Product Innovation Processes in Small Firms: Combining Entrepreneurial Effectuation and Managerial Causation

August, 2012

=== Accepted for publication in Journal of Product Innovation Management ===

Hans Berends
Faculty of Economics and Business Administration
VU University Amsterdam
De Boelelaan 1105
1180 HV Amsterdam
The Netherlands
j.j.berends@vu.nl
(corresponding author)

Mariann Jelinek
Richard C. Kraemer Professor of Strategy, Emerita
Mason School of Business
College of William & Mary
P.O. Box 8795 - Williamsburg, VA 23187
USA
mariann.jelinek@mason.wm.edu

Isabelle Reymen
School of Industrial Engineering
Eindhoven University of Technology
P.O. Box 513 - 5600 MB - Eindhoven
The Netherlands
i.m.m.j.reymen@tue.nl

Rutger Stultiëns
Chematronics BV
High Tech Campus 9 - 5656 AE - Eindhoven
The Netherlands
r.stultiens@chematronics.nl

Product Innovation Processes in Small Firms:
Combining Entrepreneurial Effectuation and Managerial Causation

Abstract

This article reports a multi-method study of product innovation processes in small manufacturing firms. Prior studies found that small firms do not deploy the formalized processes identified as best practice for the management of new product development (NPD) in large firms. To explicate small firms' product innovation, this study uses effectuation theory, which emerged from entrepreneurship research. Effectuation theory discerns two logics of decision making: causation, assuming that means are selected to attain goals; and effectuation, assuming that goals are created based upon available means. The study used a process research approach, investigating product innovation trajectories in five small firms across 352 total events. Quantitative analyses revealed early effectuation logic, which increasingly turned towards causation logic over time. Further qualitative analyses confirmed the use of both logics, with effectual logic rendering product innovation resource-driven, stepwise, and open-ended, and with causal logic used especially in later stages to set objectives and to plan activities and invest resources to attain objectives. Because the application of effectuation logic differentiates the small firm approaches from mainstream NPD best practices, this study examined how small firms' product innovation processes deployed effectuation logic in further detail. The small firms: (1) made creative use of existing resources; (2) scoped innovations to be realizable with available resources; (3) used external resources whenever and wherever these became available; (4) prioritized existing business over product innovation projects; (5) used loose project planning; (6) worked in steps towards tangible outcomes; (7) iterated the generation, selection, and modification of goals and ideas; and (8) relied on their own customer knowledge and market probing, rather than early market research. Using effectuation theory thus helps to understand how small firm product innovation both resembles and differs from NPD best practices observed in larger firms. Because the combination of effectual and causal principles leverages small firm characteristics and resources, this article concludes that product innovation research should more explicitly differentiate between firms of different sizes, rather than prescribing large firm best practices to small firms.

INTRODUCTION

Small firms contribute significantly to technological innovation and economic growth (Acs and Audretsch 1988; Audretsch et al. 2009; Ettlie and Rubenstein 1987), and product innovation is a key driver of the economic performance and growth of small firms (Freel 2000a; Rosenbusch et al. 2011; Wolff and Pett 2006). In contrast with large firms, however, small firms generally undertake fewer innovation projects. Moreover, while small firms enjoy greater flexibility than large firms, their resources and skills are more limited, and they lack the organizational and marketing capabilities of large firms (Van de Vrande et al. 2009; Yap and Souder 1994). These characteristics create challenges for small firms' product innovation efforts.

Prior research poses a puzzle about small firm's innovation processes. On the one hand, an extensive body of research on new product development (NPD) has identified benefits of a formalized process, with well-planned activities and decision points (e.g., Cooper and Kleinschmidt 1995; Ettlie and Elsenbach 2007): a formal product innovation process is considered part of NPD best practice (Barczak et al. 2009; Kahn et al. 2006). On the other hand, case study evidence suggests that small firms seldom use such formalized process structures (e.g., March-Chorda et al. 2002; Scozzi et al. 2005). Is this due to "cultural barriers" within small firms (Filson and Lewis 2000; Scozzi et al. 2005: 128) – and thus a shortcoming, to be remedied by adoption of structured product innovation approaches? Or do small firms simply require another approach due to the different nature of their product innovation processes?

