Experience-Based Learning and Cycle Time Reduction for Incremental and New-to-the-Firm Product Development Projects

Pinar Cankurtaran

Department of Product Innovation Management

Faculty of Industrial Design Engineering, Delft University of Technology

Landbergstraat 15, 2628 CE Delft, The Netherlands

p.cankurtaran@tudelft.nl

Serge A. Rijsdijk

Department of Management of Technology and Innovation

Rotterdam School of Management, Erasmus University

P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

srijsdijk@rsm.nl

Fred Langerak

Innovation, Technology Entrepreneurship & Marketing Group

School of Industrial Engineering, Eindhoven University of Technology

P.O. Box 513, 5600 MB Eindhoven, The Netherlands

f.langerak@tue.nl

Experience-Based Learning and Cycle Time Reduction for Incremental and New-to-the-Firm Product Development Projects

Abstract

Short new product development (NPD) cycle times are crucial for firms' competitive advantage. Yet little is known about how project cycle times are affected by past organizational NPD experience that has accumulated over time. In this study we distinguish between two forms of organizational NPD experience based on the technological domain from which it originates (specialized and related) and examine their differential impact on NPD cycle time reduction. Using learning curve methodology, we analyze accounting data on 169 NPD projects that took place over a seven-year span within a single firm that has multiple units operating in different technological domains. The analyses indicate that both specialized and related organizational experience help decrease project cycle times but their relative importance depends on project innovativeness. Related experience is more influential for new-to-the firm products than for incrementally new products, while specialized experience is equally important for the cycle time reduction of both product types. Additionally, for new-to-the-firm products, related organizational experience is more important for cycle time reduction than specialized organizational experience. These findings support the idea of considering organizational experience as well as different types of organizational experience when explaining NPD project cycle time. Both forms of organizational experience are important for project cycle time reduction in general while their relative importance partly depends on the nature of the focal project. Managerially, the results indicate that NPD projects can be accelerated not only by installing experienced project teams but also by deliberately and selectively drawing from different sorts of organizational experience available within the firm.

Keywords: organizational experience; organizational learning; learning curve; new product development; project cycle time; product innovativeness.

Introduction

As product life cycles shorten, it becomes increasingly important for firms to identify ways to reduce new product development (NPD) project cycle time, defined as the elapsed time from the beginning of idea generation, when the firm decided to develop the new product, to its introduction in the market (Kessler and Chakrabarti 1996). Firms with shorter cycle times have greater strategic flexibility and can choose to pursue first-mover and fast-follower strategies (Brown and Eisenhardt 1995). Also, shorter cycle times are associated with lower development costs, greater product competitive advantage, and more beneficial financial outcomes (Cankurtaran, Langerak and Griffin 2013). Overall, shorter cycle times contribute substantially to a firm's sustainable competitive advantage.

Recent meta-analytic research indicates that experience is an important determinant of NPD cycle time (Cankurtaran et al. 2013; Chen, Damanpour and Reilly 2010). Experience helps safely bypass unnecessary development steps and enables team members to identify more easily what is compatible or not with the attainment of specific project goals (Hyung‐Jin Park, Lim and Birnbaum‐More 2009). Yet previous NPD research focuses primarily on experience available within the team executing the project, but ignores recent learning-by-doing research that shows that organizational experience affects performance at the project level (Easton and Rosenzweig 2012). This work suggests organizations can accumulate experience in certain activities and be endowed with relevant knowledge that is embedded in various repositories such as technology, structure, and employees (Argote and Miron-Spektor 2011). This accumulated experience can then be reactivated and reinterpreted to address the particular demands of later projects.

This study investigates whether this mechanism also applies to NPD activities and whether accumulated organizational NPD experience affects project cycle time. It distinguishes two dimensions of organizational experience, according to the domain from which it originates: specialized or related. Specialized organizational experience results from cumulative NPD activity within the same domain as the focal project (Boh, Slaughter and Espinosa 2007). Repeated activity within a specific domain increases the organization's understanding of that domain and may improve performance. Related organizational experience is an outcome of cumulative NPD activity in other domains that relate to the focal domain (Boh et al. 2007), such that problem-solving activities in one domain can benefit from experience accumulated in other, related domains (see e.g., Schilling, Vidal, Ployhart and Marangoni 2003).

With the above distinction in mind, this study assesses whether specialized and related organizational experience affect the cycle time of current NPD projects, and whether the importance of these types of experience depends on the focal project's level of product innovativeness. Product innovativeness pertains to the lack of knowledge about the exact means for accomplishing the project (Danneels and Kleinschmidt 2001) and relates closely to the alignment between the project and the firm's capabilities. Because NPD projects vary in the extent to which their technological aspects are known to the developing firm and their level of fit with existing resources and capabilities (Stanko, Molina‐Castillo and Harmancioglu 2015), this study postulates that product innovativeness moderates the relationship between organizational NPD experience and project cycle time through its influence on the extent to which projects reuse their knowledge base, problem-solving capabilities, and practices originating from their own domain, as well as how widely they can draw on resources accruing from other domains (Brockman and Morgan 2003; Kelley, Ali and Zahra 2013). Specifically, it proposes that specialized organizational experience is more important for reducing the cycle time of projects developing incrementally new products, whereas related organizational experience should be more important for reducing the cycle time of new-to-the-firm projects.

This study offers three contributions to the product innovation management literature. First, it broadens the understanding of how NPD project cycle time can be reduced. Previous research on the experience–cycle time relationship focuses predominantly on project team experience, whereas studies in other empirical contexts indicate that organizational experience accumulated outside the project team may be highly relevant (Brockman and Morgan 2003). If wider organizational experience is important in an NPD context, managers aiming to reduce cycle times should deliberately facilitate knowledge transfer to their projects to ensure that the organizational experience base is available to all NPD projects.

