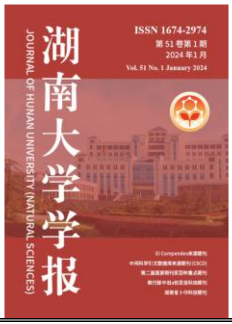

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# Exploring the Components of Uncertainty and Production Planning in Moroccan Aeronautical Industry: A Qualitative Study

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**Abstract:** In a volatile, uncertain, complex, and ambiguous (VUCA) environment, particularly following the COVID-19 pandemic since 2020, industrial companies, particularly those in the aeronautical sector, have experienced numerous disruptions in their supply chains. However, few studies have explored production planning under uncertainty in the aeronautical industry. Morocco has the potential to become a global leader in the aeronautical industry, but no study has examined the uncertainties and risks associated with its supply chain and their impact on production planning. To address this gap, we conducted a qualitative study that included semi-structured interviews and open-ended questions with supply chain practitioners from thirteen Moroccan aeronautical companies. This study aims to assess the uncertainties and risks affecting the aeronautical supply chain and the production planning methods employed. We examined factors and variables related to uncertainty/risk and production planning and explored their relationships. The original contribution of this study is to provide insights and support to companies regarding the uncertainties affecting the supply chain and production planning of Moroccan aeronautical companies. This study will aid supply chain players in the Moroccan aeronautical industry to focus on managing production planning under the most significant uncertainties and risks affecting their supply. As such, it can serve as a valuable decision-making tool.

**Keywords:** uncertainty, production planning, supply chain, Morocco.

# 探索摩洛哥航空業的不確定性和生產計劃的組成部分：定性研究

**摘要：**在不穩定、不確定、複雜和模糊的環境中，特別是自2020年以來的新冠肺炎新冠肺炎大流行之後，工業企業，特別是航空業的企業，其供應鏈經歷了多次中斷。然而，很少有研究探討航空業不確定性下的生產計劃。摩洛哥有潛力成為航空業的全球領導者，但沒有研究探討與其供應鏈相關的不確定性和風險及其對生產計畫的影響。為了解決這一差距，我們進行了一項定性研究，其中包括對來自13家摩洛哥航空公司的供應鏈從業人員進行半結構化訪談和開放式問題。本研究旨在評估影響航空供應鏈和所採用的生產計劃方法的不確定性和風險。我們研究了與不確定性/風險和生產計劃相關的因素和變量，並探討了它們之間的關係。這項研究的最初貢獻是為公司提供有關影響摩洛哥航空公司供應鏈和生產計劃的不確定性的見解和支持。這項研究將幫助摩洛哥航空業的供應鏈參與者在影響其供應的最重大的不確定性和風險下專注於管理生產計劃。因此，它可以作為一個有價值的決策工具。

**关键词：**不確定性、生產規劃、供應鏈、摩洛哥。

# 1. Introduction

In the 21st century, companies must be at the forefront of technology of product variety, flexibility, and performance, in particular, the OTD (On Time Delivery = customer service rate). It is time to ask how to reach the ideal performance to stay competitive in the market in the face of customer requirements regarding cost, quality, and time. However, in the current market instability, they need to integrate the demand uncertainty of into their planning methods to manage resources and maintain performance better.

The manufacturing environment, including the aeronautics industry, requires a planning system to balance customer satisfaction with efficient use of production resources while taking real-time corrective action when deviations from initial plans occur [1].

Production planning is essential in the management system and is a critical area of enterprise operation management. Its goal is to select the optimum solution for handling client orders while considering the organization's resources [2, 3]. However, organizations, particularly Moroccan aerospace companies struggle with the rise in environmental uncertainty. Scholars believe that dynamic skills, defined as "the ability of the firm to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments," are increasingly essential in dealing with uncertainty [4, 5]. The literature frequently raises the size and frequency of the supply chain performance issue strongly influenced by team coordination despite strong and uncertain customer demands [19].

This study explores the uncertainties in 13 Moroccan aerospace industries in detail by responding to two questions:

– Which uncertainties are most relevant to the supply chain in those firms?

– What are the impacts and challenges of uncertainty on production planning?

The following section presents the method used to perform this qualitative investigation. Then, we review the findings before moving on to conclusions and limitations of the study.

# 2. Research Methods

## 2.1. Research Model

The current study is qualitative research aimed to evaluate the variables that influence production planning and uncertainty and the interactions between those variables in Moroccan aerospace businesses.

According to [6], qualitative research seeks to uncover and test new hypotheses or ideas based on an exhaustive understanding of the significance of a given phenomenon. As a result, qualitative research strives to allow several environmental elements to naturally [6]. Because production planning and uncertainty depend on measurable and non-measurable variables, search strategies such as firsthand observation of occurrences and interviews with people concerned with this subject are required. According to [7], when the purpose of the study is to answer the "how" and "why" questions, the case study method is chosen. In this study, we selected 13 case studies in the industry.

## 2.2. Participants

This study is limited to 13 aeronautical industries in Morocco. Participants must be members of the supply chain team. The demographic data of the participants are shown in Table 1.

The 13 industries are large aerospace companies located in Morocco, as detailed in Table 2.

Table 1 Demographic data of the 13 participants (Developed by the authors)

| Position | Number | | Experience in the position |
|---|---|---|---|
| | Male | Female | |
| Supply chain manager | 3 | | 0-3 years - 5 persons |
| Procurement manager | 1 | | |
| Logistic specialist | | 2 | 3-5 years – 4 persons |
| Purchaser | | 3 | |
| Process engineer | | 1 | 5-10 years - 4 persons |
| Quality manager | | 2 | |
| Lean manufacturing engineer | | 1 | > 10 years - no |
| Total | 4 | 9 | |

## 2.3. Data Collection Tool

The literature review associated with empirical studies on production scheduling in an uncertain environment and the factors identified during company visits were used to prepare the questionnaire.

The questionnaire development framework is shown in Fig. 1.

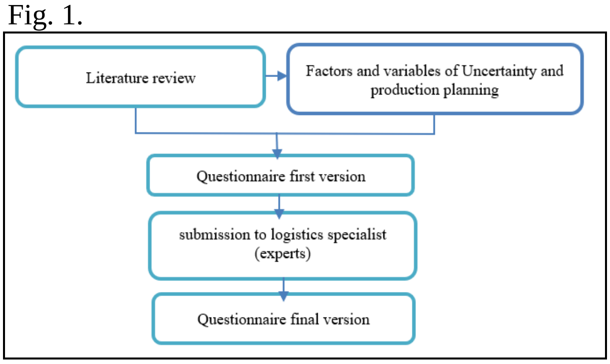


Fig. 1 Development framework of the questionnaire [20]

The final form of the questionnaire is divided into two sections. The first section of the questionnaire contains 30 semi-structured questions divided into subcategories relating to variables of uncertainty and risks that may be applicable in aerospace firms. The second part consists mainly of a listing of production planning tools, which are classified according to 5 taxonomies: exact models, analytical models, conceptual models, simulation models, and artificial intelligence. To collect data, we performed face-to-face interviews with participants, and exchanges via email and phone calls while evaluating the results.

The interviews consist of three stages:

1) We introduce the study's purpose and benefits, and then ask the respondent to describe the company, the activity, the workers, the town, and the certification.

2) The participant completes the first section of the questionnaire, which includes numerical and semi-structured questions.

3) The participant completes the second section of the questionnaire, which concerns production planning tools. This section delved deeply into the most significant risks and uncertainties affecting their supply chain, and their impact on production planning.

Qualitative research is required because it investigates variables that are not in the context of events. It discovers and explores new hypotheses or theories based on a deep understanding of the meaning of a specific phenomenon [8, 9].

