Analysis and Prediction of Supply and Demand Risks - Case of the Moroccan Company

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***Abstract*— In several entities of the supply chain, a multitude of sources of risk can be a hindrance to companies wishing to have a good level of performance. The purpose of our study is to assess the severity of the several factors that cause supply and demand risks to determine which ones contribute most to the growth of the levels of risks studied. Through the literature review and interviews with logistics and production managers, we identified 16 source factors of the supply and demand risks.**
In a perspective of improvement of the performance of the supply chain of the Moroccan companies, we have relied on the data of 32 Moroccan companies in order to analyze the criticalities of the 16 factors mentioned in this article, to identify the most critical factors and their impacts on firm objectives, and to deliver a model for predicting the risk levels by a multiple linear regression model.

***Keywords*—** *supply risk, demand risk, prediction, multiple linear regression, supply chain*

1. Introduction

In a global context where companies suffer from instability and severe volatility, the field of risk management has become one of the major concerns of industrialists and logisticians for better management of resources and permanent preservation of performance [1] [2] [3].
In Morocco, it is only recently that the notion of criticality of risks and the need to control them has begun to be established in the discourses of government agencies and companies.
The challenge of the risk management process is to propose, in spite of the risks due to market variations and the customization of products, a supply management approach that provides supply chain actors with information that is sufficiently rich and easily exploitable, so that the company has a better visibility of its demand. Moreover, how to deal with fluctuations in supply and demand is a vital issue in supply chain management. Beforehand, it is useful to discern the level of criticality disruptive sources causing an imbalance situation to generate an appropriate risk management approach. Our research, supported by data from 32 Moroccan companies from different sectors, attempts to identify the most critical factors that lead to demand and supply risks.
Our main objective is to deliver on the one hand, a model to predict the behavior of risks studied in the future. This model is based on multiple linear regressions. And on the other hand, enrich the academic literature, by determining the level of each potential source of these risks and its impact on the company's objectives.

In this perspective, the first section of this article is devoted to the justification of the typology of the risks adopted in this research. Then we will explain the methodology used to conduct the survey presented. The results of our empirical study and the prediction method will be presented and discussed respectively in the third section. The fourth section will be devoted to a conclusion of our study.

2. Literature review

Several previous studies have focused in their studies on a single category of risks especially the supply and demand risks. Indeed, the complexity of modern supply chains and the increased need for greater competitiveness throughout the supply chain increase exposure to supply risks [4]. Generally supplier risks can come from the type of relationship with the supplier, its performance and reliability of the suppliers, and the supply market. Kern et al, have developed a model for upstream

supply chain risk management and they validated the model empirically [5]. Guertler and Spinler establish in their study key indicators of supply risks [6]. In their research, Reichenbachs et al, presents initial guidelines for managers to the establishment of an effective strategic supply risk management system [7]. Concerning the demand risks, they derive generally from the volatile and unpredictable expectations on the markets [8]. Sodhi has focused on demand risk management for tactical supply chain planning [9], Songtao et al, discussed the impact of market demand risks on optimal stock decision making [10] [11]. Rezapour and Farahani formulated a stochastic mathematical programming model for designing a network of multi-product supply chains under demand risks [12].

2.1. Justification for the choice of risks

Supply and customer problems in companies are in most cases very disastrous. Our study focuses on demand and supply risks, given their significantly negative impact on supply chain performance and efficiency [13], [14], [15].

Furthermore, in [16] we carried out a questionnaire survey of Moroccan companies whose purpose was to detect the impact of risks on the supply chain performance. The result of this survey revealed that among the four risks addressed (demand risks, supply risks, environmental and infrastructure risks), those related to demand and supply influence negatively the performance of the supply chain at a very considerable level compared to environmental and infrastructure risks. This allowed us to deduce that the risks are neither in the technical installations nor in the management of the physical flows of the products using storage or transport infrastructures, but rather appear in the functioning of the supply chain. These risks are generally related to issues such as information exchange, interaction with customers and suppliers, and market volatility. So the supply chain is affected more by its functioning and activity.

3. Methodology

3.1 Identification for the choice of risks

Risk sources in a supply chain are numerous, they arise from the organization and its external environment [17]. The literature has addressed two main issues in the field of supply chain risk management: the identification of sources of risk and the consequences of risks [18]. The identification of risks sources is a very important element in determining how best to manage these risks. Avelar-Sosa et al, propose a model of structural equations to evaluate the effects of some factors of demand, supply and process risks [19]. Xin Liu's study [20], which deals the analysis of the identification of risk factors, was based also on a model of structural equations.

