

Review

Global Supply Chain Risk Management

Mouad Ben-Faress, Abdelmajid Elouadi and Driss Gretete

Ibn Tofail University of Science, Kenitra, Morocco

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Corresponding Author:

Mouad Ben-Faress

Ibn Tofail University of

Science, Kenitra, Morocco

Email: mouad.benfaress@uit.ac.ma

Abstract: Today's global supply chain structure and organizations are characterized by high physical volume variation, information and financial flow exchanges with several amount of data from supplier to the final customer, as a consequence of Market changes and customer behavior impacting the supply chain and its different actors. As part of a systematic approach we will start our research by studying the supply chain risk assessments, evaluation and analyzing the different risks which impact the global performance of supply chain and the way for good management and monitoring using one of the proven methods as Supply Chain Operations Reference (SCOR) which has been proposed for modeling and estimating intermittent demand data.

Keywords: Risk Management, Risk Assessments, Mitigation

Introduction

Supply Chain Risks (SCRs) is one of the critical topics which took a high importance in the current published scientific articles and trades, Supply Chain Risk Management (SCRM) is an area of growing importance (de Oliveira *et al.*, 2018) SCRM can be seen as a strategic activity for many companies as SCRs can directly affect, business, financial and operational performance of organizations. These trends have expressed through an increase of low cost country sourcing and collaboration with global SC partners (de Oliveira *et al.*, 2018).

The paper at hand is composed of five core sections. Provides the classification of the sources of supply chain risks and Vulnerability which reflects the Supply Chain Risk Management (SCRM), includes the Supply Chain Operation Reference model (SCOR) and finally a case study: Applied on the company XYZ in the automotive sector.

Classification of the SOURCES of Supply Chain Risk and Vulnerability

Risk can be defined as a chance of danger, damage, loss, injury or any other undesired consequences. A more scientific definition of risk was provided by the Royal Society (1992): "The probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge" (Faizal and Palaniappan, 2014).

Formally, risk in general can be defined as a collection of pairs of likelihood (L) and outcomes (or impact) (O):

$$Risk = \{(L_1, O_1), (L_2, O_2), \dots, (L_n, O_n)\}.$$

The distribution pattern of likelihood and outcome pairs is called a risk profile. Definitions of risk must also have a time dimension or a specific time horizon (i.e., day, month, year, etc.) and a specific perspective or view that defines the unit of analysis (i.e., boundaries, etc.).

Our research into the triggers of supply chain risk and vulnerability identified the following axis:

- External triggers: Customers, suppliers, market...
- Internal triggers: Manufacturing and process control

Sources of Risk

Supply Risk

One of the critical issues for supply chain risk sources which supply risk as its come on the begging of the supply flow which is characterized, such as:

- New product development issues.
- Relationship topics
- Deliveries, lead-time...
- Incapacity to fulfill customer demand (Zsidisin, 2014)

Customer Risk

Demand risk which is related to customer intermittent demand and uncertainty which impact the supply chain (Faizal and Palaniappan, 2014) in both product volume and mix which includes the below axis:

- Loss of major accounts
- Forecast inaccuracy
- Customer mix variation
- Market competitors.

Process and Manufacturing Risk

Processes are the sequences of different manufacturing operations or adding value to the product (Faizal and Palaniappan, 2014). It includes as below:

- Manufacturing variability
- Equipment maintainability
- Inflexibility processes
- Bottlenecks and capacity issues

Control Risk

Controls are the combination of systems and procedures which lead the organization and reflected by monitoring over the processes. In terms of the supply chain they may be order quantities, lot sizes, etc.. It includes (ISO, 2018):

- No visibility along the horizon
- Lack of collaboration between different SCM actors
- Bullwhip effect

External and Environmental Risk

Environmental risk is associated to the external aspects; uncertain events. From the supply chain and environmental interactions (ISO, 2018). It includes:

- Natural disasters
- Regulatory changes
- Political instability

Mitigation

As part of preventive action to lead into supply chain risk is mitigation which implement policies to maintain safety level all over the SCM and One important aspect to mitigate supply chain risk proactively is to build flexibility reactivity along the supply chain (Faizal and Palaniappan, 2014).

