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# Identify and Prioritize Supply Chain Risks by TOPSIS (Case study: Motorsazan Company)

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**Abstract :**Outsourcing is one of the key issues in supply chain management in industry sector to decrease the costs and transportation time and to increase competitive ability of industrial units. In order to carry out a successful outsourcing in supply chain management we should identify the breakdown points in supply chain. If we couldn't recognize and didn't have any process coping with them, it causes to breakdown in supply chain and we should going out from competitive market. In this case at first we reviewed the literature of supply chain management and then identified the risks in supply chain that affecting failure on it. For Identifying these risks after studying several risk identify models we chose Chopra risk classification. We continued our research for finding important indicators that causes to failure in our supply chain that was happened in Motorsazan company. For arranging this indicators (impact of their effects) we used Paratoo Graph method. Then with these indicators that identified and arranged and using TOPSIS method we prioritized the supply chain risks in Motorsazan company. The results showed that the priority of risks in this company is as followed:1.Purchase 2.Recivables 3.Delays 4.Failures and departures 5.inventory 6.Forecasting 7.Capacity 8.intellectuall property 9.Law and government regulations.

**Key words:** supply chain, supply chain risks, prioritizing risks, TOPSIS

## INTRODUCTION

### *1.Definition of Supply Chain Management:*

Supply chain management is the management of net work of organizations that are involved, through upstream and downstream linkages, in the different process and activities that produce value in the form of products and services in the hands of the ultimate consumer.(Christopher,1992). Supply chain management is the evolutionary results of inventory management. Experts in the 60s with the study on the internal relationship between inventory and transportation and their integration were able to reduce its inventory that these studies called distribution management. In the course of evolution with the addition of Construction Management, Procurement and order management to distribution management logistics concept was formed. Supply chain is the results of joining various operational chains that suppliers are in the beginning and customers are the end. Nowadays many companies for a fee ornate and market share various preparations are adopted such as the outsourcing of production and product diversification. These preparations are effective when they have been in stable condition. But these preparations can cause a variety of supply chain risks, including uncertain economic cycles, uncertain customer demand and the human and natural events. Thus, according to increasing these preparations, the need to study various strategies for risk management and supply chain solutions and increasingly is on the agenda of superior companies.(Alvani,2008)

### *2.Objectives of Risk Management in Supply Chain:*

1) survival : Keep costs below certain limit ,These costs may be higher than those that continue to threaten the survival of the chain.
2) savings : If this goal with other goal (E.g. survival) is consistent, the lowest total cost of risk management at the operational level is maintained.
3) Acceptable level of anxiety that is sure to say.
4) Earnings stability : Limit the unforeseen reduction in revenues or cash flows resulting from damage to an acceptable level.
5) Non-stop operation : Continuation of normal business activities with minimum delay; the normal activities of a company's compensation should be at least stop.
6) Continued growth, Company's continued growth, Continued growth may require the allocation of resources before any damage is occurring.
7) Social responsibility : Limiting damages to the employee; suppliers, customers and suppliers.( Richard M. Heins ; C. Arthur. Williams Jr ,1971)

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### *3. Outsourcing:*

Nowadays, organizations are widely trying to use outsourcing in order to increase their competitive ability, profits, and competitive advantage. Achieving competitive advantage through increasing differentiation strategy is a great challenge facing organizations; they should overcome this challenge by increasing their efficiency, using new technologies, and obtaining management skills. Accordingly, many organizations have outsourced their activities and improved the quality of their products and services in order to gain more advantages (Kakabadse, 2002). In the current business markets, organizations are trying to keep those key activities through which they create value for customers; they leave the other activities to other institutes which are capable of handling those (Langfield & Smith, 2003). Many studies on the importance of supplier-customer relationship have mentioned the advantages of outsourcing and its role in reducing the costs and empowering organizations. For instance, in 1997 Chrysler Corporation has added 325 million dollars to its revenue and has economized 1.2 billion dollars through outsourcing (Handy, 1995). Like other scientific issues outsourcing has different definitions from different viewpoints; some of them are as follows:

- Outsourcing is considered as using resources of external suppliers in order to perform the necessary activities.
- Outsourcing can be defined as designing activities by third parties, efficient and systematic contract with external organizations to buy activity, or a lower degree of vertical integration in a supply chain (Moomme, 2002).
- Outsourcing is transferring some internal activities of an organization and leaving decision making right to an external supplier according to a contract. In fact, the activities, manufacturing agents, and decision making right are often practically transferred in outsourcing. Manufacturing agents that can be transferred involve employees, facilities, equipments, technology, and other capital (Greaver, 1999). Due to different meanings of outsourcing and different criteria for its measurement one can consider different types of outsourcing; some of these are classified in table 1:

**Table 1:** Different types of outsourcing.

| Classification criterion | Outsourcing type |
|---|---|
| Decision making level Strategic outsourcing | Strategic outsourcing, tactical or traditional outsourcing |
| Outsourcing volume Total outsourcing | Total outsourcing, selective or partial outsourcing |
| Level of integration Outsourcing, half | Outsourcing, half-outsourcing |
| Special relationships Group or internal outsourcing, non | Group or internal outsourcing, non-group or external outsourcing |
| Administrative control level Outsourcing of function | Outsourcing of function, outsourcing of resources |
| Ownership type Private sector outsourcing | Private sector outsourcing, public sector outsourcing |