Current literature on management of product innovation is silent on this question for small firms. First, most product innovation management research has focused solely on large firms, or has failed to distinguish between large and small firms (Moultrie et al. 2007). Second, those studies specifically targeting small firm innovation have focused on the antecedents and consequences of product innovation efforts (Brouwer and Kleinknecht 1996; Ledwith and O'Dwyer 2009; Roper 1997), identifying effects of interorganizational collaborations (Bougrain and Haudeville 2002; Stuart 2000); competitor orientation (Ledwith and O'Dwyer 2009), organizational structure (Terziovski 2010), intellectual capital (Leitner 2011), and the availability of qualified scientists and engineers (Romijn and Albaladejo 2002). The vast majority of studies on small firm product innovation, like the majority of NPD studies in general, consist of cross-sectional variance research, rather than longitudinal process research (Langley 1999; Van de Ven 2007). With few or no studies of how small-firm new product innovation unfolds over time, little is known about the nature of small firm product innovation processes or dynamics (Edwards et al. 2005).

To advance theoretical understanding of how product innovation unfolds in small firms, this study deploys effectuation theory, which emerged in entrepreneurship studies (Sarasvathy 2001; 2008). This theory discerns two logics of decision making, causation and effectuation, of which the latter seems especially suited to small firms' strengths and limitations. An empirical process research study was undertaken (Langley 1999; Poole et al. 2000) which investigated the evolution of five product innovation projects in different established small firms in manufacturing industries and combined quantitative and qualitative research methods of data analysis (Langley 1999; Jick 1979).

The contributions of this article are as follows. First, the analyses provide insight in the nature of product innovation processes of small manufacturing firms. Analysis of event sequences in the small firm product innovation trajectories reveals that small firm product innovation processes comprise a combination of the effectuation logic that is also applied by experienced entrepreneurs (Sarasvathy 2008) with the causation logic that underpins dominant approaches to the management of product development. Effectuation was dominant in earlier stages, while causation was more visible in later stages of innovation trajectories.

Further qualitative analysis exposes small firms' effectual product innovation approach as resource-driven, stepwise, and open-ended. Second, this study shows that the effectual approach suits small firm characteristics, even though it differs from mainstream best practices that are based largely on research in larger firms. This suggests that product innovation research should explicitly differentiate on firm size, rather than prescribing large firm best practices to small firms. Third, this article shows the value of process methods for research on product innovation, which is currently dominated by variance research approaches focusing on antecedents and consequences. Process research is a complementary approach that helps to theorize underlying mechanisms. Finally, this study contributes to the literature on effectuation, which is largely conceptual or experimental in nature, by revealing dynamics of effectuation in the real life context of established small firms.

THEORETICAL BACKGROUND

Product innovation in small firms

Small firms are not miniature versions of large firms (Welsh and White 1981), and their characteristics constitute particular strengths and limitations for product innovation. A key strength of small firms is flexibility (Fiegenbaum and Karnani 1991): they usually lack bureaucracy; are often managed by an owner/director who is able to take key decisions quickly; they enjoy efficient and informal internal communication patterns; and develop strong relationships with customers. These characteristics enable rapid responses to technical and market changes (Chandy and Tellis 2000; Verhees and Meulenberg 2004), often resulting in differentiated products for niche markets (Almeida and Kogut 1997; Damanpour 1992; Qian and Li 2003).

On the downside, small firms have limited resources for product innovation projects (Chandy and Tellis 2000; Ettlie and Rubenstein 1987; Moultrie et al. 2007). Lack of financial resources to cover the costs of innovation was identified as a key barrier in several studies (e.g., Millward and Lewis 2005; Radas and Bozic 2009). These constraints exacerbate the risks of innovation for small firms, which cannot sustain many failures (Kaufmann and Tödtling 2002; Yap and Souder 1994). Besides limited financial and other material resources, small firms may lack the skills portfolios of their large company counterparts (Moultrie et al. 2007), especially the organizational and marketing capabilities to exploit new products (Freel 2000b; Scozzi et al. 2005). Further, a small firm's position in its industry may constrain prospects to create and exploit innovations (Schumpeter 1942), due to lack of name recognition, brand credibility, and track record (Hoffman et al. 1998); restricted influence on industry standards (Yap and Souder 1994); limited network relations with other business and governmental organizations (Hoffman et al. 1998); and inability to defend trademarks or other proprietary resources (Eden et al. 1997; Leiponen and Byma 2009).

Furthermore, small firms typically pursue few innovation projects at any one time – maybe just one, or even none at times (Laforet 2008). Consequently, their experience in product innovation is often limited. With no need to manage a portfolio of innovation projects at the same time and thus no pressure to select among projects to allocate resources, small firms have neither opportunity nor incentive to routinize innovation or formalize NPD stage-gates or selection procedures, as big firms do.

