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► To cite this version:

Youcef J-T. Zidane, Asbjørn Rolstadås, Agnar Johansen, Anandasivakumar Ekambaram, Pavan Kumar Sriram. “The Fast and the Fantastic” Time-Cost Trade-Offs in New Product Development vs. Construction Projects. IFIP International Conference on Advances in Production Management Systems (APMS), Sep 2015, Tokyo, Japan. pp.589-597, 10.1007/978-3-319-22756-6_72 . hal-01417621

HAL Id: hal-01417621

<https://hal.science/hal-01417621v1>

Submitted on 15 Dec 2016

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“The Fast and the Fantastic”

Time-Cost Trade-offs in New Product Development vs. Construction Projects

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Abstract. Today, in new product development projects, “NPDs”, time is the cutting edge. The time to market in new product development projects is a key factor in the competition between innovative companies. Research has shown that time can be managed, and speed too. Our concern in this paper is to study the time factor in the case of new product development projects based on a time-cost trade-off curve, which is important for the project success by delivering the product as fast as possible. We will explain the motivation behind delivering fast in NPD projects. In construction projects, a customer initially contracts for a project from a contractor based on specifications, budget and delay. Time to market is a key success factor in new product development projects. Does time to delivery have high importance in construction projects? We conclude by showing the significance of NPD projects' speed with respect to management in construction projects.

Keywords: New product development projects · Construction projects · Time-cost trade-offs · Time to market · Time to delivery

1 Introduction

For more than two decades, the time to market in new product development projects has gradually become the cutting edge. In fact, as a strategic weapon, time is the equivalent of money, productivity, quality, even innovation. In production, in new product development, and in sales and distribution, time represents the most powerful source of competitive advantage (Stalk & Hout, 1990, 2003) – particularly in markets where the first mover has a strong advantage (Stalk & Hout, 1990, 2003; Brown & Eisenhardt, 1998; Cordero, 1991; Mahmoud-Jouini et al, 2004). There are several companies in place that have employed time-based strategies, such as the mobile telephony industry, the automotive industry, and many other types of industries where production starts by developing new products. Delivering faster new product development projects in these markets reduces costs, increases profits and creates values (Schmelzer, 1992; Mahmoud-Jouini et al, 2004).

This paper is particularly concerned with the time-cost trade-offs in construction projects. The time-cost trade-off curve is explained in general, followed by a qualitative analysis of the same curve and its transformation in new product development projects and of how the changes happened in less than three decades to achieve the high efficiency and effectiveness that we now know within this type of projects. The curve will be used in reflecting on the actual situation within the construction industry. Four successful construction projects from other countries are presented to show that the construction industry can learn from the industry's notable innovative projects.

The research results presented are derived from the “SpeedUp” research project in Norway, which focuses on large complex construction projects. The main objective of SpeedUp is to develop and test the knowledge base that can contribute to the reduction of the total implementation time of complex projects.

2 Time-Cost Trade-offs in a Project

There is a strong relationship between a project’s time to delivery and its total costs. For some types of costs, the relationship is in direct proportion; for other types, there is a direct trade-off. For the sum of these two types of costs, somewhere in the red curve in Figure 1, there is an optimum project duration for minimum total costs. By understanding the time-cost relationship, one is better able to predict the impact of a schedule change on project cost. The costs associated with the project can be categorized as direct costs or indirect costs (Kerzner, 2009).

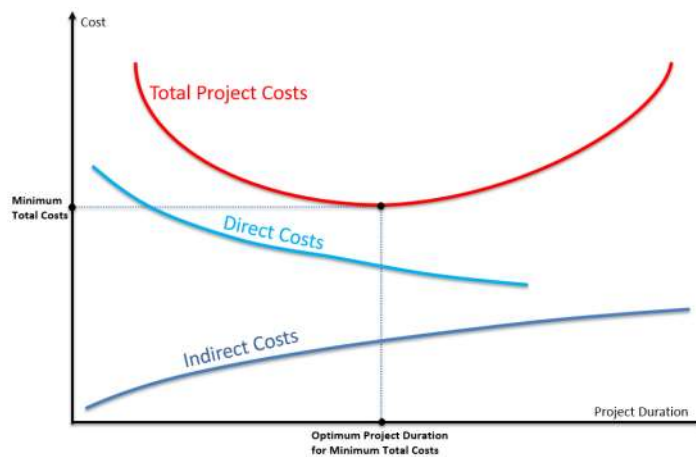


Fig. 1. Time-Cost Trade-offs (Source: Kerzner, H, 2009, p. 520)

