC (Cano-Olivos et al., 2022). As the complexity increases, the level of uncertainty and risk in the chain also increases (Xia and Chen, 2011). Increasing uncertainties in the supply chains have caused more attentions to the supply chain risk management approaches (Hajian Heidary, 2023). For these reasons, manufacturers should focus on risk management (RM) processes and make their procurement plans based on risk assessment. The supply chain may be at risk due to various factors (Arshadi Khamseh and Mohsenzadeh Ledari, 2018). One of the important risks which threatens the SC is the supplier risk. RM includes four strategies: avoiding risk, reducing theprobability and/or impact of risk, accepting the risk occurrence, and preparing contingency plans. The choice of strategy is based on the relationship between the anticipated impact and the costs assigned to the selected strategy. Risk mitigation strategies are divided into two categories: reactive and proactive. In a reactive strategy, no activities are taken before risky events occur. However,

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their implementation mitigates the impact or probability of risky events after they occur. In the strategy, there are no plans to decrease the probability of risk. However, there are many plans to decrease the impact after risk events occur. In proactive strategies, plans are designed to reduce risky events before they occur. These approaches may cover plans aimed at reducing the probability and/or impact of risky events.

Kirilmaz and Erol (2017) proposed a mitigating strategy to reduce the expected effects of risks. In their paper, they used a proactive strategy for RM that addresses the transition of orders among suppliers to mitigate the risk in SC. In their model, the supply of a commodity is considered by several suppliers but in the case of reality, several commodities are provided by suppliers. The purpose of the paper is to develop the proposed method by Kirilmaz and Erol via procuring several types of commodities from suppliers. Accordingly, a proactive plan is presented in the paper. The purpose of the approach is to take caution in dealing with unreliable suppliers as well as to reduce the amount of damage in risky events.

Deciding how to buy materials is one of the most important decisions that directly affect the profitability of the chain. This decision leads to an increase in the net value of the outputs of facilities, considering the limited resources. Many supply chains purchase multiple materials simultaneously to generate higher profit margins, by using discounts. In such a situation, due to various physical and financial constraints, the chain cannot meet the total needs of all materials at the same time. So, the paper proposes a new model to fix the shortage of theKirilmaz and Erol model by considering multi-commodity .

According to the risk factors, the risks of the supply chain are divided into different kinds. One of the risks to the supply chain is the risk borne by the suppliers (Mirghafouri et al., 2012). In this paper, considering the crucial role of suppliers in the finished product quality, and so customer satisfaction, the issue of supply chain risk management (SCRM) from the perspective of the suppliers' risks in an electromotor company located in the Middle East has been studied and decisions to reduce the level of risk has been taken. On the other hand, because of the existence of different criteria for evaluating suppliers at different times, the simultaneous assessment of current and new suppliers has always been a problem for organizations. In this paper, a risk-based process is used to identify risks from suppliers ofthe electromotor company.

The paper is organized below. The literature review and the proposed model are presented in the second part and the third part, respectively. In the fourth part, the model is evaluated by using an example, and then its validation is confirmed by approaching the Kirilmaz and Erol model. In the fifth part, the method is presented and the model is implemented in the electromotor industry. In the last part, the results are described and the future work is presented.

2-Literature Review

Tummala and Schoenherr (2011) presented a comprehensive and interconnected approach to risk management in the SC and concluded that using risk management processes of the SC can effectively manage risks. They consider three phases for risk management (see figure 1). The first phase includes identification, measurement, and risk assessment steps. At the identification stage, the potential risks of the supply chain are fully and structurally determined. In the risk measurement step, it determines the risk consequences and, at the assessment stage, it determines the probability of occurrence of each risk. The second phase includes risk assessment and contingency plans. At the measurement stage, it takes risk ranking and risks acceptance, and in risk mitigation, it provides solutions for risk response. Finally, the third phase involves risk control and monitoring. The 3rd deals with corrective actions in dealing with deviations in achieving the desired supply chain performance and providing guidance for future improvements.

Strategies of risk mitigation are divided into two categories: reactive and proactive. Reaction tools are effective measures that attempt to reduce the impact of risk. They do not take action to risk instantaneously but they intend to capture the risk damage (Tomlin, 2006). Musson (2001) suggested seven strategies to manage supply chain risk reactively.