Therefore in order to have an overview about the previous cited risks sources. The Fig. 1 reflects the classification between the internal and external sources of risks:

Supply Chain Risk Management (SCRM)

SCRM is “the monitoring and management of the supply chain actors from the first supplier till the final customer to ensure continuous improvements and profitability”. Risk management is the evaluation, analysis and interpretation risk by maintaining combined procedures and systems. Using SCM risk assessments smooth and level demand, with effective resources (Rollins, 2017).

A framework for supply chain risk management is shown in the Fig. 2.

The Fig. 2 reflects the different processes of supply chain operations can be impacted by many risks. Starting from conception design then plan procedures until the final services and support while maintaining a continuous improvements by following assesses, mitigation, monitoring and standardizing using two aspects: Risk analysis and control (Faizal and Palaniappan, 2014).

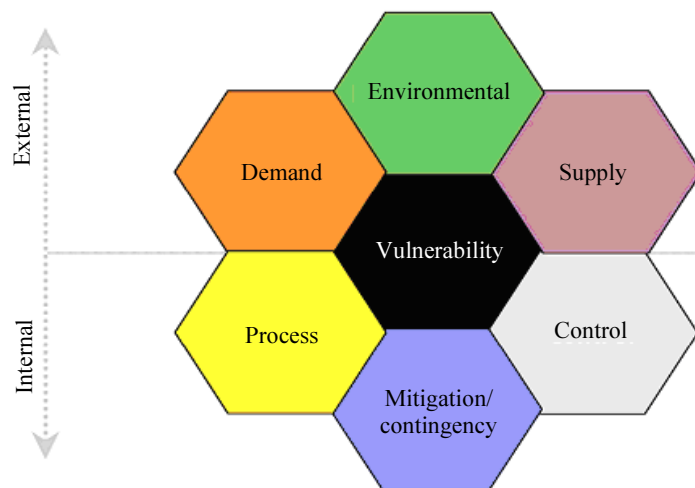


Fig. 1: The sources of supply chain risk (Britain and Peck, 2003)

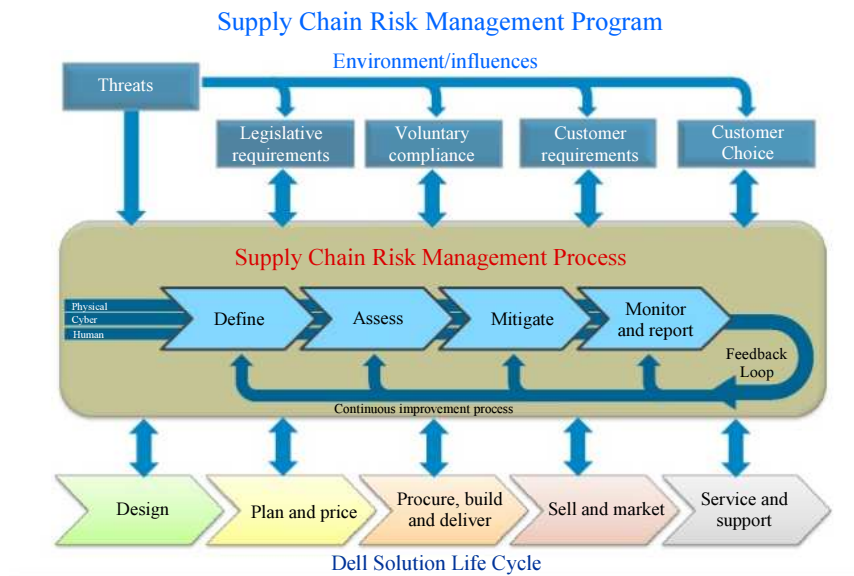


Fig. 2: Framework for Supply chain risk management (APWPS, 2013)