Evidence confirms that small firms' innovation processes differ from those of large enterprises. The formalized NPD processes considered necessary for efficient product innovation in large firms are usually not found in small firms (March-Chorda et al. 2002; Scozzi et al. 2005; Woodcock et al. 2000). Scozzi et al. (2005) found that few of the 19 Italian SMEs they studied used structured procedures to develop an innovation strategy or to plan, monitor or control their innovation development processes. Even where structured procedures were available, they were typically not codified and might actually be ignored.

Similarly, March-Chorda et al. (2002) found that very few of their 65 Spanish small companies from different sectors followed a formalized, ordered plan in product innovation. Existing case study evidence suggests that projects are often ad hoc and iterative, rather than planned and linear (Hoffman et al. 1998; March-Chorda et al. 2002). No studies were found that actually traced small firms' innovation projects over time.

Besides these generic differences between large and small firms NPD management, there are also differences in execution and timing of particular activities in small firms' product innovation processes. For example, early market screening and market research, identified as key activities in structured large firm NPD processes (Cooper and Kleinschmidt 1986), are consistently lacking or poorly executed in small firms (Hoffman et al. 1998; Huang et al. 2002; Moultrie et al. 2007; Scozzi et al. 2005).

These empirical findings undermine the assumption that new product development in small firms should mimic larger firm NPD and adopt large firms' best practices (cf., Scozzi et al. 2005; Terziovski 2010). Perhaps small firms' characteristics demand alternative approaches to product innovation management? To address this question, better theoretical understanding is needed of the actual dynamics of product innovation processes in small firms. The theory of effectuation (Sarasvathy 2001) seems particularly apropos for investigating small firm product innovation characteristics; therefore, the next section discusses causation and effectuation and their relevance for product innovation in small firms.

Causation and effectuation

To generate theoretical understanding of product innovation processes in small firms, this study builds upon the theory of effectuation, which distinguishes two contrasting logics of decision making: causation and effectuation (Sarasvathy 2001; 2008). Effectuation theory addresses entrepreneurial behaviour and therefore seems especially suitable for product innovation in small firms, which is a specific form of entrepreneurial behaviour (Carland et al. 1984; Schumpeter 1934). The distinction between causation and effectuation has been previously applied to start-up activities (Sarasvathy 2008), business strategy (Wiltbank et al. 2006), R&D projects (Brettel et al. 2012), and marketing under uncertainty (Read et al. 2009), constructs also related to product innovation. Second, the logic of effectuation suits the characteristics of product innovation in small firms: effectuation concerns action under resource constraints, a central concern for most small firms (Ettlie and Rubenstein 1987); and action choice under uncertainty, a key characteristic of product development (MacCormack and Verganti 2003). Third, effectuation and causation concern processual phenomena (Sarasvathy and Dew 2005), and are therefore well suited for developing process-based explanations of product innovation in small firms.

Causation and effectuation are two distinct logics of decision making under uncertainty: "Causation processes take a particular *effect* as given and focus on selecting between means to create that effect. Effectuation processes take a set of *means* as given and focus on selecting between possible effects that can be created with that set of means" (Sarasvathy 2001: 245; emphasis added). Causation is the goal-directed managerial process typically assumed in texts on decision making, strategic management, and marketing. Causation implies that after defining a specific goal, means are sought to achieve that goal in the most efficient way. Under uncertainty, this logic depends on predicting which means and actions are best suited to reach a particular goal.

By contrast, rather than assuming a pre-defined goal, effectuation takes available means as its point of departure to identify potential outcomes that might be realized from those means. Take, for example, the planning of a trip: Causation logic starts with a destination – a goal – and selects the best mode of transport to arrive at that destination by predicting the consequences of particular modes of transport (for instance, assessing the probability and effect of traffic jams, flight cancellations or train delays). Effectuation logic starts with available transport, time resources, or budget, and then examines potential destinations that can be reached using them. Examples of individual-level means include one's identity, knowledge, and personal networks; organizational level means include organizational capabilities, interorganizational relations, and material resources (Sarasvathy 2001; Wiltbank et al. 2006). Effectuation's key lies in creating value with available resources, however limited they may seem from an outsider's perspective (Baker and Nelson 2005), and in iteratively re-examining prospects as resources change.