The strategies may be proactively used, but they need to know how they are decided and implemented as soon as the risky events occur. Kilubi (2016) proposed six strategies for SCRM effectively, including a reactive approach. A way to proactive planning has been given by reactive planning in SCRM (Kirilmaz and Erol, 2017). As already mentioned, in the proactive method, plans are made to reduce risky events before they occur. These procedures can include plans aimed at reducing the probability and/or impact of risky events. Norrman and Jansson (2004) described how Ericsson Company has implemented tools and processes to avoid risk in supply chain risk management. They used a proactive approach after a fire in one of their suppliers. Knemeyer et al. (2009) developed a proactive plan for catastrophic risks.

The proposed plan involves risk analysis and an innovative procedure for the insurance industry. Grötsch et al. (2013) proactively implemented the risk of SC using the stochastic theoretical perspective. As an important event, they studied the past bankruptcy as criteria for the level of organizational vulnerability and inter-organizational, inter-organizational, and individual predictions. Li and Barnes (2008) proactively focused on identifying supply chain risk management procedures that can be applied to mitigate and eliminate risk sources during the choice process of suppliers in Western manufacturing factories. Kirilmaz and Erol (2017) applied a safety system versus the risky suppliers and decreased the level of loss in case of the risk occurring. In this paper, we intend to develop the model provided by Kirilmaz and Erol by increasing the variety of commodities.

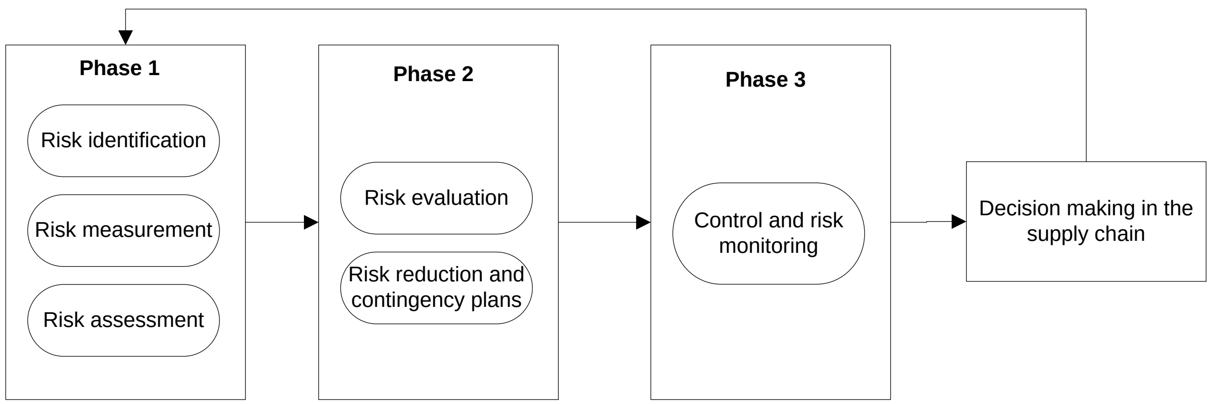


Figure 1. Process of SCRM

3- Model

The proposed model is the expansion of the Kirilmaz and Erol model known as the basic model in this paper. The difference between the basic and the proposed model is given in Table 1. The problem of Kirilmaz and Erol is modeled as a 2- part directional graph. The V1 vector is for suppliers and the V2 vector is for manufacturers. The curve A = V1 * V2 corresponds to the material flow between suppliers and the manufacturers.

$$MinCost = \sum_{i \in V_1} p_i \sum_{j \in V_2} y_{ij} + \sum_{i \in V_1} \sum_{j \in V_2} T_{ij} y_{ij} \tag{1}$$

$$\sum_{j \in V_2} y_{ij} \leq C_i \tag{2}$$

$$\sum_{i \in V_1} y_{ij} \geq D_j \tag{3}$$

$$y_{ij} \geq 0 \tag{4}$$

In the Kirlimaz model, cost is considered the first objective function (equation 1). In the first step of the approach, a primary procurement plan is implemented using the linear planning model. Constraints 2 and 3 show capacity and demand, respectively. Constraint 4 indicates thedecision variable.

