

Assessing the major sources of uncertainty in supply chains: survey

Nisrine Zougagh

Hassan First University of Settat, Faculty of sciences and Techniques, IMII, 26000, Settat, Morocco,
nisrinezougagh@gmail.com (corresponding author)

Abdelkabar Charkaoui

Hassan First University of Settat, Faculty of sciences and Techniques, IMII, 26000, Settat, Morocco;
abdelkabar.charkaoui@uhp.ac.ma

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Abstract: Reducing uncertainty in the supply chain (SC) is probably one of the major difficulties that the company must solve. Indeed, the SC is currently under enormous pressure and the decision-making process is frequently confronted with varied settings while making decisions due to the degree of uncertainty. The purpose of this study is to investigate the main major sources of uncertainty in SC. The study also examines the practices adopted to reduce uncertainty and enhance forecasting accuracy. A survey was carried out. Questionnaires were distributed amongst the managerial staff located in Morocco and other countries. We collected work e-mail addresses of managerial staff managerial working in SCs that operate in mass production and also in large-scale distribution and invited them to participate in an anonymous online survey. The questionnaire was designed to assess respondents' views about the main sources of uncertainty in SC and how they do to reduce it. Findings indicate that uncertainty occurs in any SC process, but the main uncertain processes are procurement, supply planning, and demand forecasting. In addition, uncertainty comes from external and internal factors. Moreover, the decision-making mode, SC partnership, and risk contract have an important impact on the occurrence of uncertainty in the SC.

1 Introduction

In the economic sphere, uncertainty has an important effect on growth, inflation, and financial markets. This uncertainty is a result of several factors, such as market forecasting changes, the ambiguity of monetary policy and interest rates at the state level, the lack of clarity in the fiscal policy of governments in the face of deficits and surpluses, the unpredictability of policies, laws, and legislation associated with them, possible economic crises, etc.

In addition, reducing uncertainty is one of the intrinsic objectives of information sharing in SC. In an uncertain business environment, risk is always present [1]. Previous work tried to reduce the uncertainty rate by improving the accuracy of shared data, particularly that of forecasts. Thus, economic uncertainty has an impact on business investment decisions. If an economy's level of uncertainty rises, firms that want to invest may have to postpone their choice because they are unsure whether the firm's future cash flows will pay for the cost of the investment [2,3].

This research aims to investigate the major sources of uncertainty in SC, the SC factors involved, and the practices used to reduce it. The paper is divided into five sections. This introductory section of the article provides a general overview of the research required to create a hypothesis. The methodology, survey instrument, and data analysis are all discussed in Section 2. The results of the data analysis are presented in Section 3. Section 4 addresses the findings with regard to the previously stated hypothesis. Section 5 concludes with findings and recommendations for future research.

1.1 Related works

According to [4], uncertainty means that the economic environment of tomorrow is not known today. Uncertainty refers to a circumstance in which there is a complete lack of knowledge or understanding of a probable event's happening, regardless of whether the consequence is favorable or negative [5]. Some research is based on this particular assumption that the main source of risk and uncertainty was due to the difference in the attitude of decision-makers [6].

A typology based on certainty, risk, and uncertainty is presented by Lavoie [7]. In the situation of certainty, each option leads to a definite result with a known value. In the case of risk, each decision leads to a set of possible outcomes, each of which has a monetary value and a probability of occurrence. In contrast, in uncertainty, the set of possible choices is not necessarily known, the possible outcomes are not exhaustively known, nor are the values of these outcomes or the associated probabilities.

In the SC field, modeling uncertainty is a scientific discipline to which the scientific community pays close attention. Uncertainty can occur in any process in the SC. For instance, SC planning is a process dealing with the coordination and integration of a company's essential business activities, from raw material procurement to final product distribution to customers [8].

The problems of storage, production, marketing, procurement, inventory, distribution, transportation, reverse logistics, green logistics, etc., generate a great deal of uncertainty and cost overruns in companies; it is,

therefore, necessary to identify the factors that prevent the optimal development of logistics operations in organizations [9].

Several researchers have investigated the sources of uncertainty in a SC for instance, [10] divided them into three categories: demand uncertainty, manufacturing process uncertainty, such as machine malfunctions, and supplier uncertainty, such as delivery delays. Many uncertain incidents disrupted SC activities. These incidents could be internal or external. Each aspect of uncertainty has disrupted SCM [11]. Moreover, [12] surveyed high-tech companies to identify the factors of technological uncertainty in an SC that ultimately affect overall cost and quality.