In accordance with the literature review, there are several factors causing demand and supply risk. El Abdellaoui and Moflih defined in their study seven risk factor for the upstream part and three risk factors for the downstream part [21],. Xiaohui et al, grouped the sources of supply risk into two categories, the item character and the supplier character [22]. As for the sources of demand risk, Xiaohui et al, categorized them into three categories, the item character, the market character and the customer demand [22]. Based on literature review and interviews with production and logistics managers, we have listed ten source factors for supply risk and six factors for demand risk in Table 1

Table 1. Sources of supplier and demand risks

Risk type	Risk source factors
Supply risk	Fac1 : scarcity of products in the markets
	Fac2: fluctuation and unexpected price increases
	Fac3: Unplanned stoppage of a key supplier
	Fac4: Unplanned suspension of a product line
	Fac5: Lack of logistical performance of suppliers
	Fac6: Misinterpretation of requirements by supplier
	Fac7: Quality problem
	Fac8: Stock obsolescence
	Fac9: Inventory deterioration
	Fac10: Location of suppliers
Demand risk	Fac11: Unexpected cancellation of orders by customers
	Fac12 : Receipt of urgent orders
	Fac13: Planning in a wide range of industrial sectors
	Fac14: Prediction plans under uncertainty
	Fac15: Random and highly fluctuating customer demand
	Fac16: Bad payment habits or lack of payment by customers.

3.2 Data collecting

Every source factor is characterized by its probability of occurrence and its impact on supply chain performance. To obtain the criticality level of each factor we will use equation (1) given by Dani et al [23]:

$$Ci = Pi \times Gi \quad (1)$$

Such as:

Pi : is probability of occurrence
Gi : is its impact on the performance

In order to determine the most risky situations that decision-makers may encounter within their companies, the criticality of each risk source factor must be analyzed, for this reason it is necessary to proceed to the data collection. Respondents were asked to estimate the probability of occurrence and the impact on supply chain performance, on a scale from ‘’very weak ‘’ (1) to ‘’ very high’’ (5). Concerning the profile of respondents, 50% of them are supply managers, 30% are logistic managers and 20% are production managers.
The data collection resulted in a heterogeneous sample, covering a wide range of manufacturing sectors and diversified company sizes. We did not delimit the choice of the sample by a determining criterion. Out of 220 companies solicited, we were able to exploit data of 32 companies.
Once the probabilities and impact levels are defined. Criticality calculations are performed for each factor to analyze the relationship between the risk and its source factors. In this perspective we have chosen multiple linear regression which is generally used for data analysis [24].

3.3 Data analysis

Set your page as A4, width 210, height 297 and margins as follows: Regression models are generally used to explain or predict the variance of a phenomenon using a combination of explanatory factors [24].

Multiple linear regression will allow us to answer the following questions:

- What are the factors that strongly influence the level of risk studied?
- What is the rate of influence of each factor on the risk studied?
- What are the factors that predict the level of risk studied?

The answer to these questions will provide decision-makers with ideas on how to identify effective and appropriate strategies for better management of their supply chain, and will assist managers in devoting essential time and resources to risk management.
In our case, we intend to determine which factors contribute highly in raising the level of risks studied. We consider the source factors studied as explanatory variables and the level of risk as a variable to explain. The results of this analysis are illustrated in the tables below and are delivered by the SPSS software.

4. Results

4.1 Data analysis

Before interpreting the results, we will first check the quality of the model in terms of results analysis and predictions. This will be carried out by calculating the values of the coefficients R-Squared**,** Adjusted R-Squared and Predicted R-Squared. Results are illustrated in Tables 2 and 3.

