Article

A Mixed-Method Approach to Determine the Successful Factors Affecting the Criticality Level of Intermediate and Final Products on National Basis: A Case Study from Saudi Arabia

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Abstract: COVID-19, Brexit, war, and some other similar cases will leave/have left us with a lesson that has had an impact on the supply chains of almost all product types. Countries have now recognized that some products cannot be sustained in a situation of uncertainty. This research covers the gap in understanding and identifying the successful factors affecting the criticality level of supply required of intermediate and final products (IFP) at the national level. It investigates the relationship between two factors: the casual factor supply risk (independent factor); and the impacted (dependent factors) political, economic, sociocultural, and technological (PEST) factors in terms of identifying critical products using the principle of Resource Dependency Theory (RDT). A literature review was conducted, followed by a mixed-method approach. Semi-structured interviews with 23 Saudi experts were carried out initially; then, a questionnaire was shared with 152 Saudi experts in different sectors. The qualitative study identified 30 key measurement variables for both factors, in which 19 variables were confirmed using the factor analysis (FA) technique.

Keywords: sustainable supply chain; purchasing portfolio; public procurement; resource dependence theory; national strategic reserves; criticality

1. Introduction

During the past two years, many countries have faced the issue of a lack of one or more critical products. For example, the United Kingdom (UK) had a problem with the availability of some food and critical health products during the Brexit process [1,2]. During the Russian–Ukrainian war, most Arab countries had an issue with the supply of agricultural products [3]. Most of the world faced a problem when the biggest palm oil producer restricted the supply of palm oil [4]. Around 40% of infant formula supplies were out of stock in the United States of America (USA) [5]. Therefore, it is vital that supply risk be assessed at a national level [6]. Christopher and Peck (2004) defined uncertainty of supply as the potential or actual disturbances to the flow of product or information emanating from within the network upstream of the focal firm [7]. What is measured is the ability of the supplier to deliver the required product in the required quantity and by the required date, which in turn represents the degree to which the products present risk or are classed as critical [8,9]. On a national basis, shortages in a critical product might become a political issue. In Egypt, such shortages increased food prices, which contributed to a revolution known as Arab Spring in 2011 [10]. The need to hold a strategic reserve to maintain a robust national economy has been demonstrated in many countries, a notable example being the petroleum reserve in the USA, China, and India [6,11,12]. The attitude of society can also be impacted by shortages due to a lack of income, food, and services [13], causing sociocultural issues.

In the USA, most of the population lives within 1 h of a CHEMPACK location; 1960 of these are positioned at selected hospitals and fire stations throughout the USA [14]. The

main objective of the CHEMPACK program is to maintain a stockpile of pharmaceutical agents, vaccines, medical supplies, and equipment to augment state and local resources during a large-scale disaster or bioterrorism event. Upon request, the program will deliver materials anywhere in the USA [15]. Finally, most criticality studies have focused on how to secure the future of technology and national innovation by identifying the critical raw materials and ensuring the stability of their supply. The literature review of criticality studies and strategic reserves revealed the main themes of politics, the economy, sociocultural values, and technology. These themes were confirmed by the qualitative research conducted in this study, as can be seen in the results section.

To measure the stability of a nation, firms tend to use the PEST analysis technique. It is used as a national macro-environment measurement tool to understand the opportunities or risks in the environment in which the PEST analysis is being conducted [16–18], specifically the political, economic, social, and technological factors. They are considered key elements in gaining a good understanding of the local market and ensuring its stability and sustainability [19]. In this study, the PEST factors are considered dependent factors when exposed to supply risks, the independent factor that threatens the nation's stability. The political (P) factor describes changes in the role of government and how this could be impacted by the changes that might occur due to a shortage of significant products [17,20–22]. The economic (E) factor describes those macroeconomic aspects that can be used to make an assessment of the state of the economy and practical ways to improve its performance in order to ensure economic growth, price stability, and full employment of the labor force, and to keep interest rates, inflation, and production stable [17,20–22]. The sociocultural (S) factor addresses changes in the social structure, such as age, gender, beliefs, values, health, education, green practices, consumer behaviors, and demographics [17,20–23]. The technological (T) factor refers to innovation, the worldwide web, and robotics and how their absence might affect the future of technology, production, and innovation [17,20–22].

Therefore, it is essential to determine the national needs for IFP. It is the first step in the purchasing process [24]. Once the administrative government identifies what exactly is needed, the possibility of shortage occurrence decreases by using one of the possible government tools known as the national strategic reserve [25]. The national strategic reserve for a given country means that the country establishes a governmental department to manage the storage of some products that they have identified as critical such as basic foods, water, major medicines, etc. This is generally in accordance with specific government policies to meet the needs of the country's population. The main goal of the strategic reserve is to guarantee the flow and availability of these essential products for people of a certain country over a given period of time. In the absence of critical products, the governmental management of the country may face an economic crisis that could be followed by political unrest and instability. As such, the management of this reserve of critical products can play a significant role during an emergency [26,27].

In conclusion, the criticality of IFP on national level has not been adequately addressed in the field of purchasing management—Strategic Sourcing—in particular, which has been addressed in this study. Therefore, this research study is aimed to fill a gap in the existing literature, in which, to the best of authors' knowledge, no study to date has been designed to "Identify the dimensions that help measure the importance/impact of the IFP at the national level". It seeks to answer the following question: "What are the most significant variables that help determine the measure of importance of critical IFP at the national level in Saudi Arabia?". This study contributes to the theoretical knowledge by identifying the measurement variables that determine the importance level/measurements of the critical IFP. To the best of our knowledge, previous studies on national scope focused on identifying the criticality level of raw materials, and the remaining were focused at an organizational level.

Theoretical Framework

This research is based on RDT principles. This theory was proposed by Pefeffer and Salancik [28]. They defined it as the product or item that has an impact on a given input or output to the organization, which is a result of the extent to which it is controlled by the external environment [28]. The theory discusses the possibilities of surviving by managing the critical products that could be affected by the surrounding environment. If the supplier of the required objects is available and this availability can be assured, then there is no risk as long as the market condition is stable. However, if the external environment (the supplier) of the required object is not available or dependable, the risk at this stage is different.

The adaptation of this approach arose from one of the objectives of this research, that of determining the product that needs to be reserved strategically at the national level. In order to assess the product, two main dimensions were identified by RDT. The independent factors are represented by the external environment, and the dependent factors are the internal factors. The independent factor in this study is the supply risk factor, whereas the dependent factors are the PEST factors. Based on the RDT, the conceptual framework of this research was developed, as shown in Figure 1.
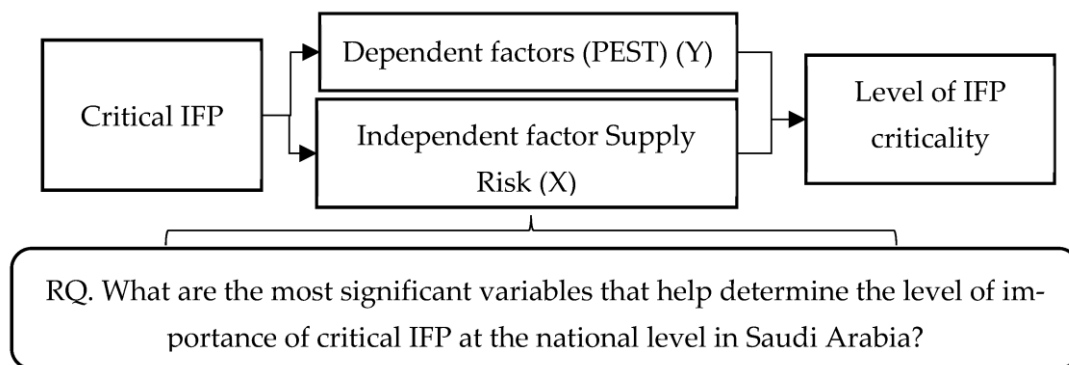

Figure 1. Theoretical framework.

2. Literature Review

Factors affecting the criticality level on a national basis were found in what are called "criticality studies", which tended to focus on critical raw materials such as lithium, copper, zinc, etc. The word criticality describes the probability of an event and the extent of severity of harm that might result during the absence of the product [29]. Achzet and Helbig categorized criticality studies into four categories: national-level studies, future technology studies, entrepreneurial perspective studies, and selected target studies [30] (p. 435). On the other hand, there are a number of studies that focus on identifying the criticality level of items, products, suppliers, etc., on an organizational level, which is a different scope to that of this study. See, for example, studies related to the Kraljic Purchasing Portfolio [31].

Criticality Studies

The scarcity of some of the critical natural raw materials (rare earth elements) was a significant reason to motivate governments and scholars to identify and hold a strategic reserve for these materials based on their national needs, known as criticality studies. There is a group of natural raw materials that are particularly critical because of their important role in the national strategy and economy; at the same time, they are extremely exposed to a high level of supply risk [32,33]. They are an integral part of the strength of the national industries because they are components in a broad range of commodities that are used on a daily basis and required for modern life and technologies. Examples are cobalt, phosphate, lithium, etc. [34].

The shortage of some natural raw materials has been a concern since the 1920s. The government of the USA listed the rarest elements on earth that could affect the defense of the

USA military at that time [35]. Thirty years later, in the 1950s, the first government action—holding a strategic reserve for these elements—was enforced to ensure defense stability. Sixty years later, the USA National Research Council introduced the first matrix, known as the criticality matrix, to identify the critical raw materials from a group of minerals [35]. Following that, a number of well-cited assessment tools were developed, such as the Oko-Institute and Japanese method NEDO, the European Union (EU) assessment, the Yale Criticality Assessment, General Electric, the M5 Model, and the SCARCE method [36–39].