Second, this study provides deeper insights into the role of product innovativeness in cycle time reduction. Mixed findings regarding the association between product innovativeness and cycle time reported in prior empirical studies suggest that innovativeness has no direct effect on cycle time but may influence the effects of other factors on cycle time (Chen et al. 2010). By focusing on product innovativeness as a potential moderator, this study addresses the question of whether product innovativeness strengthens or weakens the effects of organizational experience on project cycle times. Finding such interactions would suggest that the importance of different types of organizational experience depends on the level of product innovativeness.

Third, this study investigates the extent to which organizational experience effects are generalizable to the unstructured nature of NPD projects (Thomke 2003). Previous learning-by-doing research has addressed relatively structured work, such as manufacturing activities (Macher and Mowery 2003), product improvement projects (Mallick, Ritzman and Sinha 2013), and Six Sigma improvement team projects (Easton and Rosenzweig 2012).

This paper begins with a description of the theoretical background and presentation of hypotheses. The next section details the empirical methodology used to test the hypotheses, followed by descriptions of the results and a section that outlines the implications of these results for theory and practice. The paper concludes by addressing some limitations and suggesting directions for further research.

Theoretical background

Learning from experience

The concept of learning from experience (or "learning-by-doing") originates from studies that document that people require less time to fulfill tasks when they have more experience (Thurstone 1919). The underlying mechanism, as noted by Anzai and Simon (1979), is the system's ability to acquire knowledge about the effectiveness of its choices and use that knowledge to modify itself (p.132). A defining feature of such studies is that they assume learning follows the shape of a learning curve, which represents the relationship between cumulative past experience and some performance measure (Macher and Mowery 2003). In a typical learning curve, performance improves with increased experience, though the rate of improvement gradually declines over time (Argote 2013; Schilling et al. 2003). The capacity to learn from experience, according to this pattern, is not limited to individuals but also applies to teams, organizational units, and organizations as a whole (McKee 1992). As experience increases, these entities come to better understand certain cause-and-effect relationships and can use their stock of knowledge, accumulated through actual experience, to modify their courses of action, discover process problems that cause gaps between realized and potential performance (Pisano 1994), and select activities that promise the desired effects most consistently and effectively (Levitt and March 1988; Nelson and Winter 1982).

Whereas early learning-by-doing studies focused on a single level of experience, more recent work has explained project team performance by considering different types of experience simultaneously and at different levels of analysis. Reagans, Argote and Brooks (2005) investigate which types of experience reduce the completion time of surgical procedures and cite the proficiency of individual workers, their ability to leverage knowledge accumulated by others, and their experience working together. In their assessment of the importance of experience for Six Sigma project performance, Easton and Rosenzweig (2012) show that team leader experience and organizational experience have strong effects on project performance. These combined results hint strongly at the relevance of experience gained at the organizational level for NPD cycle time at the project level.

Specialized experience versus related experience

Several studies investigated the relevance of the degree of relatedness between types of experience and the focal task. Specialized experience accrues from conducting activities within a given domain, such as a specific software system (Boh et al. 2007), a particular problem-solving game (Schilling et al. 2003), or a unique diagnostic category, such as endocrine, nutritional, and metabolic diseases and disorders in medicine (Clark and Huckman 2012). Working within a single domain, individuals, teams or organizations complete a particular task or solve a particular multiple times, thereby gaining a deep understanding of the domain (Schilling et al. 2003). Specialized experience benefits productivity, because work in one domain over time produces task-related knowledge that can improve performance (Staats and Gino 2012).

Related experience refers to the accumulation of experience in other problem domains that are relevant to a focal domain. People might develop a new understanding of a problem by transferring knowledge from one domain to another, and knowledge from one problem domain can provide an analogous solution in another problem domain (Schilling et al. 2003). Operationalizing specialized experience as the number of modification requests organizational members had handled in a particular customer billing support system, Boh et al. (2007) assess related organizational experience as the number of modification requests handled in a customer call support system that shared common data with the customer billing support system. Schilling et al. (2003) investigate related experience by assessing whether teams that played the game Reversi showed improved performance playing the related game Go (both games are played on a non-checkered grid with stones, emphasize spatial strategy, and seek to controlling territory). Finally, Clark and Huckman

(2012) operationalize related experience as the extent to which hospital organizations gain experience in a related medical specialty (e.g., cardiology), beyond their focal specialty (e.g., endocrinology). Collectively, these studies demonstrate that problem-solving activities in a domain can benefit from experience accumulated in one or more related domains.

Both specialized and related experience can be gained within individuals or teams, by exposing them to a range of specific or related activities over time (Boh et al. 2007; Schilling et al. 2003). Both types of experience also can be gained across individuals or teams, through the transfer of experience from others exposed to a range of activities to a focal individual or team (see e.g., Clark and Huckman 2012).

The effect of specialized organizational experience on NPD project cycle time

Prior organizational experience in NPD is associated with the efficient design of technologically similar products and general management of the NPD process (Pisano 1994). The development of new products endows firms with a substantial body of NPD-related knowledge, which becomes embedded in various repositories, such as the organization's technology, structure, or employees (Argote and Miron-Spektor 2011). Subsequent NPD projects then can enjoy shorter cycle times, once the accumulated knowledge is reactivated and reinterpreted to address the particular demands of new projects.