Table 2. Model summary for supply risk level

R-squared	Adjusted R-squared	Predicted R-squared
91%	88%	80%

Table 3. Model summary for demand risk level

R-squared	Adjusted R-squared	Predicted R-squared
94,1%	92,68%	89,77%

Based on the results obtained on tables 2 and 3, it can be seen that the R-Squared values for the supply risk and the demand risk models are high, they are 91% and 94% respectively. A high value of the R-Squared means that the model is of good quality in terms of the adequacy of the observed results and the predicted values. For the adjusted R-Squared, they have considerable values, 88% for the model that interprets the supply risk, and 92,66% for the demand risk model, which can confirm that the model generates good quality results. As regards the predicted R-Squared, it displays important values, whether for the value of the supply risk model 80%, or for the demand risk model value 89,77%, this indicates the ability of both models to predict new observations.
In order to determine which factors contribute most

Table 4. Correlation coefficient values for supply risk level

		level of risk	Fac1	Fac2	Fac3	Fac4	Fac5	Fac6	Fac7	Fac8	Fac9	Fac10
Pearson Correlation	**level of risk**	1	0,43	0,46	0,461	0,303	0,36	0,159	0,817	0,037	0,282	0,207
Significance			0,006	0,004	0,004	0,05	0,024	0,193	0,000	0,420	0,059	0,127

Table 5. Correlation coefficient values for demand risk level

		level of risk	Fac11	Fac12	Fac13	Fac14	Fac15	Fac16
Pearson Correlation	**level of risk**	1	0,417	0,559	0,337	0,551	0,648	0,334
Significance			0,012	0,001	0,037	0,002	0,000	0,038

to raising the level of risks studied, we present in Tables 4 and 5 the values of the coefficients of correlations between the risk level and the source factors of the risk.

In accordance with the results presented in Table 4, the level of supply risk is correlated intensively and significantly with the problems that correspond to quality problems, because the correlation factor is 0.788[1] and the significance value is less than 5%[1]. For issues related to unpredictable stoppages of key suppliers and unforeseen price fluctuation, they have a strong impact on the risk level with correlation factors of 0.461[1] and 0.46[1] respectively, and significance value less than 5%[1]. For the problems related to the scarcity of products in the markets and suppliers' logistical performance defects problems they have a medium impact on the risk level with correlation factors of 0.43[1] and 0.36[1] respectively and significance value less than 5%[1].

As for the remaining source risk factors, they are not correlated with the supply risk level because correlation factor values are less than or equal to 0.3[1] and values of significance are greater than or equal to 5%[1].

Relative to demand risks, Table 5 shows that random and highly fluctuating customer demands, forecast plans under uncertainty, and the receipt of urgent orders contribute significantly to raising the demand risk level, with significant correlation factors of 0.648[1], 0.551[1] and 0.559[1] respectively and significance values less than 5%[1].

With regard to the remaining source factors, they are correlated with the demand risk level at a moderately rate with correlation factor values between 0.3[1] and 0.45[1] and significance less than 5%[1].

The study that we carried out, allowed us also to deliver on the table 6 the consequences of the source factors treated on the supply chain objectives (the cost, the deadlines, the quality).

Table 6 shows the degrees of impact on the company's objectives of each source factor according to their correlation factors. We seek to identify factors that make the supply chain more vulnerable, in order to give them greater attention and tighter monitoring. From Table 6, it can be seen that companies need to pay more attention to quality issues, price fluctuations and unpredictable stoppages of key suppliers, policy decision makers must also review their forecasting plans in order to control the random nature of customer requests and urgent orders, because the confrontation with these types of risks can lead to additional costs of more than 14%, considerable inefficiencies and delays that may exceed duration of 5 months.

[1] refer to Table 9 in the Appendix to tell the scale of correlation degrees

Table 6. The impact scale of the source factors

Aims	Consequences of source factors			
	Low gravity	**Moderate gravity**	**High gravity**	**Very high gravity**
	CC < 0,3	**0,3 <CC< 0,45**	**0,45 <CC< 0,5**	**CC> 0,5**
Cost	overcost from 0 to 1%	overcost from 2%to 6%	overcost from 7% to 14%	overcost > 14%
Deadlines	Increased delays from 0 to 15 days	Increased delays from 15 days to 2 months	Increased delays from 2– 5 months	Increased delays > 5 months
Quality	Degradation of quality barely detectable	A controllable quantity is assigned	quality level requiring rapid intervention by the company	Quality level unacceptable by the company
CC : Correlation coefficient				

4.2 Prediction of risk level by multiple linear regression

Predicting the future in terms of risk, enables decision-makers to improve and adapt the service offered to customer requirements. Therefore, we found it interesting to promote our study by a method of forecasting. Besides its application in data explanation and analysis, multiple linear regression is used also for prediction [25], [26]. When linear regression is used for prediction, the sample is used to create a regression equation that predicts optimally a particular phenomenon in a particular population. The target is to use the equation to predict outcomes for individuals not included in the analysis.