$$MaxZ = \sum_{ij} N_{ij} X_{ij} \tag{5}$$

$$\sum_{j} X_{ij} \leq Q_{Ti} \tag{6}$$

$$\sum_{k} X_{ki} - \sum_{j} X_{ij} \leq C_{Ri} \tag{7}$$

In the second step, the primary plan is revised using the supplier's risk profile. The amount of the order from a supplier determined using the minimum cost criteria is proportional to the risk criteria and it will be moved to a more reliable supplier. To achieve the goal, the difference between the supplier's risks is identified. To determine the difference, the overall risk criteria for the supplier with the lowest risk level is considered 0, and the risk criteria of the supplier are deducted from the risk criteria of other suppliers, and the values are normalized. In this way, the differences between all of the suppliers will be preserved (2017). Normalized values of risks indicate the status of suppliers based on the lowest risk supplier. They can be used to determine the amount of transition as a percentage of the primary procurement plan. The supplier is used which has lower cost and lower risk criteria, taking into account capacity constraints. Because the model has capacity constraints, the amount of transition from the risky supplier to the reliable supplier depends on the latter. The objective function is to maximize the amount of material transfer from the high risky suppliers to the lower risk suppliers (see equation 5). Constraint 6 is for the lowest and the highest risky suppliers. Constraint 7 satisfies the condition that the difference between the quantity entering and leaving the supplier cannot be greater than the remaining capacity of that supplier.

Table 1. The differences between the proposed and the basic method

feature / method	Risk-based process	echelon		commodity		Period		Approach	
		Multi	**Single**	**Multi**	**Single**	**Multi**	**Single**	**Proactive**	**Reactive**
Basic			*		*		*	*	
Proposed	*		*	*			*	*	

The difference between Kirilmaz and Erol model and the proposed mathematical model is only adding index k to demonstrate the multi-commodity in the basic model. The next difference is related to identifying risks to reduce in thesupply chain (see case study section).

$$MinCost = \sum_i \sum_k p_{ik} \sum_j y_{ikj} + \sum_i \sum_k \sum_j T_{ikj} y_{ikj} \tag{8}$$

$$\sum_j y_{ikj} \leq C_{ik} \tag{9}$$

$$\sum_i y_{ikj} \geq D_{kj} \tag{10}$$

$$y_{ikj} \geq 0 \tag{11}$$

i :supplier
j :manufacturer
k: commodity
P_{ik} : purchasing unit cost of commodity *k* from supplier *i*
y_{ikj} : amount of commodity *k* being transferred from supplier *i* to manufacturer *j*
T_{ikj} : transition unit cost of commodity *k* from supplier i to manufacturer *j*
C_{ik} : capacity of supplier *i* for commodity *k*
D_{kj} : demand of manufacturer *j* for commodity *k*

$$MaxZ = \sum_{ikm} N_{ikm} X_{ikm} \tag{12}$$

$$\sum_m X_{ikm} \leq Q_{Tik} \tag{13}$$

$$\sum_{m'} X_{m'ki} - \sum_m X_{ikm} \leq C_{Rik} \tag{14}$$

X_{ikm} : amount of commodity k transferred from supplier *i* to supplier *m*
N_{ikm} :the positive difference between the normalized risk value of the supplier *i* and supplier *j* for commodity *k*
m :all suppliers less risky than supplier *i*

Q_{Tik} : the amount of commodity k being transferred from supplier *i*
m' : all suppliers which is more risky than supplier *i*
C_{Rik} : the remained capacity of commodity k from supplier *i*

4- Numerical Examples and Validation of the Model

We applied the numerical example used in the basic model to illustrate that the proposed model is validated. The five suppliers located in different geographic regions are proposed in a single-echelon, two commodities, and a single-period model. Capacity and cost are determined in Table 2. The demands of manufacturers are given in Table 4. The unit transition cost of the commodity and the risk value of suppliers are also given in Table 2.

Table 2. The unit transition cost of commodity from suppliers to manufacturers ($)

	Supplier(i)									
	1		**2**		**3**		**4**		**5**	
Commodity(k) / Manufacture(j)	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
1	8.5	7	8.5	8	7	12	10	11	8	8
2	13	11	13	12	10	7	11	8	8	13
3	13	14	14	11	7	8	5.5	6	9	5
Capacity(No)	47000	75000	92000	64000	49000	77000	95000	68000	44000	89000
Purchasing cost($)	29.5	21	24	29	21.5	20	20.5	24	24.5	30
Risk(RPN)	50	50	32	32	66	66	56	56	60	60
Value of the relative risk based on the least risky supplier	18		0		34		24		28	
Normalized risk	0.173		0		0.327		0.231		0.269	

Although the risk of commodities is different, these values are considered the same for both commodities to use the validity of the basic model.

The result of the Kirilmaz and Erol model is shown for commodity 1 in Table 3 below. The proposed model is solved by theExcel solver module and the result is shown in Table 4.