### *3.1. The Process of a Successful Outsourcing:*

The most important steps of a successful outsourcing according to experts' views can be specified as follows:

- Determining key indices and processes of the organization
- Developing outsourcing plan, defining objectives, priorities, and the ways to achieve the objectives, risks, and privileges.
- Determining the limitation of outsourcing in organizations.
- A plan to prioritize outsourcing and risk control.
- A plan to decrease the effects of outsourcing risks.
- Building organizational culture about transferring activities.
- Authentic definition and comprehensive description of the performed activities within the organization for suppliers.
- Absorbing qualified suppliers.
- Transferring specialized information about special activities and experiences to suppliers.
- Executive and technical empowering of suppliers.
- Increasing the number of suppliers to create competition in order to improve quality and decrease costs.
- Considering cost decreasing factors.( Hiwa Farughi et al.,2011)

### *4.Supply Chain Risks:*

### *4.1.Risks in the Supply Chain:*

SCM is a very complex function that faces an enormous range of inherent risks, ranging from the minor irritation of delays through to the destruction of an entire chain . but a more worrying trend is for logistics managers to change operations to give better service and efficiency, without considering the consequences on risk. As a result , supply chains are becoming more efficient, but at a cost of increasing vulnerability . this means that organizations are facing greater disruption to an essential function , not because of positive decisions, but because managers are not aware of the full consequences of their actions. And a problem with any single member of a chain expands to give consequences for all the other members . this sets the scene for supply

chain risk, where each member not only is susceptible to its own risks, but also can be hit by risky events affecting other members. Even when the individual risk to each member of a chain is small, the cumulative effect over the hundreds or thousands of members a large chain becomes very significant. You can see this effect in the survey by the Aberdeen Group that found that 82 per cent of managers reported disruptions to supply chains within the preceding two years (Minahan,2005). The main causes were: Poor quality or damaged good(50%), Missed or late deliveries(49%), Unexpected increases in supply costs(47%), Longer lead times(33%), Supply capacity constraints(32%).

Even a relatively minor problem with a supply chain can have broad consequences in the way that a delayed delivery can affect operations, with effects to company reputation, perception of brands, ability to win orders quality , prices, profit margins, lead time and a host of basic performance measures . this recognition of the high costs of problems in the supply chain has encouraged managers to consider formal methods of supply chain risk management(SCRM) . but it is not only costs that are driving an increased awareness of SCRM. but also the need to comply with new legislation and regulations for improving corporate governance. Other incentives include growing demands from customers to provide evidence of risk management procedures(so that their supplies are not disrupted), desire to avoid any repetition of actual herm from risky events, new trading patterns encouraging an examination of logistics activities, and broader recognition of the potential harm from vulnerable supply chains. That suggests that organizations with well-defined policies for SCRM tend to perform better that those with no such policies . this observation is based on the important principle that SCRM is not an extra burden that adds work and costs, but is a way of reducing overall costs and improving performance . for instance, reducing the risk of late deliveries from suppliers allows a firm to reduce, its stock of raw materials , with the savings more than compensating for the increased effort of SCRM . By using such methods ,Hewlett-Packard s procurement risk management programmed is estimated to have saved the company $100 million over five years. Despite the obvious benefits of SCRM, managers are only just starting to recognize its importance, and most are at a very early stage of development. However, things are changing, and the Aberdeen group s survey strongly suggests that supply risk management will emerge as a major business discipline and measure of competitiveness within the next five years (minahan,2005). It will take a long time for SCRM to be universally implemented ,with obvious hurdles being the lack of knowledge about risk management in general, lack of senior management leadership, divided responsibilities for risk, absence of systems for measuring risk and their impact, limited information flows in the supply chain, limited cooperation with trading partners, reactive rather than proactive management style, and a whole host of other problems. Overcoming these will not be easy- but it is becoming increasingly important to try.(Donald Waters,2007)

### *4.2.Worst Supply Chain Risks:*

The supply chain is where risk becomes most probable and most damaging. If there is a disaster looking for a place to happen,the supply chain seems an obvious candidate. A survey of 98 top supply-chain executive conducted by Mark Hillman of AMR research was recently presented at a supply-chain executive conference attended by high-level analysts and corporate officials. It examined what these executives consider to be the worst risk factors. Based on AMR's survey ,these risks are : Supplier failure(28%), Strategic risk(17%), Natural disaster(15%), Geo-political events(11%), Regulatory risk(11%), Logistics failure(10%), Intellectual property infringement(7%), Other(1%). (Robert Malone,2006)

