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Team based labour assignment methodology for new product development projects

Serdar Baysan *, M. Bulent Durmusoglu, Didem Cinar

Department of Industrial Engineering, Faculty of Management, Istanbul Technical University, Istanbul, Turkey

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ABSTRACT

This study explores the organizational aspects of new product development projects and proposes a new team-based labour assignment methodology. The proposed hierarchical methodology focusses on the project value stream and aims to shorten lead time through waste reduction. Lean product development tools, such as clustering and design structure matrix tools, are integrated with the methodology. A detailed real-life case study is presented and the proposed methodology is evaluated using discrete event simulation. Experiment results show that the proposed methodology and team-based structure provide superior lead time performance when compared to conventional organizational setting. This study contributes to existing literature by presenting evidence of the effect of teams on NPD lead time performance.

1. Introduction

New product development (NPD) is the set of processes used to transform an opportunity or a concept to a product. A primary concern of NPD is NPD lead time–that is, the time it takes from recognizing and formulating an opportunity in the market to introducing that product to the market. NPD lead time is of interest because it is an important differentiator in the competition, and because design costs accumulate as development time expands. The objective of NPD lead time reduction extends beyond the scope of classical trade-off analysis, as it requires a simultaneous reduction of lead time, cost and engineering hours. A key issue with NPD lead time reduction is that NPD is iterative and highly variable in nature and requires cross-functional collaboration.

A proper labour assignment method will increase the design process performance, simplify management efforts, and increase workforce morale by incorporating accountability and structured team work. This study proposes a team-based labour assignment methodology to reduce NPD lead time and increase conformance to takt time with no additional working hours and with low cost. A framework for the design and implementation of the proposed team-based labour assignment methodology is described. This proposed methodology simultaneously utilizes a design structure matrix (DSM) to observe and alter dependencies among activities and Value Stream Mapping (VSM) to focus improvement efforts on concept-to-market lead time. To the best of the authors' knowledge, the proposed methodology is the first attempt to incorporate the VSM tool of lean management and the DSM tool of design management. Also, this study contributes to the literature by using these tools, together or separately, for a labour assignment problem. A real-life case study is presented to analyze the impact of the proposed team-based organizational setting. The performance of "a team of experts-multiple tasks setting" is compared with the conventional "single expert-multiple task setting" with the case study.

The proposed methodology is applicable to a wide range of new product development environments. For industries like the pharmaceutical or defense industries, lead time has less priority than other performance measures. For these industries, project lead time may well exceed 10 years. Thus, takt time is not applicable for these industries. In this regard, industries and new product systems with high work-in-process and relatively low takt time -such as automotive and electronics- have an improvement potential with the implementation of this methodology.

The noteworthy contributions of this study to the product development literature can be summarized as follows: (1) a coherent methodology with clear implementation guidelines is provided, (2) lean product development tools are integrated with existing techniques in a framework, (3) a detailed case study is reported concerning transformation from a conventional individual assignment setting to team-based assignment.

* Corresponding author.
E-mail addresses: baysans@itu.edu.tr (S. Baysan), durmusoglum@itu.edu.tr (M.B. Durmusoglu), cinard@itu.edu.tr (D. Cinar).

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The remaining part of the paper proceeds as follows. A literature review on new product development and team-based labour assignment is given in Section 2. In Section 3, the proposed methodology will be explained in detail. A real-life case study will be presented in Section 4. The final chapter will give a brief summary and critique of the results, and also provide a discussion of future research.

2. Literature review

2.1. New product development

Factors affecting NPD lead time and effects of NPD practices have been investigated in several studies. The majority of them are empirical research or reports on case studies. Kušar, Duhovnik, Grum, and Starbek (2004) reported a 52% reduction in lead time by using concurrent engineering, instead of sequential engineering (Kušar et al., 2004). Meybodi (2003), based on data from 51 companies, reported that companies adapting JIT (Just-in-Time) principles to their NPD processes develop new products with 52% less development time. Meybodi (2005) later extended the survey to include a total of 500 organizations and reported a 61% shorter development time for organizations who adapted JIT principles. Wang and Hwang (2005) evaluated the impact of overlapping activities through a mathematical model and concluded that the early resolution of uncertainty, and the low amount of rework required to conform to the change in the upstream, will result in shorter lead time. Herrmann and Chincholkar (2001) applied a design for production (DFP) approach which includes design guidelines, capacity analysis and estimation of throughput times using queueing networks. They showed that if it is introduced in the early stages, DFP reduces NPD lead time. Danese and Flippini (2010) reported that modularity has a positive effect on NPD time performance, based on a data analysis including 186 manufacturing plants. Everaert and Bruggeman (2002) investigated the effects of imposing cost targets. Through a series of controlled experiments, they concluded that complying to high time pressure and achieving cost targets are conflicting objectives, but under low time pressure it is possible to achieve the cost targets (Everaert & Bruggeman, 2002). In the same vein, Afonso, Nunes, Paisana, and Braga (2008), based on an empirical study of Portuguese firms, stated that target costs contribute to new product success. Samra, Lynn, and Reilly (2008) studied the effect of improvisation, and based on a survey of 392 NPD managers, concluded that through a structured process improvisation positively affects both speed and success.

