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The impact of project introduction heuristics on research and development performance

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Abstract

Assuming a fixed total R&D budget, the product pipeline management (PPM) problem has two parts: (1) Which and how many projects should be initiated? (2) Which projects should continue to be invested in or terminated? We use a dynamic model calibrated to a pharmaceutical company to study PPM, focusing on three types of heuristics — gradual increase or decrease, random-normal choice, and target-based search — to evaluate the impact of the introduction of innovation projects in the pipeline on the performance in R&D. We find that a gradual decrease of project introduction rates results in convergence, but the size of the adjustments and delays in the pipeline can limit the precision of the results. A random choice is detrimental to performance even when the average value is the optimal. A target-based search results in oscillation. The results of our analysis show that the specific problem of choosing the project introduction rate can be significantly improved by using an adequate rule of thumb or heuristic.

Keywords: System dynamics; Product portfolio management; Product pipeline management; Heuristics; Behavioural operations management; Pharmaceutical industry

Introduction

It is clear to most companies that "today's new products will decide tomorrow's company profile" as innovation is diffused (Bhushan, 2012, 2013). Previous studies in the innovation and product pipeline management (PPM) literature have examined factors that influence the various dimensions of R&D performance, such as quality, cost, lead time, and value created (Clark & Wheelwright, 1993; Cooper, Edgett, & Kleinschmidt, 1998; Griffin, 1997). However, much is still unknown about how managerial decisions affect performance in a dynamic setting and across the New Product Development (NPD) pipeline (Azar, 2012). Assuming a fixed total R&D budget, the PPM problem has two parts: (1) deciding on which projects to start, and (2) deciding which projects to continue and which to terminate at various stages of development, as well as and deciding how much to invest on each project at each phase and how to allocate people across the different stages of the process. The total amount of resources available for allocation across the stages is determined by a budgeting exercise (Chao, Kavadias, & Gaimon, 2009). In making these decisions, managers face a set of tradeoffs between the risks, returns, and time horizons for payoffs (Gino & Pisano, 2006). As was noted by Gino and Pisano (2005b):

"In theory, such tradeoffs are optimization problems that can be tackled with a technique such as dynamic programming. In reality, the sheer complexity, ambiguity, and uncertainty of most companies' R&D portfolios make this an essentially impossible optimization problem to solve."

These problems are not solvable, at least in a closed form — i.e., it is an NP-hard problem (Anderson & Morrice, 2006; Anderson, Morrice, & Lundeen, 2005; Browning & Yassine, 2008). A few studies have focused on behaviour (heuristics) in the scheduling of projects at a specific stage (Gino & Pisano, 2005a; Loch & Kavadias, 2002; Kavadias & Loch, 2004; Varma, Uzsoy, Pekny, & Blau, 2007; Yan & Wu, 2001). However, these

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studies did not focus on project introduction policies across the product development pipeline at the portfolio level. The various methods and tools most commonly used for management training are insufficient for dealing with the complexity of organizational processes such as product pipeline management. It seems clear that the system dynamics (SD) approach would allow the treatment of complexity in a more realistic way (Azar, 2012).

Some empirical studies have explored the patterns, best practices or benchmarks in the managerial decisions concerning PPM (Figueiredo & Loiola, 2012; Schmidt, Sarangee, & Montoya-weiss, 2009). The theoretic models proposed in the literature have not become a tool that is commonly used in management practice due to their highly complexity. Due to the complexity of portfolio selection and individuals' bounded rationality (Simon, 1956), companies commonly utilize heuristics for managing their R&D portfolios rather than trying to optimize them. This decision-making behaviour is very well accepted but research on the impact of specific heuristics on R&D performance is still limited (Gino & Pisano, 2005b).

It is important to note that large companies, such as pharmaceutical and chemical companies, generate new patents regularly and have structured product development processes, as illustrated in Loiola and Mascarenhas (2013).

The existence of optimal levels in the product pipeline is not obvious because the problem cannot be solved in closed form — i.e., it is an NP-hard problem that requires severe simplifications in order to be solvable (Anderson & Morrice, 2006; Browning & Yassine, 2008). This is a clear indicator that a simulation study is particularly useful for the problem under scrutiny.