Table 3. Optimum solution of Kirilmaz and Erol model

		Manufactures			Total cost	Increase in total cost considering risk criteria
		1	2	3		
Suppliers	1	0	0	0	0	4.71%
	2	61000	0	0	61000	5.801%
	3	34000	15000	0	49000	0.473%
	4	0	15000	80000	95000	1.383%
	5	0	44000	0	44000	3.25%

The procurement plan that was achieved without the risk criteria. Primary procurement values of commodity 1 are identical to both the proposed model and the basic model, which indicates that the model is validated. Now, the primary procurement values must be proportionally changed by the risk criteria. The total cost of commodity 2 is lower than commodity 1 in table 4. So manufacturers can decide to buy commodity 2.

Table 4. Optimum solution of proposed model

Manufacturer(j)		1		2		3		Total for k=1	Total for k=2
Commodity(k)		1	2	1	2	1	2		
Demand(No)		95000	92000	74000	76000	80000	79000		
Supplier(i)	1	0	75000	0	0	0	0	0	75000
	2	61000	17000	0	0	0	0	61000	17000
	3	34000	0	15000	76000	0	1000	49000	77000
	4	0	0	15000	0	80000	68000	95000	68000
	5	0	0	44000	0	0	10000	44000	10000
Total for i,j,k		95000	92000	74000	76000	80000	79000	249000	247000

Based on the supplier risk (Table 2), the most reliable supplier and the highly risky supplier are supplier 2 and supplier 3 for both commodities, respectively. According to the risk table, thetransition should be performed from highly risky suppliers to less risky suppliers. To achieve this goal, the risk profile of the most reliable supplier is subtracted from the risk profiles of other suppliers. Finally, these values will be normalized by Table 2.

The transition network is shown in Figure 2 based on the suppliers' risk profile. The calculations came from the Appendix and the results are given in Table 5. The revised procurement plan is also shown in Table 6.

