

Investigating Logistics Risky Events - An Empirical Assessment Approach

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Abstract

This paper is aimed at formalizing a better comprehensive method to analyze and assess the main logistics risk factors (LRF) in a supply chain perspective. The empirical analysis is based on a survey with a sample of manufacturing companies conducted in the Moroccan pharmaceutical industry. This tries to enrich the existing literature on supply chain risk management by prioritizing several dimensions of LRFs. The results can be useful for both managers and researchers engaged in examining the design of supply chain risk analysis models, and by pointing out critical LRFs.

Keywords

Logistics Chain, Risk, Incident, Risk Matrix, Pharmaceutical Industry, Morocco

1. Introduction

In the current business environment, companies are more and more exposed to a diverse set of risks in operating their supply chains. Industries have witnessed a remarkable change in their business environment in particular due to increased competitive pressure and the globalization of markets (Thun and Hoenig 2011; Tazelaar & Snijders 2013; Zhao *et al.* 2013). Numerous researchers emphasize that as a consequence of this development which is characterized by a relatively unstable state of the world and an increased susceptibility of supply chains to disruptions, companies are compelled to tackle LRFs just as seriously as they tackle other business risks (Elkins *et al.* 2005). In 1983, Kraljic stressed the importance to consider the risks arising from interconnected flows of material, information and funds in inter-organizational networks. (Wagner and Bode 2009). These authors stated that companies are faced with managing these risks which adversely affect their capacity to efficiently serve the final customers. In this context, in spite of its negative impact, Khan and Burnes (2007) argue that risk is less understood in the area of supply chain management (SCM) than in other disciplines and less developed. Furthermore, although supply chain risk management (SCRM) has gained attention in the past years in academia, there is a need for empirical work in the field of SCRM analyzing the main LRFs (Jüttner and Ziegenbein 2009; Thun and Hoenig 2011).

The purpose of this paper is precisely to contribute to the enrichment of the corpus on SCRM, on which Sodhi *et al.* (2012) emphasize great promptness during this decade.

- The LRF meaning in the SCM sphere:

In view of the literature on SCRM, a few definitions of the notion of risk are suggested, amongst others, by Rao and Goldsby (2009) or Tang and Nurmaya Musa (2011). For example, Jüttner and Ziegenbein (2009) extends the construct of logistics risk and argues that risk in the supply chain centres around the disruption of flows between organizations. These flows relate to information, materials, products, and money. A key feature of LRF is that it extends beyond the boundaries of the single firm, and moreover, the boundary spanning flows can become a source of supply risks. In this article, the concept of "Logistics risk factor" refers to those little predictable disruptive incidents, affecting one or several partners in a supply chain and negatively impacting the achievement of organizations' goals.

- LRFs typology and characteristics:

In the process of LRF analysis, the identification step is often considered as fundamental (Kern *et al.* 2012). Through the recent literature about SCRM, we can identify a whole of LRFs related to the operations in the supply chains, and being able to harm the level of logistical performance. Although it is virtually impossible to list every

conceivable risk (Waters 2011), the LRFs faced by an organization can be classified in different ways depending on the criteria.

LRFs can, for example, be listed according to their origin, endogenous, exogenous (Trkman and McCormack 2009) or internal and external (Peck 2005; Thun and Hoenig 2011). In a supply chain, risks can be classified into two types: risks arising from within the supply chain network and risks external to it. For the former, the attributes are due to the interaction between firms across the entire supply chain network. This set of internal risks can encompass supply risk, demand risk, and trade credit risk for instance. External risks, on the other hand, arise from the interactions between the supply chain network and its environment (Faisal 2009, p.47). LRFs can also be classified regarding their scope : operational, catastrophic, bureaucratic and legal, economic, etc. (Wagner & Bode 2009; Behnezhad et al. 2013), or according to the process to which they refer: supply side, demand side, etc. (Jüttner and Ziegenbein 2009).

Regarding existing typologies of the LRFs, we adopted a classification into three families inspired from Tang and Tomlin (2008), Wagner and Bode (2009) and Sodhi *et al.* (2012). It successively analyzes the risks associated with management of the upstream supply chain (relations with suppliers), internal or operational risks (internal to the company), and the risks associated with management of the downstream supply chain (customer relationships). In terms of internal supply chain risks, cross- company-based risks and internal company risks can be differentiated. Internal company risks deal here with disruptions caused by problems within the organizational boundaries of the company such as machine breakdowns or IT functioning problems (Rice and Caniato 2003). These risks can be influenced or controlled by a company directly. Then, the adopted LRFs taxonomy can be summarized in the equation (1) below:

$$\text{Supply Chain LRF} = f(\text{UPLRF}_i, \text{ILRF}_i, \text{DLRF}_i) \quad (1)$$

One finds a relatively close vision in Pfohl *et al.* (2010) speaking about risks within a focal firm and risks outside of the company and within the supply chain. The authors add the risks outside of the supply chain that affect the focal firm, such as natural disasters or wars, which we will not discuss in this article. A recent synthesis is proposed by Behnezhad *et al.* (2013).

Moreover, every LRF has three main characteristics: a probability of occurrence, an impact and a level of criticality. The latter is the combination of the impact (effect or severity) and the likelihood occurrence of a LRF. In other words, criticality is related to the intensity of the incident when it occurs (Dani 2009).

- The Moroccan pharmaceutical industry:

As already announced, this research relates to the pharmaceutical supply chains Morocco. The interest in this branch of activity comes from both its importance in the national economy, and its fertility as a field of research in the SCM area. The pharmaceutical industry constitutes one of the pillars of Moroccan economy. In recent years, this sector has experienced a sustained growth, with a level of performance and expertise recognized by the World Health Organization (C.M.C. and S.I.S 2011; MMI 2013). Otherwise, the conformity of the production of the sector to the international standards of quality, including the “Good Manufacturing Practices” (GMPs), enabled companies to export more than 10% of their production towards European, Arabic and African countries. Additionally, Moroccan pharmaceutical sector is strongly regulated in all its aspects including, the creation, the functioning and the control of the industrial pharmaceutical establishments, the launches on the market and the prices of the medicines (C.M.C. and S.I.S 2011). However, in spite of its mentioned importance, this branch of industry is one of the least explored in research on SCM and SCRM in Morocco. To our knowledge, this research constitutes a first reflection on the LRF analysis and assessment within the national pharmaceutical industry, on the scale of the business sector.

2. Research methods and design

The empirical part of this article begins with a description of the research methods. The findings from the questionnaire survey are reported and the LRFs related to three classes are assessed.

2.1. Survey instrument and measures:

The empirical findings come from a questionnaire survey. The questionnaire is based on items composing three classes of LRFs (Table 1). The measurement of the variables employed 5-point Likert-type scales where possible employing items from existing scales drawn, for the majority, from previous researches. Upstream LRFs were measured using five items associated to the management of the upstream supply chain including suppliers and

economic conditions in the supply markets (Zsidisin *et al.* 2000; Svensson 2004). The internal LRFs were evaluated using three items related to the potential failures of infrastructure, whether for technical or human reasons (Rice and Caniato 2003; Thun and Hoenig 2011). Finally, downstream LRFs are linked to the management of the downstream supply chain. They are measured by four items related to the variability of the market downstream and the risks associated with the business relationship (Cavinato 2004; Spekman and Davis 2004; Svensson 2004). For each LRF, the respondents were asked to estimate the probability and the consequences concerning their company. The scale ranged from “never” to “always” for probability measurement; and from “no gravity” to “very serious consequences” for the impact.

Table 1: Questionnaire composition

LRFs Area	Upstream LRFs					Internal LRFs			Downstream LRFs			
Code	UPLRF					ILRF			DLRF			
Item number	1	2	3	4	5	1	2	3	1	2	3	4
Items	Supplier failure	Supplier products poor quality	Increasing in RM prices	Unpredictable Trade barrier	Upst. transportation failure	Machine breakdown	Outage of IT System	Accident	Unexp. demand fluctuations	Inventory shortage	Delivery chain disruptions	Decline in market prices

2.2. Empirical data collection:

Empirical data were collected through an electronic survey administered from October 2012 to January 2013 to a random quota sampling of 27 logistics and supply chain managers operating in pharmaceutical companies. The mailing and one follow-up generated 21 feedbacks and 18 usable responses, yielding a high response rate of about 67%. Indeed, in Morocco, there are 40 pharmaceutical laboratories (C.M.C. and S.I.S 2011). Therefore, our useful sample represents 45% of the total population. Figure 1 bellow shows general descriptions of the sample in terms of annual revenue and company size.

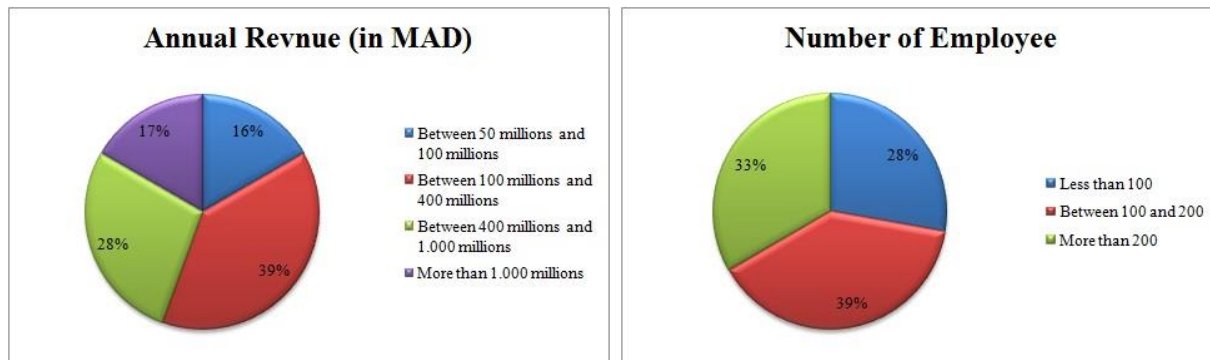


Figure 1: Sample structure and characteristics

As summarized in Figure 1, about 28% of the sample is composed by big companies with a revenue exceeding 400 M of MAD (*more than 48 940 Millions of USD*). 17% of the companies have an annual revenue of more than 1.000 millions of MAD. Likewise, more than 33% have a staff exceeding 200 people. As previously mentioned, our questions focus on the assessment of the selected LRF within the companies supply chains. In this perspective, a particular attention was paid to the features of likelihood and severity of these LRFs. Once the probabilities and levels of severity characterized, we will implement a useful tool to visualize the hierarchy of risks: the risk matrix. Finally, criticality diagrams were created in order to assess the criticality of LRFs involved in each stage of the supply chain. The statistical processing was performed using SPSS software (version 20.0) and MS Excel (version 2007). The results will be explained in the following paragraph.

3. Research results:

First of all, we have calculated the likelihood of occurrence and the impact of all the LRFs. Table 2 shows the impact and probability values (based on average means) for different LRFs relating to each stage.

3.1. Likelihood/probability analysis:

In order to assess the LRFs probabilities and impacts, the LRFs individual features from Table 2 are compared to the groups averages. First, in the upstream side, two LRFs have notable probability values: *Supplier failure* and *increasing in RM prices*. The two LRFs and *supplier quality problems* gain great impact values. Second, in the internal side, *malfunction of IT system* has a value exceeding impact average of its group. Third, concerning the downstream LRFs, *unexpected demand fluctuations* and *inventory shortage* achieve notable values both in terms of probability and impact.

Table 2: LRFs Occurrence and business impact values

	Code	Occurrence	Business Impact	SC Area Occurrence Average	SC Area Business Impact Average
Upstream activities	UPLRF1	3.1	3.9	2.6	3.8
	UPLRF2	2.5	4.4		
	UPLRF3	3.0	3.7		
	UPLRF4	2.3	3.5		
	UPLRF5	2.1	3.5		
Internal activities	ILRF1	2.1	3.0	2.1	3.0
	ILRF2	2.1	3.1		
	ILRF3	2.1	3.0		
Downstream activities	DLRF1	2.4	3.9	2.3	3.8
	DLRF2	2.8	4.1		
	DLRF3	2.2	3.6		
	DLRF4	1.9	3.4		

3.2. Logistics risks matrix:

In order to consolidate the empirical evidence concerning the potential LRFs the pharmaceutical supply chains are confronted with, the various LRFs are depicted in the *probability-impact matrix*. The LRFs can be visually compared regarding their probability of occurrence and their impact on the supply chain. Furthermore, the most critical risks can be identified. The risk matrix shows the overall picture of LRFs in the survey, with the probability increasing from left to right, and move towards the upper right corner, the greater is the LRF criticality (Figure 2).

As the figure illustrates, there are observable differences between LRFs. *Supplier quality problems* (UPLRF2) must be regarded as most grave LRF and *Supplier failure* (UPLRF1) and *increasing in RM prices* (UPLRF3) as most probable LRFs. *Unexpected demand fluctuations* (DLRF1), *delivery chain disruptions* (DLRF1), *decreasing market prices*, *unpredictable trade barrier* (UPLRF4) and *upstream transportation failure* (UPLRF5) are seen as severe LRFs but are less likely to occur. The highest probability values are observed in terms of *supplier failure* and *increasing raw material prices*. However, ILRFs have the least probability-impact positions.

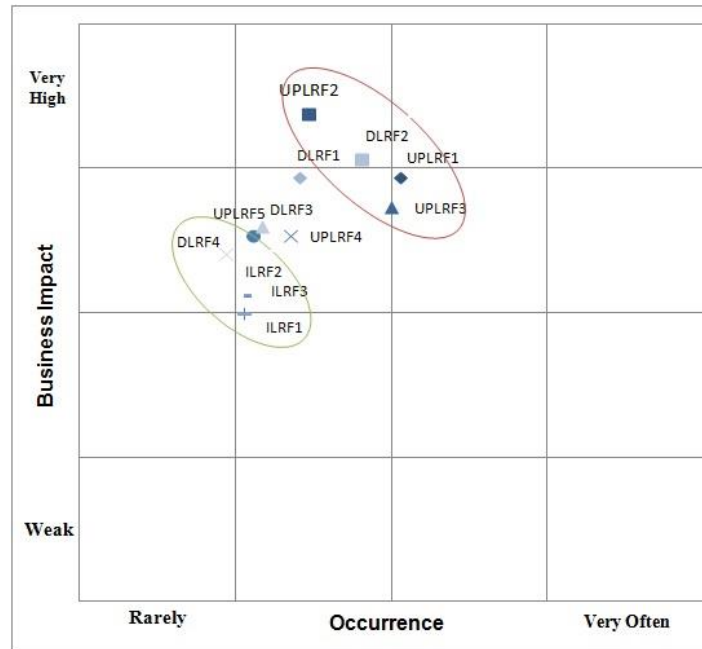


Figure 2: LRFs Matrix

3.3. LRFs criticality levels:

Concerning the criticality, it is a calculated variable. Based on the product of the averages of the probability of occurrence (POi) and the business impact (BIi), one can obtain the level of criticality (CTi) for each LRF (Dani 2009, p.54). In order to confirm previous findings, we calculated the LRFs levels of criticality. Figure 3 below indicates criticality levels for different LRFs studied. Five LRFs may be considered as critical (surpass average value which is 8.7). As it can be seen from Figure 3, *supplier failure*, *inventory shortage*, *increasing in RM prices*, *supplier quality problems* and *unexpected demand fluctuations* have the highest criticality levels. In addition, ILRFs i.e. *malfunction of IT system* (value of 6.4), *machine breakdown* and *work accidents with a same value* (6.2), have the lowest criticality levels. At a medium criticality level, we find *trade barriers*, *delivery chain disruptions*, and *upstream transportation non-performance*. Obviously, these results converge with our previous analyses about LRFs probability-impact matrix.

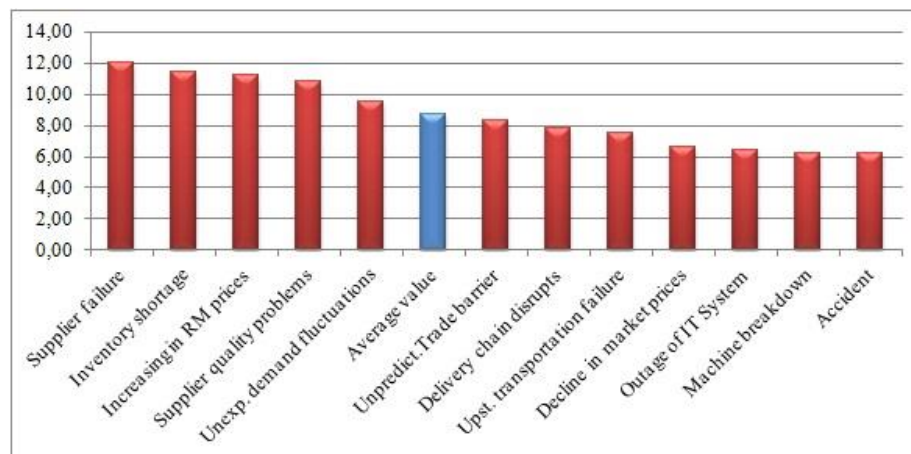


Figure 3: LRFs by levels of criticality

4. Discussion

This study aims to identify the LRFs that occur more frequently in pharmaceutical supply chains in Morocco and their severity in supply chain networks. It focuses on the real need of supply chain managers to be vigilant to the increasingly competitive global environment. To discuss the main results of this research, we first need to remind some essential features of the Moroccan pharmaceutical activity. On the one hand, Morocco has adopted a very rigorous pharmaceutical regulation. Consequently, the issues like drugs availability, their quality and their prices in the domestic market are rigorously monitored by Moroccan Ministry of Health. On the other hand, Moroccan pharmaceutical industry is mainly focused on the production, but the share of imported drugs is in steady growth. The distance of suppliers as well can thus be a source of risk. These elements may explain the fact that the majority of LRFs have low to medium probabilities of occurrence, but are estimated as serious to very serious. For example, a problem in supplier delivered products/raw materials is considered as the most grave. This severity may also originate company's dependence on global suppliers, which many authors consider as a supply chain vulnerability driver (Wagner and Neshat 2010). Also, a supplier failure, for example because of a weak logistical performance, or even a bankruptcy, is also regarded as the most critical LRF. Otherwise, increasing in RM prices (supply side) is estimated to be critical because the selling prices of drugs on the market are regulated and the sales margins are likely to be rigid. Indeed, only the Ministry of Health is able to set the prices of medicines and eventually to increase or to reduce them. Likewise, inventory shortage is not allowed for the medicine as a vital product. In spite of its relatively mastered probability of occurrence, this incident is considered as very serious. Nevertheless, decline in market prices (demand side) does not matter to pharmaceutical companies, because of the same cited regulatory control on prices.

From another point of view, the national pharmaceutical market is animated as much by domestic and international companies. The latter contribute for more than half of the total sales of the sector (C.M.C. and S.I.S 2011; MMI 2013). Moroccan pharmaceutical industrial and technological know-how is recognized on a world level and according to (C.M.C. and S.I.S 2011), Morocco is classified in Europe zone in terms of the quality of drugs. Accordingly, "obtained" values by ILRFs in terms of probability, impact and criticality, can be explained by companies infrastructure performance and the implementation of the GMPs. Thus, ILRFs are perceived as less grave, less probable and less critical; yet it is that *Machine breakdown* and *work accidents* are the lowest critical LRFs in the investigation results.

5. Managerial implication, concluding remarks and future Developments

The aim of this empirical investigation into pharmaceutical supply chains LRFs is to contribute to the current literature on supply-chain risk management by prioritizing several dimensions of pharmaceutical SCR risk factors. Our attention was focused on the main LRFs at three stages of the supply chain: upstream, internal and downstream. On a managerial level, our contribution represents a solution to estimate and assess the extent of a range of potential incidents throughout the three strands. In addition, the methods used in this paper can be useful for managers and researchers engaged in investigating the design of LRFs analysis models, as well by pointing out critical LRFs which should retain main attention in the pharmaceutical industry context. In the upstream supply chain, close working partnerships with suppliers can play a key role in firm survival and success in turbulent environments. In the downstream supply chain, supply chain managers may adopt strategies focusing on stockpile inventories as useful and practicable to minimize risk as long as disruptions do not affect stocks. In this context it is important to protect stocks from internal and external disruptions e.g. by decoupling or storing them outside of the danger area or in proximity to costumers (Hollstein and Himpel 2013). Future research could compare pharmaceutical supply chain concerns with of other supply chains and design a framework to supply chain managers to support their decisions concerning risk assessment within their supply chains. Besides, improved analysis can be made after assessing the LGRFs impact on supply chain performance. This work might help Moroccan pharmaceutical companies to design their risk strategies and methodology and to identify which LRFs largely impact their capacity to better serve their customers.

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