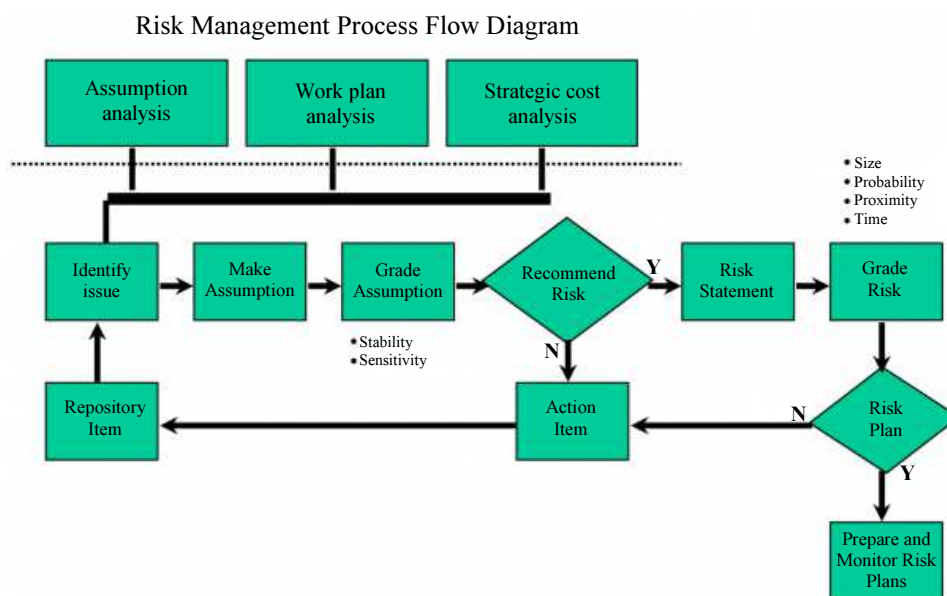


Fig. 3: Flow chart for supply chain risk management (Faizal and Palaniappan, 2014)

Risk Analysis and interpretation of the impact of risk along the SCM deals with identification and evaluation of risks, moreover risk control deals with monitoring and continuous improvement of process and operations. As reflected below in Fig. 3. The risk management process can be developed using the flow chart which is shown below Fig. 3.

Risk management process which is constituted of two main elements; supply chain risk identification, analysis and risk control.

Risk Evaluation and Identification

Risk analysis and evaluation used in order to identify and measure risks through the SCM by defining procedures and roadmap for clear identification and flow which will be reflected in the Fig. 4.

Risk Assessment and Measurement

So for risk evaluation and measurements a qualitative tool used to define the probability of occurrence and its impact as in Fig. 4.

Qualitative risk

Probability Of occurrence	Consequence of occurrence				
	Very Low	Low	Moderate	High	Very High
Very Low	Low Risk	Low Risk	Low Risk	Medium Risk	Medium Risk
Low	Low Risk	Low Risk	Medium Risk	Medium Risk	High Risk
Moderate	Low Risk	Medium Risk	Medium Risk	Medium Risk	High Risk
High	Medium Risk	Medium Risk	High Risk	High Risk	High Risk
Very High	Medium Risk	High Risk	High Risk	High Risk	High Risk

■ Low Risk ■ Medium Risk ■ High Risk

Fig. 4: Qualitative risk assessment (APWPS, 2013)

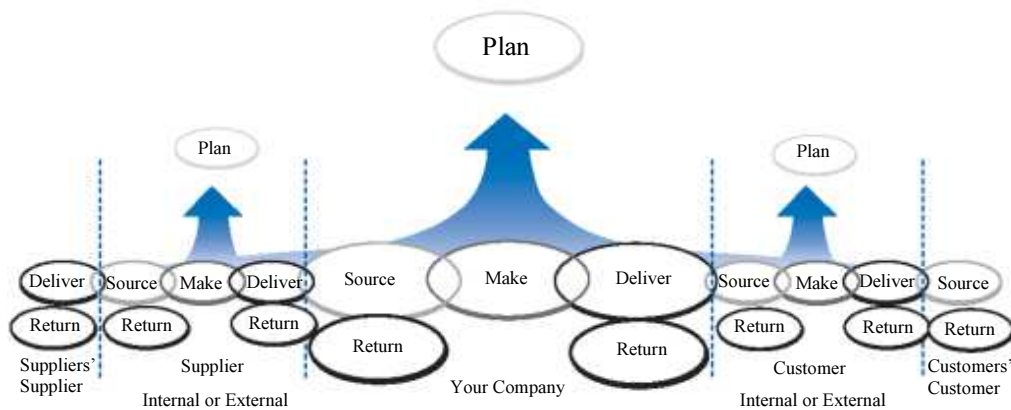


Fig. 5: Six major management processes of SCOR model (SCOR, 2010)

Risk Control and Monitoring

As mentioned in the previous section the identification and analysis of risk had a crucial role for monitoring and the management by standardizing best practices (McCormack *et al.*, 2015).