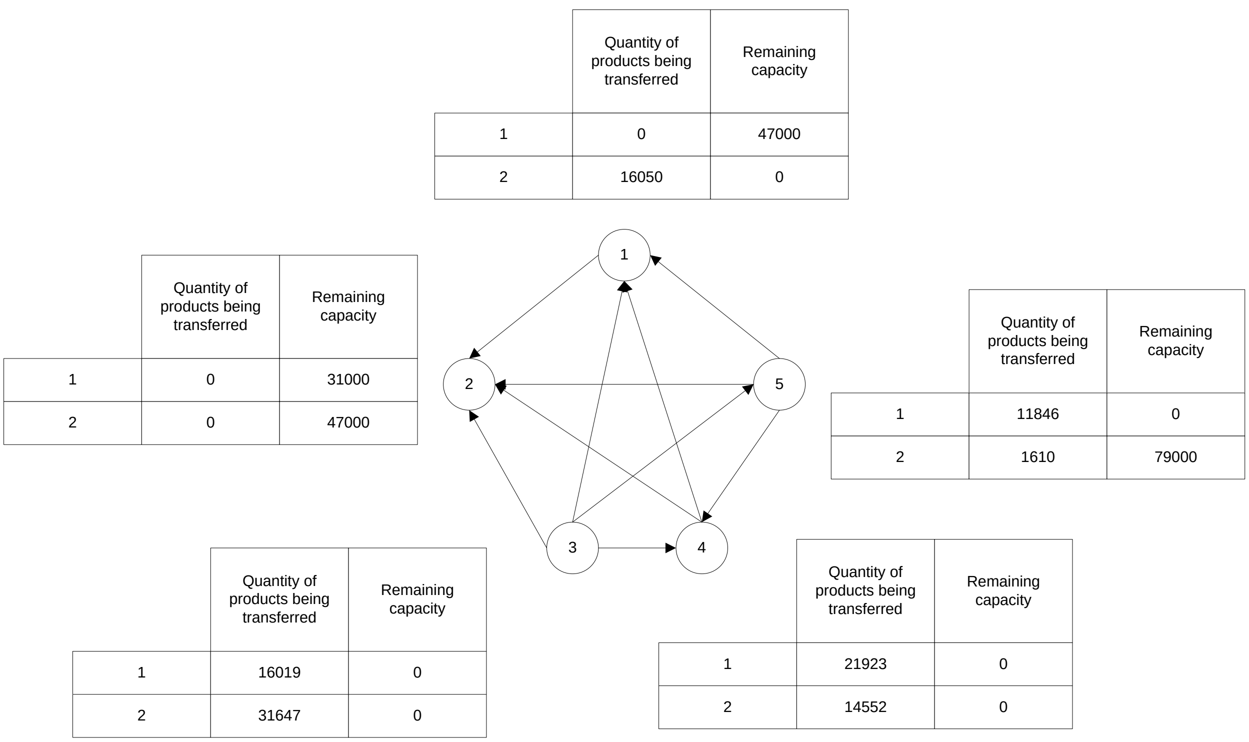


Figure 2. Material transition network based on the suppliers' risk profile

Table 5. Optimum solution of the revised plan

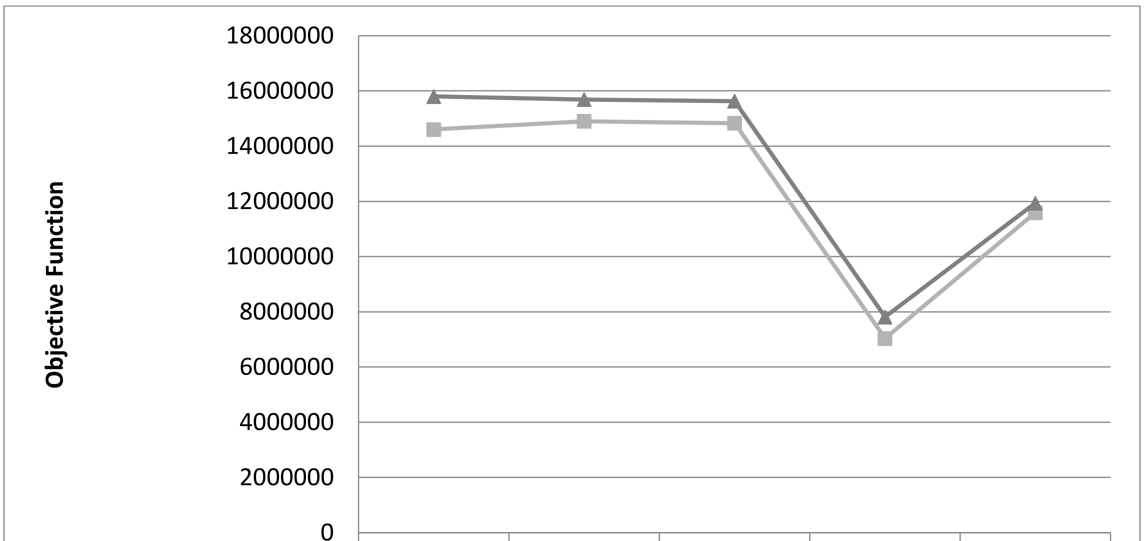
Row	Variable	Value	Row	Variable	Value	Row	Variable	Value
1	X_{112}	0	8	X_{122}	16050	15	X_{521}	104
2	X_{311}	12240	9	X_{321}	15946	16	X_{522}	1144
3	X_{312}	3779	10	X_{322}	15254	17	X_{325}	0
4	X_{411}	570	11	X_{421}	0	18	X_{324}	447
5	X_{412}	21353	12	X_{422}	14552	19	X_{524}	362
6	X_{511}	5978	13	X_{512}	5868	20	X_{315}	0
7	X_{314}	0	14	X_{514}	0			

Table 6. Primary and revised plans

Supplier (i)	Commodity(k)	Procurement plan of min cost	Procurement plan of cost and risk criteria together
1	1	0	18788
	2	75000	75000
2	1	61000	92000
	2	17000	64000
3	1	49000	32981
	2	77000	45353
4	1	95000	73077
	2	68000	54257
5	1	44000	32154
	2	10000	8390
Total for k=1		249000	249000
Total for k=2		247000	247000

4-1- Sensitivity Analysis

The model is tested five times for five suppliers and the changes of the objective functions are shown in the figure 3. As you can see in diagram of figure 3, procurement plan including risk criterion gains average of 6.60% increase in costs. Based on an evaluation of 827 disruption announcements created over a 10-year period, Hendricks and Singhal (2005) discovered that factories suffering from the uncertain events occurrence experienced 33%– 40% lower stock returns rather than their industry benchmarks. In comparison, the cost growth incurred by the suggested model is significantly low. Table 3 shows that the mean of increasing total cost is 3.2% after adding risk criteria in single commodity. The value is approximately one-half of taking account two commodities. It is obvious the more constraints are added, the more complexities are added, and so the solution of problem will not be better.



	1	2	3	4	5
Before taking the risk	14605500	14900000	14830000	7035000	11590537
After taking the risk	15802258.5	15689880	15631075	7814219	11941876

Figure 3. Comparative diagram of objective functions

5- Case Study

The purchasing process is studied to identify these risks in an electromotor company in the Middle East. The process of purchasing is to do some activities on the inputs to achieve the output. This process is investigated by inputs and outputs in the electromotor company and is shown in Fig. 4.