Direct costs are those directly associated with project activities, for instance salaries, travel expenses, subcontracting and project materials and equipment that have been purchased directly. If the speed of the project is increased in order to decrease project duration, which is called crashing project’s activities, the direct cost increases; consequently more resources must be allocated to speed up the project delivery (Kerzner,

2009; Pmbok, 2013). Indirect costs are those not directly associated with explicit project activities; for example taxes, cost related to administration and its staff, and office renting. Such costs tend to some extent to be relatively steady per unit of time over the project life cycle. This is not always the case, including large-scale projects where their cycles end after several years; here, the net present value should be taken into consideration. Per se, the total indirect costs decrease as project duration decreases. One basic assumption that needs to be made when estimating project costs is whether the estimates will be limited to direct project costs only or whether the estimates will also include indirect costs. So, indirect costs are those costs that cannot be directly traced to a specific project and that therefore will be accumulated and allocated equitably over multiple projects by some approved and documented accounting procedure (Pmbok, 2013). Furthermore, the project cost is the total sum of direct and indirect costs.

The purpose behind balancing time and cost is to avoid wasting resources. If the direct and indirect costs can be accurately obtained, then a region of feasible budgets can be found, bounded by the early-start and late-start activities. Time–cost trade-off relationships are made by searching for the lowest possible total costs (i.e., direct and indirect) that likewise satisfy the region of feasible budgets. These methods, like the Critical Path Method (CPM), contain the concept of slack time and the maximum amount of time that a job may be delayed beyond its early start without delaying the project completion time. The optimum project duration is determined by the critical path, and this will determine the minimum total costs of the project (Kerzner, 2009). One of the most important problems in projects is the time-cost trade-offs. Crashing the project's schedule would lead to increment in the project cost (Marco, 2011; Mohmoud Belal et al, 2013).

3 Methodology

In order to attain the research objective, a literature review has been done on the concept of time-cost trade-offs in new product development projects and construction projects. Although many authors have written about the time-cost trade-offs based on quantitative methods, nothing, to the best of our knowledge, has been said about the explanation of the time-cost trade-off curve and its interpretation by relating it to the efficiency and effectiveness of the project. During the course of this paper, we have mainly used the results of the work conducted by some researchers on NPD projects and construction projects and not limited to Hutchinson (2007), Demartini & Mella (2011), Schmelzer (1992), Mahmoud-Jouini et al (2004) and Karlsson et al (2008). Construction project cases studied by the School of Civil Engineering at the University of Leeds were used to look at their time and cost overrun to try to allocate them on the time-cost trade-off curve in construction projects. The same is done for the four cases used from Karlsson et al (2008) to come up with a new assumption about the time-cost trade-off curve. For NPD projects, the time-cost trade-off curve is a qualitative conceptual interpretation coming from the changes taking place in industries that are based on innovative projects from a few decades ago until the present. This is based on the interpretation of Stalk & Hout (1990, 2003), Schmelzer (1992) and Hutchinson (2007).

4 Time-Cost Trade-offs in NPD Projects

The evolution of time-based competition follows a continually evolving global manufacturing environment, where the order winners quickly become order qualifiers (Hutchinson, 2007). The manufacturing industries, which are based on innovation and NPD, have struggled to keep up with the global competition in the new millennium, as the basis of competition has shifted from cost to quality, to variety, and now to speed; where time to market has been becoming more important than the amount of invested money and accounting (Hayes et al, 2005; Hutchinson, 2007).

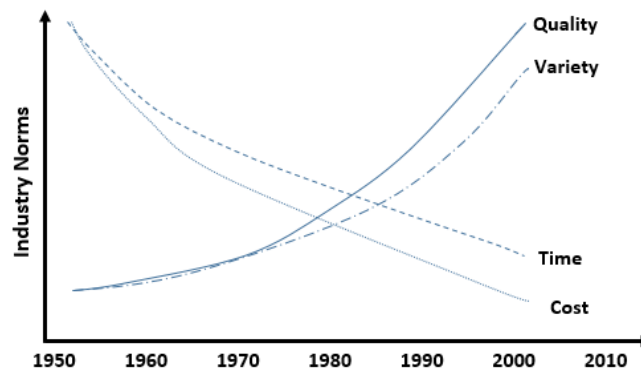


Fig. 2. The Trend of Manufacturing: Towards Time-Based Competition (Source: Hutchinson, 2007, p. 34)

Most innovative companies in this new era of globalization are more concerned with time reduction as their first / major priority, than cost reduction (Ansoff, 1965; Porter, 2008; Rich & Hines, 1997; Demartini & Mella, 2011). Hutchinson (2007) and based on an adaptation from Blackburn (1991), as illustrated in Figure 2, concerning the long-term trends in manufacturing. Graphs for the 1950s, 60s, 70s, 80s, 90s, 2000s and beyond on the x-axis are made, and plotting lines indicate roughly how industry norms have changed from decade to decade. Changes in the periods present a revealing picture of the evolution towards time-based competition that is almost universal across all industries.