Three common factors were considered to measure the criticality of raw material: the supply risk factor, the environmental impact factor, and the vulnerability to supply, national strategy, and economy [40]. With reference to the research question, "What are the most significant variables that help to determine the level of importance of the critical IFP in Saudi Arabia?", Table 1 summarizes the measurement variables that are most commonly being used to measure the criticality of natural raw materials on a national basis. Most of these variables were outlined by Helbig et al. in their articles [30,40], "An overview on how to evaluate raw materials supply risk, and how to evaluate raw material vulnerability". Additional variables were added to the table considering the latest published articles related to critical raw materials.

The use of these variables is varied [30,36,40]. Some previous studies, for instance, used selected variables (from one to four variables) to measure the vulnerability factor and the supply risk factor, while other criticality studies used different variables to measure the same factors. In addition, some of these variables were used in studies as independent variables, while in other studies, they were used as dependent variables to measure a similar factor [36]. The third factor being considered is the environmental factor: how the extraction process affects the environment and the pollution caused by the use of these raw materials.

The types of data and methodology used to measure critical raw materials are also varied. Most previous studies relied on secondary data such as accessible government data or available index data [33,36,40]. Where these are unavailable, expert judgment is considered, and it is used in some studies to quantify the variables on a four- or five-point scale [30,33,40,41]. Different arithmetic formulas have been applied to analyze these data and determine the criticality of the raw materials on a national basis, for example, the SCARCE model [42] or NEDO in Japan [43].

Table 1. Critical Raw materials variables.

	Measurement Variables	Reference
	Dimension 1: Vulnerability to Supply restriction and Strategy	
1	National economic	[38,41,42,44]
2	Value of products affected	[33,40]
3	Human development	[38,42,44,45]
4	Future demand	[30,33,40,43,46]
5	Performance substitute	[41,47]
6	Strategic importance (importance of materials)	[38]
7	Spread of utilization	[42]
8	Target group demand share	[40]
9	Consumption volume	[40]
10	Utilization in future technology	[48]
11	By-product dependency	[30,33,44]
12	Risk of strategic use	[30]

Table 1. *Cont.*

	Measurement Variables	Reference
	Dimension 2: Supply risk	
13	Change in imports	[40]
14	Import dependence	[33,40–42]
15	Mine production change	[40,43]
16	Ability to innovate	[40,42,44]
17	Exploration degree	[30]
18	Company concentration	[40]
19	Production costs in extraction	[30]
20	Available substitute	[33,40–44,46]
21	Water scarcity (natural resource)	[42]
22	Concentration of reserve	[30,43,46]
23	Market balance	[30]
24	Country risk (political and economic risk)	[30,33,38,41,44–46,49]
25	Mine/refinery capacity	[30]
26	Depletion time	[30,41–45]
27	Future market capacity	[30]
28	Supply concentration in mining	[33,38,41,42,44,45]
29	Investment in mining	[30]
30	Recycling/recycling potential	[30,33,40,43,46]
31	Climate change vulnerability	[30]
32	Price sensitivity	[33,40,43]
33	Temporary scarcity	[30]
34	Export restrictions	[33,50]
35	Abundance in earth's crust	[30]
36	Policy intervention	[38,41,44,45]
37	Trade agreement	[42,46,48]
38	Global production (global concentration)	[42,48,49]
	Dimension 3: Environment	
39	Extraction damage	[41,42,44]
40	Usage damage	[33,38,41,42,44,46]

In this study, the types of products being tested are different from natural raw materials. Some of these variables might be applicable to measure the criticality level of IFP, but others are not. Therefore, there was a need to conduct qualitative research to explore, validate and determine the applicable measurement variables, which are presented in the result section. Indeed, one of the measurement variables being tested to measure the supply risk factor of critical IFP is the availability of the required raw materials to produce the product being tested.

Dissipation has not been considered in the criticality studies for raw materials. This might be due to the difficulties of quantifying this variable [36], or it might be due to the type of products being tested. However, the qualitative result of this research shows that it is vital to measure consumer behavior concerning critical IFP and how they are purchased, used, and disposed of by the final users [51]. The availability of qualified personnel is an important variable when measuring the supply risk factor, particularly for critical IFP. One of the participant experts of this study mentioned the consequences of not having people who can produce insulin in Saudi Arabia and how that might affect national security and threaten supply flow. However, 60 percent of the health sector has undergone Saudization, including engineering and technical professions related to medical appliances, sales, and medical appliances and supplies [52]. The availability of qualified personnel variable was intensively used on an organizational level to measure the performance of external suppliers. However, it was not considered internally on a national basis as a supply risk variable to measure the criticality of the product.

On the other hand, not all of the dependent variables that measure the PEST factors were considered, such as the criticality of the product to survive, societal attitude, and return on investment, which is different from the availability of investors that is used to measure the independent supply risk factor. The use of price, government stability, and expenses as dependent variables is different from using them as independent variables to measure the supply risk factor. To measure the critical IFP on a national basis, these variables need to be considered as dependent factor measurements. The following section discusses the methodology of this exploratory research and how the research question was tackled.

3. Research Methodology

There are times when qualitative research is the most suitable method to apply, for example, when exploring a problem, honoring the voices of participants, or conveying multiple participants' perspectives. On the other hand, the quantitative method is suitable for understanding the relationships between variables or comparing different groups [53]. In other studies, mixed methods could be the best way of addressing the research problem. In mixed methods, the researcher combines elements of qualitative and quantitative methods, such as the use of qualitative and quantitative viewpoints, data collection, analysis, and reasoning techniques. A mixed-method study is used for the broad purposes of width and depth of understanding and corroboration [54]. Regarding the selected research methods of this study, mixed methods were adopted as being best suited to answer the research question.

3.1. Qualitative Research

When studying a research problem that needs an in-depth understanding of its causal factors and its consequences, qualitative methods are recommended [53,55]. Due to the limited number of studies published on the topic of identifying the criticality level of IFP, particularly in the field of supply chain management, a qualitative method is an ideal methodology to apply for exploratory research. A Delphi technique was employed for this qualitative research; this is an interaction technique between investigators and a group of experts, with the aim of obtaining the experts' opinions and judgments on a specified topic [56]. It is used as an exploratory technique and involves interviewing experts in the field individually to explore a full range of opinions [57].

To ensure the creditability of the qualitative output, it is crucial to prepare for and design the interview. This qualitative research followed the framework of interview protocol refinement presented by Castillo-Montoya (2016), which consists of four phases [58]. The first phase is ensuring that the interview questions align with the research questions, as there is a difference between the research and interview questions. The second phase involved constructing an Inquiry-Based Conversation. At this phase, the researcher develops an interview protocol, which is considered an instrument of inquiry. The third phase is receiving feedback on the interview protocol, which enhances the reliability and trustworthiness of the qualitative research instrument. In the final phase, the researcher simulated the actual interview in as real conditions as possible by piloting the interview protocol.

3.2. Data Collection

To collect the required data for this exploratory research, two rounds of interviews were conducted, as mentioned earlier, using the Delphi technique. The first round was called brainstorming and focusing in preparation for the second round. The brainstorming aimed to identify the most applicable measurements for measuring the criticality level of IFP in Saudi Arabia.

The brainstorming consisted of three phases. Phase one was an introduction phase where the researcher explained the aim of the research and the purpose of conducting the interview and asked the participant to sign the consent form. A transition question followed, linking the introductory questions with the key question of the second phase.

Then, the main interview discussion, where the investigator presented the model without the variables and started the conversation by using the key questions, prompting the interviewees to express their own thoughts and ideas. Finally, the outro phase (closing questions), where the interviewees had an opportunity to discuss all the relevant points related to the model. At this phase, the interviewees are invited for the second round of interviews. The interviews were recorded using an appropriate recording device after the consent form had been signed. Figure 2 and Table 2 illustrate the interview protocol.
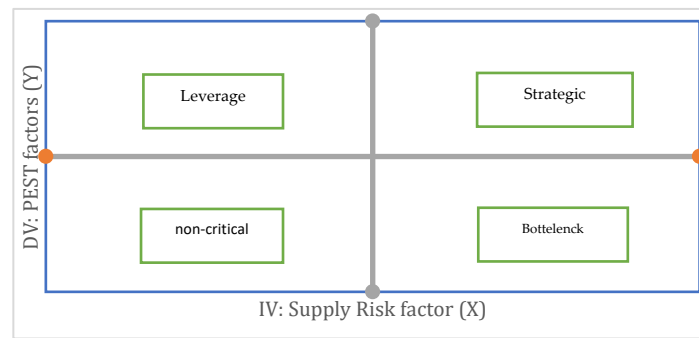

Figure 2. Proposed model (National Classification Model (NCM) for Critical IFP).

Table 2. Interview protocol.

Introduction	Main Questions	Outro
Illustrated the aim of the study, the purpose of conducting the interview, and the reason for nominating the interviewee. If they agreed to participate in the study, they were asked to read and sign the consent form before starting the interview.	Researcher presented the proposed model (Figure 2) to the participants and asked them to name and place a product into the matrix; then, the following questions were used for discussion: - How can we move this product from the strategic, bottleneck quadrants to the non-critical quadrant? - On the national level, how will (a) politics, (b) economics, (c) sociocultural, and d) technology be impacted if there is a supply interruption or shortage of stock for one of these major products: grain, insulin, oxygen, petroleum, semiconductors, phosphate, COVID vaccine? in other words, what might occur if we run out of the product? - What (is/are) the factor(s) that limit or prevent the availability of this type of product in Saudi Arabia? - How can we ensure the continuity of supply flow without relying on external sourcing (foreign suppliers)? - From your experience, have you had any challenges or obstacles with either purchasing products from or supplying products to the local market? - How satisfied are you with consumer behavior toward the strategic products in terms of obtaining the product, its usage, and its disposal? - What do we need to do to maintain stocks of these types of products?	In this phase, the participants were asked: - If they had any comments related to the model. - They were thanked for their participation. - They were invited to the focusing round, which discussed only the extracted variables.