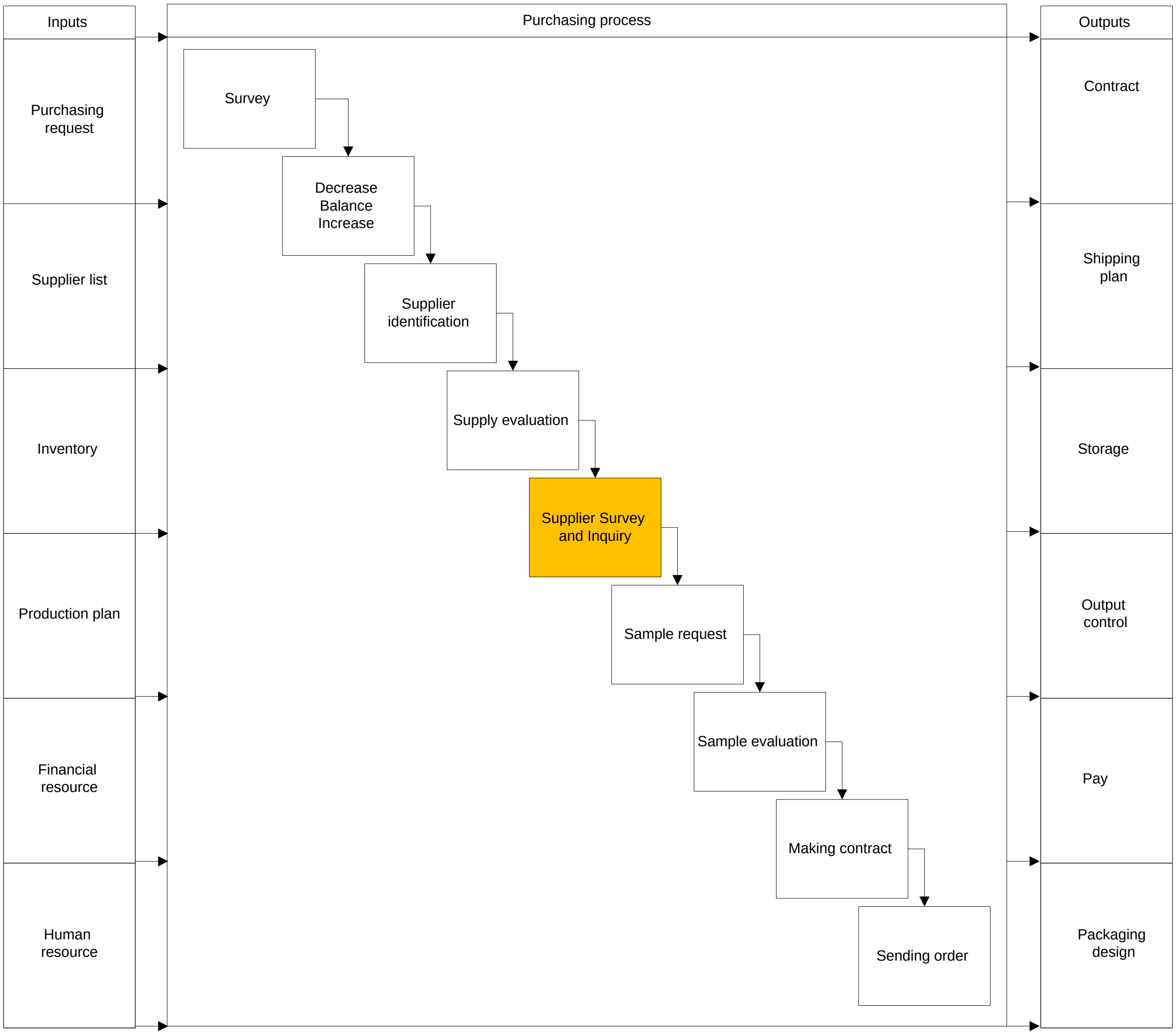


Figure 4. Risk-based process

The risks incurred by the supplier are identified in the activities of theSupplier Survey and Inquiry. Table 7 shows the requirements to be met by suppliers that are classified into four categories. Each of the requirements has subsets if it is not implemented, andis considered a risk.