Forecasting errors are a source of uncertainty in SCM. Indeed, forecast management is one of the key driving factors in planning and decision-making for any SCM [13]. These errors generate a big gap between the real values and the expected ones. Thus, a good forecasting model could be efficient for dealing with forecasting errors. In addition, [14] examined retailer decisions (forecasting and replenishment models) and supplier decisions regarding the production decisions of the supplier. The results show that the selection of the forecasting model influences SC performance and information sharing. Their finding is aligned with those [15]. Indeed, [15] considered that the demand for finished products is a random variable whose expectation and variance are known. They found that the first source of uncertainty in material requirement planning is that relating to demand. The demand comes from outside and varies depending on a variety of factors (seasonality, culture, natural disasters, political conflicts, etc...). Because demand is affected by wider economic and political factors [16]. More accurate and precise predictions provide visibility on demand and hence ensure efficient SCM, decreasing the influence of market volatility and uncertainty on demand. To counter uncertainty, [15] proposed sizing a safety stock for each component for a predetermined probability of failure. The mathematical expectation and variance of the component demand are obtained by simply summing the expectations and variance of the demands of the finished products that use them.

1.2 Uncertainty and information sharing in SCM

Information sharing is a hot topic in SCM that has emerged as a result of the integration of new information and communication technologies. Information sharing is one of the well-known mechanisms for reducing uncertainty in SCM. The better information sharing is, the more uncertainty is reduced. Asymmetric, incomplete, or inaccurate information is frequently cited as a contributing factor to SC uncertainty and inefficiency. Therefore, uncertain factors in SC can cause more serious information distortion and lower the performance of SC [17].

Decision mode is an essential element in the information-sharing process. For managing a SC, there are

two types of decision modes: centralized and decentralized mode. The firm chooses the appropriate one according to the goals previously established. These two types are largely studied in the literature.

The centralized decision mode is the mode in which the manager at the top of the structure makes all of the decisions, and all information must go back to him to help him make the best decision possible. Different levels of centralization can be used to manage SC. For instance, the vendor-managed inventory program (VMI) is an example of a centralized SC in which the supplier makes inventory control choices for both the supplier and the customer [18], [19]. High centralization has proved to be valuable for managing complex problems [20].

On the other hand, there is the decentralized decision mode, in which independent work units have autonomy in decision-making. The decentralized mode can represent more viable and less cumbersome coordination than centralized coordination because each entity retains its autonomy [21]. It allows the organization to react quickly to changing local conditions [22].

SC partnerships are also involved in the information-sharing process. The characteristics of SC partnerships have been extensively studied in the literature [23-26]. Customer and supplier relationships are one of the most important ones. The interaction with external partners to create inter-organizational strategies, practices, and activities into synchronized collaborative processes is known as customer and supplier integration [27]. It comprises strategic communication and interaction, information system capabilities, collaborative planning activities, and information sharing about planning [28]. In addition, the competitive advantage is gained by organizations that have committed relationships with their customers [29]. The relationship with the supplier is purposefully and naturally strategic, and it primarily involves the organization's top management. It is because the market is highly complex and enterprises' resources are limited [30].

According to [31] shared information is exploited for both purposes: better supplier replenishments and better allocations to the retailers. The traditional method of supply is to have a large number of suppliers. Even when the buyer provides comprehensive technical specifications, there is typically limited contact and information exchange. For the buyer, this relationship offers benefits such as easy switching between providers, lower costs, having the supplier act as a shock absorber, and not disclosing personal information [32]. In addition, the value of information sharing could be influenced by whether the information is shared with only a limited number of a company's customers and not with many small customers.

Moreover, [33] allowed a firm to manage all of its operational operations by combining various management functions into one system: order management, inventory management, payroll and accounting management, e-commerce management, etc. Companies can progress

towards an extended enterprise business model by implementing ERP, which increases value across the whole SC. Indeed, companies must share a huge amount of planning and operational data, ranging from information for annual contracts and periodic progress reports to real-time delivery and invoicing data, to obtain SC efficiencies.

Furthermore, [34] emphasized the goal of management software packages to reduce the uncertainty of information by working on four important aspects: availability, representability (accuracy of the information concerning the message to be transmitted), the delay between the occurrence of an event and its consideration, and the periodicity of information renewal.

Risk contracts are mentioned in many previous works as an essential element involved in information sharing in SCM [35-38].

Risk contracting is necessary for an uncertain environment where the risk rate is high. Today, the contract is announced as a model of modern management, in which all economic and even political actors and stockholders seem to want to be involved [39]. Risks occur because people never know exactly what will happen in the future. People can use the best forecasts and do every possible analysis, but there is always uncertainty about future events [33]. Consequently, [40] proposed to contractualize the notion of risk between customer and supplier to improve the overall profit of the SC actors because it allows them to legally bind the stakeholders around one or several objectives [41]. The presence of risk is unavoidable in any project, and it can be tough to identify at times. When a SC enters into a risk contract with a supplier or retailer, the main goal is to reduce the project's risk. They then agree on a set of clauses. This strategy has the potential to protect SC or even put SC in an embarrassing situation. As a result, it is strongly advised to carefully discuss the clauses with the partner(s).