### *4.3. Sources of Risks and Uncertainty in Global Supply Chain*:

Kleindorfer(2000) argued to mitigate risks in supply chain one must first identify the underlying sources of risks. By risk mitigation, miller (1992) means those strategic actions organizations pursue to thwart the uncertainties identified from variety of sources. Therefore, because risks are caused by unexpected events and uncertainty , it is necessary to identify and categorize the sources of risks in global supply chains logistics . GSC risks can emanate from various forms. Sources of supply chain risks emanate from environmental , organizational , or supply chain logistics- related factors that cannot accurately be predicted and can impact the supply chain outcome variables (juttner et al., 2003). Also, due to the inherent complexities of the physical and economic systems, the unfolding of most processes shows attributes that cannot be forecast with absolute accuracy(Moschini and Hennessy,1999). For the supply chain context, these sources can be classified into three groups namely (juttner et al.,2003):1) Environmental(external) risk sources to the supply chain. These include market risk(e.g., exposure to adverse market price movements such as value of securities , exchange rates , interest rates or spreads, and commodity orices);business- volume risk (e.g., changes in demand or supply from competition, exposure to revenue volatility); natural disaster; geopolitical action; public policies; among others .2) Organizational (internal) risk sources to the supply chain. These include operational risk ( e.g., exposure to loss due to in adequate internal processes and systems, labor strike or lack of skilled labor, machine breakdown).3) network related risk sources within the supply chain are lock of ownership, chaos, and inertia ( Christopher and lee,2001) lack of ownership risk sources in supply chains can lead to little or no control because of ambiguous lines of responsibility ; chaos risk sources in supply chains are due over- reactions,

unwarranted interventions, false alarm ,lack of transparency , etc .; and inertia risk sources emanate from the inability of organizations to sense and respond to changing environmental and market conditions (Juttner et al., 2003). Van Landeghem and Vanmaele (2002) posit that sources of uncertainty in supply chain include customs regulations , price changes , information delays, competitor action , political environment, stochastic cost, available capacity , supplier quality , manufactouri yield, and internal organization.A recent McKinsey Quarterly (2006) global survey of business executives reported that the executives ranked cost and the general availability of quality labor (43%) , regulatory concerns (63%) , and reliability of suppliers (33%) as the top three sources of global supply chain risk on which they focused on during their most recent round of planning . following these top three sources were commodity shortages/ price fluctuations(29%); fluctuations in foreign-exchange rates (23%) ; intellectual property theft (22%); obsolescence of product inventory or technology (21%); war, terrorism, other geopolitical concerns (15%); problems with supply chain infrastructure (11%); plant breakdowns/ mechanical failures (10%); natural disasters(10%); and other(4%).( Enyinda, Chris I. et al.,2008)

### *4.4.What are Supply Chain Risks:*

Modeled along the line of Martin Christopher,Kiser and Kitrell define risks outside and inside the supply chain :External risks can be driven by events either upstream or down stream in the supply chain :

- Demand risks related to unpredictable or misunderstood customer or end customer demand.
- Supply risks related to any disturbances to the follow of product within your supply chain.
- Environment risks that originate from shocks outside the supply chain.
- Business risks related to factors such as supplier's financial or management stability.
- Physical risks related to the condition of a supplier's physical facilities.

Internal risks are driven by events within company control :

- Manufacturing risks caused by disruptions of internal operations or processes.
- Business risks caused by changes in key personal, management, reporting structures, or business processes.
- Planning and control risks caused by inadequate assessment and planning, and ineffective management.
- Mitigation and contingency risks caused by not putting in place contingencies.(Kiser, J., Cantrell, G., 2006)

**Table 2:** Chopra risk category.

| Category of Risk | Drives of Risks |
|---|---|
| Disruptions | ▪ Natural disaster<br>▪ Labor dispute<br>▪ Supplier bankruptcy<br>▪ War and terrorism<br>▪ Dependency on a single source of supply as well as the capacity and responsiveness of alternative suppliers |
| Delays | ▪ High capacity utilization at supply source<br>▪ Inflexibility of supply source<br>▪ Poor quality or yield at supply source<br>▪ Excessive handling due to border crossing or to change in transportation modes |
| Systems | ▪ Information infrastructure breakdown<br>▪ System integration or extensive system networking<br>▪ E-commerce |
| Forecast | ▪ Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycle, small customer base<br>▪ "Bullwhip effect" or information distortion due to sales promotions, incentives, lack of supply-chain visibility and exaggeration of demand in times of product shortage. |
| Intellectual property | ▪ Vertical integration of supply chain<br>▪ Global outsourcing and markets |
| Procurement | ▪ Exchange rate risk<br>▪ Percentage of a key component or row material procured from a single source<br>▪ Industry wide capacity utilization<br>▪ Long-term versus short-term contracts |
| Receivables | ▪ Number of customers<br>▪ Financial strength of customers |
| Inventory | ▪ Rate of product obsolescence<br>▪ Inventory holding cost<br>▪ Product value<br>▪ Demand and supply uncertainty |
| Capacity | ▪ Cost of capacity<br>▪ Capacity flexibility |

(Sunhil Chopra;Manmohan S.Sodehi,2004)

### *4.5.Supply Chain Risks and their Drives:*

Before companies can devise effective means of reducing supply chain-risks, managers must first understand the universe of risk categories as well as the events and conditions that drive them. Then , armed

with clear, specific knowledge about these crucial risks , companies can proceed to select and tailor mitigation strategies likely to be most effective.

## MATERIALS AND METHODS

Study in terms of purpose, is applied. Materials and methods Study in terms of purpose, is applied. The findings that identify and prioritize risks in the supply chain is achieved, the Motorsazan Company by directors and managers used other manufacturing companies. Also according to the study to review the situation and analysis of research examines the relationship between variables, research is descriptive survey.