In Tables 2 and 3, the Predicted R-Squared values for the supply risk and the demand risk models are 82.01% and 89.77%, respectively. These are considerable values indicating the possibility of making a very satisfactory prediction in our case study. The multiple linear regression prediction equation we want to deliver has the level of risk studied as output, for the inputs, the factors that have a considerable significance in the table of coefficients delivered by SPSS software (Table 7).

The multiple linear regression equation with p variables is as follows:

$$Y = b0+b1\ X1 + b2\ X2 +...+ b\ Xp \qquad (2)$$

With:
Y : variable to explain.
X : explanatory variable.
b : parameters to estimate.

To determine the prediction equation we present the tables 7 and 8 of the values of parameters to estimate (b Coefficients). The factors that will participate in the prediction equation must have significance less than 5%.

Table 7. Coefficients values for the supply risk level (SRL) equation

Factors	b values	Significance values
Constant	40,048	0,000
Fac1	0,142	0,076
Fac2	0,568	0,002
Fac3	0,550	0,001
Fac4	-0,827	0,300
Fac5	0,619	0,015
Fac6	0,361	0,335
Fac7	1,032	0,000
Fac8	0,267	0,104
Fac9	0,379	0,128
Fac10	-0,099	0,528

Table 8. Coefficients values for the demand risk level (DRL) equation

Factors	b values	Significance values
Constant	-44,353	0,000
Fac11	0,615	0,096
Fac12	1,776	0,000
Fac13	4,370	0,000
Fac14	0,972	0,004
Fac15	1,989	0,000
Fac16	1,241	0,000

The results obtained on Table 7 indicate that the prediction equation will retain only factors 2, 3, 5, and 7 since the corresponding significance values are less than 5%. So the equation for predicting of the supply risk level (SRL) is as follows:

$$SRL = 40{,}048 + 0{,}568\ fac2 + 0{,}55\ fac3 + 0{,}619\ fac5 + 1{,}032\ fac7 \quad (3)$$

Equation (3) shows that problems related to quality, supplier performance deficiencies, unpredictable stoppages of key suppliers, and price fluctuations are the factors involved in predicting the supply risk level, which constrains decision-makers **to** reconsider their supplier selection policies.

As to the demand risk level (DRL), all source factors contribute to the prediction equation other than factor 11, because the corresponding significance value is greater than 5%. The equation will be:

$$DRL = -44{,}353 + 1{,}776\ fac12 + 4{,}370\ fac13 + 0{,}972\ fac14 + 1{,}989\ fac15 + 1{,}241\ fac16 \quad (4)$$

As indiqued in equation (4), all source factors act in the prediction model except for the problems related to unpredictable cancellations of orders by customers. This result is explained by the current environment which is tainted by uncertainties, urgent and random orders with a personification and a very high requirement of volatile customers.

The prediction model generated by multiple linear regression, will allow us to integrate several constraints in the risk management model that we intend to propose, we envisage to establish a vendor selection model to achieve effective procurement management, and ensure a substantial competitive advantage through customized products of good quality, and delivered as soon as possible.

We also intend to incorporate indicators into our vendor selection model, to control the fluctuating behavior of customers and to follow their volatile rhythm.

5. Conclusion

From our study, we drew up a survey among Moroccan companies, to find the most effective and provocative sources of supply and demand risks. Our contribution represents an estimation of the magnitude of several potential sources of risk discussed in this paper and draws a prediction model of the risk levels.

As a result of this study, the challenge for managers will be to pay more attention to their supplier selection and evaluation policies. Indeed, the quality criterion can have an extremely remarkable impact on the performance and efficiency of the supply chain.

In addition, the unstable characters and dynamic customer behaviors have become abundant phenomena. This makes the task of preparing forecasting plans more and more complex, hence the interest of developing an approach allowing the understanding of volatile and fluctuating customer attitudes.

In conclusion, our study has limitations on sample size. For this purpose, we envisage to replicate our survey by expanding the sample studied to provide further clarification on the relation between risk and its potential sources. We will also to improve the quality of our prediction model by applying artificial intelligence methods that have recently attracted the attention of many researchers.

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Appendix

Table 9. scale of correlation degrees

	Correlation degree			
Significance less than 5%	CC < 0,3	0,3 <CC< 0,45	0,45 <CC< 0,5	CC> 0,5
	weak correlation	moderate correlation	high correlation	Very high correlation
Significance greater than 5%	No correlation			
CC : Correlation coefficient				