A total of 23 experts were involved in the brainstorming round. They all had theoretical and practical knowledge about the concept of national strategic reserves, and they dealt with at least one of the critical products, such as grain, oil, medicines, metals, or semiconductors, in Saudi Arabia. They had to be a professional in the field with more

than 5 years' experience. Semi-structured interviews were conducted individually with 12 experts in petroleum economics, water, agriculture economics, health economics, pharmacoeconomics, minerals, politics, and purchasing, Table A1 summarizes the participants' backgrounds (see Appendix A). The interviews lasted between 1:00 and 1:30 h at the participants' workplace. As in-person interviews were difficult to arrange, online interviews were conducted with the remaining 11 participants on Zoom, following Dublin City University's (DCU) guidelines [59]. The online interviews did not exceed 30 min. After the twenty-three interviews, the decision was taken to stop, as the saturation level had been reached, and no additional data were collected.

To gain an in-depth understanding of the research phenomena, the qualitative data were collected in Arabic as this was the participants' language for everyday communication in Saudi Arabia. It was also the first language of the main investigator. Using their daily language gave the participants the confidence to express, explain, and share their knowledge and experience, and this was reflected in the quality of the data collected. Indeed, it is a recommended strategy in cross data collection when one of the researchers or more speak the same language as the participants and conduct the interview themselves [60]. One advantage of this strategy is that there is no need to employ additional members or third parties as the researcher can work alone; however, if the participants' language is not the researcher's first language or if the participants speak different languages, it is advisable to use different strategies such as a community researcher, professional interpreter/translator, or researcher and interpreter in tandem [60].

3.3. Data Analysis

The brainstorming data were analyzed by employing the thematic analysis technique. It consists of six steps: familiarization with data, generation of initial codes, search for themes, revision of themes definition, naming of themes, and writing the results—as proposed by Braun and Clarke [61].

3.4. Qualitative Credibility (Validity and Reliability)

Testing the reliability and validity of the qualitative findings relies on the researcher's ability and effort in terms of collecting and analyzing the data, as qualitative findings are based on non-statistical forms [53,62,63]. In qualitative research, validity means finding a method of assessing the accuracy of obtained information through qualitative data collection in terms of the date being described as credible, transferable, dependable, and confirmable [53]. It reflects the trustworthiness, rigor, and quality of the qualitative paradigm [63]. Creswell and Poth suggested nine validation strategies, and they encourage researchers to use at least two of them. These are prolonged engagement, triangulation, peer review, negative cases, clarifying researcher bias, member checking, collaborating with participants, generating (rich and thick) description, and other peers or external audits. Three of these strategies have been employed to validate the qualitative research in this study: the use of external audits, member checks, and triangulation [62].

Two peers (graduate students) were invited to evaluate and examine the codes extracted by the main researcher [53,64]. Both were Ph.D. students in the field of Business Management, and they were familiar with qualitative research. They were volunteers, and they had no connection to the study.

A members check validation is part of the Delphi technique. It was described by Yvonna and Egon as the most important validation technique in qualitative studies. The investigator returned to the key participants after the data had been analyzed in order to collect their opinions about the results (the measurement variables) and whether or not they agreed with the outcomes [65]. They were also asked if there were any additional matters that needed to be considered from their perspective [53]. The variables extracted from the literature review and interviews were presented to the focus group, which consisted of eight of the twenty-three participants in the brainstorming phase, as shown in Table A1. They were invited individually to evaluate the extracted variables. First, the variables were

emailed to them along with a brief statement about the research objectives. A week later, an individual meeting was conducted to discuss the variables in order to validate, rank and prioritize them in terms of how they measured the criticality of IFP at the national level in Saudi Arabia. This was conducted for both the supply risk and PEST factors. The results are presented in the result section.

Triangulation is the third validation strategy used to test the credibility of the qualitative result of this research. In triangulation, the researcher has a chance to apply different methods, sources, theories, and/or investigators to validate the qualitative result [62]. In this study, the process of triangulation was considered at multiple stages. As illustrated earlier, this research uses a mixed-method strategy to reach and validate its findings. It started with a qualitative research approach and ended with a quantitative finding.

3.5. Quantitative Research

The second phase of the exploratory sequential design in mixed-method research is the quantitative method. At this stage, the results of the qualitative research were translated into an instrument for quantitative research [53]. It was used to statistically confirm the study's variables by applying FA and to test the following hypotheses:

H0: *There is no relationship between supply risk and PEST factors in terms of determining the criticality level of IFP.*

H1: *There is relationship between supply risk and PEST factors in terms of determining the criticality level of IFP.*

The Likert questionnaire deployed in this study contained seven sections (see Table A2 in Appendix B). It aimed to measure the criticality level of products on a national basis within a 10–15-minute timeframe. A scale from 1 to 7 was applied where 1 represents the negative answers, such as 'extremely scarce' or 'disagree', graduating to 7, which represents the positive answers, such as 'extremely available' or 'agree' [66]. As with the qualitative questionnaire, a pilot study was conducted to test and assess the quantitative survey. Two rounds, consisting of a pilot study and external judgment for content validity, were used as a technique to test the feasibility of the instrument before moving toward the actual study [67]. In the pilot study, ten participants were involved in the first round of the study. It consisted of six Ph.D. qualified participants, two master's qualified participants, and two experts in the field of supply chain management. They were asked to consider the clarity of the questions and the procedure, and the process of answering the questions. After this, the researcher updated and modified the questionnaire based on the comments and feedback. Then, a second round of the pilot study was conducted, which involved seventeen participants, including the previous ten. They were not included in the study's sample. Again, they were asked similar questions, clarity of the questions, and the procedure and process of answering the questions. As the final step of assessing the instrument, two academic professors in the field of supply chain management in Saudi Arabia voluntarily evaluated the questionnaire. They were asked to consider the clarity of the questions and the procedure and process of answering the questions, and to what extent the instrument measures what it is meant to measure. After receiving their feedback, the instrument and researcher were ready to conduct the actual study.

3.6. Data Collection

In the qualitative research, an expert sampling technique was adopted to verify the model variables. However, in the quantitative research, the aim was to test the model by using the results from the qualitative research. To test the model's variables, experts in four different product types (rice, gasoline, semiconductors, and insulin) were invited. In this regard, it is very important to ensure that the participants have the appropriate knowledge and experience to answer the questionnaire. Therefore, the focus was on

professors in petroleum economics, agricultural economics, pharmacoeconomics, professors in technology, and traders and professionals at the executive level.

A total of 653 individual invitations were directed to the target participants either by email, text messages, social media, or by visiting them in their workplace. The questionnaire was distributed among faculty members in 13 Saudi universities: University of Jeddah (UJ), King Abdulaziz University (KAU), King Saud University (KSU), King Abdullah University of Science and Technology (KAUST), Umm Al-Qura University (UQU), King Fahad University of Petroleum and Minerals (KFUPM), King Faisal University (KFU), Qassim University (QU), Jouf University (JU), Jazan University (JaznU), Yanbu University College (RCYCI), and Jeddah, Riyadh, Jizan and Dammam College of Technology. In addition to individuals in Saudi universities, experts in the following public sectors were invited: King Fahad Medical City (KFMC), the Ministry of Environment, Water and Agriculture (MEWA), and the Saudi Food and Drug Authority (SFDA). Finally, executive-level traders in relevant products were invited to take part in the study. During the six-month period of data collection, 152 experts who met the criteria for this research completed the questionnaire. An online Google ® form was used as a platform to gather the required data by sharing a link with the target participants.

3.7. Data Analysis

To ensure the reliability of an instrument meets the quality standard, the reliability of the instrument was tested first. The score of Cronbach's alphas was (0.830 > 0.70) which is considered an acceptable, reliable score [68]. The test of the research hypothesis indicated a significant relationship (r = 0.297, *p*-value < 0.001) between the model's dimensions of supply risk and the PEST factors in terms of identifying the criticality level of IFP nationally. It means that the null hypothesis is rejected, and the alternative hypothesis is accepted [69]. Due to the significant relationships between the study's factors, further statistical analysis was considered.

To determine the model's variables, the FA technique was used. It is a statistical technique used to validate the internal structure of an instrument and determine the potential variables that should be measured or excluded [70]. It was considered an important step during the development and validation of the instrument as it determines the optimal number of factors prior to using them in other analysis techniques, such as multiple regression and multivariate analysis [71]. To assess the possibility of using factor analysis: the Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity were chosen as test methods. The KMO result (0.698) indicates that the data are suitable for FA [71]. On the other hand, Bartlett's Test of Sphericity tests the strength of the relationships between variables. It is used to test the null hypothesis, which is supposed to be close to zero—as long as the result does not exceed the value of 0.05. As of this research, the significant value (0.001) is close enough to zero to confirm the suitability of the data for FA [71].

4. Results and Discussion

4.1. Qualitative Result

One of the important elements of this research is the study's scope, which is the assessment of risk of supply at a national level. It seeks to identify the most applicable measurement variables as there is a difference between national and organizational levels in terms of interest and approach to assessing the criticality of products. As the study reveals, there is a relationship between the concept of the criticality level of products on national level and the five study factors (themes): politics, economics, sociocultural, technology, and supply risk. Each of these themes consists of a number of variables (codes) that were translated into an instrument for the quantitative part of this research. In presenting the research findings, it starts with the independent factor, the supply risk, then ends with the impacted dependent factors, PEST.