Knowledge accumulated within a certain technological domain is not necessarily exclusive to the particular project from which it originates and is a readily available resource for future NPD projects within that same technological domain (Danneels 2002). Technologies, solutions, and components developed for one product can be used directly, or with minimal modification, in future products, which enables future project teams to economize on the time needed for extensive design, engineering, and manufacturing activity. Specialized organizational experience also acts as a valuable source of problem- and solution-related information that can promote problem-solving efficiencies and shorten project cycle times for future projects in the same domain (Thomke 2003). Extant work on organizational learning has established that specialized knowledge, accrued from past experience, becomes embedded in formal and informal routines and standard operating procedures of the organization, such as in the form of information sharing mechanisms and ways to organize project work (Cyert and March 1963; Eisenhardt and Tabrizi 1995; Leonard-Barton 1995). Rather than creating modes of conduct from scratch, NPD project teams can draw on an existing repertoire of routines and practices that exists for their specific domain and identify those applied successfully in the past. Then NPD teams can tailor routines and practices to the project at hand, to economize on the time and resources expended (Madhavan and Grover 1998). For these reasons, we expect specialized organizational experience accumulated within a certain technological domain to facilitate cycle time reduction, and we hypothesize:

H_1 Specialized organizational experience reduces NPD project cycle time.

The effect of related organizational experience on NPD project cycle time

Since NPD projects often do not exist in isolation but are positioned within a larger organizational context (Scarbrough, Swan, Laurent, Bresnen, Edelman and Newell 2004), there is scope for knowledge transfer between NPD projects carried out in different technological domains. A project team operating within a given domain can exploit related organizational experience that has been generated by others developing products in other technological domains. Related experience grants project teams a pool of NPD knowledge, distinct from their own (Reagans et al. 2005), and thus access to a rich, diverse set of skills and information that can be applied to the project at hand but that otherwise would have been unavailable. Project teams use this external knowledge, which is complementary to their own internally accumulated knowledge base, to create new insights and solve development problems. Although products in different domains may vary in their technical features, the NPD process likely displays similarities in the kinds of problems to be addressed or the ways project activities get organized. By borrowing technical solutions embodied in other organizational units' existing hardware and software components for example (Hansen 2002), NPD teams can avoid repeating certain tasks or making similar mistakes and complete projects more quickly. These arguments suggest that NPD projects in a particular domain can learn from the knowledge accumulated in other domains and use it to reduce cycle time. Noting that related organizational experience refers to experience accumulated in other technological domains, we hypothesize:

H_2 Related organizational experience reduces NPD project cycle time.

Product innovativeness as a source of heterogeneity in learning rates

Product innovativeness refers to the lack of knowledge about the exact means for accomplishing the project (Danneels and Kleinschmidt 2001); it is closely linked to the extent to which technological aspects of products are familiar to the developing firm and fit with its existing resources and capabilities. Organizations typically have a portfolio of development projects, with varying levels of product innovativeness (Chao and Kavadias 2008). On the one hand, some projects involve "the adaptation, refinement and enhancement of existing products and/or product delivery systems" (Song and Montoya‐Weiss 1998, p.126) and do not require new skills, because they demand only minor improvements to existing technology. Because they entail extensions of, or improvements over, existing products, these products are characterized by low levels of innovativeness and will be referred to as incrementally new products. On the other hand, products may be relatively new and require technological approaches that have not been tried before. These products are characterized as being more innovative, because they require the use of substantially different skills and introduce the need to develop and apply new knowledge and will be referred to as new-to-the-firm products.

Project innovativeness may lead to heterogeneity in learning rates, in that the level of product innovativeness influences the extent to which projects can reuse the knowledge base, problem-solving capabilities, and practices of their own domain or draw on such resources from other domains to accelerate their own NPD. Specialized organizational experience gained within a domain represents a unique, specific stock of knowledge and is therefore likely to be rich in detail but narrow in scope (Schilling et al. 2003). Incrementally new products involve technologies, materials, and processes with well-understood constraints and limitations, because they are variations of (or improvements over) prior offering (Chen, Reilly and Lynn 2012; Song and Montoya‐Weiss 1998). Consequently, existing technological specifications and blueprints originating from NPD activity within the domain can be applied in a relatively straightforward manner, to meet the demands of current projects. Because they are being developed using familiar technologies, tasks also should be carried out more expediently, in light of the in-depth, relevant knowledge accumulated within the organization.

In contrast, new-to-the-firm product development projects explore unfamiliar domains and are characterized by greater risk than their incremental counterparts (Song and Montoya‐Weiss 1998). A high level of product innovativeness implies a poor understanding of technologies, which increases ambiguity about not only the solution of technical problems but also the identification of which problems need to be solved (Brockman and Morgan 2003). Considering the specificity of specialized organizational experience, projects developing new-to-the-firm products have less scope for using knowledge, in the form of existing components and processes, to reduce cycle time. The greater degree of innovativeness likely renders the organization's problem-solving experience within the same technological domain less adequate for addressing the issues that arise during their development (De Carolis 2003), because ambiguity surrounding new-to-the-firm products demands greater reconsideration of existing modes for managing the NPD process and reducing the immediate applicability of existing routines and practices. Because projects developing new-to-the-firm products have little or no input carried over from previous generations (Griffin 1997), the organization's knowledge of a given domain likely falls short of the level of providing components or blueprints to build on or technologies to be readily extended. In light of these arguments, we hypothesize:

H_3 Specialized organizational experience reduces NPD project cycle time more for projects developing incrementally new products than for projects developing new-to-the-firm products.

Related organizational experience instead delivers an opportunity to see problems or tasks from a different perspective (Tortoriello, Reagans and McEvily 2011). Although the information requirements of projects developing incrementally new products are characterized by depth (McDermott and O'Connor 2002), teams engaged in new-to-the-firm product development require a wider array of informational inputs and different expertise that can stimulate the generation of fresh insights (Brockman and Morgan 2003). Consequently, teams engaged in the latter type of projects are more likely to benefit from relevant solutions obtained from other domains. Drawing on related organizational experience accumulated in other domains introduces teams to new knowledge elements, which increases the variety of informational input they have at their disposal to combine in productive ways (Katila and Ahuja 2002) and provides them with extensive choices for solving new problems (March 1991). Even when technical solutions are not directly applicable, perhaps due to differences in their technological architecture, they can be decoupled from their original domain and applied to the new context. This can be done by abstracting away from the particular project in which the competence is embedded and identifying the competence in its own right or by linking that existing competence with a new competence and thereby achieve time efficiencies (Danneels 2002).

This diversity of problem-solving approaches can emerge from other sources in the organization and help development teams overcome the challenges associated with new-to-the-firm projects (Yan and Dooley 2013). In turn, interaction with employees operating in other domains enhances the focal team's problem solving and learning (Nonaka 1994), ultimately contributing to a more efficient, timely project execution. Teams engaged in incrementally new product development projects should have less need for additional informational input or problem-solving capabilities from other domains to achieve timely project completion. These projects predominantly benefit from high levels of relevant technological knowledge, problem-solving capabilities, and modes of conduct forged by past NPD activity within their own domains. In short, the time efficiency benefits of using related organizational experience is smaller for projects developing incrementally new products than for those developing new-to-the-firm products, because the content of transferred knowledge may not apply readily to the current project. As such, we hypothesize:

H_4 Related organizational experience reduces NPD project cycle time more for projects developing new-to-the-firm products than for projects developing incrementally new products.

Methodology

Empirical context

We tested the hypotheses using a data set that consisted of 169 product development projects, conducted in different organizational units of the plastics division of a large corporation. The database span a sufficient time period for learning to occur (7 years and 4 months), a key requirement for applying the learning curve approach and discerning its effects on cycle time reduction. The database also permits a clear distinction between specialized and related experience, with the 169 projects spread across seven organizational units. Each organizational unit develops a specific type of polymer (e.g., one unit develops polycarbonates while another unit develops polystyrenes) and therefore accumulates specialized experience for its specific type of polymer. However, the NPD activities within these different organizational units do share similarities in that they all develop new polymer resins. As such, the experience accumulated in each organizational unit is related to the activities conducted in the other organizational units.

Measures

Dependent variable: Project cycle time. As described previously, the firm's database contained each project's commencement and completion dates and the organizational unit to which it belonged. Project cycle time (CT_{ij}) was operationalized as the number of weeks between the commencement and completion dates for project *i* run by organizational unit *j*.

Independent variables: Specialized and related organizational experience. The measure of specialized organizational experience is based on experience accumulated from prior NPD activity within the organizational unit to which the project belongs, while the related organizational experience measures is based on the prior NPD activity accumulated in other units. Learning curve studies typically operationalize past experience as a cumulative output (Macher and Mowery 2003). Applying the same logic to this study context, experience available to project *i* would equal the cumulative number of projects completed prior to the start of project *i*. However, such an operationalization would fail to account for knowledge generated by ongoing projects, ignoring research showing that a great deal of learning takes place during the course of a NPD project (e.g., Scarbrough et al. 2004). To ensure that the variables capture prior NPD experience as fully as possible, similar to this study operationalizes experience as the completed portion of ongoing projects, together with fully completed projects (see Argote, Beckman and Epple 1990). The specialized organizational experience variable $EXPSP_{ij}$ thus included the number of completed projects within project *i*'s organizational unit *j*, plus the completed proportion of projects ongoing in unit *j* when project *i* began. Similarly, the related organizational experience variable $EXPREL_{ij}$ was the sum of the number of completed projects in the other six units and the completed portion of ongoing projects in these units.

Moderating variable: Product innovativeness. Data on product innovativeness came from each product manager who, in face-to-face interviews, classified the focal project as incrementally new or new to the firm. Because the managers had to evaluate multiple projects, this study used a dichotomous measure of product innovativeness, which is logically appealing and effective for collecting data retrospectively, particularly when, as in this case, objective information is impossible to obtain. The widely used dichotomous approach also has proven reliable and valid (Henard and Szymanski 2001). The dummy variable $INNO_{ij}$ equals 1 if project *i* in unit *j* of the project entails a new-to-the-firm product and 0 if the project concerned the development of an incrementally new product.

Control variables. Several control variables helped isolate the effect of cumulative past experience from other potential factors. First, indicator variables ($UNIT_{ij}$) in all models removed the confounding effects of any unobserved differences at the unit level, such as unit size or the level of resources available. Allowing each unit to have its own starting point on the learning curve also eliminated any confounding effects of relevant experience that might have accumulated within the unit, beyond the time frame of the data set (see Ingram and Simons 2002).

Second, $TIME_{ij}$ captured unobserved confounding factors, such as changes in the organization's innovation strategy, structure, or resources that occurred during the study period and may have affected project cycle time. In line with (Boh et al. 2007), the operationalization of $TIME_{ij}$ used the start date of project *i* in organizational unit *j*, expressed in weeks, where 1 is the start date of the first project in the data set.

Third, concurrent project activity also might confound the relationship between past NPD experience and cycle time, captured by the variable CPA_{ij} and operationalized as the number of projects in the company running parallel with project *i*. Higher levels of concurrent project activity likely are associated with longer cycle times, because the company's resources are spread more thinly across projects (Datar, Jordan, Kekre, Rajiv and Srinivasan 1997; Kessler and Chakrabarti

1996). Because the number of concurrent projects shrinks consistently toward the end date, the computation of concurrent project activity included only those projects that finished before the end date of the focal project, to avoid right truncation concerns. The descriptive statistics and correlations among the main variables are in Table 1.

<<<Table 1 about here>>>

Estimation procedure

In most learning curve applications, the relationship between past experience and performance takes the form $y=ax^{-b}$, where y is the performance measure (i.e., cycle time), x is the measure of cumulative experience (i.e., number of projects), a is a constant, and b is the learning rate (see e.g., Darr, Argote and Epple 1995). For estimation purposes, a common practice takes the natural logarithm of both sides of the equation, to rewrite it as $\ln y=a-b\ln x$. Implicit in this log–log formulation is the assumption that performance cannot improve at a linear rate indefinitely. Rather, it improves with increased experience but at a decreasing rate, as it becomes more difficult for the organization to extract value from its experience base. Thus, the learning curve is steep at early stages of activity but gradually loses this steepness, until it reaches a plateau. This widely used formulation provides the basis for the following model for project cycle time:

$$\ln(CTij) = \beta_0 + \beta_{ij} \cdot UNIT_{ij} + \beta_1 \cdot TIME_{ij} + \beta_2 \cdot \ln(CPA_{ij}) + \beta_3 \cdot \ln(EXPSP_{ij}) + \beta_4 \ln(EXPREL_{ij}) + \beta_5 \cdot INNO_{ij} + \beta_6 \cdot (INNO_{ij} \times \ln(EXPSP_{ij})) + \beta_7 \cdot \left(INNO_{ij} \times \ln(EXPREL_{ij})\right) + \epsilon_{ij}$$

The coefficients in this model can be interpreted as follows: β_{ij} is a vector of coefficients for the organizational unit dummy variables. Because the intercept is a linear combination of all seven unit dummies, a dummy variable for unit 1 is not included, and β_{ij} indicates the extent to which the average cycle time for unit j differs from the average cycle time of unit 1. In addition, β_1 captures the effect of time, and β_2 captures the effect of concurrent project activity; β_3 and β_4 indicate the extent to which specialized and related organizational experience, respectively, bear on the cycle time of projects developing incrementally new products. For both β_3 and β_4, a negative, significant estimate implies that greater experience is associated with shorter cycle times for these projects. The estimate for β_5 reflects the extent to which the average cycle time of projects developing new-to-the-firm products differs from that of their less innovative counterparts. The interaction terms $INNO_{ij} \times \ln(EXPSP_{ij})$ and $INNO_{ij} \times \ln(EXPREL_{ij})$ support the comparison of the specialized and related organizational experience learning rates across the two levels of product innovativeness. The coefficients β_6 and β_7 indicate the extent to which the effects of specialized and related organizational experience, respectively, differ for high versus low innovativeness projects.

Results

Hierarchical regression analyses

An ordinary least square (OLS) regression served to estimate the model, with variables entered across columns in a stepwise manner (see Table 2). Model 1 included the control variables for organizational unit-specific differences, time, and concurrent project activity, producing an R-square value of .56 (F = 25.30, p < .01). The cycle times progressively shortened (-.90, p < .01). Concurrent project activity was associated with an increase in cycle time, showing a positive, statistically significant estimate (.29, p < .01).

Model 2 introduced the main effects for specialized organizational experience, related organizational experience, and product innovativeness. This model was accompanied by a significant increase in the R-square value of .25 (ΔF = 65.08, p < .01). The main effects of specialized and related organizational experience were both negative and statistically significant.

The negative effect (-.23, $p < .01$) of specialized organizational experience suggested that, regardless of the level of product innovativeness, it contributed to shorter cycle times, in support of H_1. Similarly, the effect of related organizational experience was negative and significant (-.29, $p < .01$), in line with H_2. The effect of product innovativeness on cycle time was not significant (-.02, n.s.), in line with findings from previous studies (Chen et al. 2010). Also, in Model 2, the effect of time became non-significant (.14, n.s.), indicating that the reduction in cycle times could not be attributable to the passage of time itself but instead reflected increased levels of specialized and related organizational experience.

The final stage (Model 3) also included interactions between product innovativeness and the specialized and related organizational experience variables. The coefficient estimate for the specialized organizational experience – product innovativeness interaction (.04, n.s.) provided directional but not significant support for H_3, suggesting that specialized organizational experience had similar time-efficiency implications for incremental and new-to-the-firm projects. The coefficient for the related organizational experience – product innovativeness interaction was negative and statistically significant (-.15, $p < .05$), in support of H_4 regarding the proposed moderating effect of product innovativeness on the link between related organizational experience and cycle time. As indicated by the significant change in the R-square statistic ($\Delta F = 3.42$, $p < .05$), including these interactions improved the explained variance by a small, significant amount.

<<<Table 2 about here>>>

Progress ratios

To quantify the relative and absolute strength of the different experience effects in Table 2, the next test computed a progress ratio for each experience variable, indicating the percentage of change in cycle time when experience doubles, or p=2-b, where –b is the learning rate and unstandardized regression coefficient (Lapré and Nembhard 2010). The four progress ratios computed for this study varied somewhat, but they all fell well within the 55%–108% range and close to the modal ratio of 80% indicated by previous studies (Boone, Ganeshan and Hicks 2008). For low innovativeness projects, specialized organizational experience indicated a progress ratio of 85%, such that each doubling of the level of specialized organizational experience led to a (100% – 85%=) 15% reduction in cycle time (Wiersma 2007). The cycle time of low innovativeness projects also fell by 15% with a doubling of related organizational experience. For high innovativeness projects, cycle time shortened by 12% when specialized organizational experience doubled and by 24% when related organizational experience doubled.

Discussion

This study used learning curve methodology to investigate the extent to which the specialized and related NPD experience of an organization influence the cycle time of current NPD projects, and examined the moderating role of product innovativeness on the link between NPD experience and cycle time.