Rudi and Drake (2009) recognize that behavioural aspects in operational settings have received increasing attention, including areas such as the consumer estimation of household inventories (Chandon & Wansink, 2004), revenue management (Bearden, Murphy, & Rapoport, 2008), the bullwhip effect (Bloomfield, Gino, & Kulp, 2007; Croson & Donohue, 2006; Croson, Katok, Donohue, & Sterman, 2005), and the effect of social preferences (Loch & Wu, 2007) and service-level agreements (Katok, Thomas, & Davis, 2008) for the supply chain coordination. Many papers focus on portfolio management (managing one stage of a pipeline), but fewer papers focus on managing the pipeline as a whole. One exception is the study by Gino and Pisano (2005b), which generated resource allocation insights for product portfolio management. These insights adopted a behavioural viewpoint in terms of the heuristics for resource allocation at one stage of the pharmaceutical R&D process.

Organizations often commit to more product development projects than they can handle. The over-commitment of development resources (i.e., when too many projects are introduced into the pipeline) is a common phenomenon, as evidenced by case studies. The evidence suggests that many organizations have far more product development projects in progress than their capacity allows (Gino & Pisano, 2006). For instance, Wheelwright and Clark (1992) mentioned that organizations tend to pursue a larger number of projects than they have the resources to fund and suggested that companies often operate their development organizations at 200–300% capacity utilization. Ash (2009) finds that loading a resource pool to 300% or 400% of capacity while allowing preemption may be good for the engineering talent utilization rate; however, this procedure is detrimental for completing individual projects on their due dates. Ash, however, did not focus on the relationship between capacity utilization and the quality of the development activities.

For most firms that operate with high capacity utilization rates, the simplest form of heuristics would be to gradually decrease the project introduction rates (also referred to here as starts) from the high levels to lower levels, aiming to balance the pipeline and increase value creation.

Yu, Figueiredo, and De Souza Nascimento (2010) developed a simple, static model of the product development pipeline that establishes the upper limits for the capacity to develop and launch new product families. This ideal number of projects may function as a warning for firms that are trying to develop and launch too many product families. Figueiredo and Loiola (2012), Figueiredo and Loiola (2014a, 2014b, 2016), and Figueiredo, Travassos, and Loiola (2015) reached similar conclusions with a dynamic model that established a concave relationship between the number of projects started and the total value created in the pipeline. Based on another dynamic model, Repenning (2001) showed how a surge of resource demand can cause havoc in the NPD process in the phenomenon known as firefighting.

The traditional approach to the problem of over-commitment is to develop better models for project management and more sophisticated in-process management tools (such as real time scheduling) and to undertake more planning activities. Gino and Pisano (2006) suggest that these models would be more useful if they rest on cognitively and behaviorally compatible assumptions, i.e., incorporating elements into the models that will reduce common cognitive biases that people incur in their decision making processes.

In this paper, we use a dynamic simulation model adapted and modified from Figueiredo and Loiola (2012), Figueiredo and Loiola (2014a, 2014b, 2016), and Figueiredo et al. (2015) to explore such phenomena in the pharmaceutical industry, with a specific focus on the impact of project introduction heuristics on NPD performance. The use of heuristics is a way of searching for a better policy and/or making necessary adjustments whenever there are changes in the shape and performance of the pipeline. It important to point out that the working problem at hand is not actually solved by the use of heuristics. Heuristics are a tool to deal with complex, dynamic problems in a limited, simplified manner, aiming tentatively to achieve better results. As was explained previously, heuristics are a very common tool and reflect managerial behaviour. It is not argued that the tool should be adopted as the best one, but it is perhaps the most practical. It is arguable that the working problem is significantly large and the planning horizon is also large, demanding severe, drastic simplifications in case a solution in closed form is needed (Anderson & Morrice, 2006; Browning & Yassine, 2008).

The model was rebuilt and adapted to reflect the use of such heuristics. In particular, we focus on three types of heuristics: