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# Risk information formalisation with graphs

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ABSTRACT

The logistics is an essential economic activity that is intended to manage the physical and data flows (informative, customs and financial), in order to provide the resources corresponding to more or less determined needs in compliance with the specified economic and legal conditions (subject to the quality-of-service targets and the security and safety conditions are satisfactory). The links between formalized information, risk management in production logistics and adaptation to technological and market changes, are essential to industrial companies. In this paper, we have followed a structured approach, keeping within a formal risk management framework, for continually improving production logistics practices and procedures by experience feedback processes. The information derived from the risk assessment in production logistics is formalized by the conceptual graphs, permitting to ease the logical expressions and enhance the semantic quality of visual representation produced. The proposal is illustrated more clearly by a concrete case study of the production logistics adopted for aircraft manufacturing in an European Aeronautic Company.



## 1. Introduction

An industrial system, from a systemic point of view, is both an open system and a finalized system, meaning that it is conceived and managed according to some objectives. The objectives that can be assigned are numerous: the cost, the quality, the production volume, the delay and the sustainability. These objectives encountered can be classified into three main categories:

- Customer service improvement: understanding the needs, response time, quality and guidance provided.
- Cost control: the direct and indirect costs imposed on businesses.
- Productivity growth: the overall and individual productivity of the various actions.

The strategies of industrial systems that are intended to contribute to achieve these objectives can be challenging but their attainment helps to develop the economic potential and ensures the survival, protection and prosperity of the considered enterprises. This requires a level of productivity and profitability that is supported by the consistency and continuity of events occurring between the internal and external environments. In particular, there is a growing need for promoting good risk management practices [23] in order to anticipate and prevent all risks which may occur within the company and work continuously to eradicate them.

Risk management is defined as the identification, assessment, and prioritization of risks followed by the engagement of resources to treat (minimization or avoidance) and monitor the probability and/or impact of unfortunate events [13]. Furthermore, risk management is not limited to a purely static and negative outlook of these events. It also integrates a dynamic dimension showing a temporal distribution of the actions in the short, medium and long term with the options to exploit the realization of opportunities [19]. According to these constraints, the heart of the risk management is thus to find a suitable combination of provisional, preventive and curative actions, contributing to a significant reduction of the risks; and through the implementation of three main categories of risk analysis and assessment techniques (qualitative, quantitative, hybrid) [26].

In the industrial environment, within production logistics, the organization is often a full reflection on the way in which it could improve the means to achieve customer requirements and resources efficiency. Meanwhile, the production systems can operate in a constantly changing environment that causes the effect of uncertainty or hazards on target objectives (e.g. production rate of finished products). In this document, the selected domain of interest is ***production logistics*** that aims to

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ensure that each machine and workstation receive the right product in the right quantity and quality at the right time within a value- added system (e.g. a manufacturing unit or an industrial company) [28]. As the supply chain management encompasses all logistics management activities, the production logistics is a part of the supply chain that streamlines and controls the flow of things (goods and services) through value-added processes.

The core characteristics of supply chain risk can be classified in three main categories [18]:

- Risk-affected objective (efficiency and effectiveness),
- Risk exposition: disruptive triggers (triggering event and probability), time-based characteristics, and affected supply chain (vulnerability and resilience),
- Risk attitude (aversion, seeking, neutrality).

The risk exposition is particularly determined by the occurrence of a triggering event, as well as by time-based characteristics of the underpinning supply chain. Indeed, all the logistics associated with the production chain can be based on the importation of parts and tools from external suppliers. In such situations, there is an increase in the risk factors, particularly in terms of delays, non-compliance issues and damaged or missing parts. Add to this the internal factors of risks including the loss and damage of parts or tools, misunderstood requirements and overproduction. That is a disadvantage to the smooth functioning of the production systems of industrial companies and therefore with possible different risks, particularly in terms of the timetables and processes for delivery in the supply chain. Indeed, production logistics management is required to properly analyze the production chain and consider various risks to this chain in order to try to eliminate, minimize or overcome some of the generated drawbacks by reducing the vulnerability of enterprises.

The paper is structured as followed. Section 2 describes related research works. Section 3 exposes a process of risk management in production logistics with a focus on the risk identification and risk assessment. Section 4 presents the graph-based representation for a formalized description of risk information following identified production logistics risks and validates our approach with a real case study from the aeronautical industry. Section 5 provides a discussion on risk identification and assessment using formalization with conceptual graphs Finally, Section 6 gives the conclusion based on research findings and underlines some challenges.

## 2. Related works

According to standard ISO 31000 [17], risk management should be a systematic and structured process (including establishing the context, risk identification, risk assessment, risk control and risk monitoring), which is capable of continual improvement and enhancement. Risk management is of great interest to ensure continuity of production, proper supplies and the stability of the enterprise. In production logistics, each phase of the risk management process can be identified by the issues and questions that many researchers and engineers working in the field ask themselves:

- **Risk identification**: does it have a risk? What are the damages associated with risks in the enterprise and its partners? What is the impact on customers, on the organization, etc.?
- **Risk assessment**: what is the severity of a considered risk? What is the probability of a risk occurrence?
- **Risk control**: through the implementation of actions planned in the short, medium and longer term: how to master, contain and control a risk? By implementing techniques of prevention and protection measures (e.g. training of company personnel), it is possible to develop proper mitigation measures of a risk or shared it with some partners?
- **Risk monitoring**: What are the indicators to be put in place to monitor the evolution of risk and the effectiveness of a given action that was implemented?

This four-step process is cyclic and it may be supplemented, if necessary, by the **assessment of the residual risks** remaining after the risk response or after the application of risk mitigation measures. In spite of all the measures and precautions aimed at reducing a risk, what consequences should follow on from the occurrence of this risk?

The literature comprises several methods on risk assessment in the field of production logistics; only two of the most well-known methods will be described: the Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) [30]. FMEA is a method that thoroughly analyses the elements and their failure mode features to assess risk and reliability in production systems. It begins by the decomposition of the system into subsystems. This method identifies and evaluates all potential causes that may be sources of error to determine the effect they have at the element level. However, it does not clearly integrate element interactions but relies only on experienced knowledge.

FTA describes event itineraries from failure root causes to top-level consequences. This method is applied in the production system to guarantee the safety and improve the reliability of product development. FTA is intend to permit an actor to detect all serious routes that might lead to an undesirable event such as system malfunction or failure. Nevertheless, FTA also particularly depends on knowledge and experiences of stakeholders that are working in the target system. The collaborations and dynamics of the performance requirements are not sufficiently apprehended for supporting the principles of supply chain resilience in complex organizations of enterprises [20]. In practice, complex systems require means to supplement and reinforce the performance impact of their supplier integration operations through production logistics risk management policies in risky environments [40]. Furthermore, with the increased competition among the production logistics of organizations, modelling is important for analysing the level of maturity in enterprise risk management in complex international companies [29]. Such large companies have to comply with security initiatives and build a higher level of safety measures to reduce the frequency of supply chain disruption occurrences [32]. In an environment of networked enterprises, it is admitted that the identification and management of these supply chain disruptions and risks is therefore crucial for the effective management of production logistics [12]. Effective management of supply chain risks requires a comprehensive yet rapid assessment of internal and external sources of risk events in the supply chain and their potential impacts in complex production systems (e.g. manufacturing system) [1]. Simulation and optimization models can be combined through some iterative procedures to achieve the best values for risk reduction by selecting a combination of mitigation strategies [2]. It is significant that most of the existing methodologies of risk management in production logistics lack inbuilt and practical techniques that take into consideration the complex interactions and dynamic feedback properties, which can meaningfully affect the reliability of risk management results [25].

In the following section, a methodological approach is presented with three steps including risk identification, risk assessment and risk treatment. This methodological approach provides an information formalization for influencing factors in risk management for production logistics.