The effect of Lean implementation on the efficiency and effectiveness of new product development processes

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Key words: Lean product development, Efficiency, Effectiveness, System Dynamics Modelling

The management discipline of the paper: Operations management

Research methodology:

This paper is a part of my PhD project and introduces the System Dynamics Modelling of Lean product development. It briefly explains the literature review phase of the project and the first stages of System Dynamics Modelling. After finishing the modelling process, model will be validated using a qualitative approach.

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Balancing the efficiency and effectiveness of new product development through implementation of Lean principles

Abstract:

Although increasing the new product development speed and improving its cost effectiveness as well as enhancing the process quality have been at the centre of attention of many companies, there is still significant opposition to the 'better, faster and cheaper' paradigm. Improvement of new product development processes using Lean principles has been claimed to be an effective way to reach to this goal. In this conceptual paper, first the efficiency and effectiveness in new product development processes and the key components of Lean product development has been defined, then, an introduction to modelling the process based on System Dynamics, to develop the interrelationships between Lean components and performance measures, has been discussed.

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Research purpose:

The main aim of this research is to develop an innovative model to support manufacturing companies in implementing Lean in their new product development processes by focusing on improving both the efficiency and effectiveness of processes. This aim is in response to the overall research question: how different is Lean implementation for innovative and knowledge-intensive environments such as new product development? By combining Lean product development principles and practices the model is expected to help companies in developing more customer-focused and innovative new products with better quality, while reducing time-to-market and development costs. To reach to the answer of the general research question it is divided into three sub-questions as shown in figure 1.

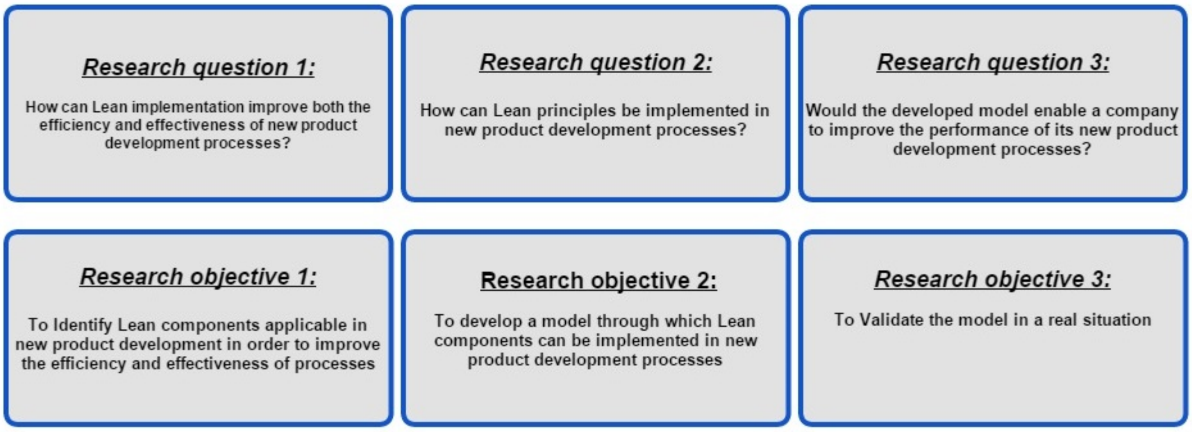

Figure 1: Research questions aligned with objectives

Efficiency and effectiveness in new product development

By viewing the new product development as a transformation process which uses allocated resources to produce a definite output, its performance can be translated as the efficiency and effectiveness of the purposeful action (Neely, Gregory and Platts 2005). As Tangen (2005) mentioned most researchers agree that the main difference between these two concepts is that the efficiency is input oriented and relates to the internal performance of a process while the effectiveness is about the results and output oriented, so links to the external performance. Efficiency as defined by Neely, Gregory and Platts (2005) is the measure of economically utilization of a firm’s resources in order to provide a certain level of customer satisfaction. On the other side, effectiveness of new product development processes is very difficult to quantify in most cases because as Neely, Gregory and Platts (2005) argued it is about the extent to which customer requirements are being met. Despite efficiency, effectiveness is about the outcomes, results and the ability of a firm to reach a desired objective or the degree to which a desired results are achieved (Tangen 2005). It is the combination of high values of efficiency and effectiveness in a transformation process such as new product development which leads to higher achievements.

To be applicable from industrial perspective, performance measures should be dynamic (Yazdani 2000). Most of researchers have selected the parameters of time, cost and quality as the dynamic measures for the performance of development processes in companies. For instance, Smith and Reinertsen (1998) mentioned that there are four objectives, to name, development speed, product cost, product performance and development expense, which should be measured in the management of new product development processes. They indicated the existence of trade-offs between these objectives, which should be modelled based on specific company conditions and the economic balance to allow managers to make dynamic decisions at project and company level. Similarly, Clarks and Fujimoto (1991) identified lead time, productivity, and total product quality as the performance dimensions based on long term competitiveness of new product development processes. In this research a combination of measures proposed by Clark and Fujimoto (1991), and Smith and Reinertsen (1998) have been used which have formed a basis for the process of modelling.

1- Development speed which is the key component of time-based strategy and has become increasingly important for managing new product development processes in a fast-changing business environment (Chen, Damanpour and Reilly 2010).
2- Productivity which is the level of resource consumption, including engineering hours worked, and the cost of equipment, services, and materials used mainly for prototype construction and testing, required to take the project from concept to commercial product.

These two factors are measures of the efficiency of the new product development processes.

3- Product quality which is defined as the degree of match between the final design ready to be manufactured, and approved product concept from the point of view of performance, aesthetics, style and experience (perceived quality). It is a measure of the effectiveness of the new product development processes.

Key components of Lean product development

Applying Lean concepts to technical and engineering operations, such as new product development, where work is less repetitive than the manufacturing and the product is less tangible, is not straightforward (Liker and Morgan 2006). Additionally, since components and structures that have been found to support an efficient and effective new product development process show only few similarities between manufacturing and product development (Haque and Moore 2004), most of the authors, instead of just adopting tools from the manufacturing, have taken the approach of investigating and identifying best practices in the field of new product development, mainly from Toyota, that leverage the benefits of Lean principles. By acknowledging Toyota as the origin of Lean thinking and identifying two completely different approaches in Toyota production system (TPS) and Toyota product development system (TPDS), and based on the models and frameworks proposed by different researchers, including Karlsson and Åhlström (1996), Morgan and Liker (2006), Ward (2007), Cooper and Edgett (2008), Hoppmann, et al. (2011), and Khan et al. (2013) following key components for Lean product development can be defined.

1- Concurrent (simultaneous) engineering
2- Customer focus
3- Chief engineer system
4- Process and product standardization
5- Set-based design
6- Supplier integration

System dynamics modelling:

Lean product development includes interrelated components as elements of a coherent system (Karlsson and Åhlström 1996, Morgan and Liker 2006, Hoppmann, et al. 2011), and each component has a unique effect on the parameters of performance. An accurate way to understand these effects is by performing experiments in the real world, which may be very expensive, time consuming and even risky if the decision is proved wrong. Compared to real experimentation, modelling has lower cost, and is faster, safer and more legally compatible while it is also possible to replicate the same conditions in order to repeat the simulation with any combination of decisions (Pidd, 1998 in Galanakis 2002).

System dynamics modelling aims to describe the system, understand the effect of feedback loops on system's behaviour, and design vigorous information feedback structures and control policies through simulation and optimisation (Galanakis 2002). In this modelling approach connections between different system elements and their behaviour are at the centre of study, and the changes in policies are being designed based on the feedback structures and the system's response to feedbacks (Pidd, 1996 in Galanakis 2002). A five-stage approach, suggested by Sterman (2000), to understand, control and improve a system in System Dynamics Modelling has been adapted for this research as shown in figure (2). The preliminary steps of the modelling process will briefly described in the rest of this section.

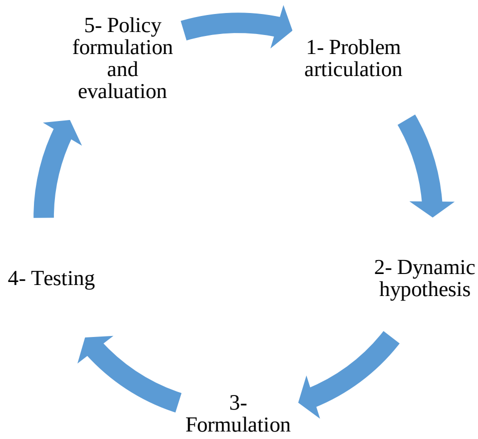

Figure 2: The process of system dynamics modelling

There is no consensus on the way that development speed, productivity and product quality as three interrelated characteristics of the performance in new product development behave over time. While some argued that there is a trade-off between these factors in a way that emphasising on each of them based on the strategy of the company will necessarily have a negative effect on other factors (for example, between development speed and product quality (Harter, Krishnan and Slaughter 2000, Calantone and Di Benedetto 2000), or development speed and cost (Crawford 1992, Gupta, Brockhoff and Weisenfeld 1992)), some researchers, mainly based on the evidence from the Japanese companies, claimed that it is possible to increase the development speed and reduce the cost of the process while still the final product is of higher quality compared with competitors (Womack, Jones and Roos 1990, Clark and Fujimoto 1991, Wheelwright and Clark 1992). Based on the first principle of system thinking as Senge (1993) defined "structure influences behaviour", so as the first step in System Dynamics Modelling the problem could be articulated based on finding a process structure in new product development which satisfy the latter view.

In the second step, it is needed to determine the reference mode to show the expected pattern of behaviour for productivity and product quality as a result of increasing development speed over a period of time (figure (3)). It will help to define the simplest structure that is sensible and capable of generating patterns of behaviour that qualitatively resemble the reference mode.

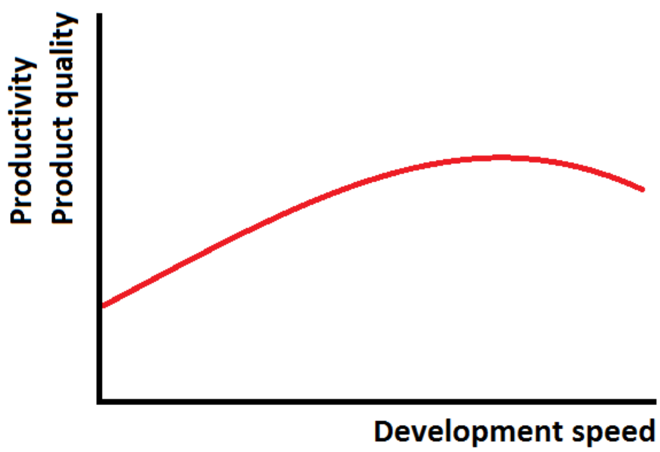

Figure 3: The expected pattern of behaviour of the performance parameters

The main goal of the modelling is to show and formulate the way interrelationships between performance measures result in a behaviour such as what has been shown in the reference mode. The reference mode includes three variables which need to be present in the model. A dynamics hypothesis, which is an idea or theory about the structure that might be capable of generating behaviour like that in the reference modes, should be formulated by thinking about how the variables in the reference mode are connected. Dynamics hypothesis could be verbalized as: “increasing the development speed to an optimum point because of implementing Lean in new product development processes will result in higher process productivity and product quality”. To complete the development of the dynamics hypothesis and become ready to formulate the simulation model it is needed to represent the causal structure between the process components and performance metrics, using tools such as causal loop diagrams and stock and flow maps. A basic idea for the causal loop modelling of the process has been presented in figure 4.