4.1.1. Supply Risk Factor

The causal factor (independent factor), supply risk, comprises a total of 20 variables under three sub-themes: availability, capability, and supplier properties, as summarized in Figure 3.
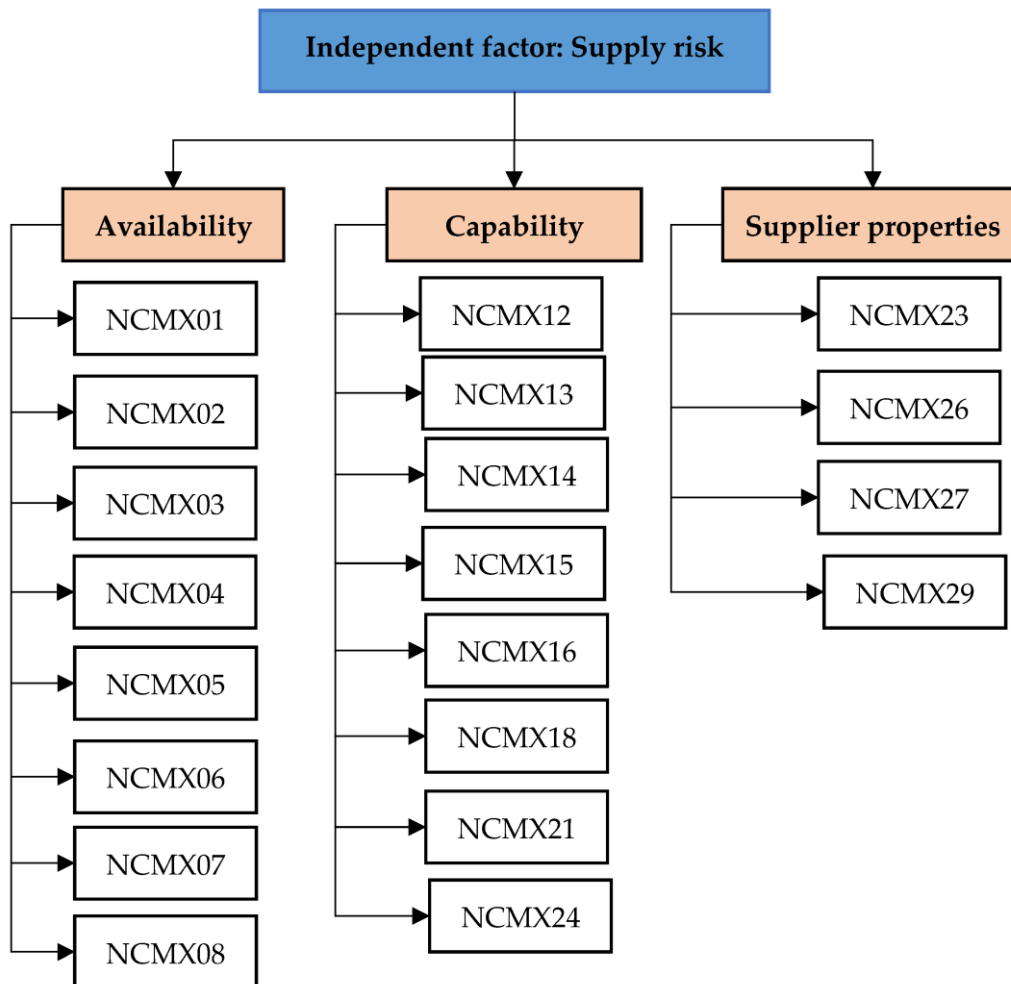
Figure 3. Qualitative result (Supply Risk).

Sub-Theme (1): Availability

1. NCMX01: The availability of required raw materials and natural resources:

In order to produce any type of IFP, it is important that the required raw materials and natural resources are available. This determines whether or not the product can be produced locally. One of the challenges to insulin manufacturing in Saudi Arabia is the availability of the required raw materials, " . . . *although we just started localising the insulin industry here in Riyadh, still one of the obstacles we have here is the availability of raw materials, it depends heavily on raw materials, which are totally supplied from outside the kingdom . . . it's a challenge, a big challenge*" (AA02). To farm locally in Saudi Arabia, the availability of the most important neutral element, water, is a big challenge. Most of the participants mentioned that. For example, MQ04 said, "*here in Saudi Arabia, water is an extremely strategic product . . . we don't have any natural sources unlike Ireland, if you dig less than one metre you might find water, whereas in Saudi Arabia you are talking about more than three hundred meters . . . so in your model, water in Saudi Arabia definitely comes here (participant pointed at strategic quadrant), while in Ireland if they have a shortage that means they have a problem with supplying the water, which is here (participant pointed at bottleneck quadrant)*". On the other hand, SS06 talked about cement and how the availability of the required raw materials makes it easy and profitable

to produce over there: "*take for example cement. In my opinion, it is a highly demanded product, profitable for investors, requires simple technology, and all the other required components, or let me say raw materials, are available here in Saudi Arabia*". In terms of the literature, the variable has been considered to measure the supply risk factor in scopes of organizational level, such as [31,72]. However, on the national level, it is used as an object to measure whether the available or not known as critical raw materials [30,33,38,40–42,73–75].

2. NCMX02: The availability of feasible alternative:

As long as there is an alternative to the product, the criticality of this particular product becomes less. The variable was considered at different scope levels as a supply risk measurement variable; see, for example, [30,31,33,38,40,42,44,72–80]. During the interview with NK05, who was talking about the availability of perfect substitutes for products in Saudi Arabia, he said, "*running out of wheat is not an issue that could harm the society . . . as long as you have other alternatives, which we already have . . . not only rice, but dates could also be an alternative . . . our antecedents used to live on it . . . so you will be fine . . .* " MQ04 agreed with NK05, as he mentioned, " *. . . I don't believe we will be having issues . . . we already have other alternatives to satisfy our needs . . . well, it might not be the perfect substitute as I understand the importance of grains to our culture, but you won't have a famine, do you see what I mean? There is always something else*". There is also the electric car, which is considered an alternative solution to the petrol car. While MS01 was speaking about the use of gasoline and how other alternative reduces the demand for this type of crude oil product, he said: " *. . . transportation sector is the largest . . . 60% consumed by the transportation sector and the remaining 40% . . . they are trying to reduce it by implementing other energy options . . . In the UK, you will find a charger at every parking meter. I was in London two weeks ago, a lot of things had changed . . . Electric cars become more efficient, and cost less, approaching gasoline cars and sometimes less. The electric battery is amazing, made from lithium keeps car running for more than 300 miles with the same charge . . . China will export more than nine to ten million cars in a year, which will be increased in a form of geometric fit . . . it's a big improvement*". MM61 provided an example of a perfect substitute in the automobile sector, Tesla: " *. . . other alternatives start to appear like Tesla in the automobile industry . . . solar has become or let me say is now considered the perfect energy substitute*".

3. NCMX03: The availability of qualified personnel:

On a national level, it is crucial to determine whether or not there are people who can produce a product. Due to its criticality, the variable of availability has been used as a supply risk measurement by many scholars at different levels, such as the national and organizational levels [9,38,42,45,77,78,80–83]. In addition, this was mentioned during the interview by AA02, SM08, and KM33. AA02 looked at it from the national security standpoint, "*currently, most of the pharmaceutical industry in Saudi Arabia are foreigners, not Saudis, this has a security sense, Aiman . . . all medical factories are run by non-citizens . . . for any reason at any time they might leave, what will you do then?*". However, as part of solving this issue and ensuring the availability of qualified people, SM08 mentioned the Saudi's government initiative of providing scholarships in different disciplines to fill the local labour market gap: "*now . . . we started seeing the output of the scholarship programme . . . many scholars return back with high knowledge and experience that makes them able to do it*".

4. NCMX04: Self-sufficiency:

This refers to the extent to which the nation can sustain itself without relying on others [84]. It aims to measure the availability ratio of domestic reserves to consumption and the ratio of local production. In the case of a shortage or if the local supply does not meet the required demand, it is necessary to hold a strategic reserve for the required critical product in order to achieve self-sufficiency. As SF02 said: " *. . . the strategic reserve has become essential for many countries suffering from the shortage of the basic needs, like here in Saudi Arabia . . . our government is more concerned about achieving self-sufficiency for most critical products . . . look for example at the grain and petroleum strategic reserves we hold*". The concept was

also applied on the organizational level under the name of safety stock, which is used to measure the supply risk factor; see, for example, [9,30,33,38,40–43,73–75,77,78,80–83].

5. NCMX05 (A, B): Availability ratio of (local/global) suppliers:

One of the core variables that is considered at all levels is the availability of suppliers, whether local or global. If the suppliers of required products are available, there will not be a risk in product supply, unlike the scarcity of suppliers. However, what makes a product more critical is if there are a limited number of available sources all over the world. For this reason, the availability of suppliers was one of the variables found in the literature to measure the level of supply risk, such as [7,31,37,72,78–80,82,83,85,86]. Additional to the literature review, semiconductors were mentioned by AM38 during the interview: "*now that features are approaching the single nanometer sizes, only a handful of companies worldwide can produce these devices*". Then he said: "*it is not comparable to other industries, and thus, only a few foundries are involved in this business. The raw material is not the main issue, though always there is a need for new materials. The main issue is the necessary semiconductor-manufacturing equipment and maintaining them. The equipment is produced by a few companies based in Japan, Europe, and the USA*". Although the USA is leading the semiconductor industry, due to the shortage of semiconductors, " . . . *the USA president announced that they are attempting to open other manufacturers other than Intel to assure the flow of supply for this type of product*". (KM33). In Saudi Arabia, as part of the solution for this issue, the government tends to encourage Saudi investors—in particular those who deal with products in high demand—to diversify their investment locations with government support. "*You know in Saudi Arabia we have agreements with other countries like Brazil and India . . . for example, our investors here own many lands and farms in Brazil, India, Ethiopia, and other countries . . . in fact in so many countries . . . so if there is any supply issue in Brazil we have alternative sources and so on*" (SF03). Speaking about the status of insulin in Saudi Arabia, BB10 looked at it from the cost point of view. He preferred outsourcing instead of localizing the industry: " . . . *Currently, only three insulin manufacturers produce 100% of insulin in the US market (the top insulin manufacturers are Eli Lilly, Novo Nordisk, and Sanofi) and more than 90% of the global insulin. Few countries can manufacture insulin, namely, the USA, Canada, Denmark, France, Germany, Italy, Ireland, Russia, Japan, China, and Brazil. Hence, as there is more than one foreign supplier of insulin, outsourcing insulin is cost effective*".