### *6.Statistical and Research Community Sample:*

Motorsazan Company is the makers of this study population. Sample research enterprise through 20 units, 12 units have been selected to supply chain organization with a total of 69 are working as an expert in it. The unit and number of employees is given in Table 3.

**Table 3:** Sample survey.

| Name of unit | Number of empolyee |
|---|---|
| Supply Dep. | 10 |
| Applied Engineering Dep. | 4 |
| Technical & Engineering Dep. | 13 |
| Quality Assurance Dep. | 7 |
| Production Planning Dep. | 2 |
| Engineering Research Dep. | 7 |
| Manufacturing Dep. | 2 |
| Material and inventory control Dep. | 3 |
| Production, assembly, testing Dep. | 8 |
| Internal logistics Dep. | 3 |
| Project Planning Dep. | 6 |
| Managment | 4 |
| Total | 69 |

The total 69 experts were chosen as the sample was distributed. The 69 questionnaires,69 copies were returned.The questions are of two main parts. The first part includes questions about the features such as the respondents of the organization, experience in corporate, educational level and age. The second part consisted of several parts that tries to measure the research variables. Also answer all questions on a Likert scale of five options from very low to very high class is classified. Summary of the second part of questionnaire is presented in Table 4. In the present study to determine its validity content validity of the method is used. Content validity is usually some kind of validity as a tool for studying the components of to be used. Content validity of an instrument constituent question, it depends If the questionnaire is to introduce the concepts and attributes that the researcher is trying to measure it, The questionnaire has content validity. Content validity in this research to enhance the accurate identification of instances of each component and study the same questionnaire, articles, books and magazines, from teachers and experts has also been used. It is noteworthy that for the validity of the questionnaire has been validated and used in scientific papers. In this study, Cronbach's alpha for reliability of measurement tools have been used. The method for calculating the internal consistency of measurement tools such as questionnaires or tests that measure different features are used.

In order to assess the reliability assessment, a questionnaire originally designed for 10 participants from the community survey was distributed and then collected were analyzed. Some questions were revised again and part of the questionnaire questions were changed. 10 cases were distributed among members of society again. Check the validity of the results of the questionnaire showed that Cronbach's alpha coefficient is 0.905. The validity coefficient for questionnaire research that at least 0.7 Cronbach's alpha coefficient of 0.905 calculated from this value is higher, It can be concluded from the questionnaire used is valid. In the present study this test was performed using SPSS software. In this research, supply chain risk as the dependent variable and each of the failures and uncertain factors, laws and government regulations, delays, systems, forecast, intellectual property, purchasing, accounts and notes receivable, inventory and capacity as an independent variable affecting the dependent variable is considered. Variables used in this study are as follows: Study variables in Table 5 in terms of scale and spectrum measurement is shown.

**Table 4:** Questionnaire reliability coefficients.

| Variables | Number of questions for each variable |
|---|---|
| Disruptions | 11 |
| Delays | 2 |
| Systems | 6 |
| Forecast | 7 |
| Intellectual property | 7 |
| Procurement | 5 |
| Receivables | 3 |
| Inventory | 2 |
| Capacity | 5 |
| Governmental laws and regulations | 2 |
| Total | 50 |

**Table 5:** Variables.

| Row | Variables | Type of variable | Measurement scale | Measurement Spectrum |
|---|---|---|---|---|
| 1 | Disruptions | Qualitative | comparative | Likert |
| 2 | Delays | Qualitative | comparative | Likert |
| 3 | Systems | Qualitative | comparative | Likert |
| 4 | Forecast | Qualitative | comparative | Likert |
| 5 | Intellectual property | Qualitative | comparative | Likert |
| 6 | Procurement | Qualitative | comparative | Likert |
| 7 | Receivables | Qualitative | comparative | Likert |
| 8 | Inventory | Qualitative | comparative | Likert |
| 9 | Capacity | Qualitative | comparative | Likert |
| 10 | Governmental laws and regulations | Qualitative | comparative | Likert |

### *7.Methods of Data Analysis:*

- The study analyzed data from a multi-stage were as follows:
- First stage: The first stage of data collected through the questionnaire to test the hypothesis And 9 the first research hypotheses were tested using SPSS software.
- Second stage : Using the Pareto chart of the causes of failure identified factors on the supply chain variables were identified.
- Third stage : The second questionnaire developed And the value of the variable factors in the first stage of research approved by the spectra were measured in five-option Likert.
- Fourth stage : Using the values obtained in the third stage and calculate the average dipole using TOPSIS technique with the profiting of variable factors were isolated rankings. TOPSIS procedure is as follows:

1. No-scaling and making a decision matrix (N): for no-scale making, no Norm scaling is used.
2. Matrix to obtain a weighted scale (V): Scale matrix by (N) in the diagonal matrix of weights ($W_{n*n}$) are multiplied by a, $V = N * W_{n*n}$.
3. The positive ideal solution and negative ideal solutions: The positive ideal and negative ideal solution for solving linear, is defined as follows:

- [Worst values for each index vector matrix V]=The negative ideal solution ( $V_j^-$ )
- [The best values for each index vector matrix V]= The positive ideal solution ( $V_j^+$ )