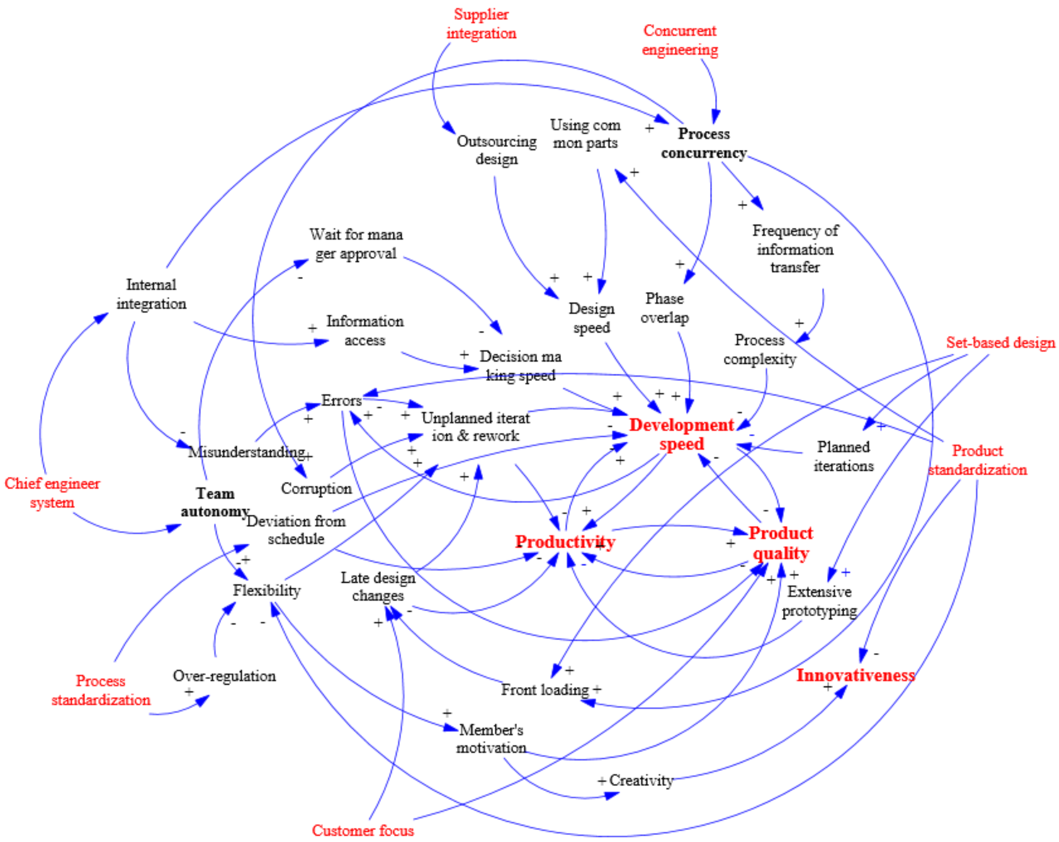

Figure 4: Causal loop diagram of Lean product development

Conclusion and the future plan:

Despite committed employees and innovative products, organizations always break down just because of their inability to pull their functions and talented individuals into a productive whole. System thinking is a discipline to see wholes rather than parts, and dynamic interrelations rather than static snapshots

(Senge 1993). Seeing wholes will allow managers to understand the structures that underline complex situations. Improving quality, reducing costs and time, and satisfying customers in a sustainable way, through implementing innovative approaches, such as Lean thinking, in new product development processes is a dynamic problem which requires a holistic view on the system elements and their interrelationships. To answer the main research question, using system dynamics approach which requires the intense use of qualitative data and human judgment in all stages of model development, a model which relates different Lean components to performance metrics, such as process speed, productivity and quality, should be constructed. Defining the relationships and estimating the dynamic behaviour of performance measures will guide the research towards finding the optimal balance between different performance measures. The validated model could be used by managers to predict the effect of different policies on different aspects of performance in new product development processes, and will help them to design improvement policies.

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