6. NCMX06: Availability ratio of investors:

One of the key elements is the availability of investors who can serve society under the supervision of the government, either for a certain period of time or with other incentives. One of the examples mentioned by SF03 was government agreements with other countries. However, not all types of industries are favored by investors. For instance, AA02 said: "*We don't have the capital or investor who would like to wait to have a return on an investment after 50 or 60 years . . . why should I hold more than 100 million on something and get it back after these years while there are some other opportunities for me, and it might be more profitable?*". Therefore, AF56 suggested diversifying government funding to include sectors other than agriculture and health: "*as a government promotes agribusiness finance and investment, it promotes agroecology and biodiversity like hydroponics on a large industrial scale*". In terms of the literature review, this variable has been studied on the national level [30].

7. NCMX07: External dependence:

The variable aims to measure the level of reliance on external suppliers, i.e., the import ratio. In terms of measuring the supply risk factor, the increase in reliance on external suppliers increases the possibility of supply risk. " . . . *we are still in the early stage of producing insulin . . . we still import a large amount from outside*" (AA02). This was how he viewed the insulin status in Saudi Arabia, whereas SS06 used the medical devices industry in Saudi Arabia as an example of how we rely on external suppliers: " . . . *you know that we are importing 98% of our major medical devices since we don't have local manufacturer . . . what are*

you seeing is just packaging or maybe a distributor". The variable has been considered in many national studies, such as [30,38,40,42,74].

8. NCMX08: The availability of scientific research centers:

This variable has a major role in reducing the criticality level of IFP; therefore, it has been considered a supply risk measurement variable in many studies on a national level, such as [37,40,42,45]. During the interviews for this research, SM08 suggested scientific research centers as a way of solving the supply risk issue for major medicine in Saudi Arabia. She said, " . . . *not only this Aiman, but you also need scientific research centres before... then you think about factory to start the process*". MM61 made the same suggestion: " . . . *you need to focus on developing a technology facility, I mean inside your country . . . stop importing technology . . . do more research centres ensure having an agreement with leading manufacturers*".

Sub-Theme (2): Capability

9. NCMX12: Supply vulnerability:

Speaking about the national strategic reserves and the reasons for holding a reserve for critical products is a consequence of the vulnerability of the supply flow for required products. This variable aims to measure a product's vulnerability to disruption through any of the following circumstances: adverse weather, natural disaster, climate change, war, global pandemic, or cyberattack. Having regards to the literature review, the following are examples of studies that used the supply vulnerability as a variable to measure the supply risk factor at organizational and national level studies [7,30,74,77,78,83,85,87–90]. During the interview, the variable was repeated many times by different participants; for instance, MS01 commented: "*when Al-Houthi attacked our refinery . . . although it was a very short period of time, two weeks only, approximately 50% of our production capacity per day of crude oil, completely stopped . . . the question here that most people are concerned about right now is what will happen if we have a war that attacked more than two oil fields at one time. Will we be able to return back quickly or not? This question is still being asked up to this day . . . Some arguments said it's an imported product from unsecure sources, which is not true in my opinion*". SF03 looked at it from a political point of view: "*political prudence is to have a strategic reserve for the most important and major things, to be prepared for any unexpected issues, especially in the case of wars or emergencies*". This was confirmed by ZA44: "*we are located in an unstable region, look around you . . . Yemen, Syria, Lebanon, Sudan, Iraq . . . even though we are safe so far and the government is doing all the efforts to ensure the safety of our nation, still they could interrupt any imported product or export*".

10. NCMX13: Supplier's country stability:

One of the elements most considered while outsourcing required products or raw materials at all levels is the stability of the government regime in the supplier's country. If there is a concentration of a product that is in high demand in an unstable country, that will threaten the flow of supply. Therefore, on a national level, this variable has been used to measure the supply risk level. See, for example, [6,33,38,41,42,74,75,81,82,87,88,91]. While being interviewed, SF03 kept repeating that "*the better the executive authority, the better the rest of government agencies' performances are*". MS01 provided an example when he compared (participant preferred not to mention the country's name) with other governments in terms of using one of the national resources, crude oil. He said: "*look at them and how they are selling their valuable sources, do you know, although they are under economic sanctions, still they are exporting a very limited volume by the black market . . . why? They offer a great discount to market their products as it's not accepted internationally to deal with them*".

11. NCMX14: Logistic challenge:

Nation's capabilities are varied. Some countries are able to support a high standard of infrastructure, such as many ports and airports with good facilities, different warehouses, and transportation methods, while others hardly have a silo to reserve grain in. Therefore, it is important while evaluating the supply risk on a national level to assess the logistic

services that the nation is characterized by. This variable aims to measure the level of overall internal logistic facilities related to the product being tested in Saudi Arabia, such as ports, roads, warehouses, communication, distribution, storage risk, etc. The variable has been considered as a supply risk measurement in different studies [31,76,77,81,85,92]. Looking at the study participants' points of view, SS06 was not satisfied with the performance of some of the government departments, compared with the funding they have in terms of logistic services "*they do have a problem with distribution . . . Supply chain is your brain, your muscles . . . we use a brain for planning, forecasting, measuring the demand . . . and the muscles to act by delivering, storing,* etc. *We are just using our muscles, sorry to say that . . . we still have a big problem with the logistics*".

12. NCMX15: Policy and procedures intervention:

In some cases, for a certain type of product, governments tend to impose a policy to manage the availability of the product based on local needs and interest. In IFP, we have seen the government of Indonesia, which banned palm oil in order to give priority to the local consumers, and the government of Egypt when they banned the export of rice to Saudi Arabia due to local needs. Therefore, it is crucial to measure the extent of intervention ratio of government policy and procedures in a supplier's country and whether it is (with or against) the (use or supply) of the product or raw materials externally. The variable has been employed to measure the supply risk factor on the national and organizational levels. See, for example, [9,29,38,41,72,76–78,80]. That was confirmed by NK05, who had previously managed a strategic product in Saudi Arabia. He said: "*you remember back in 2008 or 9 when Egypt banned exporting rice to Saudi Arabia, it was not because of a diplomatic issue or something like that . . . they were looking to satisfy their local needs. How are you going to export something while you need it locally?*". Indeed, while we were writing this report, two different cases occurred. India stopped exporting rice, but they excluded Saudi Arabi from the ban, which might be because of the agreement between these two countries. Following that, Indonesia banned exporting palm oil as they were giving priority to the local market and industries.

13. NCMX16: Forecasting accuracy ratio:

In today's economy, it is crucial to predict the future demand for and supply of a product. On an organizational level, companies usually hold what is called a safety stock inventory in order to meet unexpected demand—on the national level, this is called a strategic reserve. If there are repeated forecasting errors, this can limit a company's profit. However, on the national level, it might affect one of the PEST factors, if not all of them. Therefore, it is important to predict the future demand for products, for example, by looking at population growth. By identifying the future demand, the flow of supply can be managed, which reflects positively on the level of supply risk. Refs. [30,40,43,75] are examples of studies that have used this variable to measure the supply risk factor. During the interviews, MS01 highlighted the issue of unexpected seasonal demand in Saudi Arabia, "*we had a problem before with the seasonal demand during Hajj, there was a high demand for diesel*". OH15 understood that it was essential to have accurate forecasting of demand "*to plan the inbound stock level, the forecasted consumption accuracy is a must*".

14. NCMX18: Complexity ratio:

Some products are very sophisticated; therefore, they are not easy to produce, or they might require a specific condition or environment for their manufacture, such as insulin in Saudi Arabia. AA02 commented: "*you are talking about a sophisticated and very complicated industry; it requires special manufacturing conditions and investment . . . in 2016 or 18, I forget, we opened a new insulin factory for this reason, to meet the local demand . . . frankly speaking they are suffering*". For this type of industry, BB10 agreed with AA02, as he said: "*they need a sequencing machine to build human protein and synthesise DNA and large tanks to grow bacteria*". In addition, SS06 mentioned: "*I just finished a meeting related to manufacturing (participant preferred not to mention the product) here in Saudi Arabia, instead of importing them. Still, we are*

studying the project, it's a big challenge, to be honest with you". AM38 shared the same point of view about producing semiconductors in Saudi Arabia: "*the main issue is the necessary semiconductor-manufacturing equipment and maintaining it . . . it is very difficult to establish*".

To the best of our knowledge, this variable has so far only been included in studies with a national scope [30,50,75].

15.　NCMX24: Operational cost:

One of the consequences that increase the risk of supply for critical IFP is their high operational cost, such as the oil product. MS01 said: "*As for oil . . . its costs are very high, there is no doubt about it. The insurance itself is very pricy, especially with the political affairs*". The variable was conserved in many studies to measure supply risk on the national and organizational level, such as [30,31,37,39,40,42,72,74,79,81–83,93–97].

16.　NCMX21 (A, B, C, D, E): Consumer behavior:

Since the focus of this research is critical IFP, it is appropriate to measure consumer behavior towards products: how they buy them, consume them, and dispose of them. Solomon define consumer behavior as "*the study of the processes involved when individuals or groups select, purchase, use, or dispose of products, services, ideas, or experiences to satisfy needs and desires*" [98] p. 28. One of the examples of consumer behavior was mentioned by MS01 when he was talking about how people consume gasoline in Saudi Arabia. He said: "*since it's a subsidised product we don't appreciate the real value of this resource, you just use your car even for a short distance . . . this is a waste of resources . . . now with the new polices and changes in the price, people start to think before they go anywhere . . . is it worth or not to use my car?*".

In this study, to measure this variable, the question directed to the experts was divided into three parts: how satisfied are you with (a) users' consumption behavior in terms of usage and disposal methods; (b) the availability of policies and procedures to manage the consumption behavior of consumers (e.g., increase the price, impose fines, educate society about the optimal use of products, etc.); and the level of implementation of these policies and procedures? In terms of recyclable products, they were asked to express their level of satisfaction level with the available policies and procedures on recycling products, as well as their implementation. Most previous criticality studies have only considered the recycling ratio on a national basis [30,33,40,43,46].