1.3 Hypothesis formulation

Based on the above, the following hypotheses are postulated:

- **H1:** *There is a relationship between uncertainty and the decision mode*
- **H2:** *There is a relationship between The supplier and retailer's numbers and uncertainty.*
- **H3:** *There is a relationship between uncertainty and using an ERP.*
- **H4:** *Using a specific tool for reducing forecast errors affects uncertainty in SC.*
- **H5:** *There is a relationship between Risk contracting and uncertainty.*

2 Methodology

2.1 Survey instrument

2.1.1 Questionnaire design

A questionnaire is the primary research instrument for this study. Questionnaires are considered to be a successful

method for collecting information from respondents, particularly when the researcher understands what is needed and how to measure the variables of interest.

The questionnaire was divided into three main parts. The first part was based on the respondent's profile, including gender, country, and position. The second part was based on the SC profile, including legal status, sector, company structure, and decision mode. The third part concerned the origin of uncertainty in the SC and how to reduce it.

The questionnaire consists of 23 questions that are checkbox questions, multiple-choice questions, open-ended questions, and Likert scale questions.

2.1.2 Questionnaire elaboration

Based on the literature and the hypothesis, the initial version of the questionnaire was created. This version was given to three experts for assessment and evaluation of the structure and content. The questionnaire was modified following their feedback and then sent to 8 researchers (SC analysts, statisticians, and data scientists) from four universities for further refinement.

The original survey was designed in French. The French version is needed since the survey sample targeted managerial staff who graduated from Moroccan universities. A version of English is designed for all researchers. The French questionnaire was translated into English by the first author for analysis. Based on the suggestions received from the respondents after the first release of the online survey, the questionnaire is improved even more by adding some options.

2.2 Profile of the participants

Our study targeted staff working in SCs that operate in mass production and also in large-scale distribution. The questionnaire is shared with an updated database from ANAPEC (National Agency for the Promotion of Employment and Skills), a Moroccan public institution in charge of accompanying job seekers in their search for work and meeting the recruitment needs of companies.

Moreover, questionnaires were sent by e-mail to the professors, associate professors, assistant professors, postdoctoral researchers, and all graduated students of the Laboratory of Engineering, Industrial Management and Innovation IMII whose e-mail addresses were available on the Hassan First University in Morocco website. The anonymity of participants was guaranteed. Reminders were sent after 2 weeks. Data were collected from May 2021 to September 2021.

The e-mail was sent with "Questionnaire pour Recherche Doctorale" as the subject of the e-mail explaining the purpose of the study and providing a link to the online questionnaire (French version and English version) to all the target researchers.

2.3 Statistical methodology

The authors obtained 151 valid responses. Data were collected, categorized, and coded in SPSS before being analyzed. The data is divided into two groups numerical values and categorical values.

Comparisons between variables were performed using the Chi-square test for the binary variable (uncertainty) and categorical variables (using ERP, Risk contract, Tool/mechanism for reducing uncertainty, Decision mode, customer and supplier number). In general, the null hypotheses were that our variables do not affect uncertainty in SC.

We formulate our test:

H0: the variables are independent

H1#H0

If the $p\text{-value} \leq 0.05$, we reject H0 and therefore accept H1, which states that the two variables are related.

3 Result

We sent a total of 3200 e-mails, and 695 e-mails were bounced back in the first release. These addresses to which e-mails were not delivered successfully were regarded as invalid addresses. For the second round, we sent reminder e-mails to the other valid e-mails. Only complete responses and responses with fewer than two invalid answers were included. After eliminating incomplete responses, 151 completed questionnaires were analyzed.

3.1 Demographic information

According to the demographic characteristics of the respondents, the majority of respondents were male (66.2%). The respondents were mainly Logistics Planners (senior or junior) (20.5%), Inventory Managers (15.2%), SC researchers (12.6%), Freight Agent / Import-Export Operations Agents (9.9%), logistic assistants (9.3%), Warehouse Manager (8.6%) and Procurement Manager (7.3%). More than 80% of the respondents live in Morocco, and 10.6% live in Europe (5.30% lives in France, 2.00% in Switzerland, and 1.30% in Germany).

3.2 Characteristics of supply chains

Concerning SC's legal status, 41% of respondents worked in a Limited company (SA) and 38% in a Limited liability company (SARL). 6% and 3% of respondents worked, respectively, in a Limited liability company (LLC) and General partnership (SNC).

In the context of the economic sectors, 21% of the companies belong to the Automotive industries and 18% belong to Food, beverage, and tobacco industries. 9% of SCs belong to the Mechanical, electrical, and telecommunications sector and 6% belong to the building materials sector. The Chemical Industries and Energy sectors are made up of 5% of companies in each of the two sectors. 4% belong to the Plastic industries sector while Aeronautics, Wood; pulp and paper, Cosmetic and fashion industries, Mining (coal; other mines), and Petrochemical industries are made up of 3% of companies in each one.

72% of the firms used the centralized decision-making mode, while 42% used the decentralized mode. The main structure for the SC structure is the convergent network (38%). 23% of SCs structures were serial networks and 19% were divergent networks.