Our aim here is to understand the NPD projects and to reflect and learn how the same behavior can be relevant to construction projects. By going through the literature about NPD projects, we tried to interpret the information in a conceptual, qualitative way to develop the time-cost trade-offs curve, as illustrated in Figure 3. We can see that NPD projects went through two paths crossing three major states (“0”, “1” and “2”). State “0” depicts many companies that are cost-reduction oriented; this is because the markets are closed and less newcomers enter the local market. One example that illustrates this: Less Japanese cars were sold in Europe a few decades ago than what is the case nowadays. When globalization appeared, the survivors were the companies that changed direction from cost-reduction orientation to time-reduction orientation. The

value of time (time-to-market) increased, and this increment led companies to crush their NPD projects to be first in the market, thus ensuring their survival (Moving gradually from state “0.1”, “0.2”, etc., as the competition increases, till state “1”). Based on some case studies, Schmelzer (1992) explains that when comparing an increase in the total project costs of 50 percent (crashing the project, state “0.1” and up) versus trying to fit the optimum path duration (state “0”); the latter will be more harmful.

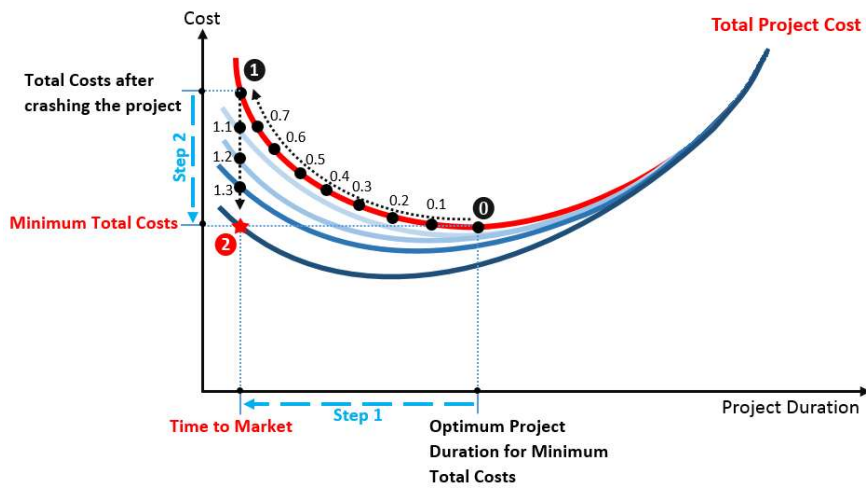


Fig. 3. Time-Cost Trade-offs in NPD Projects

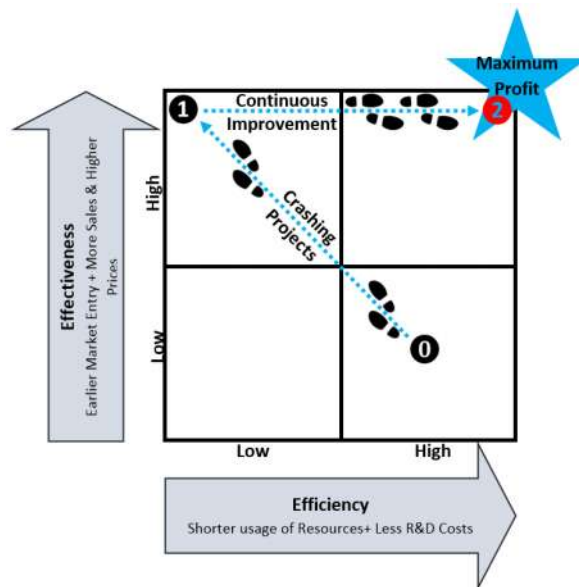


Fig. 4. The steps based on efficiency vs. effectiveness matrix of time-based management

Being maximum effective will ensure the company's competitive advantage in the market. On the other hand, companies want maximum profits from their NPD projects, and they increase efficiency to its maximum while they have the maximum effectiveness. Figure 4 is based on Schmelzer (1992) after combining it with Figure 3. The leading companies are those ended in the state “2”, where they are (1) highly effective by being the first into the market with high sales and prices and (2) as secondary objective, being increasingly efficient by improving their NPD projects’ delivery management and methods by continuous improvement.