The results indicate that NPD experience accumulated in the wider organization is highly relevant for project cycle time reduction. NPD projects benefit from specialized organizational experience gained in the same technological domain and from related organizational experience accumulated in other domains. New-to-the-firm projects realize greater cycle time reductions from related organizational experience compared to their incremental counterparts. They also benefit more from related organizational experience than from specialized organizational experience. These findings corroborate previous work and highlight the need for more varied informational input, to address the fluid, uncertain character of new-to-the-firm projects (Brockman and Morgan 2003). New-to-the-firm product development projects benefit from prior specialized organizational experience just as much as projects developing incrementally new products in terms of reduced cycle time. These findings underscore the importance for research on NPD cycle time reduction, to take into account both the historical and the organizational context within which projects are embedded and deepen our understanding of the effect of experience on NPD project cycle time in several ways. The following sections detail their theoretical and managerial implications, as well as some limitations and suggestions for further research.

Theoretical Implications

This study has important theoretical implications for both the NPD cycle time literature and the organizational learning literature. First, this study shows that experience at the broader organizational level substantially influences project cycle time. Prior studies have mainly investigated antecedents to cycle time at the project level (Chen et al. 2010). However, this study shows that the cycle time of individual projects is also strongly affected by the number of projects that was previously conducted by the entire organization, irrespective of whether previous projects were conducted within the same or another technological domain that the focal project.

Second, this study adds to the understanding of the product innovativeness–cycle time relationship. Although academic literature generally suggests that more innovative products take longer to develop (Griffin 1997), meta-analyses by and Cankurtaran et al. (2013) indicate that the empirical support for this idea is ambiguous. The present study specifies that related organizational experience is more useful for highly innovative projects than for those with lower levels of innovativeness. As such, the difference in cycle time between incrementally new and new-to-the-firm projects might depend on the level of related organizational experience that is present within a firm. In a firm with little accumulated related experience, the cycle times of incrementally new product development projects might be shorter or similar to those of new-to-the-firm products. Ceteris paribus, for a firm with a high level of related experience, the cycle time of incrementally new product development projects might be similar or perhaps even longer than for those of new-to-the-firm products. As such, the ambiguous findings concerning the product innovativeness-cycle time relationship can possibly be partly explained by the nature of and accessibility to the accumulated NPD experience within a project's organizational context.

Third, the study shows that specialized and related organizational experience affect the cycle time of new-to-the-firm development projects in different ways. For these projects that are characterized by a high level of innovativeness, related experience has a stronger impact on cycle time reduction than specialized experience. This suggests that the development speed of new-to-the-firm products benefits more from diverse experience from other technological domains than from experience gained in the same technological domain. This is in line with the finding of previous studies that show that new-to-the-firm product development projects require a wider array of informational inputs and expertise (Brockman and Morgan 2003) and more extensive choices for solving new problems (March 1991). However, our study is the first to show that this wider variety of inputs can be more important than in-depth knowledge that results from experience in a specific technological domain. More importantly, this finding suggests that the literature aimed at explaining NPD cycle time would benefit from acknowledging that organizational experience can be more or less related to certain activities.

Fourth and more generally, this study adds to the organizational learning literature by showing that a learning curve methodology is applicable to unstructured NPD tasks, just as much as it is to (relatively) structured tasks (see e.g., Macher and Mowery 2003). The rate of learning (reflected in the progress ratios) in an NPD context is comparable to other studies in manufacturing settings, which tend to involve more structured, less knowledge-intensive tasks. However, the finding that related organizational experience is more important for high than for low innovativeness projects shows that the extent to which tasks can be programmed and structured helps explain learning rates. In this first study to provide empirical support for this idea, the results show that learning rates may vary with the characteristics of the contexts in which the tasks are executed (see Wiersma 2007 for an overview), as well as with the characteristics of the focal task itself.

Managerial implications

Each new project offers a potential opportunity for a firm to expand its existing knowledge and capabilities, but learning is not an automatic outcome of NPD. Managers must take measures to prevent their loss and generalize lessons from each project, with special attention to their unique information requirements. To reap the full benefits of the organizational context, project teams also must have an opportunity to access sources of experience in the wider organization. When such conditions are in place, firms seeking to reduce project cycle time benefit from encouraging the use of previous experience accumulated, both within a given technological domain and across related domains. Specialized organizational experience is important for all projects, regardless of the level of product innovativeness. In addition, managers should especially attend to the wider, related organizational knowledge base, beyond their focal domain, to manage new-to-the-firm product development projects (see also Lin and McDonough 2014).

Despite the importance of experience for cycle time reduction, the learning curve approach and the resulting progress ratios indicate that the effects of all experience dimensions decrease over time. In particular, NPD projects benefit from experience gained in early phases, after the implementation of new development processes or production technologies for example. However, as these organizational innovations mature, cycle time comes to be affected less by experience, and managers must start to draw on other available sources to reduce cycle time substantially.

Finally, managers need to limit the number of NPD projects running in parallel. The effect of concurrent project activity is substantial; concurrent projects can easily nullify the benefits of accumulated experience. Thus it is imperative for managers to ensure the allocation of sufficient resources to each project, through effective portfolio management, if they want their efforts to exploit organizational experience to produce benefits.

Limitations and Suggestions for Further Research

This study did not differentiate between products that achieved success in the marketplace and those that did not. Learning-by-failing (Buonansegna, Salomo, Maier and Li - Ying 2014; Meyers and Wilemon 1989) is another way NPD learning can take place. Unsuccessful NPD efforts can provide valuable input for identifying necessary reconfigurations and improvements, as well as act as a potential leverage point for generating new product concepts and technological alternatives. It is also possible that projects characterized by different levels of innovativeness learn differentially from terminated and completed but commercially unsuccessful projects.