Given the characteristics of SCs, we analyzed variables to discover any relationship between these characteristics and the uncertainty in SC. The analysis was performed using the Chi-square test for binary variables (uncertainty in SC) and categorical variables (economic sector, decision-making mode, and SC structure).

3.2.1 Cross analysis between "uncertainty" and "Economic sector", "supply chain structure" and "decision-making mode"

In table 1, we want to know if the uncertainty is related to the nature of our study's economic sector, SC structure, and decision-making mode.

According to the results. It is noticed that the probability obtained with the Chi-square test is equal to $0.448 > 0.05$. We accept the null hypothesis of independence, which implies no relationship between the two variables. So economic sector has no impact on the uncertainty.

For SC structure, the p-value of this Chi-square test is 0.760. Consequently, we accept the null hypothesis of independence, so the SC structure has no impact on the uncertainty in SC.

In contrast, for the decision-making mode, the p-value of this test is 0.000, and it is significant at the 5% threshold. We, therefore, reject the null hypothesis, which assumes that the two variables are independent and we conclude that the two variables are dependent and we conclude that the uncertainty and the decision-making mode are linked. The straightness of this relationship is examined as well. In table 2, the value of Cramer's V is 88.6% which shows that the relationship between uncertainty and decision-making mode is strong. So, the first hypothesis H1 is verified.

Table 1 Cross analysis between "uncertainty" and "economic sector", "supply chain structure" and "decision-making mode"

	Chi-square test
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		Val	ddl	Asymptotic significance (bilateral)
Economic sector	Pearson's chi-square	22,205 ^a	22	,448
	Likelihood ratio	26,912	22	,215
	N of valid observations	151		
	a. 36 cells (78.3%) have a theoretical size lower than 5. The minimum theoretical size is .28.			
supply chain structure	Pearson's chi-square	1,172 ^b	3	,760
	Likelihood ratio	1,176	3	,759
	N of valid observations	151		
	b.0 cells (0.0%) have a theoretical number less than 5. The minimum theoretical size is 8.26.			
decision-making modez	Pearson's chi-square	118,404	1	,000
	Correction for continuity	114,066	1	,000
	Likelihood ratio	124,508	1	,000
	Fisher's exact test			

Table 2 Symmetrical measurements

		Val	Approximate Signification
Nominal by Nominal	Phi	-,886	,000
	Cramer's V	,886	,000
N of valid observations		151	

3.3 Uncertainty sources (outside or inside of SCM)

Concerning online sources, 76.2% of the respondents reported that the uncertainty comes from external and internal factors, (14%) reported that it comes from External factors, while fewer (9%) reported that it comes from internal factors.

3.4 Working with more than one supplier/customer effect

3.4.1 supplier/customer number effect

The relationship between the number of supplier/customer and uncertainty were examined as well. According to the results, a substantial number (57%) of respondents reported that having more than one supplier decreases uncertainty. In contrast, almost half of the

respondents (47%) indicated that having more than one customer increase uncertainty. In addition, 35.1% of respondents indicated that working with more than one customer decrease uncertainty, whereas 29.8% indicated that working with more than one supplier increases uncertainty. Fewer (17.9% and 12.6%) indicated that the number of relationship partners (customers and respectively suppliers) is without effect.

3.4.2 Cross-analysis between "uncertainty" and "supplier/customer"

The cross-tabulation in Figure 1 displays uncertainty by the number of suppliers and customers. This number is represented by an interval. Figure 1 shows that uncertainty is strongly correlated with the number of suppliers between [31,50] and customers number which is more than 30.

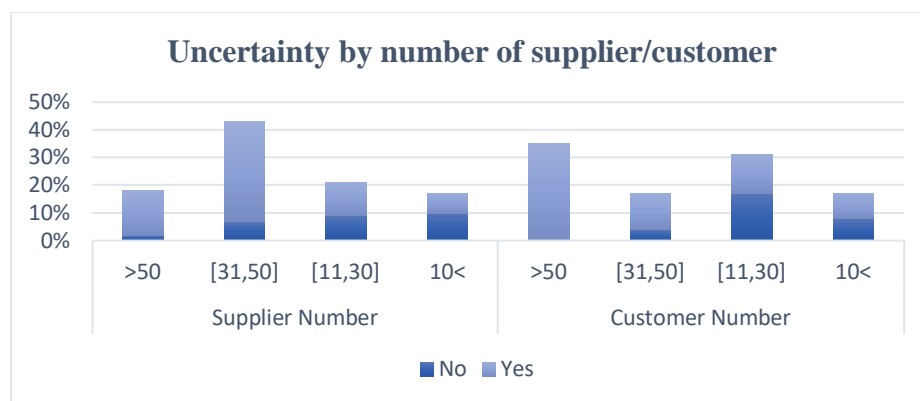


Figure 1 Cross analysis between "uncertainty" and "supplier" and "customer number"

Table 3 displays the Chi-square test for number, The p-value of this test is 0.000, and it is significant. We, therefore, reject the null hypothesis, which

assumes that the two variables are independent, and we conclude that the two variables are dependent and we conclude that the level of uncertainty and supplier number are related. Table 4 shows that Cramer's'V value is 51.8% which means a moderated relationship. For the customer number, The p-value of this test is 0.000 (Table 3). Then we conclude that the two variables are

dependent. Table 4 shows that Cramer's'V value is 39.1% which means a moderated relationship. According to this finding, we can conclude that supplier/customer numbers affect uncertainty in SC. The more suppliers/customer increases, the more the uncertainty level change. H2 verified.