Table 7. Requirements to be met by Suppliers

Standard requirements			**Organizational requirements**			**Customer requirements**			**Legal and Governmental Requirements**		
ISO 14001 certification	ISO 18001 Certification	ISO 9001 certification	Pay term	capability	Lead time	Warranty	Price	quality	Environmental permission	Health & Safety permission	National standard

Legal and governmental requirements have the highest impact among other requirements. Both legal requirements and governmental requirements are required by law. These requirements are non-negotiable and the organization must comply with them. Breaking the law may result in penalties for such failure. Customer requirements can be categorized intotwo groups. The first one isin which the customer explicitly states their requirements and the second one is that the customer does not thestate but customer expects to meet them by theorganization. Organizational requirements where an organization claims to meet some requirements. The customer will be dissatisfied with the organization's performance, if not. The organization is required to comply with the standards when the organization obtains.

Table 8. Risk Classification

Risk number	**Classification**	**Definition**
5	**Severity**	Very severe damage is largely irreparable, braking national and international laws, it has a high loss and the loss of credibility and essential resources of the manufacturer
	Probability	Frequently happened and Almost definitely, It is repeated, it has long precedents in the manufacture, The probability of occurrence is very high
4	**Severity**	The severe impact that can make challenges for the manufacturer in the relevant areas and bring significant damage, breaking laws, it is compensated at a very high cost
	Probability	Much, It happens almost continuously at the manufacturer, it has fairly long precedents of repetition
3	**Severity**	Severe impact, Waste of resources, Damage that can be compensated by rework
	Probability	The probability of risk occurrence is high in the manufacture
2	**Severity**	Low waste of resources, impact of relatively severe damage, it is Compensated in the short term
	Probability	Rarely happens in the manufacturer, the probability of occurrence is low
1	**Severity**	The small and insignificant impact that can be compensated, Without loss
	Probability	Very little, There are no precedents for the risk occurrence in the manufacturer

There are 2 criteria to measure risk: the probability of an occurring risk and the impact of the occurring risk. In the following, the probability-impact matrix is presented by interviewing the experts and using Table 8 in Table 9. Since the impact of each requirement is the same for all suppliers and risk values are calculated from themultiplication of the impact, we avoid writing theprobability of risk occurrence. Commodity 1 includes a type of plastic gasket that is used inside the shaft and commodity 2 includes a plastic cap for the capacitor. Demand for commodity 1 is approximately 1,040,000 (2 plastic gaskets are used in an electromotor), and for commodity 2, it is about 520,000 per year. The company purchases 624,000 commodities, 1 from supplier 1 and 416,000 commodities, 1 from supplier 2. 156000 commodities; 2 are purchased from supplier 1 and the rest from supplier 2. The capacity of commodity 1 is about 700,000 for supplier 1 and 1,000,000 for supplier 2. The capacity of commodity 2 is approximately 180,000 for supplier 1 and 400,000 for supplier 2.

Table 9. Probability-impact matrix

Risk Quantity of Supplier 2		**Risk Quantity of Supplier 1**		**Impact**	**Sub-requirements**	**Type of requirements**
Commodity 2	**Commodity 1**	**Commodity 2**	**Commodity 1**			
5	5	5	5	5	National standard	Legal and Governmental Requirements
10	10	5	5	5	Health & Safety permission	
4	4	8	8	4	Environmental permission	
16	12	16	20	4	quality	Customer requirements
12	12	15	12	3	Price	
20	20	8	8	4	Warranty	
6	3	12	9	3	Lead time	Organizational requirements
6	3	9	6	3	Capacity	
12	15	9	12	3	Pay term	
3	3	6	6	3	ISO 9001 certification	Standard requirements
3	3	6	6	3	ISO 18001 Certification	
1	1	2	2	1	ISO 14001 certification	
98	91	101	99	R_t		

The risk profile is a criterion to show the supplier's risk level. This risk profile is derived from the sum of the risk criteria larger than the maximum accepted manufacturer standard by the following formula. In the electromotor company, the upper bound of risk is 20. Risks are unacceptable if they are higher than this amount.

$$R_t = \sum_{k=1}^{k} R_k * Z_k \tag{15}$$

If the risks are within the acceptable range of the company, Z_k is equal to one and otherwise Z_k is equal to zero in equation 15. The normalized risk values for each commodity group are given in Table 10.
The number of commodities being transferred from a highly risky supplier to a less risky supplier is shown in Table 10.

Table 10. Amount of commodities being transferred/ revised procurement Plan

Supplier	Commodity	Risk profile	Normalized risk profile	amount of commodities being transferred	amount of commodities remained in the supplier	Current procurement plan	revised procurement plan
1	1	99	0.52	0.52*624000=324480	299520	624000	299520
	2	101	0.51	0.51*156000=79560	76440	156000	120000
2	1	91	0.48	0.48*416000=199680	216320	416000	740480
	2	98	0.49	0.49*364000=178360	185640	364000	400000

The revised procurement plan is shown in Table 10 based on the risk criteria. As you can see, supplier 1 is the riskiest supplier for purchasing both commodities. The amount of commodity 2 purchased from supplier 1 will be reduced to 79,560 and transferred to supplier 2 as long as the capacity of 400,000 is completed and the remaining commodity 2, meaning 43,560, will still be purchased from supplier 1.

6- Conclusion and Future Work

Today, supply chain risk management brings not only cost advantages but also competitive advantages. But the number of quantitative models is very small compared to qualitative models. Although Kirilmaz and Erol proposed a mitigating strategy to reduce the expected effects of risks, they did not consider a multi-commodity in their model. The paper showed that manufacturers could earn more profit by applying multi-material. The purpose of the process is to use a safety system against risky suppliers and reduce the level of damage in risky events. The first step in the approach is to obtain a primary procurement plan using linear planning to minimize costs. The second step is to update the procurement plan using risk criteria in the planning approach. To show the condition of the real world inside the model, some constraints need to be added to the model. But the more constraints are added, the more complexities are added, so the solution to the problem will not be better. The number of costs imposed is analyzed by entering the risk criteria and the rate of increase in costs is 6.6%. The benefits of supply chain risk management were not understood before the risky events. For this reason, potential costs due to the implementation of risk management may be unnecessary from the perspective of the senior manager and lead to the non-application of this approach. However, the costs associated with dealing with risky events will generally outweigh the potential costs for supply chain risk management. For this reason, there must be a balance between these two costs. Hence, the cost analysis on 5 data sets was presented. The cost increase is much less than the cost imposed on the system in risky events and disruptions. Although this transfer plan is obtained before ordering and, therefore, suppliers will be provided with the latest order plan based on cost and risk, the results are presented to a senior manager as a future supply plan.

The risks of the electromotor Company were identified and the model was implemented in this industry. We used the basic model to validate the proposed model. The proposed method can be expanded to multi-echelon in future studies so that the risks of other supply chain members can also be considered.

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APPENDIX

The model of material transition from high risky suppliers to reliable suppliers is show in equations 1-17.

$$\begin{aligned} Maxz &= 0.173X_{112} + 0.173X_{122} + 0.096X_{511} + 0.096X_{521} + 0.058X_{411} + 0.058X_{421} + \dots \\ & 0.154X_{311} + 0.154X_{321} + 0.269X_{512} + 0.269X_{522} + 0.231X_{412} + 0.231X_{422} + \dots \\ & 0.327X_{312} + 0.327X_{322} + 0.058X_{315} + 0.058X_{325} + 0.096X_{314} + \dots \\ & 0.096X_{324} + 0.038X_{514} + 0.038X_{524} \end{aligned} \quad (1)$$

$$X_{311} + X_{411} + X_{511} - X_{112} \le 47000 \quad (2)$$

$$X_{321} + X_{421} + X_{521} - X_{122} \le 0 \quad (3)$$

$$X_{112} + X_{312} + X_{412} + X_{512} \le 31000 \quad (4)$$

$$X_{122} + X_{322} + X_{422} + X_{522} \le 47000 \quad (5)$$

$$X_{311} + X_{312} + X_{314} + X_{315} \le 16019 \quad (6)$$

$$X_{321} + X_{322} + X_{324} + X_{325} \le 31647 \quad (7)$$

$$X_{314} + X_{514} - X_{411} - X_{412} \le 0 \quad (8)$$

$$X_{324} + X_{524} - X_{421} - X_{422} \leq 0 \tag{9}$$

$$X_{411} + X_{412} \leq 21923 \tag{10}$$

$$X_{421} + X_{422} \leq 14552 \tag{11}$$

$$X_{511} + X_{512} + X_{514} \leq 11846 \tag{12}$$

$$X_{521} + X_{522} + X_{524} \leq 1610 \tag{13}$$

$$X_{315} - X_{511} - X_{512} - X_{514} \leq 0 \tag{14}$$

$$X_{325} - X_{521} - X_{522} - X_{524} \leq 79000 \tag{15}$$

$$X_{112} \leq 0 \tag{16}$$

$$X_{122} \leq 16050 \tag{17}$$