A Discrete-event Simulation Model for Supporting the First-tier Supplier Decision-Making in a UK's Automotive Industry

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ABSTRACT
The automotive supply chain industry is characterised for a well-known hierarchical structure, where manufactures exchange partially their forecasting with their first-tier suppliers as a requirements demand, which implies in the most of the cases that suppliers must be prepared for handling a variety of potential requirements. Moreover, considering technological tools for handling such variety are crucial for managing efficiently the decision-making in this domain. Therefore, this paper presents a simulation-based model to support the resource allocation decision-making process in a real automotive first-tier supplier UK company. Results shown that operations management is enhanced across the selected first-tier supplier by reducing the reworks, which leads to achieve its production targets.

Keywords: Conceptual modelling, Simulation, automotive industry, decision-making, supply chain.

1. Introduction

Current globalisation phenomenon trends are implying that manufacturing management is moving towards strategic changes from local to global levels [10]. In this case, Just- In- Time (JIT) or lean manufacturing are required at production sites, which looks at well-managed information exchange synchronisation and material flow collaborations for activities among different tiers of suppliers and customers [4]. According to [8], companies that waged the achievement for JIT activities for three to five years have experienced a reduction cost of 20% to 40% of sales revenue due to a poor product quality. One of the well-positioned and representative industries that requires huge efforts in coordination the whole tiers in the supply chain is the automotive industry [3]. In this domain suppliers decision-makers should thusly make efforts to support the optimisation of the company's supply chain activities in different stages of the operations processes, this within a view of running the business in a more profitable way. In a fact, as established by [7], simulation models are suggested for handling a variety of scenarios, since they might help to achieve the optimal cost-effective network design. Hence, and for the purpose of supporting the first-tier supplier decision-making, a discrete-event simulation-based model is considered for modelling the main manufacturing processes in an automotive industry in UK. For handling this endeavour, the following structure is considered. In the first place, a background is addressed for realising the key automotive supply chain decisions as well as to realise how simulation approaches can be considered in this kind of domain. Secondly, the simulation based modelling methodology is covered with a view of its real implementation. Next, the real case study for the UK's automotive supply chain is described and the main experiments are tested. Finally, the main conclusions and further research are covered.

2. Background

2.1 Decision-Making in supply chains

By the 1990s, when the concept of supply chain was arising, decision-makers were well experienced in mathematical and statistical techniques such as utility analysis, operations research, decision matrices and probabilistic

decision trees. One of the main decisions in this industry was the selection of resource systems. These systems normally covers these requisites in different ways and not always considering all of them [15]. In fact, the best system approach for managing the organisations, within a supply context, should be decided by decision-makers using various methodologies. In this context, [14] propose different decision-making approaches which will be appropriate for different sort of analysis requirements, such as: process models, structural models, empirical methods and solutions. In a fact, [9] establishes that by supplying an adaptive problem-solving solution to a worker will help the business enterprise improve service and quality. Therefore, decision-making processes in supply chains can be covered from different perspectives and approached. One of the most well-known and relevant approaches are the simulation-based models, which combines process, structure and empirical approaches. This is approach is briefly described and analysed in the following section within a practical view in automotive supply chains.

2.2 Simulation modelling in the automotive industry

A production line is a bounded system that is dedicated to manufacture one or several standardised parts [16]. This system has an identifiable material flow, which remains the same each time that a new part is manufactured. Simulation modelling has demonstrated to be useful and applicable to almost any assembly or manufacturing production line including those of the automotive industry. In this context, simulation has become a powerful tool that is starting to be widely used in the main automotive companies and their suppliers. According to [19], the main generic applications of discrete-event simulation in the automotive industry are: (a) the designing of manufacturing system in its conceptual stage and testing operational policies during the launching phase; (b) the assessing of the performance of the manufacturing site when it is operating; and (c) Determining causes and solutions of operational problems that are affecting or might affect the desired performance of a manufacturing site.

In this context, [19] describe different case studies in which simulation modelling was applied in some major and small component plants. Some outstanding examples are the following:

Design of conveyor systems: simulation was used in an automotive assembly line to design a power and free conveyor. This conveyor was required to move a minimum number of carriers so that the manufacturing line could achieve its daily throughput.

Design of material handling systems: simulation was used in a stamping plant in order to determine the best possible material handling system and its policies. As a result, the plant was able to evaluate buffer space requirements.

Identification of bottlenecks in an instrument panel assembly line: Simulation was used to evaluate different ways in which the line could be arranged and the number of pallets needed to obtain the maximum output.

As it has been discussed, simulation modelling has several applications in the automotive industry. In fact, some of the first computer based simulations were carried out in this sector [19]. The possible reason for it is that the automotive industry requires high investments of money each time that a new plant, vehicle or assembly line is launched. Hence, simulation modelling can be seen as a powerful tool to design, assess and redefine processes within, especially in complex and dynamic environments such as the automotive industry.

2.3 Relevant discrete event based tool

The majority of the current simulation software packages are known as "Visual Interactive Modelling" [5]. This means that the model can be built as an animated representation that will show how the movement of the elements are actually deployed. Furthermore, the model can be built in several steps, can be changed at any of those steps, and can be tested when any of its variables are modified. The most common simulation software packages are Arena, AutoMod and Witness [10]. Regarding to this, Table 1 shows the main characteristics of the aforementioned software packages ([1]; [18]; [12]; [17] and [9]).