One of this best practices and model is Supply Chain Operation References (SCOR) using the metrics enables Supply Chain Risk monitoring. In Real time reports and statistical analysis which help to provide decisions about the future risk and way for control and monitoring. And provides visibility into from supplier to the final customer (McCormack *et al.*, 2015).

Supply Chain Operation Reference Model (SCOR)

The Supply Chain Operations Reference (SCOR) model Is a consolidated and connected model of supply

chain operations using a parametrical metrics, best practices and effective resources involving all supply chain partners and actors from the supplier till the final customer, keeping the tracking through system information, physical and financial flow (SCOR, 2010).

Implementing the SCOR model represent a crucial role in supply chain process flexibility and reactivity. It was developed and improved to ensure a model with possibility to measure, analyze and evaluate all the parameters which impact supply chain performance which is the necessity to involve and use this model as international tool with continuous and sustainable development (SCOR, 2010).

The SCOR model as mentioned earlier is based on three major principles: Process modeling, performance evaluation and process development. SCOR has 3 levels of process (APWPS, 2013), as mentioned on the above Fig. 5.

PLAN (P)

These are processes that relate to demand plan and planning collaboration with supply chain actors and partners with the involvement of customer in order to ensure accurate forecast and avoid demand variation with smooth leveled demand keeping standard process of communication through the global supply chain APWPS (2013).

SOURCE (S)

This step in the SCOR model consist on supplier panel with committed and planned quantities in order to be flexible and reactive toward customer demand and market variation, the material and procurement planning present here in this step a crucial part as its provide the right quantity at the right moment and place with the suitable price and quality (APWPS, 2013).

MAKE (M)

In this step and in order to meet customer demand it comes the execution and adding value to the received raw material to be transformed into finished good ensuring transportation and distribution till the final customer using the agreed and committed incoterm and part of responsibility in order to meet planned or actual demand, with a clear road map to fulfill customer as it must be support by a good planning and communication via supply chain partners (APWPS, 2013).

DELIVER (D)

Is the execution of deliveries following customer demand, with the involvement of distribution, transportation in order to meet customer delivery date and manage returnable with the suitable packaging and conditions customer requirements (APWPS, 2013).

The lower level process is Level 2 process which is classified by each type of products as follows:

- 1 = Make-to-stock
- 2 = Make-to-order
- 3 = Engineering-to-order
- 4 = Retail product
- S1: Sourcing of make-to-stock product
- M3: Manufacturing and production transformation

Level 3 which includes products storage and warehousing in order to keep a safety stock level to meet customer changes, variation and delivery date (APWPS, 2013).

Level 4 includes scheduling and collaborative planning via supply chain partners and ensuring received

material inspection to validate the product conformity (APWPS, 2013).

So for more details below Fig. 6 showing different SCOR steps and levels.

Case Study: Applied on the Company XYZ in the Automotive Sector

The SCOR Model as mentioned before is based on five processes of Plan, Source, Make, Deliver and Return. Using this reference model can provide a challenging and strategic tool for management and risk assessments through the Supply Chain of the company XYZ: Is a global automotive supplier producing wire harnesses, cables and components such as connectors and over-molding. With international coverage, 90% of its employees were outside the home country.

The company ranks among the largest worldwide automotive equipment, ranked 13th by the industry journal Automotive News in 2015.

The company's product lineup includes electrical cables, solar-powered systems, renewable energy, over-molding, molding, sub-assemblies... As a first tier supplier, which provides auto makers and, to a lesser extent, electric power, connectors, cables and general construction companies. And it is among the top 100 companies receiving the most US patents.

Our study is focalized on the company XYZ in order to measure, analyze and evaluate the different risks following the different concepts already mentioned on the previous paragraphs, so we will implement and define different processes with guideline for risk assessment and processes management.

Risk Assessment and Management Process

So in order to assess and manage the process risk identification many steps to follow as it mentioned on the Table 1 explains the different steps: First to understand the context and environment status, identify and classify risks. Second steps after risk identification this step provides the analysis and evaluation of risk, then the classification of major to lower risk impact on the activity of the company and finally implement procedures and system to be standardized as best practices.

Context Establishment

The context or the environment of our work will be the supply chain of the company XYZ. After modeling the supply chain using the SCOR model is able to understand the processes in general and the different relationships that exist between them.

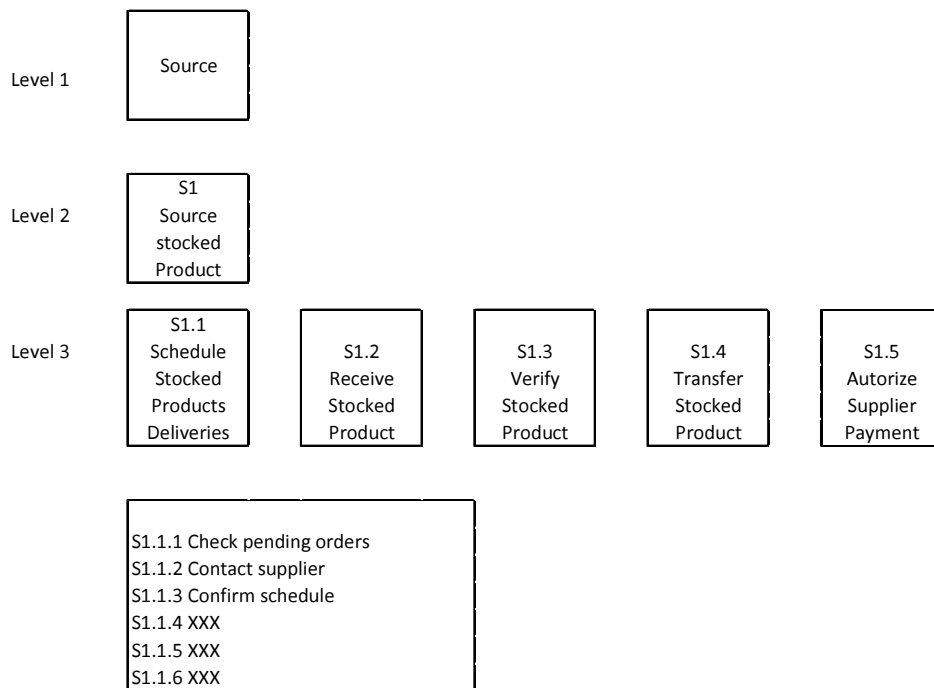


Fig. 6: Score steps and levels (Gulledge and Cavusoglu, 2014)

SCOR processes have unique identifiers:

- Level 1 processes are: *P, S, M, D* and *R*

- Level 2: *P1, S2, M3, D2, D4* Two groups of exceptions for level 2:

• Enable: *EP, ES, EM, ED* and *ER* (5 in total) and

• Return: *SR1, DR1, SR2, DR2, SR3, DR3* (6 in total)

- Level 3 processes: *P1.1, P1.2, S2.1, M1.5* and *D3.12* (111 processes in total) Two groups of exceptions for level 3:

• Enable: *EP.1, ES.3, EM.4, ED.8, ER.1* (47 in total)

• Return: *SR1.1, DR1.3, SR2.2, DR2.4, SR3.5, DR3.1* (27 in total)

X = level 1, *Xn* = level 2, *Xn.m* = level 3.

Table 1: Risk assessment and management process (Gulledge and Cavusoglu, 2014)

Risk assessment and management process	
Establish the context	Understand the operating context and environment
identify the risks	Identify the internal and external risks/hazards that poses threat
Analyze & Evaluate the risks	Analyze the risks to develop an understanding of the risk. Risk Analysis provides an input to Risk Evaluation, to decisions on wether risks need to be treated
Prioritize the risks	characterize and prioritize the list of risks for further action
Tackle the risks	Identify the range of options to tackle the risk & implement the best choice using available resources

Risk Identification and Evaluation

Following the SCOR model that has been developed before and after discussion, with Logistics manager, Planning Manager, Procurement Manager and Distribution Manager, to categorize the risks into the five areas of the supply chain: Plan, source, make, deliver and return:

- Manufacturing risks:

- Production activities not scheduled
- Bottlenecks
- Product not tested

- Manufacturing yield variability
- Forecast reliability
- dealing with waste disposal
- Delivery and shipment risks:
 - Order Not Received, Entered and Validated
 - No Reservation of Inventory and Determination of Delivery Date
 - Orders not included in forecasts
 - Error when Consolidating Orders
 - Damage of product during product pick and Loading

- Bottlenecks in Route Shipments
- Right Shipping Documents not generated
- Returnables risks:
 - Defective Product and MRO product Condition Not Identified
 - No schedule of return Defective Product Shipment and receiving
 - Return defective products not verified and transferred
- Plannification risks:
 - Not identify, prioritize and aggregate supply chain requirement/resources
 - Supply chain resources with requirements not balanced
 - Plans for the whole supply chain not established or communicated

Analyze and Evaluate the Risks

For analyzing potential failures and after identify the risks which is a major step which help to identify priority and risk classification to lead with risk triggers which impact the global supply chain performance so the high potential failures and risk is evaluated and measured using

the RPN which help to provide mode failure, triggers that impact supply chain and potential risks definition, occurrence with classification to handle the high triggers lead to risk occurrence using the formula below:

$$RPN = Occurrence\ score \times Severity\ score \times Detection\ Score \text{ (Issar and Navon, 2016)}$$

Major Steps of Risk Classification

The major steps for identification and risk classification to follow:

- Define the potential risks
- Rank and weight risk by factor impact
- Define the occurrence of the effect
- Define detection coefficient
- Calculation of the RPN
- Implement roadmap and action plan
- Standardization and implementation of best practices process (Issar and Navon, 2016)

After collecting all the necessary data to implement all the raking and calculation on the Table 2:

Table 2: Risk score values and calculated RPN

Risk	Occurrence	Severity	Detection	RPN
Supply Risks				
Variability in lead times	5	5	3	75
Unexpected scheduled parts in MRP	2	4	6	48
Raw material quality issue	2	5	4	40
change issue	4	3	2	24
Production risks				
Production activities no scheduled	1	7	1	7
Bottlenecks	2	3	10	60
Product not checked	5	6	3	90
Manufacturing issue	2	2	5	20
Forecast reliability	7	6	8	336
Dealing with waste disposal	9	5	4	180
Delivery risks				
Order not received./validated	5	9	2	90
DeliverY in delay	2	9	4	72
Damage of product during loading/unloading	5	5	5	125
Custums issue	5	3	6	90
route shipment issue	2	5	5	50
Documents issue	2	3	5	30
Weather and envirenment issue	8	5	4	160
Return risks				
Defective product and MRO product	3	4	6	72
Defective returnable	3	4	5	60
No schedule of return defective product	3	3	5	45
Planning risks				
Schedule/ customer order issue	3	5	3	45
Requirement not leveled	3	5	3	45
Communication issues	4	5	3	60

Table 3: Potential risk identification

Category of risks	Risk	Level of Risk	Mitigation strategies
Production Risk	• Forecast reliability	High	• Monitoring and creating reliable forecast. • Implementing quality management.
Delivery Risks	• Error when consolidating orders • Orders are not included in forecasts	High	• Making a categorization space for orders. • Improve EDI's reliability. • Continuous checking of orders.

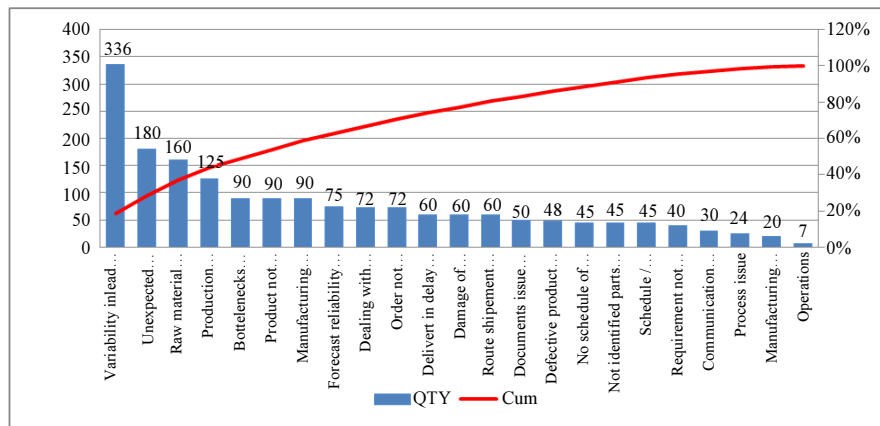


Fig. 7: Risk priority number's Pareto chart

Pareto Analysis

The Pareto analysis also known as the 80/20 classification it is based on the concept that 80% of a project benefit can come from doing 20% of the work. Conversely, 80% of a situation's problems can be related to 20% of the causes (Kaliszewski, 2014). The same goes here with the risks using the Pareto chart based on Risk Priority Number (RPN) to see the individual values in descending order and the cumulative total, as mentioned in the below Fig. 7 to identify the major triggers generating as source of risk.

According to the previous Fig. 7 which shows two out of the four highest risks are of production type risks. Forecast reliability and dealing with waste disposal. The other risks (error when consolidating orders and orders not included in forecast), related to customer changes, marketplace, forecast inaccuracy and changes in short-term.

A framework of risk evaluation for the company XYZ's supply chain is shown in the Table 3.

According to the global analysis basing on the Table 2, Fig. 7 and Table 3 we could conclude that the supply chain is always impacted by many risks: Supplier, manufacturing, production, warehouse, distribution, transportation, customer returnable, deliveries, customer variation in short-term, environmental effects which need to be handled and actions must be implemented in order to prevent any risks and standardize the way to lead with the triggers and decrease risk probability occurrence using preventive actions.

Results and Discussion

As mentioned previously the source identification of supply chain risks comes is the most import thing to be focused on, in parallel with deep analysis of the different processes and flow along the supply chain supported by a good planning from material acquisition, quality inspection, product conformity, manufacturing, production transformation until the final good and product distribution using the adequate transportation mode to ensure the right product on time and fulfill all customer orders including market variation and ensuring flexibility among the supply chain by using strategic methods and review management meeting as communication one of the best way for business growth and sustainable development, training peoples, keeping the same level of information between the supply chain actors from the supplier to the final customer (de Oliveira *et al.*, 2018).

Moreover, supply chain risk management is the best way to keep and maintain the global system inside the organization stable and standardized with best practices share (de Oliveira *et al.*, 2018).

Nevertheless, in light of this, the question arises: How could we control and have a clear customer order with accurate forecasts? And how collaboration could maintain a high level of relationship reflecting the VOC or voice of customer?

Another important aspect is how to keep the processes and procedures along the supply chain well controlled with best practice share and experience as way of good management review (de Oliveira *et al.*, 2018).

Conclusion

The aim of supply chain risk management is to provide a method and a clear roadmap of source identification, processes analysis, measurement and evaluation of supply chain risks, by providing also a processes approach that help to classify statically using a metrics qualitative evaluation using ranking method and weight for risk prioritizes and their potentials impact on the supply chain performance, flexibility and reactivity to ensure the customer order fulfillment and satisfaction avoiding the bullwhip effect from the supplier until the final customer which is always the driver of the global business.

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Author's Contributions

Mouad Ben-Faress: Provides all the intellectual inputs, designs, the acquisition, analysis, interpretation of data for the work, reviewing and approves the protocols to be followed in the study and responsible for the manuscript as it moves through the entire publication process.

Abdelmajid Elouadi: Data analyzing, manuscript correction, proof reading, provided technical assistant, support and substantial contributions to the conception.

Driss Gretete: Final approval of the version to be submitted, related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics

This research will contribute in my career development for both professional and academic levels and it may also help towards the advancement of human knowledge by adding something new and more creative.

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