4. The gap between the ideal option to get any positive or negative:

   $d_i^+ = \sqrt{\sum (v_{ij} - v_j^+)^2}$ i=1,2,…m

   $d_i^- = \sqrt{\sum (v_{ij} - v_j^-)^2}$ i=1,2,…m

5. Determine the relative closeness $CL^*$ an option to the ideal solution:

   $CL_i^* = \frac{d_i^-}{d_i^- + d_i^+}$

6. Ranking of options: Every option that is greater than CL * It is better (Momeni, 2006).

***8.Research Findings:***

In this study, using the first questionnaire, we were able to identify Risks in the supply chain according to the research model presented. After data analysis and quantification of numbers using statistical methods, The assumptions were tested and the results are as follows in table 6:

**Table 6:** Hypothesis test results.

| Row | Hypothesis | Test Result |
|---|---|---|
| 1 | Component failures and interruptions is supply chain risk in Motorsazan Company. | accepted |
| 2 | Governmental laws and regulations is supply chain risk in Motorsazan Company. | accepted |
| 3 | Purchase is supply chain risk in Motorsazan Company. | accepted |
| 4 | Delays Purchase is supply chain risk in Motorsazan Company. | accepted |
| 5 | Forecast is supply chain risk in Motorsazan Company. | accepted |
| 6 | Intellectual property and intellectual is supply chain risk in Motorsazan Company. | accepted |
| 7 | Systems is supply chain risk in Motorsazan Company. | Not accepted |
| 8 | Receivables is supply chain risk in Motorsazan Company. | accepted |
| 9 | Inventory is supply chain risk in Motorsazan Company. | accepted |
| 10 | Capacity is supply chain risk in Motorsazan Company. | accepted |

After identifying the risks associated with supply chain risk indicators Motorsazan Co. remove system and the other phases of research were gone and the following results. Of 50 specific indicators for measuring risk, 7 indicators related to the system due to rejection of the hypothesis has been excluded and the remaining 43 indicators used technique Paratoo more important and influential factors were identified as follows in table 7:

**Table 7:** Risk factors influencing the supply chain by Paratoo.

| Row | Indicator | Number of indicators on analyze tables |
|---|---|---|
| 1 | Low financial strength of suppliers | 43 |
| 2 | Low flexibility in the supply and demand by suppliers | 50 |
| 3 | Rapid changes in exchange rates | 39 |
| 4 | Exclusive suppliers | 11 |
| 5 | The time delay in deliveries from suppliers | 15 |
| 6 | High financial value of inventories | 47 |
| 7 | Uncertainty in the supply and demand for producer organizations | 48 |
| 8 | Bankruptcy and financial problems with suppliers | 6 |
| 9 | High cost of inventory maintaining | 46 |
| 10 | Inability to rapidly changing production technology | 45 |
| 11 | Inaccurate forecasts of product delivery time | 27 |
| 12 | Predict the wrong amount of product demand | 28 |
| 13 | Wrong predictions for production diversification | 29 |
| 14 | Late return of suppliers capital | 8 |
| 15 | Long-term versus short-term contracts | 40 |
| 16 | Low quality suppliers products | 16 |

Risk Rating to determine the risk factors through the first questionnaire and its quantification were determined according to the average dipole. At this stage of the analysis method was used Pareto and Number of factors from 1 to 10 of 43 indicators approved by the assumptions affect the index fell to 16. In the next stage of the second questionnaire to determine the index value defined in the original measures were approved by the Design. The second questionnaire collected data and their quantification using the average dipole, the decision matrix for ranking risks were obtained using the following form by TOPSIS.

The first stage : Create a decision matrix:

Convert qualitative indicators into quantitative indicators of different methods can be used. But the best use of space and scale out or scale is bipolar. A general method for the measurement of quality indicators with a scale interval use the "bipolar scale space" which is as follows in table 8. (Momeni, 2006)

**Table 8:** Distance scale bipolar.

| Negative | Very low | low | medium | High | Very high | Positive |
|---|---|---|---|---|---|---|
| - | 1 | 3 | 5 | 7 | 9 | + |

Therefore, the number of supply chain risks (decision matrix) to prioritize supply chain risks Motorsazan Company has been obtained as follows in table 9:

**Table 9:** Decision matri

| Effective factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Failures and interruptions | 7.56 | 5.15 | 7.85 | 7.27 | 6.57 | 6.24 | 5.14 | 7.17 | 5.21 | 6.87 | 6.27 | 5.01 | 6.57 | 6.91 | 6.2 | 7.1 |
| Governmental laws and regulations | 3.25 | 3.18 | 7.14 | 5.21 | 4.89 | 3.25 | 3.14 | 5.24 | 5.11 | 6.57 | 4.58 | 3.58 | 6.45 | 3.89 | 6.15 | 3.94 |
| Delays | 6.9 | 6.71 | 4.51 | 6.98 | 7.21 | 5.67 | 6.25 | 6.87 | 6.84 | 6.45 | 6.99 | 6.54 | 6.33 | 6.84 | 6.14 | 6.77 |
| Forecast | 5.39 | 5.94 | 7.01 | 6.58 | 5.85 | 5.78 | 5.44 | 6.21 | 6.17 | 6.74 | 7.07 | 7 | 6.93 | 5.89 | 6.5 | 5.57 |
| Intellectual property | 3.7 | 5.11 | 4.25 | 5.47 | 4.5 | 5.21 | 5.07 | 5.51 | 4.12 | 6.15 | 4.58 | 5.25 | 6.08 | 4.5 | 5.48 | 5.87 |
| Purchase | 7.43 | 6.34 | 7.36 | 5.95 | 6.1 | 6.78 | 6.11 | 6.85 | 6.71 | 6.41 | 6.2 | 6.11 | 6.22 | 6.78 | 6.81 | 6.95 |
| Receivables | 7.85 | 6.44 | 7.05 | 5.14 | 7.06 | 6.54 | 6.14 | 6.95 | 6.83 | 6.85 | 6.85 | 6.27 | 6.78 | 6.89 | 6.2 | 5.35 |
| Inventory | 5.21 | 7.28 | 6.47 | 6.45 | 7.12 | 7.22 | 7.22 | 5.98 | 7.11 | 7.1 | 6.99 | 6.95 | 6.28 | 5.11 | 6.1 | 6.18 |
| Capacity | 4.15 | 7.4 | 6.01 | 5.68 | 4.12 | 5.28 | 7.1 | 6.21 | 5.35 | 6.58 | 4.39 | 6.98 | 6.48 | 4.01 | 6.47 | 4.78 |

Index may be a special dimension so in order to compare the different dimensions being measured, the scale of the matrix should be used in the scale model of TOPSIS, we use norm-making in this case the values of various parameters, dimensionless and can be collected.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}$$

**Table 10:** Matrix scaling by using the Norm.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Failures and interruptions | 0.42 | 0.28 | 0.4 | 0.4 | 0.36 | 0.35 | 0.29 | 0.37 | 0.29 | 0.34 | 0.34 | 0.28 | 0.34 | 0.4 | 0.33 | 0.4 |
| Governmental laws and regulations | 0.18 | 0.17 | 0.37 | 0.28 | 0.27 | 0.18 | 0.18 | 0.27 | 0.28 | 0.33 | 0.25 | 0.2 | 0.33 | 0.22 | 0.33 | 0.22 |
| Delays | 0.39 | 0.37 | 0.23 | 0.38 | 0.4 | 0.32 | 0.36 | 0.36 | 0.38 | 0.32 | 0.38 | 0.36 | 0.33 | 0.39 | 0.33 | 0.38 |
| Forecast | 0.3 | 0.33 | 0.36 | 0.36 | 0.32 | 0.33 | 0.31 | 0.32 | 0.34 | 0.34 | 0.39 | 0.38 | 0.36 | 0.34 | 0.35 | 0.31 |
| Intellectual property | 0.21 | 0.28 | 0.22 | 0.3 | 0.25 | 0.3 | 0.29 | 0.29 | 0.23 | 0.31 | 0.25 | 0.29 | 0.31 | 0.26 | 0.29 | 0.33 |
| Purchase | 0.42 | 0.35 | 0.38 | 0.32 | 0.34 | 0.38 | 0.35 | 0.36 | 0.37 | 0.32 | 0.34 | 0.34 | 0.32 | 0.39 | 0.36 | 0.39 |
| Receivables | 0.44 | 0.35 | 0.36 | 0.28 | 0.39 | 0.37 | 0.35 | 0.36 | 0.38 | 0.34 | 0.38 | 0.34 | 0.35 | 0.4 | 0.33 | 0.3 |
| Inventory | 0.29 | 0.4 | 0.33 | 0.35 | 0.39 | 0.41 | 0.41 | 0.31 | 0.39 | 0.36 | 0.38 | 0.38 | 0.32 | 0.3 | 0.33 | 0.35 |
| Capacity | 0.23 | 0.41 | 0.31 | 0.31 | 0.23 | 0.3 | 0.4 | 0.33 | 0.3 | 0.33 | 0.24 | 0.38 | 0.33 | 0.23 | 0.35 | 0.27 |

hen the linear scaling for scaling by the norm of the matrix is done using the following formula:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}$$

**Table 11:** Linear no- scaling matrix.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Failures and interruptions | 0.146 | 0.095 | 0.135 | 0.134 | 0.122 | 0.119 | 0.099 | 0.125 | 0.098 | 0.114 | 0.115 | 0.095 | 0.114 | 0.137 | 0.11 | 0.136 |
| Governmental laws and regulations | 0.063 | 0.058 | 0.125 | 0.094 | 0.092 | 0.061 | 0.061 | 0.091 | 0.095 | 0.11 | 0.085 | 0.068 | 0.11 | 0.075 | 0.11 | 0.075 |
| Delays | 0.135 | 0.126 | 0.078 | 0.128 | 0.136 | 0.109 | 0.122 | 0.121 | 0.128 | 0.107 | 0.129 | 0.122 | 0.11 | 0.133 | 0.11 | 0.129 |
| Forecast | 0.104 | 0.112 | 0.122 | 0.121 | 0.108 | 0.112 | 0.105 | 0.108 | 0.115 | 0.114 | 0.132 | 0.129 | 0.12 | 0.116 | 0.117 | 0.105 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intellectual property | 0.073 | 0.095 | 0.074 | 0.101 | 0.085 | 0.102 | 0.099 | 0.098 | 0.078 | 0.104 | 0.085 | 0.098 | 0.104 | 0.089 | 0.097 | 0.112 |
| Purchase | 0.146 | 0.119 | 0.128 | 0.107 | 0.115 | 0.129 | 0.119 | 0.121 | 0.125 | 0.107 | 0.115 | 0.115 | 0.107 | 0.133 | 0.12 | 0.132 |
| Receivables | 0.153 | 0.119 | 0.122 | 0.094 | 0.132 | 0.126 | 0.119 | 0.121 | 0.128 | 0.114 | 0.129 | 0.115 | 0.117 | 0.137 | 0.11 | 0.102 |
| Inventory | 0.101 | 0.136 | 0.111 | 0.117 | 0.132 | 0.139 | 0.139 | 0.104 | 0.132 | 0.12 | 0.129 | 0.129 | 0.107 | 0.102 | 0.11 | 0.119 |
| Capacity | 0.08 | 0.139 | 0.105 | 0.104 | 0.078 | 0.102 | 0.136 | 0.111 | 0.101 | 0.11 | 0.081 | 0.129 | 0.11 | 0.078 | 0.117 | 0.092 |

Now to find $E_{ij} = -k \sum_{i=1}^{m} \left| p_{ij} . lnp_{ij} \right|$ We perform the following procedure:

**Table 12:** Table $p_{ij} . lnp_{ij}$

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Failures and interruptions | -0.28 | -0.22 | -0.27 | -0.26 | -0.25 | -0.25 | -0.22 | -0.26 | -0.22 | -0.24 | -0.24 | -0.22 | -0.24 | -0.27 | -0.24 | -0.27 |
| Governmental laws and regulations | -0.17 | -0.16 | -0.26 | -0.22 | -0.22 | -0.17 | -0.17 | -0.21 | -0.22 | -0.24 | -0.21 | -0.18 | -0.24 | -0.19 | -0.24 | -0.19 |
| Delays | -0.27 | -0.26 | -0.19 | -0.26 | -0.27 | -0.24 | -0.25 | -0.25 | -0.26 | -0.23 | -0.26 | -0.25 | -0.24 | -0.26 | -0.24 | -0.26 |
| Forecast | -0.23 | -0.24 | -0.25 | -0.25 | -0.24 | -0.24 | -0.23 | -0.24 | -0.24 | -0.24 | -0.26 | -0.26 | -0.25 | -0.25 | -0.25 | -0.23 |
| Intellectual property | -0.19 | -0.22 | -0.19 | -0.23 | -0.21 | -0.23 | -0.22 | -0.22 | -0.19 | -0.23 | -0.21 | -0.22 | -0.23 | -0.21 | -0.22 | -0.24 |
| Purchase | -0.28 | -0.25 | -0.26 | -0.23 | -0.24 | -0.26 | -0.25 | -0.25 | -0.26 | -0.23 | -0.24 | -0.24 | -0.23 | -0.26 | -0.25 | -0.26 |
| Receivables | -0.28 | -0.25 | -0.25 | -0.22 | -0.26 | -0.26 | -0.25 | -0.25 | -0.26 | -0.24 | -0.26 | -0.24 | -0.25 | -0.27 | -0.24 | -0.23 |
| Inventory | -0.23 | -0.27 | -0.24 | -0.25 | -0.26 | -0.27 | -0.27 | -0.23 | -0.26 | -0.25 | -0.26 | -0.26 | -0.23 | -0.23 | -0.24 | -0.25 |
| Capacity | -0.20 | -0.27 | -0.23 | -0.23 | -0.19 | -0.23 | -0.27 | -0.24 | -0.23 | -0.24 | -0.20 | -0.26 | -0.24 | -0.19 | -0.25 | -0.22 |

**Table 13:** Table of confidence.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| sum | 2.184 | 2.197 | 2.171 | 2.195 | 2.182 | 2.181 | 2.197 | 2.185 | 2.193 | 2.174 | 2.176 | 2.18 | 2.189 | 2.18 | 2.17 | 2.153 |
| | 0.9937 | 0.9996 | 0.9878 | 0.9987 | 0.9928 | 0.9924 | 0.9996 | 0.9942 | 0.9978 | 0.9892 | 0.9901 | 0.9919 | 0.996 | 0.9919 | 0.9874 | 0.9796 |

As mentioned, the index number for ranking risks were identified. Since the degree of importance of these indicators are not identical, is needed to determine the weight of each indicator. So, the Shannon Entropy was used. $W_j = \frac{d_j}{\sum_{j=1}^{m} d_j}$

**Table 14:** Table of Weights of criteria.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Dj=1-Ej | 0.0201 | 0.0124 | 0.0078 | 0.0037 | 0.0078 | 0.0097 | 0.0106 | 0.0019 | 0.0056 | 0.0001 | 0.0074 | 0.0069 | 0.0010 | 0.0119 | 0.0001 | 0.0060 |
| Wj | 0.1716 | 0.1056 | 0.0668 | 0.0319 | 0.0668 | 0.0823 | 0.0901 | 0.0164 | 0.0474 | 0.0009 | 0.0629 | 0.0591 | 0.0086 | 0.1017 | 0.0009 | 0.0513 |

Then the diagonal matrix of weights and multiplying this matrix the diagonal matrix of scale weights in the weighted matrix of the scale are achieved.