Sub-Theme (3): Supplier Properties

17.　NCMX23: Global market competition:

With critical products, in the case of a few suppliers, an increased demand increases the level of supply risk. On a company level, that could be represented by the market share—the higher the market share, the higher the profit. However, on a national level, it has different implications. Du and Graedel (2011) used global market competition to measure the level of supply risk where higher global competition for the product increases its criticality level [99]. The product assessed was raw materials. In his interview, MS01 described the current global competition for petroleum products: "*to this date, the whole world still relies on petroleum products although there are alternatives, and I believe the demand will remain to the end of this decade, after that the oil will lose its value*".

18.　NCMX26: Market conditions and structure:

Understanding the market conditions and structure is one of the most important elements when evaluating product suppliers on a national basis—is it a monopoly, or a small group of people controlling the market, for example, cartels [75–77,80,86,88,100]? On the organizational level, market conditions have been considered when measuring supply risk [75–77,80,86,88,100]. One of the things that surprised me while interviewing MK31 was that he said, "*corruption may also be a player in the matter when certain parties get benefit from importing some medicines, which we have seen unfortunately*". It might be worse when the source of the product is unknown, "*you might get it from black market, sometimes you don't know the source of it or t is not preserved within the required conditions*" (MK31).

19.   NCMX27: Export capacity:

If the required product is not available locally, it is essential to identify the capacity limit of external product suppliers. This variable has been used in many studies to measure the supply risk factor, such as in [6,50,75,77,85–87]. In some conditions, suppliers are unable to satisfy demand due to their limited facilities or the global demand for the product. As an example, when KM33 talked about the possibility of manufacturing semiconductors in Saudi Arabia, he said, " . . . *we have made it here lately as the minster Al-Sowaha mentioned in his last speech, but I'm not really sure if we could supply other countries or not, still there are some points not clear for me*".

20.   NCMX29: Trade agreements:

When there is flexibility between buyer and supplier, the level of supply risk decreases. On an organizational level, where profit is the ultimate goal, that might be manageable in a mutual agreement between both parties; however, on a national basis, there is usually government (diplomatic) intervention in the form of a trade agreement. As FA60 suggested, to ensure the flow of the product supply, the government should "*try in-country farming, do more research on farming technology developments, ensure that you expand or have better storing facilities, focus on value-added facility developments, ensure you have long-term foreign trade agreements on raw materials*". One of the practical examples, as mentioned earlier, is the government-level agreement between Saudi Arabia and India, Brazil, and many other countries, "*we have an agreement with other countries like Brazil and India, for example, our investors here own several lands and farms in Brazil, India, Ethiopia*" SF03. Examples of studies that have applied this variable as a supply risk measurement are [37,42,50,78].
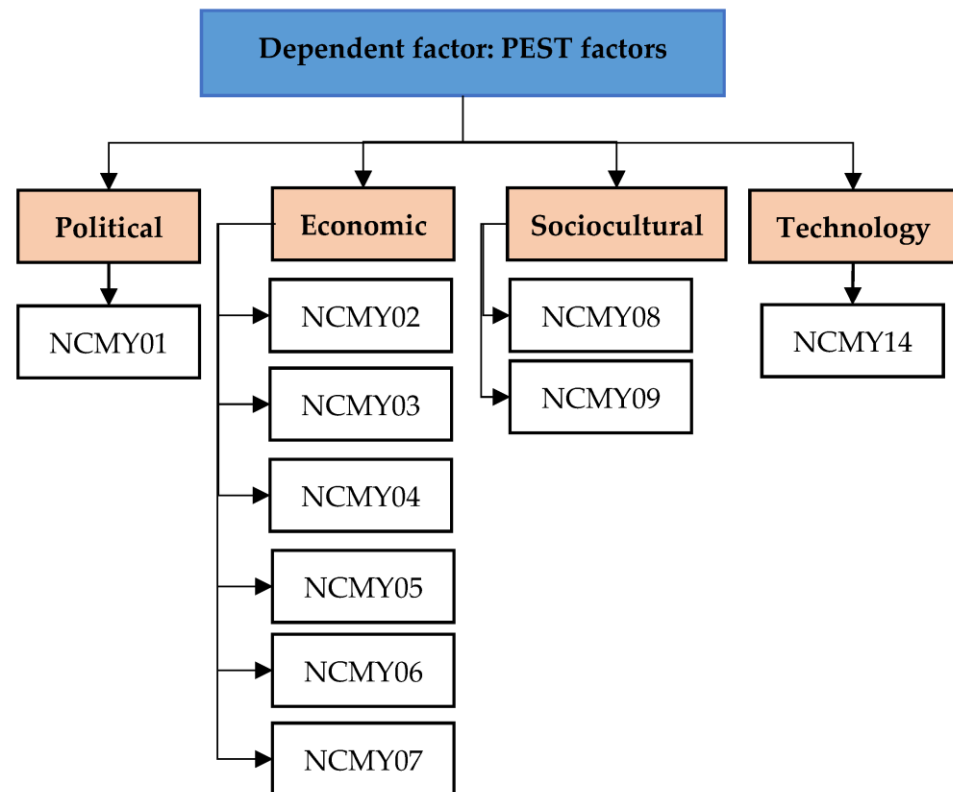
4.1.2. PEST Factors

This section presents the factors that were extracted from the qualitative data. It deals with the political theme, economic theme, sociocultural theme, and technology theme. Under each of these themes, a number of codes were created to represent the themes, as discussed in detail below. The political and technological themes consist of one code, whereas the economic theme contains six codes, and there are two codes to measure the sociocultural theme, as shown in Figure 4.

Political (P) Theme

1.   NCMY01: National stability and security:

A number of variables (codes) were extracted from the interviews related to the political factor, such as government reputation, stability, performance, productivity, and national security. All of these variables (codes) were merged to form the national stability and security variable. Most studies have considered this variable under the supply risk factor to measure the level of risk that might occur when sourcing products; see [10,18,30,87,101]. However, since this study focuses on national stability by holding a national strategic reserve for required products, it considers this variable as a dependent variable that might be affected by the independent variables (supply risk factor). During the interviews, most of the participants mentioned the political sense during critical product shortages. For example, SF03 said, "*government does all these administration duties to make our life much better and safer. Always when you would like to understand other cultures or societies, you look at the political system first . . . it gives you an indication of which level this society is in . . . the knowledge, the power of these people. So, . . . the better regime, the better life you will have . . . if not, people will suffer a lot*". SY48 referred to the Arab revolution and to the lack of basic needs, which led to a change in the regime of many Arab countries, "*there is no doubt that failing to provide the basic needs for your people will increase their dissatisfaction with their government. This may break down the security, which increases the level of instability; perhaps it might lead to demands to change the system, like the Arab revolutions in Egypt and Algeria before . . . I believe you are aware of what happened during that time . . . it was not safe*". NE51 mentioned that "*riots and tension*

erupted during the era of President Anwar Sadat in 1977. It was about to become a revolution because the bread price increased due to the shortage in supply".

Figure 4. Qualitative result (PEST factors).

Economic (E) Theme

2.   NCMY02: National macroeconomics:

"It concerns national income, total consumption, investment and the money supply" (Rutherford, 2002: p. 361) [84]. Holding a national strategic reserve for the required product has a positive impact on many economic factors such as employment rate, interest rate, GDP, etc. When NE51 spoke about the consequences of the shortage, he mentioned that *"stopping the factories led to layoffs of their employees, which resulted in an increase in the number of unemployed".* In addition, SS06 said, *"you need an industry that creates a job for your people, you are a big country, almost 30 million, not like our brothers and families in the United Arab Emirates or Kuwait . . . the total population does not exceed 5 million. Therefore, I'm telling you to keep what you have . . . change it, modify it, but don't destroy them . . . these are people's jobs . . . the reality is more accurate than academia in some cases, right?".* (SS06). To the best of my knowledge, this variable has only been applied in national scope studies, such as [13,17,18,30,36,74,86–88,91].

3.   NCMY03: Price stability:

One of the reasons behind the holding of national strategic reserves is a desire to maintain the product price. During the interviews, one of the most mentioned variables was the price of the product. MS01 talked about the beginning of the national strategic reserves concept when there was a diplomatic issue between Saudi Arabia and the US. He said, *"the world was worried . . . If you remember, the first thing that happened when the disruption occurred was that the price of oil jumped up to more than $70 . . . since then the concept of strategic reserves began".* SY48 referred to the law of supply and demand, *"of course, once we run out of any type of product, the first thing that will be affected is the price . . . definitely it will increase, it is a supply and demand law".* ZK07 pointed out that *"price means supply and demand".* In the studies reviewed in the literature review, the variable was applied in different levels [9,12,74,78,85–88,91,95,102,103].

4.   NCMY04: Demand:

An increase in demand means that the product is critical for its consumers. As long as supply meets and satisfies the required demand, the market is considered stable. However, if, for any reason, an interruption occurs, that will be reflected in the criticality level of the product. A shortage of some products, such as insulin, might lead to disaster, especially in a case of high demand, while the lack of some other products that are in high demand might not harm society. In this regard, AA02 mentioned, "*we do not have self-sufficiency of almost 20% of the essential medicines . . . this is the problem, self-sufficiency . . . the demand is high, local manufacturer does not cover the existing demand, so you have to source from outside*". On the other hand, when MQ04 was talking about the grain in Saudi Arabia and how people consume it, he said "*we use it daily, especially here in the kingdom. This is the most important product, we a lot as we use it in our breakfast, lunch, dinner. You can do different types of food using grain, unlike other products*". Different studies have considered this variable as a dependent variable when measuring the criticality level of the object being tested [31,36,42,78,80,100].

5.   NCMY05: Criticality of the product:

One of the reasons why the government was concerned about holding strategic reserves for certain types of products is the criticality of these products for the national interest. For instance, in Saudi Arabia, "*oil is considered a dominant product in Saudi Arabia . . . this is your front line, the whole world uses it*" (MS01). Later during the interview, he also said, "*in the nineties, the world was relying on petroleum significantly. Each economic growth unit needs one and a half of oil to grow economically one unit. So yes, it was very significant. The importance of oil now not like before, most countries are now trying to separate their economic growth from oil, so they can grow without the need to have oil*". SK36 gave an example of semiconductors and how that affected the automobile industry all over the world, "*I'm not an expert in this field but I have heard in the news lately that there is a shortage of semiconductors, which affects the car industry mainly*". On a similar theme, NE51 commented: "*the interruption of cotton may stop the production of cotton clothes, but the interruption of fuel leads to great damage to the industry sector and factories . . . it may stop the production of all consumer goods or reduce production . . . it might interrupt or stop transportation and communications . . . it might completely stop the country*". In addition to qualitative results, the variable has been used at the organizational and national level. See, for example, [12,13,18,30,31,78,86,91,99,104].

6.   NCMY06: Investment:

Some products are considered to be critical inputs for public projects or services. If there is a delay in the supply of these products, the consequences of this shortage might affect the expected return on investment. On the organizational level, this is understandable, as return on investment is the ultimate goal in most cases. Therefore, it has been considered in many studies as a dependent variable [31,103,105]. Confirming the validity of this variable, SM08 mentioned during the interview that "*it might take more than 50 years to start getting a return on your profit... from their point of view, is not worth it... Why should I hold my money for 50 years, and usually you are talking about billions, while I have some other opportunities with an immediate return?*". MK31 believed that "*the small profit margin, especially in the case of some products with low consumption, is not encouraging the investors, the difficulty of securing the required raw materials . . .* ".

7.   NCMY07: Government expenses "Overfunding":

Overfunding is defined as "*the issue of more government bills and bonds than is necessary to finance government expenditure*" (Rutherford, 2002: p. 433) [84]. A shortage of some products might increase the national debt in order to satisfy the local market needs. When AM09 was talking about shortages and to what extent they might affect the nation, he said, "*what will happen here, the government might either get a loan and let the country suffer 100 years ahead or print more money without having a cover for that, which makes the issue worse*". This might lead to subsidies of some products, as is the case with wheat in Saudi Arabia, "*You know this is one of the products that is subsidised by the government. The price for one kilo is five SAR*

but what you pay is 0.5 SAR, yah half a riyal only . . . rice for instance is not subsidised" (MQ04). In addition, as mentioned earlier, SM08 talked about the cost that might occur due to the absence of insulin or other critical medicines. She said, "*really costly . . . this is how we classify the diseases . . . by knowing how much it costs the government . . . We have different types of costs, not only the cost of treatment but the spread of the disease has a very big role. The more it spreads, the more costly and stressful it is to eradicate it*". Looking at the literature review, many studies have mentioned this variable as a shortage consequence that the public sector might have during the absence of critical products. See, for example, [13,18,21,87,106].

Sociocultural (S) Theme

8. NCMY08: Criticality of the product's survival:

What is the purpose of a strategic reserve if it is not to survive? A strategic reserve refers to products that are essential for our human life; without them, someone might lose his/her life. This study does not consider luxury products such as beauty treatments or video games. The variable has been applied in national-level studies. See, for example, [10,13,18,28,38,106–108]. During the interview, SF03 detailed the difference between critical and luxury products. He said, "*when I look at my needs, I find thousands of things, but what do I really need in order to live and exercise the minimum in my normal lives? This what matter*".

9. NCMY09: Society's attitude:

The lack of some critical products might affect attitude in terms of purchasing habits, crimes, abusing the law, or un-behavior attitude. It depends on the product and the duration of the product's absence. Some studies have linked the effects of product shortages with society's attitude, such as [13,30,38,42]. These studies were carried out on a national basis as they were concerned about the stability of society. When a question was directed to the participants about what might happen if there was a shortage of an essential product, I received so many answers. One of them was from AF56, who said, "*in instances of scarcity of key resources, individuals would be fighting with each other to secure these basic essentials for survival. When survival is at stake, human beings cannot be expected to abide 'strictly by the book'. The very fabric of social unity would be at risk and it would be a society whose only intent would be survival and nothing beyond. The sociocultural interaction will be the main casualty and it would be 'every woman/man for herself/himself' sort of a scenario*". MQ04 talked about the example of steel during the shortage back in the 1990s in Saudi Arabia, "* . . . ten years ago the price of steel reached 4000 SAR for one ton . . . unfortunately, some people stole the sewer covers and sold them . . . it was really a big issue at that time and so risky, even the outside box of our air conditioning . . . *".

Technology (T) Theme

10. NCMY14: Advancement of national technology and innovation:

Technology plays a major role in Saudi's economy and community. One of the government's aims is to be one of the most advanced countries in science, technology, and innovation by launching a program called the National, Science, Technology, and Innovation Plan (NSTIP). The aim of the program is to determine which technology is strategic for future development in Saudi Arabia [109]. That was in line with MM61, who said, "* . . . although that we are still in our early stages in term of technology . . . but look what we have done with the use of technology, most of the government services became digital, Absher, Enjaz . . . *" However, one of the major components to ensure the sustainability of technology is a semiconductor that considers "* . . . the brain of technology*", as it was described by KM33. Looking at the literature, one of the main reasons for carrying out criticality studies was to ensure the future of technology by determining the required raw materials that are scarce. See, for example, [21,29,38,39,41,43,47,48,73,75,100,110,111].

At this point, the qualitative research is concluded. In the coming section of this chapter, the quantitative data are presented.

4.2. Quantitative Result

The eigenvalues test resulted nine components that are greater than 1, which is effective enough to represent the remaining 35 variables. The values of components 1–9 were 5.997; 4.760; 3.501; 2.614; 2.053; 1.489; 1.307; 1.157 > 1; and 1.064, respectively. These were all greater than 1, and they explained 68.408 of the variances with other variables. The values of the remaining components were less than 1. The Scree plot graph was drawn by comparing the number of components and eigenvalues. It shows that the first nine eigenvalues' components were greater than 1, whereas the remaining 35 account for a very small proportion of the variability, as shown in Figure 5.
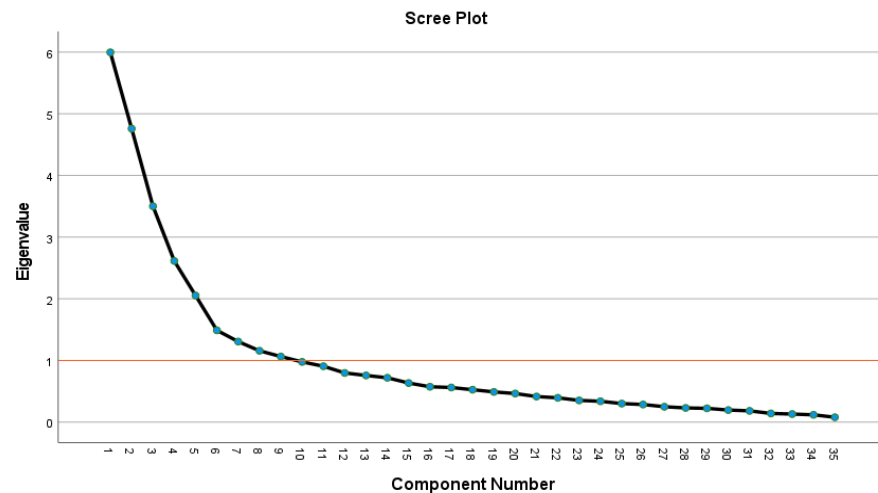

Figure 5. Scree Plot Result.

With regard to the study's factors and objectives, the component was reduced from 9 components to 2. As a result of a rotated component matrix, the following Table 3 represents the final measurement variables resulted based on the factor analysis.

Table 3. Successful factors.

S. No.	Variable Name	V. Code	Communality after Extraction	Mean	SD	Factor Loading
		Component 1: Supply Risk Factor				
1	Availability ratio of (local/global) suppliers	NCMX05 (A)	0.190	4.99	1.82	0.366
		NCMX05 (B)	0.398	3.00	1.53	0.593
2	Availability ratio of investors	NCMX06	0.373	4.19	2.04	0.610
3	Self-sufficiency	NCMX04	0.494	3.84	1.99	0.702
4	The availability of scientific research centers	NCMX08	0.170	4.78	1.74	0.334
5	Logistic challenge	NCMX14	0.550	3.33	1.97	0.741
6	Forecasting accuracy ratio	NCMX16	0.654	3.86	1.74	0.808
7	Consumer behavior	NCMX21 (A)	0.426	4.50	1.58	0.651
		NCMX21 (B)	0.592	4.50	1.73	0.769
		NCMX21 (C)	0.531	4.66	1.68	0.728
8	Export capacity	NCMX27	0.324	2.94	1.41	0.569
9	Trade agreements	NCMX29	0.342	2.99	1.31	0.585

Table 3. *Cont.*

S. No.	Variable Name	V. Code	Communality after Extraction	Mean	SD	Factor Loading
			Component 2: PEST factors			
1	National stability and security	NCMY01	0.534	4.22	1.86	0.730
2	Demand	NCMY04	0.386	5.64	1.48	0.567
3	Price stability	NCMY03	0.223	5.57	1.65	0.454
4	Investment	NCMY06	0.394	4.90	1.58	0.599
5	Criticality of the product	NCMY05 (A)	0.534	4.69	1.71	0.718
		NCMY05 (B)	0.599	5.04	1.53	0.737
6	National macroeconomics	NCMY02	0.357	3.88	1.77	0.593
7	Government expenses "Overfunding"	NCMY07	0.493	4.21	1.78	0.656
8	Criticality of the product's survival	NCMY08	0.430	4.36	1.99	0.636
9	Society's attitude	NCMY09	0.280	4.30	1.78	0.511
10	Advancement of national technology and innovation	NCMY14	0.439	4.09	2.09	0.608

As can be seen in the above table, by reducing the number of components from 9 to 2, seven variables were excluded due to the weakness of their correlation (<0.30) [112]: NCMX01 the availability of raw materials; NCMX02 the availability of feasible alternatives; NCMX03 qualified personnel; NCMX07 external dependency; NCMX18 complexity ratio: ease of production and storage; NCMX24 operational costs; and NCMX13 supplier country stability. In contrast, NCMX12 supply vulnerability, NCMX23 global competition, NCMX15 policies and procedures interventions, and NCMX26 market conditions are all loaded under component 2, which consists of all the PEST factors.