5 Time-Cost Trade-offs in Construction Projects

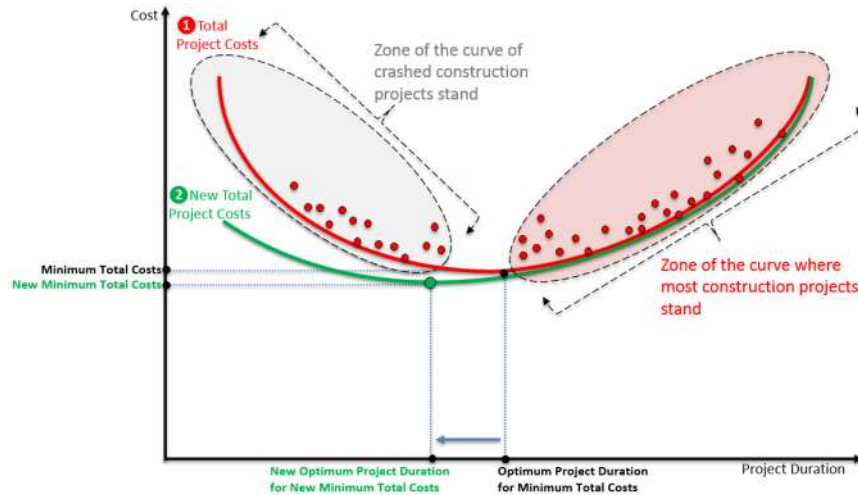
The construction industry is notoriously fragmented; a typical project would involve up to six or more different professional disciplines / suppliers. This has led to numerous problems including, inter alia, an adversarial culture, the fragmentation of the design and construction data, and the lack of the true life-cycle analysis of projects (Anumba et al., 1997; Zidane et al, 2015). The number of organizations involved within a single construction project will increase by the increment in the project size and complexity (Zidane et al, 2013, 2015). Therefore, when comparing the NPD projects, one main reason behind the bad performance of construction projects in general is the project’s attributes - including the project’s environment. The motivation behind NPD projects to finish fast is driven more by globalization. (These issues are discussed in Section 6.) However, construction projects cannot be generalized in that way; each project is singular to the point where the motivation behind being fast depends on the definition of project success given / interpreted by its key stakeholders.

Table 1. Four cases of medium-size construction projects ended ahead of schedule and under budget (Source: Karlsson et al, 2008, p. 297)

Project type	Country	Planned duration	Estimated cost (US\$ million)	Ahead of schedule	Cost saving US\$
Mixed-use office Building	Finland	3 years	25	29 working days	17300
School	Sweden	10 months	7.5	4 calendar months	81000
Commercial retail store	UK	1 year	25	20 working days	19000
Educational Training center	USA	10 months	5.2	46 working days	27000

Figure 5 represents time-cost trade-off curves in construction projects. The red zone to the right represents the majority of the construction projects. Here, we refer to the study done by the University of Leeds on many construction megaprojects in Europe; all the projects came in over budget and behind schedule (represented by red dots in the red zone in Figure 5). In the same figure, the left grey zone depicts construction projects that are ended ahead of schedule but over budget due to compression or crashing the projects. There are a few rare cases, but in general these kinds of projects are motivated

to speed up because of their sense of emergency, their immediate needs to materialize their outcome and purpose. Going through many construction project cases, we found that some cases have been completed ahead of schedule and under budget. Table 1 (Karlsson et al, 2008, p. 297) summarizes a few of them. These cases are represented



by the green dot on the green curve in Figure 5.

Fig. 5. Time-Cost Trade-offs in Construction Projects

The cases can provide another interpretation of the curve in construction projects, knowing that these four projects were using a different methodology, which is based on concurrent engineering philosophy. That means there are possibilities for construction projects to allocate themselves on the left side of the green curve by first looking for the value of time to delivery, then introduce competitive management methods, and keep using continuous improvement to their practices.

6 Conclusion

Time to market in NPD projects has not the same emphasis and value compared to time to delivery in construction projects. Due to the different attributes, stimuli, environments of each type of projects, we cannot apply all the learnings from NPD projects directly into construction projects. Nevertheless, knowing that NPD projects exhibited the same behaviors before globalization, and that they transformed gradually to effective and efficient projects after the emergence of globalization, one can assume that the same may happen to construction projects. A contractor or contractors deliver construction projects in general, depending on the size of the project by involving subcontractors and suppliers and many other stakeholders. This is contrary to NPD projects, since they are delivered from a single organization and the main players are the organization and the consumers. This difference plays a significant role in each key stakeholder's perception on the effect of time-to-delivery in construction projects.

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