Table 3 The relationship between uncertainty and supplier/customer number

Chi-square test						
	Supplier Number			Customer Number		
	Val	ddl	Asymptotic significance (bilateral)	Val	ddl	Asymptotic significance (bilateral)
Pearson's chi-square	40,579 ^a	3	0,000	23,078 ^a	3	0,000
Likelihood ratio	53,013	3	0,000	22,818	3	0,000
N of valid observations	151			151		

Table 4 Symmetrical measurements

	Supplier		Customer	
	Val	Approximate significance	Val	Approximate significance
Phi	0,518	0,000	0,391	0,000
Cramer's V	0,518	0,000	0,391	0,000
Total	151		151	

3.5 Uncertain processes

On a scale of 0 to 3, each SC process was evaluated for its degree of uncertainty (0 being the least uncertain and 3 being the most uncertain).

According to our findings, demand forecasting is the most uncertain process (Figure 2). 19% of respondents indicated that demand forecasting is the most uncertain, whereas 15% indicated Supply planning.

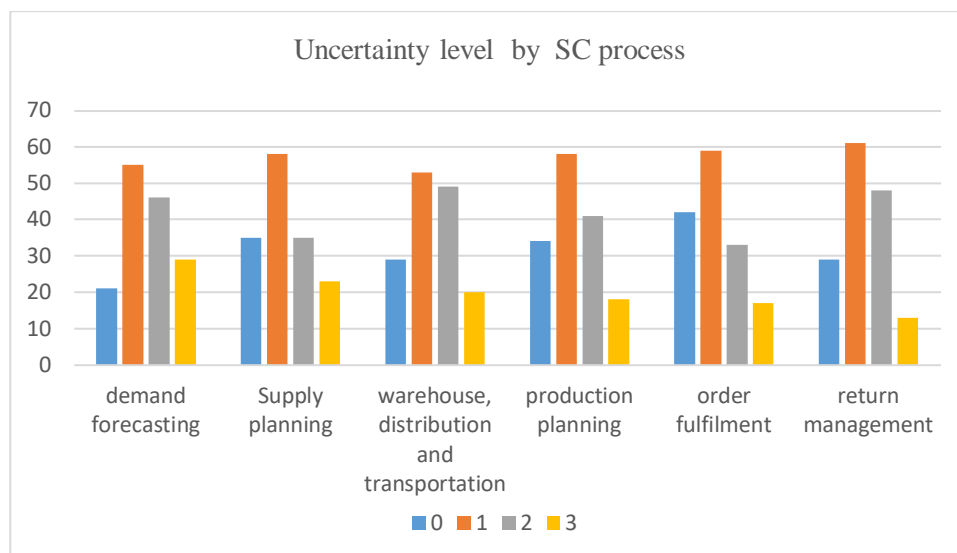


Figure 2 Uncertainty by process

Indeed, [42] has developed a theoretical review for SC uncertainty. This review identifies a list of 14 sources of uncertainty, including those that have received much

research attention. Based on the result of their analysis, their finding was included in the study to classify different uncertainty factors according to their importance.

Figure 3 displays a classification of uncertainty factors identified by [42]. 12% of respondents tended to agree that the suppliers are the main factors of uncertainty, while product characteristics and end-customer demand are made up of 10% of factors for each one. The manufacturing process, Cost forecasting horizon, Environment and

Policy, Complexity of the decision, and Disaster are likely to have the same level of uncertainty. At the practical level, more than half of the respondents stated that the most critical factors are related to procurement, product characteristics, and demand forecasting processes.

