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A Quality Function Deployment approach for Production Resilience improvement in Supply Chain: Case of Agrifood Industry

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Abstract: Supply chains have become increasingly complex and extended. This context has been intensified especially with globalized market, sourcing, factory and facilities. Such an increase in organizational and operational complexity is driving companies to take account of new constraints that increase their vulnerability and make them more exposed to a multitude of risks. This paper aims to develop a methodology that help dealing with vulnerabilities and provide a procedure based quality function deployment to enhance the resilience capacities of supply chain. The empirical analysis is carried out through a real case study on agrifood supply chain.

Keywords: Resilience, vulnerability, supply chain, QFD, AHP, Ishikawa diagram

1. INTRODUCTION

Today business context is characterised by a complex dependency between organizations, coupled with intense market competition and growing demand for high quality, value-added and customised products requirements from customers, these factors have made supply chains more vulnerable and augmented the potential effects of disruptions to be proliferated throughout the different links of supply chains. This concept of vulnerability is widely dealt in supply chain literature. Bonnefous et al. (1997) define vulnerability as the status or the degree of fragility of a system. According to CRAIM (2007), "Vulnerability is the readiness with risk". Vulnerability is a constituent element of risk concept. In fact, according to Elleuch et al (2016), risk is the probability of loss given the occurrence of a hazard and the presence of vulnerable state in supply chain. Hazard or disturbance is defined as unexpected events occurring in a supply chain (Wu et al, 2007). E.g. a limited production capacity (vulnerable state) and a strong increasing demand (Hazard) lead to lost sale (Risk). The focus in this research is on the supply chain vulnerabilities.

To survive and to overcome these vulnerabilities, supply chains need to be resilient. Supply chain resilience has been defined by a number of authors harmoniously. Vugrin et al. (2011) define system resilience as the ability of a system to respond to a ‘disruption’ due to an event or set of events. Along the same vein Christopher et al. (2004), Ponomarov et al. (2009) and Jüttner et al. (2011) define supply chain resilience as the ‘capability of the supply chain to responds to disruptions and recover from them’. Azevedo et al. (2008) define supply chain resilience as the ability to return to its original state or to a more desirable state after a disturbance and to avoid the occurrence of failure modes. The empirical study of Pettit et al. (2013) show that resilience increase to offset the severity of vulnerabilities

Pettit et al. (2013) developed a supply chain resilience framework by identifying seven categories of vulnerabilities and creating supply chain capabilities along 14 areas (sourcing, order fulfilment, capacity development; among others). The authors surmise that current level of vulnerabilities and capabilities must be assessed in order to ascertain the current level of resilience. Literature emphasizes that developing resilience capability is vital for organizations. It enables organizations to improve system performance Schmitt et al. (2015); Vugrin et al. (2011), achieve sustainable competitive advantage (Ponomarov et al. 2009), gain market share in competitive environments (Sheffi et al. 2005), and decreases vulnerabilities Jüttner et al. (2011); Pettit et al. (2013); Pettit et al. (2010). Chowdhury et al. (2015) have developed a QFD approach for ranking resilient supply chain strategies for mitigating vulnerabilities with an application on general supply chains of three large ready-made garment companies.

The objective of this study is to develop a QFD approach to enhance agrifood supply chain resilience, by given a procedure for identifying the major risks in production supply chain, relative vulnerability factors that could lead to the occurrence of these risks and the potential resilience capacities that would mitigate the vulnerability factors in a global manner. The aim is also to investigate the relationships between vulnerability factors and resilience capacities and in the end prioritize the latter as solutions for agrifood industry.

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This study provides a contribution in the procedure of vulnerability identification and the application of the methodology on agrifood supply chain on production and operational link. After the introduction, the next section expose the procedure of the methodology and related steps in section 2, while Section 3 present the application following the methodology on the agrifood supply chain and explains the results and provides discussions. In the 4th and last section, conclusion and contributions of the study are discussed.

2. METHODOLOGY DESCRIPTION

The proposed methodology is based on four steps (Fig. 1), namely the identification of vulnerability factors in supply chain, the evaluation of vulnerability factors and selection of the most critical ones, the identification of potential resilience capacities and their prioritization as solutions for improving resilience in the agrifood production supply chain.

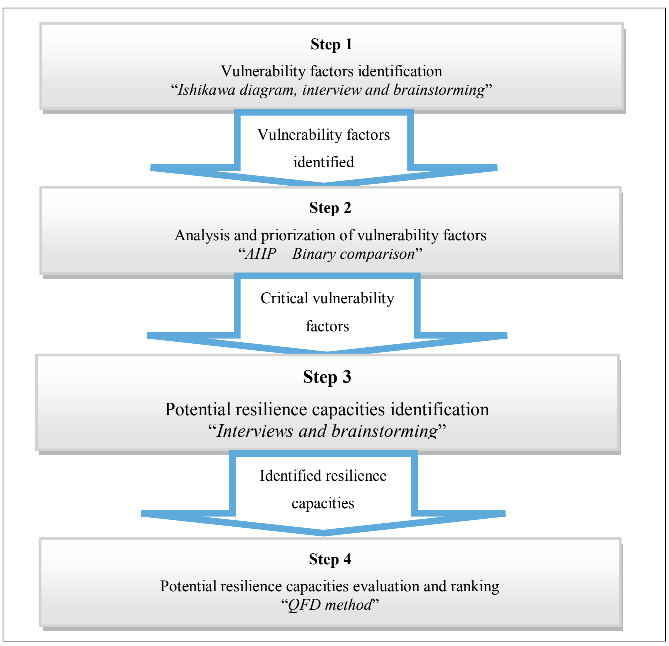

Fig. 1. Procedure for supply chain resilience enhancement

The first step consider the identification of vulnerability factors in the production supply chain. This step is achieved by interview and brainstorming with technical staff of the department. As risk is the consequence of the association of a vulnerability factor and a disturbance event, we plan to identify first the main risks that threaten the production supply chain and then earlier determine the vulnerability factors by applying Ishikawa diagram. As a result, a number of vulnerability factors is identified and then classified into the 5M of Ishikawa diagram namely raw material, working condition, management, material and workers. The second step consist of evaluating the severity of identified vulnerability factors. This step is achieved by applying the binary comparison of AHP method submitted to the director of the production department. As a result, we obtain a prioritisation of the vulnerability factors according to the level of severity and with their corresponding weight. The most critical vulnerability factors are selected based on the priority order and the preference of the director. The third step consider the identification of potential resilience capacities. This step is achieved by designating one or more than a resilience capacity to each selected vulnerability factor and based on the literature review covering the resilience capacities in supply chain. The potential resilience capacities identified are classified into the large classes raised in the literature such as flexibility, collaboration, efficiency etc. The last and fourth step consist of the application of the QFD method in order to translate the need to mitigate the vulnerability factors into a mitigation solutions called resilience capacities.

3. APPLICATION TO AGRIFOOD SUPPLY CHAIN

3.1 Agrifood supply chain: case of ALCO Company

The company ALCO denominated "ALiment COmposé" produce compound feed products for livestock with a production of 500 tons per day. ALCO Company has twelve compound feed products for cattle, ovine, cow, sheep, rabbits and poultry livestock. The supply chain of the ALCO company consists of three links ie the supply link that has the task of purchasing and storage of raw materials in the silos of the factory and storage depot of raw materials, then the generation that link its mission is the supply of raw materials from the enterprise storage depots, the production of compound feed and transfer in bulk or in bags to silos or deposits to the company's finished products. Finally, the distribution link that is dedicated marketing of foods made from farmers and agricultural cooperatives. In this research, the focus is on the production supply chain starting with the reception of raw material (RM) in depots and ending with storing end products (EP) in depots in bags or in bulk. Only physical and informational flows crossing the production supply chain are considered. Parts considered are shown in grey colour in Fig. 2.

The interviewed team consists of three executive members. The director of the factory, the operational chief and a monitor section.

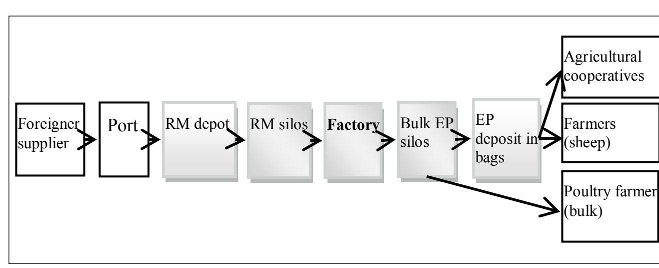

Fig. 2. Agrifood Production supply chain of ALCO Company

3.2 Supply chain vulnerability identification

Based on the interview with the interviewed team, two main risks were identified and represent the consequences that could happen for every existent vulnerability concerning the factory of ALCO Company. These risks are the impact on the quality of the compound feed and the slowdown or fall in production. Risk is the consequence of the association of a hazard event and the state of the system or the existent