**Table 15:** Non-Scale matrix weighted.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Failures and interruptions | 0.025 | 0.010 | 0.009 | 0.004 | 0.008 | 0.010 | 0.009 | 0.002 | 0.005 | 0.0001 | 0.007 | 0.006 | 0.0010 | 0.014 | 0.0001 | 0.007 |
| Governmental laws and | 0.011 | 0.006 | 0.008 | 0.003 | 0.006 | 0.005 | 0.005 | 0.001 | 0.005 | 0.0001 | 0.005 | 0.004 | 0.0009 | 0.008 | 0.0001 | 0.004 |
| Delays | 0.023 | 0.013 | 0.005 | 0.004 | 0.009 | 0.009 | 0.011 | 0.002 | 0.006 | 0.0001 | 0.008 | 0.007 | 0.0009 | 0.014 | 0.0001 | 0.007 |
| Forecast | 0.018 | 0.012 | 0.008 | 0.004 | 0.007 | 0.009 | 0.009 | 0.002 | 0.005 | 0.0001 | 0.008 | 0.008 | 0.0010 | 0.012 | 0.0001 | 0.005 |
| Intellectual property | 0.013 | 0.010 | 0.005 | 0.003 | 0.006 | 0.008 | 0.009 | 0.002 | 0.004 | 0.0001 | 0.005 | 0.006 | 0.0009 | 0.009 | 0.0001 | 0.006 |
| Purchase | 0.025 | 0.013 | 0.009 | 0.003 | 0.008 | 0.011 | 0.011 | 0.002 | 0.006 | 0.0001 | 0.007 | 0.007 | 0.0009 | 0.014 | 0.0001 | 0.007 |
| Receivables | 0.026 | 0.013 | 0.008 | 0.003 | 0.009 | 0.010 | 0.011 | 0.002 | 0.006 | 0.0001 | 0.008 | 0.007 | 0.0010 | 0.014 | 0.0001 | 0.005 |
| Inventory | 0.017 | 0.014 | 0.007 | 0.004 | 0.009 | 0.011 | 0.013 | 0.002 | 0.006 | 0.0001 | 0.008 | 0.008 | 0.0009 | 0.010 | 0.0001 | 0.006 |
| Capacity | 0.014 | 0.015 | 0.007 | 0.003 | 0.005 | 0.008 | 0.012 | 0.002 | 0.005 | 0.0001 | 0.005 | 0.008 | 0.0009 | 0.008 | 0.0001 | 0.005 |

The weighted-scale matrix used in the next step to determine the positive and negative ideal solution:

**Table 16:** Table of the positive and negative ideal solution.

| Effective Factors | Risk factors affecting the supply chain | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | 50 | 39 | 11 | 15 | 47 | 48 | 6 | 46 | 45 | 27 | 28 | 29 | 8 | 40 | 16 |
| Vj+ | 0.026 | 0.015 | 0.009 | 0.004 | 0.009 | 0.011 | 0.013 | 0.002 | 0.006 | 0.0001 | 0.008 | 0.008 | 0.001 | 0.014 | 0.0001 | 0.007 |
| Vj- | 0.011 | 0.006 | 0.005 | 0.003 | 0.005 | 0.005 | 0.005 | 0.001 | 0.004 | 0.0001 | 0.005 | 0.004 | 0.0009 | 0.008 | 0.0001 | 0.004 |

And finally, the ideal interval between positive and negative factors by The following table is obtained:

**Table 17:** Results of the ideal distance between the positive and negative factors and the relative proximity.

| Risks | $d_i^+$ | $d_i^-$ | $C_i^*$ | Risks | $d_i^+$ | $d_i^-$ | $C_i^*$ |
|---|---|---|---|---|---|---|---|
| Failures and interruptions | 0.0071 | 0.0183 | 0.720472 | Purchase | 0.0036 | 0.0201 | 0.848101 |
| Governmental laws and regulations | 0.0221 | 0.0033 | 0.129921 | Receivables | 0.0040 | 0.0205 | 0.836735 |
| Delays | 0.0062 | 0.0182 | 0.745902 | Inventory | 0.0101 | 0.0161 | 0.614504 |
| Forecast | 0.0103 | 0.0132 | 0.561702 | Capacity | 0.0150 | 0.0131 | 0.466192 |
| Intellectual property | 0.0170 | 0.0075 | 0.306122 | - | - | - | - |

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### *10.Conclusion:*

If Motorsazan Company of ITMCO want to have successful supply chain without breakdown and failure also if they want to decrease their purchase costs and good quality of products their mangers should have some process to copied with those risks that we identified in this research.Our results showed that the priority of risks in Motorsazan Company of ITMCO is as followed:

**Table 18:** Priority of risks in Motorsazan Company of ITMCO supply chain.

| Risks | Priority of Risks |
|---|---|
| Purchase | 1 |
| Recivables | 2 |
| Delays | 3 |
| Failures and departures | 4 |
| inventory | 5 |
| Forecasting | 6 |
| Capacity | 7 |
| intellectuall property | 8 |
| Law and government regulations | 9 |

When they want to copied with risks in supply chain they should have some preventive systems and in this case priority of risks will help them that where they should start to establish their preventive systems.

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