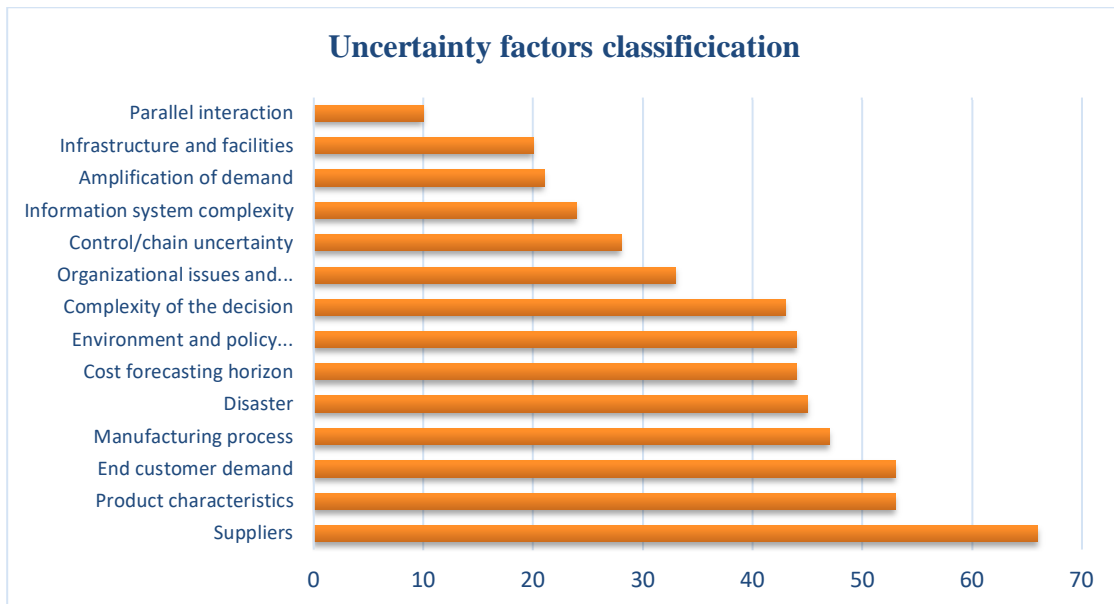


Figure 3 Uncertainty factors classification

3.6 Reducing uncertainty in SC

According to Figure 4, 66.2 % of respondents indicated that they use an ERP for forecasting management, and 84% of them use a specific tool to reduce errors generated by forecasts. Some responders mentioned some mechanisms for correcting forecast errors, such as the contingency plan,

standard operating procedures, and kick-off meetings. Collaborative communication between different SC stages is also cited as a corrector of errors related to uncertainty. To mitigate forecast uncertainty and share the damage due to uncertainty, some firms use a risk contract with customers and/or suppliers. 72.8% reported using the risk contract with SC partnerships.

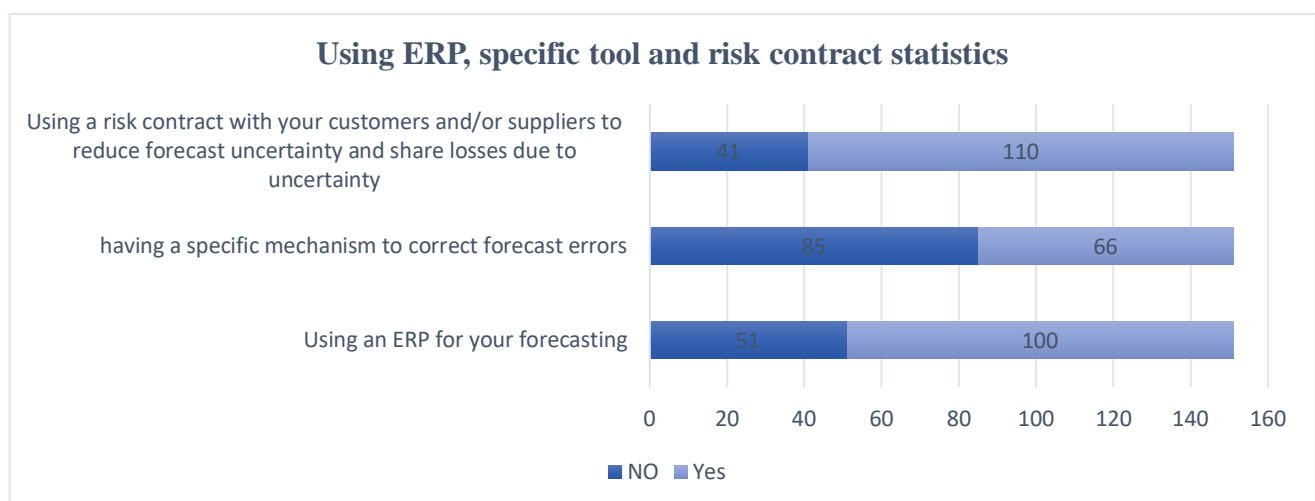


Figure 4 Using ERP, Specific tools, and Risk contract statistics

3.6.1 Cross analysis between "uncertainty" and the use of "ERP", "a tool for forecasts errors" and "risk contract"

In this part, a Chi-square test is done to discover the relationship between uncertainty and the use of ERP, tool,

and risk contract. For the use of an ERP, according to table 5, The p-value of this Chi-square test is 0.573. we, therefore, accept the null hypothesis and we conclude that the level of uncertainty and the use of an ERP is not related. H3 verified.