Besides data analysis, analytical modelling is also used to investigate the factors affecting the NPD lead time. Narahari and Viswanadham (1999) used queuing network models to evaluate several scheduling alternatives and lead time reduction strategies. Viswanadham and Narahari (2001) applied queueing network analysis to pharmaceutical drug development, and showed that a fluctuation smoothing technique reduces lead time without any additional resources. Moreover, it is inferred that critical mass which is similar to cross-functional teams, but in the context of drug development, reduces the lead time. Dragut and Bertnard (2008) developed a representation model for the solving-time distribution using queuing systems for design tasks. Abdelsalam and Bao (2006) proposed a simulation-based optimization framework to determine the process sequences in order to minimize the project duration. Bassett, Gardner, and Steele (2004) developed a mixed integer programming model and proposed a simulation-based heuristic for scheduling NPD process. Koyuncu and Erol (2015) proposed a particle swarm optimization based algorithm and developed a software for scheduling NPD projects having overlapping activities. Wang and Lin (2009) proposed an overlapping process model and developed a simulation algorithm to investigate the influence of process structure on the new project development lead time. Yang, Zhao, and Lan (2014) analyzed the impacts of risk attitudes on the wage contract mechanisms by using uncertain principal agent models and characterized the information value of the idea and the effort.

There is a large volume of literature about project scheduling which includes a generalised problem of lead time reduction. Several studies use lead time minimization as the primary objective for a single project scheduling case (Boctor, 1993; Chen, Khoo, & Jiao, 2002; Cho & Eppinger, 2005; Chua & Hossain, 2011; Lova, Tormos, Cervantes, & Barber, 2009; Mori & Tseng, 1997; Zhang, 2012). On the other hand, project scheduling literature is relatively scarce on the issue of lead time minimization for multiple project settings (Elazouni, 2009; Gonçalves, Mendes, & Resende, 2008; Kara, Kayis, & Kaebernick, 2001; Xue, Wei, & Wang, 2010). Together, these studies provide insights and means to reduce NPD lead time. Yet, no structured road map is provided.

2.2. Team-based labour assignment

Team-based practices have been extolled to achieve lean manufacturing and improve integrated system performance (Fitzpatrick & Askin, 2005). Cellular manufacturing (Agustín-Blas et al., 2011; Aleisa, Suresh, & Lin, 2011; Askin & Huang, 2001; Suresh & Slomp, 2001), office cells (Durmusoglu & Kulak, 2008) and assembly systems (Bukchin & Masin, 2004; Cevikcan, Durmusoglu, & Unal, 2009; Dimitriadis, 2006) are some of the areas in which a team-based labour assignment has been applied.

In NPD literature, only a few studies aimed to rationalize the team-based organization and there is no study that compares team-based organizational and conventional organizational settings. Griffin (1997) reported that cross-functional teams effectively reduce product development time. Durmuşoğlu (2013) performed a conceptual study to investigate the intrafirm social relational structures and the effect of the task advice interactions of NPD teams on NPD outcomes. Based on 130 development projects, Swink (2002) inferred that co-location or isolation of project development teams have a negative effect on project timeliness. Patanakul et al. (2012) investigated the effect of autonomous teams on NPD. According to the results obtained from 555 NPD projects, autonomous teams are more effective for projects with high technology novelty or radical innovation than other team structures. Based on 93 NPD projects in Turkey, Dayan and Di Benedetto (2010) investigated the factors effecting the interpersonal trust and the impact of interpersonal trust in NPD teams. Interpersonal trust has an impact on team learning and new product success when there is higher task complexity, but has no impact on speed-to-market.

LaBahn, Ali, and Krapfel (1996) analyzed 188 NPD projects and pointed out that outsider involvement complicates product development and lengthens the product development lead time. Likewise, Swink (2003) reported that utilizing additional human resources in a project may negatively affect the on-time performance due to increased complexity, unless these additional human resources are employed strategically.

Considering 107 NPD teams from Taiwanese high-technology small and medium-sized enterprises, Chang et al. (2011) inferred that the complex organizational structure is preferable for managing the knowledge conversion of NPD. Carbonell and Rodriguez-Escudero (2013) examined the relations between management controls and job satisfaction for NPD teams. The results obtained from 197 NPD projects showed that professional and output controls has more positive effect on NPD teams than process controls. Moreover, participative decision making moderates the