An interesting avenue for research would be to explore whether the project phase has any bearing on the performance implications of NPD experience. Related organizational experience could have a greater impact in terms of reducing project cycle time in earlier phases of the development process; specialized organizational experience may have a greater impact later (Brockman and Morgan 2003). In addition, in the current research context, the organizational units were co-located groups, using different technology platforms and operating in different technological domains. Varying levels of abstraction used to define the "organizational unit" instead could produce different learning and knowledge transfer rates. For example, researchers might investigate learning that takes place within and across R&D facilities in different locations (Darr et al. 1995). Research that incorporates these possibilities can advance understanding of the ways in which past experience informs current NPD projects, as well as how organizations can exploit their stock of knowledge to its maximum potential.

References

Anzai, Y. and H.A. Simon. 1979. Theory of learning by doing. Psychological Review 86(2): 124-140.

Argote, L. 2013. Organizational learning: Creating, retaining and transferring knowledge. Springer: New York, NY.

Argote, L., S.L. Beckman and D. Epple. 1990. The persistence and transfer of learning in industrial settings. Management Science 36(2): 140-154.

Argote, L. and E. Miron-Spektor. 2011. Organizational learning: From experience to knowledge. Organization Science 22(5): 1123-1137.

Boh, W.F., S.A. Slaughter and J.A. Espinosa. 2007. Learning from experience in software development: A multilevel analysis. Management Science 53(8): 1315-1331.

Boone, T., R. Ganeshan and R.L. Hicks. 2008. Learning and knowledge depreciation in professional services. Management Science 54(7): 1231-1236.

Brockman, B.K. and R.M. Morgan. 2003. The role of existing knowledge in new product innovativeness and performance. Decision Sciences 34(2): 385-419.

Brown, S.L. and K.M. Eisenhardt. 1995. Product development: Past research, present findings, and future directions. Academy of Management Review 20(2): 343-378.

Buonansegna, E., S. Salomo, A.M. Maier and J. Li‐Ying. 2014. Pharmaceutical new product development: Why do clinical trials fail? R&D Management 44(2): 189-202.

Cankurtaran, P., F. Langerak and A. Griffin. 2013. Consequences of new product development speed: A meta‐analysis. Journal of Product Innovation Management 30(3): 465-486.

Chao, R.O. and S. Kavadias. 2008. A theoretical framework for managing the new product development portfolio: When and how to use strategic buckets. Management Science 54(5): 907-921.

Chen, J., F. Damanpour and R.R. Reilly. 2010. Understanding antecedents of new product development speed: A meta-analysis. Journal of Operations Management 28(1): 17-33.

Chen, J., R.R. Reilly and G.S. Lynn. 2012. New product development speed: Too much of a good thing? Journal of Product Innovation Management 29(2): 288-303.

Clark, J.R. and R.S. Huckman. 2012. Broadening focus: Spillovers, complementarities, and specialization in the hospital industry. Management Science 58(4): 708-722.

Cyert, R.M. and J.G. March. 1963. A behavioral theory of the firm. Prentice Hall, Englewood Cliffs, NJ.

Danneels, E. 2002. The dynamics of product innovation and firm competences. Strategic Management Journal 23(12): 1095-1121.

Danneels, E. and E.J. Kleinschmidt. 2001. Product innovativeness from the firm's perspective: Its dimensions and their relation with project selection and performance. Journal of Product Innovation Management 18(6): 357-373.

Darr, E.D., L. Argote and D. Epple. 1995. The acquisition, transfer, and depreciation of knowledge in service organizations: Productivity in franchises. Management Science 41(11): 1750-1762.

Datar, S., C. Jordan, S. Kekre, S. Rajiv and K. Srinivasan. 1997. New product development structures and time-to-market. Management Science 43(4): 452-464.

De Carolis, D.M. 2003. Competencies and imitability in the pharmaceutical industry: An analysis of their relationship with firm performance. Journal of Management 29(1): 27-50.

Easton, G.S. and E.D. Rosenzweig. 2012. The role of experience in six sigma project success: An empirical analysis of improvement projects. Journal of Operations Management 30(7-8): 481–493.

Eisenhardt, K.M. and B.N. Tabrizi. 1995. Accelerating adaptive processes: Product innovation in the global computer industry. Administrative Science Quarterly 40(1): 84-110.

Griffin, A. 1997. The effect of project and process characteristics on product development cycle time. Journal of Marketing Research 34(1): 24-35.

Hansen, M.T. 2002. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. Organization Science 13(3): 232-248.

Henard, D.H. and D.M. Szymanski. 2001. Why some new products are more successful than others. Journal of Marketing Research 38(3): 362-375.

Hyung‐Jin Park, M., J.W. Lim and P.H. Birnbaum‐More. 2009. The effect of multiknowledge individuals on performance in cross‐functional new product development teams. Journal of Product Innovation Management 26(1): 86-96.

Ingram, P. and T. Simons. 2002. The transfer of experience in groups of organizations: Implications for performance and competition. Management Science 48(12): 1517-1533.

Katila, R. and G. Ahuja. 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. Academy of Management Journal 45(6): 1183-1194.

Kelley, D.J., A. Ali and S.A. Zahra. 2013. Where do breakthroughs come from? Characteristics of high‐potential inventions. Journal of Product Innovation Management 30(6): 1212-1226.

Kessler, E.H. and A.K. Chakrabarti. 1996. Innovation speed: A conceptual model of context, antecedents, and outcomes. Academy of Management Review 21(4): 1143-1191.

Lapré, M.A. and I.M. Nembhard. 2010. Inside the organizational learning curve: Understanding the organizational learning process. Foundations and Trends in Technology, Information and Operations Management 4(1): 1-103.

Leonard-Barton, D. 1995. Wellsprings of knowledge: Building and sustaining the sources of innovation. Harvard Business Press: Boston, MA.

Levitt, B. and J.G. March. 1988. Organizational learning. Annual Review of Sociology 14: 319-340.

Lin, H.E. and E.F. McDonough. 2014. Cognitive frames, learning mechanisms, and innovation ambidexterity. Journal of Product Innovation Management 31(S1): 170-188.

Macher, J.T. and D.C. Mowery. 2003. "Managing" learning by doing: An empirical study in semiconductor manufacturing. Journal of Product Innovation Management 20(5): 391-410.

Madhavan, R. and R. Grover. 1998. From embedded knowledge to embodied knowledge: New product development as knowledge management. Journal of Marketing 62(4): 1-12.

Mallick, D.N., L.P. Ritzman and K.K. Sinha. 2013. Evaluating product‐centric continuous improvements: Impact on competitive capabilities and business performance. Journal of Product Innovation Management 30(S1): 188-202.

March, J.G. 1991. Exploration and exploitation in organizational learning. Organization Science 2(1): 71-87.

McDermott, C.M. and G.C. O'Connor. 2002. Managing radical innovation: An overview of emergent strategy issues. Journal of Product Innovation Management 19(6): 424-438.

McKee, D. 1992. An organizational learning approach to product innovation. Journal of Product Innovation Management 9(3): 232-245.

Meyers, P.W. and D. Wilemon. 1989. Learning in new technology development teams. Journal of Product Innovation Management 6(2): 79-88.

Nelson, R.R. and S.G. Winter. 1982. An evolutionary theory of economic change. Harvard University Press: Cambridge, MA.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. Organization Science 5(1): 14-37.

Pisano, G.P. 1994. Knowledge, integration, and the locus of learning: An empirical analysis of process development. Strategic Management Journal 15(S1): 85-100.

Reagans, R., L. Argote and D. Brooks. 2005. Individual experience and experience working together: Predicting learning rates from knowing who knows what and knowing how to work together. Management Science 51(6): 869-881.

Scarbrough, H., J. Swan, S. Laurent, M. Bresnen, L. Edelman and S. Newell. 2004. Project-based learning and the role of learning boundaries. Organization Studies 25(9): 1579-1600.

Schilling, M.A., P. Vidal, R.E. Ployhart and A. Marangoni. 2003. Learning by doing something else: Variation, relatedness, and the learning curve. Management Science 49(1): 39-56.

Song, X.M. and M.M. Montoya‐Weiss. 1998. Critical development activities for really new versus incremental products. Journal of Product Innovation Management 15(2): 124-135.

Staats, B.R. and F. Gino. 2012. Specialization and variety in repetitive tasks: Evidence from a japanese bank. Management Science 58(6): 1141-1159.

Stanko, M.A., F.J. Molina‐Castillo and N. Harmancioglu. 2015. It won't fit! For innovative products, sometimes that's for the best. Journal of Product Innovation Management 32(1): 122-137.

Thomke, S.H. 2003. Experimentation matters: Unlocking the potential of new technologies for innovation. Harvard Business School Press: Boston, MA.

Thurstone, L.L. 1919. The learning curve equation. Psychological Monographs 26: 1-51.

Tortoriello, M., R. Reagans and B. McEvily. 2011. Bridging the knowledge gap: The influence of strong ties, network cohesion, and network range on the transfer of knowledge between organizational units. Organization Science 23(4): 1024-1039.

Wiersma, E. 2007. Conditions that shape the learning curve: Factors that increase the ability and opportunity to learn. Management Science 53(12): 1903-1915.

Yan, T. and K.J. Dooley. 2013. Communication intensity, goal congruence, and uncertainty in buyer–supplier new product development. Journal of Operations Management 31(7): 523-542.

Table 1
Descriptive Statistics and Correlations

Variables	Mean	SD	1	2	3	4	5
1. Project cycle time	66.42	51.84					
2. Specialized organizational experience	9.12	9.08	-.70 **				
3. Related organizational experience	51.03	43.77	-.82 **	.73 **			
4. Product innovativeness	0.50	0.50	-.04	.07	.09		
5. Time	234.48	69.12	-.65 **	.65 **	.82 **	.10	
6. Concurrent project activity	54.94	36.62	.39 **	-.07	-.14	.05	-.10

* $p < .05$. ** $p < .01$.

Table 2
Estimated Coefficients for Models Predicting NPD Project Cycle Time

Variable	Model 1	Model 2	Model 3
Constant	-.18	**-.18** *	**-.19** *
Step 1: Control variables			
Organizational unit 2	**.32** *	**.41** **	**.43** **
Organizational unit 3	.05	.07	.08
Organizational unit 4	.21	**.31** **	**.31** **
Organizational unit 5	.26	.13	.17
Organizational unit 6	.07	-.02	.01
Organizational unit 7	.34	.20	.22
Time (β_1)	**-.90** **	.14	.08
Concurrent project activity (β_2)	**.29** **	**.25** *	**.26** *
Step 2: Main effects			
Specialized organizational experience (β_3)		**-.23** **	**-.23** **
Related organizational experience (β_4)		**-.29** **	**-.24** **
Product innovativeness(β_5)		-.02	-.01
Step 3: Two-way interaction effects			
Specialized organizational experience × Product innovativeness (β_6)			.04
Related organizational experience × Product innovativeness (β_7)			**-.15** *
R^2	.56	.80	.81
F-statistic	25.30 **	58.26 **	51.35 **
R^2 *change*		.25	.01
F-change statistic (df_1, df_2)		65.08 ** (3, 157)	3.42 * (2, 155)

*$p \leq .05$. **$p \leq .01$ (n = 169).