5. Conclusions

To the best of the authors' knowledge, no study to date has answered this research question for this particular type of products on a national basis, even for critical raw materials, confirmed by Schrijvers et al. in their recent article in 2020 [36]. This gap has been reflected in reality by the shortage issue that has emerged during the past two years. Being part of the supply chain community, it is very important to apply our theories and practices to serve the community and ensure the nation's sustainability and stability. Identifying the critical product on a national basis that need to be reserved will contribute to solving an important issue related to national stability and sustainability. By identifying the critical IFP, the government administration can ensure the continuity of supply flow for critical products, address the reasons behind the shortage, and work to solve the issue as much as possible to reduce the shock that might occur due to the shortage.

Regarding the limitations of this study and recommendations for future study, this research does not consider any type of product related to military purposes. It focuses on the following IFPs: agricultural products (the cereals family, such as rice and wheat); energy products (gasoline and diesel); essential pharmaceutical products (insulin); and tangible technology products (semiconductors). In addition, the study was conducted in one country, Saudi Arabia, from April 2021 to November 2022. Therefore, it is highly recommended that a similar study be conducted in a different country to confirm the validity of these variables in a different environment. When testing the reliability of the instrument, the number of valid cases was 43, and the number of excluded cases was 109. This was due to the fact that the questions asking the experts about their satisfaction level with the availability and implementation of policies and procedures were taken to manage the recyclability of the products being studied. Semiconductors are considered to be recyclable, whereas gasoline and insulin are not. Therefore, the number of missing cases was higher than that of valid cases, which weakens the generalizability of the results [113]. When these two questions were removed, the number of valid cases became higher (118) than the excluded cases (34),

which is within the acceptable range [113]. Learning from this, it is recommended that future researchers differentiate between recyclable and non-recyclable products to reduce the excluded cases (question no. 8).

A well-known tool in the literature of supply chain management and, more specifically, in the field of purchasing/sourcing is the purchasing portfolio model. The concept of a purchasing portfolio has been used extensively since it was published in 1983 by Peter Kraljic in his article, "Purchasing Must Become Supply Management" [31]. This tool was the first to bring portfolio models into the purchasing area [76,94,114–116]. The model's main concern is about classifying the importance level of the object that is being tested. Therefore, it is recommended for future studies to apply the model using the proposed instrument would allow further aspects to be added to the purchasing portfolio, which would, in turn, improve the management of the national strategic reserve and our understanding of the model across a variety of contexts.

Appendix A

Table A1. Participants' Background.

S. No.	P. Code	Participant Background	Round 1	Round 2
1	SF03	Former government consultant, social science professor interested in national strategic reserve	√	√
2	MS01	Senior advisor to the Minister (leading ministry), professor of economics, dealt with the national strategic reserve	√	√
3	MQ04	Professor of water and agriculture economics, former government consultant, farm owner	√	√
4	AA02	Pharmacoeconomic professor interested in industry, logistics, and the economy, with great experience in the public and private sectors	√	√
5	SS06	CEO of a leading company (billions of Saudi Riyals) that produces a critical product	√	
6	NK05	Former president of an organization responsible for securing one of the national strategic products—Ph.D. holder.	√	√

Table A1. *Cont.*

S. No.	P. Code	Participant Background	Round 1	Round 2
7	SM08	Health economics professor	√	
8	ZK07	Procurement supervisor in one of the top five leading companies in Saudi Arabia	√	
9	AM38	Computer science engineering professor	√	
10	KM33	Expert in technology interested in semiconductor industry	√	
11	AA39	Computer science engineering professor	√	
12	MK31	Medical logistics officer in a global organization	√	
13	SY48	Political and economist analyst interested in national strategic reserve	√	
14	SK36	Former government consultant interested in national strategic reserve	√	
15	ZA44	Chief procurement officer for leading company—Ph.D. holder	√	
16	BB10	Former Vice President of the Research Centre at a well-known hospital in Saudi Arabia—Epidemiologist expert—Ph.D. holder	√	√
17	AS50	Responsible (coordinator) for securing one of the national strategic reserve products—Master holder	√	
18	NE51	Geological expert interested in strategic reserve, dealt with energy and minerals—Master holder	√	
19	AF56	Vice President of a reputable organization in the Middle East. Managed multiple divisions related to fast-moving consumer goods (FMCG) sales and distribution, including food and beverage, personal and home care in modern and traditional trade channels in competitive markets	√	
20	FA60	Food trader	√	
21	AM09	Well-educated historian interested in political, economic, and sociocultural issues	√	
22	OH15	Chief procurement officer in leading companies. Managed mega project in Saudi Arabia	√	√
23	MM61	Computing and AI Professor	√	√

Appendix B

Table A2. Study Questionnaire.

SN	Question	Indicators			
1	Gender	Male	Female		
2	Level of education you have completed	Bachelor's degree or less	Master's degree	Doctoral degree	
3	Work experience	Less than 7	7 to less than 10	More than 10 years	
4	Experience background	Practical (A person who has practical knowledge by working in the field like traders, suppliers, farmers, producers, staff... etc.)	Theoretical (A person who has academic knowledge or is interested in the field/product by reading, researching . . . etc.)	Both	
5	In Saudi Arabia, (From 1 to 7) how available are/is the:				
		Scale used: Extremely scarce (1) . . . Extremely available (7)			
	NCMX01	Raw materials needed for producing gasoline?			
	NCMX02	Feasible alternatives for gasoline?			
	NCMX03	Qualified personnel in gasoline?			
	NCMX05 (A)	Local gasoline producers?			
	NCMX06	Gasoline investors?			
	NCMX04	Strategic reserves of gasoline?			
	NCMX08	Scientific research centers for gasoline?			

Table A2. *Cont.*

SN	Question	Indicators
6	In Saudi Arabia, (From 1 to 7) how satisfied are you with:	
		Scale used: Very dissatisfied (1) . . . Very satisfied (7)
	NCMX14	The overall logistic services for gasoline (harbor, warehouses, distribution channels, etc.)?
	NCMX16	The accuracy of available data for forecasting the gasoline demand?
	NCMX21 (A)	The consumption behavior by gasoline users in terms of product usage, and disposal methods -if applicable?
	NCMX21 (B)	The availability of policies and procedures to manage the consumption behavior of gasoline consumers (e.g., increase the price, impose fine, educate the society about optimal use of product . . . etc.)?
	NCMX21 (C)	The implementation of policies and procedures to manage the consumption behavior of gasoline users?
7	Is gasoline consider a recyclable?	
		Yes No (go to Q.9)
8	If yes, In Saudi Arabia, (from 1 to 7) how satisfied are you with:	
		Scale used: Very dissatisfied (1) . . . Very satisfied (7)
	NCMX21(D)	Availability of policies and procedures to recycle gasoline?
	NCMX21 (E)	Implementation of policies and procedures to recycle gasoline?
9	In Saudi Arabia, (From 1 to 7) how easy is it to:	
		Scale used: Not easy at all (1) . . . Very easy (7)
	NCMX18 (A)	Produce gasoline?
	NCMX18 (B)	Store gasoline?
10	In Saudi Arabia, (From 1 to 7) to what extend:	
		Scale used: No affect at all (1) . . . Extremely affected (7)
	NCMX24	Gasoline operational activities cost the government?
11	To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for rice?	
		Yes No (go to Q.14)
12	If gasoline was produced outside Saudi Arabia, (From 1 to 7) how available are/is the:	
		Scale used: Extremely scarce (1) . . . Extremely available (7)
	NCMX05 (B)	Global gasoline supplier?
13	If gasoline was outsourced (From 1 to 7):	
		Scale used: Extremely low (1) . . . Extremely high (7)
	NCMX07	How does the market of Saudi Arabia rely on external gasoline supplier?
	NCMX27	What is the capacity limit of the supplier to export gasoline to Saudi Arabia (Production limit)?
	NCMX29	How flexible is the trade agreement between Saudi Arabia and the most reliable gasoline supplier's country?
	NCMX12	How vulnerable is the flow of gasoline supply to any of the following events: adverse weather, natural disaster, war, pandemic, climate change, cyberattack?
	NCMX13	How stable is the political regime of gasoline producer countries in general?
	NCMX15	How do policies and procedures at supplier's country negatively affect the supply of gasoline to Saudi Arabia (Quotas, and restriction in supplier's country)?
	NCMX26	How the supplier's gasoline market condition is subject to one of the following practices: monopoly, cartels . . . etc.?
	NCMX23	How tough is the global competition of gasoline?
14	Hypothetically, if there were a lack of gasoline from local markets in Saudi Arabia, (From 1 to 7) to what extent would you expect the effect be on the:	
		Scale used: No affect at all (1) . . . Extremely affected (7)
	NCMY01	Nation's stability and security?
	NCMY04	Gasoline's demand?
	NCMY03	Gasoline's price stability?
	NCMY06	Return on government investment for businesses related to gasoline projects?
	NCMY02	National macroeconomic (GDP, employment rate, interest rate, inflation . . . etc.)?
	NCMY05 (A)	Public projects/services that rely on gasoline?
	NCMY05 (B)	Local industries and businesses that rely on gasoline?
	NCMY07	Government expenses (subsidize, national debt, etc.)?
	NCMY08	Human life (mortality rate)?
	NCMY09	Societal attitude (purchasing habits, crimes rate, antisocial activities)?
	NCMY14	Advancement of national technology and innovation?

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