Table 5 The relationship between uncertainty and ERP, a tool used for reducing uncertainty and Risk contract

		Val	ddl	Asymptotic significance (bilateral)
ERP	Pearson's chi-square	,317	1	,573
	Correction for continuity	,139	1	,710
	Likelihood ratio	,314	1	,575
	Fisher's exact test			
	N of valid observations	151		
The tool used for reducing uncertainty	Pearson's chi-square	53,963	2	,000
	Likelihood ratio	58,951	2	,000
	N of valid observations	151		
Risk contract	Pearson's chi-square	67,905	1	,000
	Correction for continuity	64,605	1	,000
	Likelihood ratio	65,741	1	,000
	Fisher's exact test			
	N of valid observations	151		

It seems that the use of a specific tool for reducing forecasting inaccuracy could be beneficial. This assumption is examined as well. According to Table 5, the p-value of this test is 0.000. We reject the null hypothesis, which assumes that the two variables are independent and we conclude that the use of a specific tool for reducing forecasting uncertainty has a tangible effect on uncertainty

in SC. Table 6 shows that Cramer's V value is 59.8% which means the relationship is relatively strong. H4 verified.

The relationship between Risk contracts and uncertainty is examined as well. The p-value of this test is 0.000 (Table 5), we reject the null hypothesis, and we conclude that the use of a Risk contract affects uncertainty in SC. Table 6 shows that the Cramer's V value is 67.1% which means the relationship is strong. H5 verified.

Table 6: Symmetrical measurements

		Val	Approximate significance
The specific Tool	Nominal by Nominal	Phi	,598
		Cramer's V	,598
	N of valid observations	151	
Risk Contract And Uncertainty	Nominal by Nominal	Phi	,671
		Cramer's V	,671
	N of valid observations	151	

4 Discussion

Indeed, SCs are confronted with various risks that are hard to assess. According to [43], there are two types of risk in SC; internal risk and external risk. External risk comes from outside the SC; usually related to economic, social, governmental, and climate factors, including the threat of terrorism, and also caused by factors such as a supplier's financial or management stability, or the purchase and sale of supplier companies. Internal risk is caused by disruptions of internal operations or processes, by changes in key personnel, management, reporting structures, or business processes, such as the way purchasers communicate to suppliers and customers, and

by inadequate assessment and planning, which amount to ineffective management. The results of the study discovered that uncertainty came from both internal and external factors.

This finding is aligned with many works. Indeed, [44] describe four sources of uncertainty: physical manifestations, perceptions, behavioral response repertoire, and social expectations. However, [33] examines the impacts of SC and risk on the logistics performance in the Australian courier industry and indicates that the greatest impact of SC uncertainty comes from an outside company.

In addition, [42] identified a comprehensive list of 14 sources of uncertainty, including those that have received a lot of attention in the past, such as the whiplash effect, as well as those that have only recently been described, such as parallel interaction. Techniques for controlling these sources of uncertainty are divided into two categories: ten approaches that aim to minimize uncertainty from its source, and eleven approaches that aim to manage uncertainty while reducing its impact on performance. Manufacturing strategy theory, which includes the ideas of alignment and contingency, is then applied to the development of an SC uncertainty model, which is then fed with data from the literature review to demonstrate alignment between sources of uncertainty. According to his work, [42] has divided the origins of uncertainty into three categories: (1) Internal organization uncertainty, which includes product characteristics, manufacturing process, control/chaos, decision complexity, organizational/behavioral challenges, and information technologies IT complexity. (2) Internal SC uncertainty, which includes end-customer demand, demand amplification, supplier, parallel interaction, order forecast horizon, chain configuration, infrastructure, and facilities, and is within the control domain of the focal company or its SC partners. (3) External uncertainties arise from elements outside the SC that are beyond a company's direct control, such as government regulations, competitor behavior, and macroeconomic concerns, as well as disasters, such as earthquakes, hurricanes, and high sea waves.

Moreover, it is found that the most uncertain SC process is procurement. This topic is largely studied in the literature [45-48]. According to [46] the importance of procurement in the SC can be realized from the percentage of the cost it takes in the industry. They noticed that procurement risk is the probability of variance associated with supply disruption in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to the subsequent process in the SC operation. As there is no systematic way for managers to classify the source of procurement risk once the unexpected risk has happened, procurement risk has primarily relied on the manager's expertise and intuition [46].

From our results, it is clear that the mode of decision-making has an impact on the occurrence of uncertainty in the SC.

Centralization can be considered the most powerful mechanism to coordinate decisions in the organization. All decisions are made within the same structure, which ensures consistency of decisions and better results concerning the overall goals of the SC [49]. However, the decentralized mode may represent more viable and less cumbersome coordination than centralized coordination because each entity retains its autonomy. Moreover, it allows the organization to respond quickly to changing local conditions [50]. Even if the centralization reduces the

uncertainty in the SC, it doesn't eliminate the increase in variability [51,52].

Consequently, the choice of one of the two modes is a crucial choice for managers because, from the above, each mode has its advantages and has its disadvantages. Thus, the company can decide on the right mode to improve the information sharing in their SC, reducing uncertainty and ensuring the survival of the SC.

From the Chi-square tests between uncertainty and the number of suppliers and customers, we conclude that there is a strong relationship between them. Therefore, the number of suppliers and the number of customers influence uncertainty by then sharing information in the SC.

Some works are aligned with this finding. Indeed, [53] showed that the value of information sharing decreases when the number of customers increases. As the number of customers increases, the random variation in demand tends to balance out, reducing the value of information sharing. The value of information sharing is influenced when information is shared with a limited number of customers of a firm and not with large small customers.

Furthermore, having multiple suppliers can be advantageous because they can reduce not only the uncertainty of obtaining materials or products for the retailer but also the wholesale price due to competition among suppliers, the uncertainty of delivery time, and the cost of a shortage caused by a single supplier [54-56].

According to the results, the impact of using ERP and a specific mechanism to correct forecast errors on uncertainty is small.

Some responders mentioned some mechanisms for correcting forecast errors. They mentioned the contingency plan, S&OP, and kick-off meetings. S&OP (Sales and Operations Planning) is a method of creating tactical plans that allow management to strategically guide their company to achieve a competitive advantage. The goal is to combine a customer-focused marketing strategy for new and existing items with SC management regularly.

A kick-off is the initial meeting between a project team and a client or stakeholder to discuss project fundamentals and general planning activities. The project kick-off meeting is usually held just before the start of project execution. The project kick-off meeting is an important tool in the formulation of a project management strategy.

Based on the answers, the Kick-off mistakes can be rectified and anticipated eventual errors can be in advance. Thus, a checklist is essential to list and store the errors that have been reported with their solutions.

Collaborative communication between the bodies in the chain is also cited as a corrector of errors related to uncertainty.

It is found that there is a strong relationship between the use of risk contracts with customers and/or suppliers to reduce forecast uncertainty and share losses due to uncertainty. We can therefore answer our hypothesis and say that the existence of a risk contract reduces uncertainty.

Indeed, global market conditions, marked by increased and fierce competition, have forced SCs to modify their risk management strategies. More specifically, SCs must develop strong contractual mechanisms to manage uncertainty and fluctuating demand. For instance, [57] developed a risk-sharing contract in a SC to study strategic and vital components exposed to the combined risk of demand uncertainty and price volatility. The proposed contract guides establishing a long-term SC contract to mitigate known and unknown risks. In addition, [58] proposed a risk-sharing contract that requires the retailer to partially compensate the manufacturer's loss due to overproduction and the manufacturer to provide partial credit for the retailer's loss due to overstocking. Moreover, [58] proposes contracting the risk between the customer and supplier to improve the overall profit of SC actors. To mitigate the risk, [59] suggested combining contract and open market to obtain the optimum procurement under the uncertain market price.

Respondents cited other sources of uncertainty that may be useful for future research. Lack of communication, especially with management, was the most mentioned. Other sources related to the political and legal situation, such as the complexity of laws and bureaucracy. The constraints of the economic market are also cited; the fluctuation of needs, the hazards at the level of the prices practiced in the market, customs, international politics, insurance, environmental factors, and macroeconomics.

To minimize uncertainty errors, respondents left some recommendations. They recommend the proximity of customers-suppliers because the basis of SC planning is the sales forecast and suppliers. They thought it was imperative to control these two first before moving on to the remainder.

In addition, the reliability of the forecast models must be checked. A rate of uncertainty should be applied to avoid disruptions of upstream operations; on the other hand, a demand forecast with a better rate of accuracy will allow the minimization of the costs necessary to allocate to face the hazards (raw material breakage, underestimated production capacity...).

On the relational side, they propose coordination and collaboration through information systems that govern and organize relationships and information between stakeholders.

They also recommend risk assessment before and during procurement and having a maintenance management system that guarantees the start-up in real-time and developing a risk-sharing contract to study strategic and vital components exposed to the combined risk of demand uncertainty and price volatility. The proposed contract guides establishing a long-term SC contract to mitigate known and unknown risks.

5 Conclusion

The challenges of information sharing and eliminating -or reducing- uncertainty in SCs is one of the important

issues, and it prompts SCs to study possible ways. The current study aims to explore the different sources of uncertainty in SCs, the main factors involved, the most uncertain process, and the policies adopted to reduce uncertainty. A survey was conducted to answer our problem. Through our online survey among SC researchers, we have answered and validated the hypothesis previously formulated.

The main contribution of this chapter is to know the closeness between the problem of uncertainty in the working area and what is already studied in the literature and to what extent this closeness is reached. This study recommends certain practices that can reduce the level of uncertainty. Good communication is a witness between others.

Rationally, every research output is followed certain limitations. Similarly, this article possesses some limitations. However, sufficient attention was taken to increasing our survey sample. We recognize that the relatively low number of respondents affects the generalizability of our study. Moreover, this survey was done in 2021, So these results are relatively affected by inflation taking hold in Morocco as well as around the world.

In summary, the overall results indicate that uncertainty in SC is an interesting area that requires further research.

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