The data gathered have been compiled and filled in for each company. To explain the correlation of challenges, we examined the relationship between factors and variables. We contacted respondents to check assumptions and interpretations due to the complexity of the production planning function. Finally, we compared the research findings with published results.

Table 2 Sectors and activities of the thirteen Moroccan aerospace companies studied (Developed by the authors)

| **Sector of company's activity** | **Responses** | |
|---|---|---|
| | **No.** | **%** |
| On-board control and cockpit electronics | 2 | 15 |
| Precision machining | 3 | 23 |
| Wiring/electrical systems | 2 | 15 |
| Heat treatment | 1 | 8 |
| Aeronautic structure | 4 | 31 |
| Manufacture and repair of the engine parts | 1 | 8 |
| Total | 13 | 100 |

# 3. Results and Discussion

## 3.1. Subcategories and Degree of Importance

Among the sub-sections of the questionnaire, the uncertainties that may apply to the supply chain and impact production planning of the 13 companies (A≥ M) studied were discovered and deduced according to the qualitative analysis, as shown in Table 3. We used the Likert scale as an essential measurement tool in the qualitative approach.

Table 3 Degree of application of uncertainties in the supply chain of thirteen aeronautical companies (Developed by the authors)

| **Trands and authors** | **The uncertainty means:** | **The risk means:** |
|---|---|---|
| The entrepreneur | Objective attitude | Subjective attitude |
| Dual trend | Ignorance of the future | Consequences of decision-makers' actions |
| Hey J. | Lack of certainty | Uncontrolled certainty |
| Keynes J.M. | Unquantifiable | Quantifiable |
| Knight F.H. | No probabilistic determination | Certainly a probability |
| Neo-classical | Vague non compensatory risk | Certain equivalent uncertainty |
| Neo-Keynesien | Unpredictable damage | Predictable loss |
| The skeptics | Indifference | Reticence |
| Subjectivists | Independently from the decision maker | Mainly belonging to decision-makers |
| Roumasset | State of mind | Customize a given situation |

Likert described a simple and effective method to construct an attitude scale based on the fact that groups of related questions measure a subject's attitude about an issue addressed by these questions [13].

Based on the literature, we can classify these uncertainties into 2 main families: internal and external.

Pareto's Law, or the 80/20 rule, reminds us that most things in life are not evenly distributed and that 80% of the effects are caused by 20% of the causes [10]. In this context, we used this law to identify the most significant uncertainties that can be applied to our supply chain and therefore impact our production planning.

Table 4 illustrates the classification of the most significant uncertainties applicable to our aeronautical supply chain.

Table 4 Significant uncertainties applied within the Moroccan aeronautical supply chain according to Pareto's law (Developed by the authors)

| **Type of uncertainty** | **Uncertainty** | **%** |
|---|---|---|
| Internal uncertainty | Urgent customer orders | 85 |
| Internal uncertainty | Raw material availability | 82 |
| External uncertainty | Delayed deliveries from suppliers | 82 |
| External uncertainty | Supplier non-conformities | 82 |

We deduce from this analysis that the most significant uncertainties applicable to the Moroccan aeronautical supply chain are as follows:

– Urgent customer orders;
– Raw material availability;
– Delayed deliveries from suppliers;
– Supplier non-conformities.

## 3.2. Relationship between Uncertainty and Risk and Degree of Importance

Risk and uncertainty attitudes are crucial to manufacturing activity, and since there is a strong link between them, the goal of this paragraph is to highlight the main distinctions between risk phenomena and uncertainty. According to ISO 31000:2018, risk is the effect of uncertainty on objectives. Table 5 shows a summary of the difference between risk and uncertainty because there is a great similarity between them [11, 12].

Table 5 Difference between risk and uncertainty [11]

| Uncertainty | Moroccan Aerospace Companies | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M |
| a- Customer Forecast | 4 | 3 | 3 | 5 | 4 | 4 | 4 | 5 | 3 | 3 | 4 | 3 | 3 |
| b- Demand Plan, S&OP | 5 | 3 | 3 | 2 | 3 | 3 | 4 | 5 | 4 | 3 | 3 | 4 | 3 |
| c- Customer order changeover | 5 | 3 | 5 | 5 | 4 | 4 | 3 | 4 | 1 | 3 | 4 | 2 | 3 |
| d- Urgent customer orders | 5 | 3 | 5 | 5 | 4 | 5 | 5 | 3 | 5 | 4 | 5 | 4 | 2 |
| e- Customer order cancellation | 5 | 3 | 5 | 5 | 5 | 4 | 3 | 5 | 1 | 2 | 2 | 1 | 1 |
| f- Amplification of customer demand | 5 | 3 | 5 | 4 | 4 | 3 | 4 | 5 | 3 | 3 | 3 | 4 | 4 |
| g- Equipment availability | 4 | 3 | 3 | 1 | 5 | 3 | 5 | 4 | 3 | 3 | 1 | 3 | 3 |
| h- Raw material availability | 5 | 3 | 3 | 4 | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 3 |
| i- Raw material procurement lead time | 5 | 3 | 4 | 4 | 5 | 4 | 4 | 5 | 2 | 2 | 4 | 4 | 3 |
| j- Raw material cost | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 0 | 4 | 2 | 3 | 3 |
| k-Raw material supply capacity | 5 | 3 | 2 | 1 | 5 | 4 | 3 | 5 | 0 | 3 | 1 | 2 | 3 |
| l- Alternative sourcing | 4 | 3 | 3 | 2 | 5 | 3 | 4 | 0 | 1 | 3 | 2 | 1 | 3 |
| m- Availability of machines | 5 | 3 | 3 | 0 | 5 | 4 | 5 | 4 | 4 | 3 | 0 | 2 | 4 |
| n- Processing time for internal operations | 5 | 3 | 4 | 1 | 5 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 4 |
| o- Workforce issues | 5 | 3 | 4 | 0 | 5 | 4 | 4 | 2 | 2 | 1 | 2 | 2 | 2 |
| p- Information technology problems | 3 | 3 | 3 | 0 | 4 | 3 | 4 | 3 | 1 | 3 | 1 | 2 | 1 |
| q- Instability of working capital availability | 3 | 3 | 2 | 1 | 5 | 4 | 3 | 3 | 2 | 2 | 0 | 2 | 3 |
| a- Delayed deliveries from suppliers | 5 | 3 | 5 | 4 | 5 | 4 | 4 | 5 | 5 | 3 | 4 | 4 | 2 |
| b- Supplier non-conformities | 5 | 3 | 5 | 3 | 5 | 5 | 3 | 5 | 5 | 3 | 3 | 4 | 4 |
| c- Natural disasters | 5 | 3 | 2 | 0 | 5 | 4 | 4 | 4 | 2 | 3 | 1 | 2 | 1 |
| d-competitiveness | 3 | 3 | 4 | 1 | 5 | 3 | 2 | 3 | 0 | 3 | 0 | 2 | 2 |
| e- Environment | 3 | 3 | 2 | 1 | 4 | 3 | 2 | 3 | 0 | 2 | 1 | 2 | 1 |
| f- Inflation | 3 | 3 | 2 | 0 | 4 | 4 | 2 | 2 | 0 | 3 | 2 | 3 | 2 |

After an overview of the difference between uncertainty and risk, we have extracted from the literature the top 10 risks that can be applied and impact the aeronautical supply chain, as shown in Table 6 [11, 12]. Table 6 (average determined using SPSS software) ranks the TOP 10 risks that could apply to the Moroccan aeronautics supply chain in ascending order [13].

Table 6 Average, in ascending order, of the TOP 10 risks impacting the Moroccan aeronautics supply chain (SPSS) – descriptive statistics (Developed by the authors)

| TOP 10 risks of the Moroccan aeronautics supply chain | | N | Min | Max | Average |
|---|---|---|---|---|---|
| 1 | Volatile geopolitical and economic environment | 13 | 2 | 5 | 3. 62 |
| 2 | Bad supply chain management | 13 | 1 | 5 | 3 |
| 3 | Competition in national and international markets | 13 | 0 | 5 | 2. 85 |
| 4 | Skill retention | 13 | 0 | 4 | 2. 85 |
| 5 | Inability to reproduce and grow (attract potential new customers) | 13 | 1 | 5 | 2. 77 |
| 6 | Changes in regulations and restrictions | 13 | 1 | 4 | 2. 69 |
| 7 | Incapacity and inability to innovate | 13 | 1 | 5 | 2. 69 |
| 8 | Failure to achieve objectives and benefits of mergers, acquisitions, and partnerships | 13 | 0 | 5 | 2. 62 |
| 9 | Exposure to cyberattacks | 13 | 0 | 5 | 2. 62 |
| 10 | Foreign exchange fluctuations | 13 | 0 | 4 | 2. 23 |

From Table 6, we can deduce that the four risks with an average higher than 2.85 applicable to the Moroccan aeronautical supply chain are as follows:

– Volatile geopolitical and economic environment;

– Bad supply chain management;

– Competition in the national and international markets;

– Skills retention.

According to paragraphs 3.1 and 3.2, we find that in practice, the most significant uncertainties that can apply and impact the Moroccan aeronautical supply chain have no connection with the TOP 10 risks raised in the literature that apply to the aeronautical supply chain.

### 3.3. Production Planning

A relatively comprehensive review of the state of the art in production planning in an uncertain environment is presented in [21]. The author identifies the four main modeling approaches designed to cope with different forms of uncertainty: conceptual models, analytical models, artificial intelligence models, and simulation models.

Through the literature, the authors could classify production planning methods/tools into four approaches, as listed below [14, 17, 18].

– Classical techniques, such as manufacturing resource planning, just in time, and theory of constraints.

– Optimization methods: Among the approaches to resolution by optimization, three groups were identified such as exact methods, metaheuristics, and heuristics. The first group combines the following techniques: constraint programming linear programming, and the separation algorithm and evaluation (branch and bound). Metaheuristics is a stochastic approach that aims to find an optimal solution through iterative processes. Strongly inspired by natural systems, these algorithms take physical phenomena (algorithm of simulated annealing) as the basis, genetics (genetic algorithm), and behavior animals (ant colony algorithm). This inspiration in natural phenomena is the main difference from heuristics, which seeks to find feasible solutions, but not necessarily optimal or exact [15-18].

– Simulation models: Simulation is a technique for evaluating the performance of a system based on the development of different scenarios based on a virtual model of the system. The process of simulation is based on the generation of the history of a system and then analyzing that history to anticipate the prediction of the outcome and improve the working of real systems. Some types of simulation were identified in the sample research: discrete-event simulation, discrete-event systems, and multi-agent and digital twin [15-18].

– Artificial intelligence (AI): With the force of the present data innovation, ever quicker Internet associations, and AI calculations, the store network can depend on man-made brainpower to improve its cycles such as planning creation. Simulated intelligence is a part of software engineering that aims to program machines to tackle issues, learn, plan, control, and move objects. It targets creating yield information dependent on the recognizable proof of patterns by the arrangement of the information and mathematical relapses. In this way, the AI can expect, as per the numerous boundaries (supply of unrefined components, creation speed, and season), what it will particularly propose as indicated by these boundaries, an ideal activity plan for the creation site and its different lines [17].

Through semi-directive interviews with the 13 companies contacted, Table 7 shows the degree of importance of the production planning tools identified in our study.

Table 7 Illustration of the production planning tools identified in our study – descriptive statistics (Developed by the authors)

| Tools | N | Min | Max | Average | SD | Variance |
|---|---|---|---|---|---|---|
| Enterprise resource planning | 13 | 3 | 5 | 4.46 | 0.776 | 0.603 |
| Master production plan | 13 | 2 | 5 | 4.38 | 0.961 | 0.923 |
| Manufacturing resource planning | 13 | 2 | 5 | 4.15 | 0.987 | 0.974 |
| Commercial industrial plan | 13 | 0 | 5 | 4.08 | 1.441 | 2.077 |
| Material requirement planning | 13 | 0 | 5 | 3.85 | 1.463 | 2.141 |
| Excel file | 13 | 0 | 5 | 3.69 | 1.702 | 2.897 |
| Just in time | 13 | 0 | 4 | 2.85 | 1.281 | 1.641 |
| Demand driven material requirement planning | 13 | 0 | 5 | 2.54 | 1.561 | 2.436 |
| Aggregate production planning | 13 | 0 | 4 | 2.23 | 1.363 | 1.859 |
| Advanced planning systems | 13 | 0 | 5 | 2.23 | 1.641 | 2.692 |
| Dynamic programming | 13 | 0 | 4 | 2.15 | 1.405 | 1.974 |
| Linear programming | 13 | 0 | 4 | 2.08 | 1.605 | 2.577 |
| Theory of constraints | 13 | 0 | 4 | 2 | 1.291 | 1.667 |
| Multi-objective programming | 13 | 0 | 4 | 1.92 | 1.553 | 2.41 |
| Mixed integer programming | 13 | 0 | 4 | 1.85 | 1.405 | 1.974 |
| Fuzzy set theory | 13 | 0 | 4 | 1.69 | 1.494 | 2.231 |
| Reinforcement learning | 13 | 0 | 4 | 1.69 | 1.653 | 2.731 |
| Multi-agent systems | 13 | 0 | 4 | 1.54 | 1.45 | 2.103 |
| Fuzzy logic | 13 | 0 | 4 | 1.46 | 1.391 | 1.936 |
| Quantile regression | 13 | 0 | 3 | 1.38 | 1.261 | 1.59 |
| Genetic algorithms | 13 | 0 | 3 | 1.31 | 1.251 | 1.564 |
| Ant colony theory | 13 | 0 | 4 | 1.31 | 1.377 | 1.897 |
| Integrated planning | 13 | 0 | 3 | 1.23 | 1.301 | 1.692 |
| Monte Carlo simulation techniques | 13 | 0 | 3 | 1.08 | 1.188 | 1.41 |
| AI | 13 | 0 | 3 | 1.08 | 1.188 | 1.41 |

We note that the production planning tools most widely used in the aeronautical sector in Morocco are resource planning, master production plan, manufacturing resource planning, commercial industrial plan, Excel file, and just in time.

## 4. Conclusion

Through this qualitative study, we discovered that in large aeronautical companies, where the supply chain is under the impact of various uncertainties, the most significant uncertainties (up to 80%) include urgent customer orders, raw material availability, delayed deliveries from suppliers, and supplier non-conformities, which mainly represent internal uncertainties. Researchers in the literature have focused more on uncertainties linked to customer demand management (internal uncertainty).

Because we have identified a strong correlation between uncertainties and risks, we are sure that the outcomes of this work concluded through a field study that the risks that are deemed essential have no relationship with the uncertainties identified through a theoretical study of 13 aeronautical companies in Morocco. In this case, we have a gap between theory (literature) and the field (through the questionnaire). As a result, in future articles, we will measure the relationship between uncertainties and risks applied to Moroccan aeronautical companies by increasing the response sample populations.

However, we established the average number of production planning tools suitable for the aviation supply chain reported in the literature throughout our semi-structured interviews. This will assist top management in viewing production planning approaches from a strategic perspective and contribute to establishing mid- and long-term goals.

This qualitative study focused on defining the potential uncertainties applicable to the aeronautical supply chain of large companies, where production planning is considered an important function. Because these companies are in Casablanca, Morocco's industrial metropolis, we cannot apply the findings of this study to small- and medium-sized businesses in smaller towns. Before generalizing the results of this study, we propose to complement it with exploratory and descriptive case studies in small- and medium-sized companies [7] to have a basis for decision-making.

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