The defining characteristics of effectuation, being *means-driven*, versus causation, which is *goal-driven*, have been developed into four associated principles. First, effectuation seeks to *control an unpredictable future* by avoiding uncertainties and focusing on what is under short term control, where causation focuses on *predicting an uncertain future*. Second, effectuation chooses actions *based upon an affordable loss criterion,* whereas causation seeks to *maximize expected returns*. The affordable loss criterion means that downside risks that cannot be handled will be avoided. Third, effectuation seeks to *build strategic alliances* to expand the firm's accessible resource base, whereas causation starts from *competitive analysis.* Strategic allies' commitment affects and co-determines the effectual course of action. Fourth, effectuation is open to whatever actually happens. Effectuation learns as it goes, *exploiting emergent contingencies*, whereas causation *exploits prior predictions or pre-existing knowledge*. While unexpected occurrences may distort a predictive approach, emergent contingencies are embraced by an effectual approach, since they may be productively utilized in the creative process.

Effectuation and causation are distinct logics, but neither is universally superior to the other, and actual processes may exhibit a combination of effectual and causal reasoning

(Sarasvathy 2001). Burgeoning empirical research on effectuation consists chiefly of studies of individual decisions in an experimental setting (e.g., Dew et al. 2009; Read et al. 2009; Sarasvathy 2008), which reveal that experienced entrepreneurs enact effectuation logic, whereas other subjects display causal logic. Few studies have investigated effectuation in action in real life settings. Exceptions are Sarasvathy and Dew (2005), applying an effectuation perspective to analyse the creation of a new market; and Wiltbank et al. (2009), who investigated investors' decisions. Finally, a meta-analysis that reinterpreted prior research on new ventures in terms of effectuation principles, found that these principles (except for the affordable loss principle) were associated with higher new venture performance (Read, Song, and Smit 2009).

Causation, effectuation, and product innovation

To investigate whether and how small firms apply causation and effectuation logics in their new product development efforts, this study models the product innovation process as an interaction of goal setting, resource commitment, and idea development. While goals and resources are central to the logic of effectuation, the application to the domain of product innovation in this study also includes ideas, because innovation concerns the development and implementation of new ideas (Van de Ven 1986).

The literature on product innovation rests principally on large, established-firm research, and depicts product innovation as a process that matches a causal logic. Best practice studies advise firms to set clear goals for product development, determine a strategy that can drive project selection, and take a long term perspective (e.g., Barczak et al. 2009; Kahn et al. 2006). Thus, a portfolio of ideas is to be developed, targeting these goals. Resources are allocated to project ideas according to their rank-ordering by discounted cash flow and payback periods (Barczak et al. 2009; Terwiesch and Ulrich 2008). In large firms, such decisions are often informed by upfront market research to elicit customer preferences and predict future sales (Read et al. 2009). Projects, then, should be guided by clear and stable product definitions (Cooper and Kleinschmidt 1995; Lynn and Akgün 2001). Deliverables are determined for each gate in a formal stage-gate process, and resource commitments depend on the actual deliverables at each gate in comparison to planned milestones (Cooper 2001). Thus, the overall direction is from goal setting to idea development and resource commitment. It should be noted, though, that such best practices have begun to be challenged, with more flexible approaches advocated for more radical innovation projects (Biazzo 2009; Cooper 2008; Seidel 2007; Song and Montoya-Weiss 1998).

By contrast, effectuation logic would result in a different sequence among goal setting, idea development, and resource commitment. Since effectuation reasons from resources to goals, goal setting would follow resource commitment. No specific differences are expected with regard to the place of ideas in the sequences. This study investigates whether and how small-firm product innovation projects follow causation or effectuation logic, or a combination of both.

METHODS

To examine how product innovation unfolds in small firms, a process research approach was adopted, investigating small firm product innovation as "a sequence of events or activities that describe how things change over time" (Van de Ven 2007: 197). Multi-method longitudinal studies of small firm product innovation were used to depict the evolution of actual processes in their natural environment. The combination of multiple methods of data collection and analysis served the exploratory nature of this study and provided cross-validated findings (Jick 1979; Langley 1999). The study employs replication logic, investigating multiple homogeneous but independent small firms' innovation trajectories for potential corroboration of findings (Yin 2003). In line with Eisenhardt's (1989) guideline that four to ten organizations typically suffice for establishing replication, five small firms were investigated, resulting in a theoretically saturated analysis.

Candidate firms and projects were sought among participants at a series of product design workshops offered by Syntens, a Dutch government-sponsored organization, in which firms collaborated with external designers. Small firm innovation projects were selected from among 50 participants in five workshops held from 2005 to 2008 based upon a telephone interview with each of the 45 firms that could be reached.

Five small firms were selected to focus on comparable product innovation projects. First, the subjects are all established small firms, for whom the product innovation project was not a first product. Second, according to European Commission (2003) definitions, case study firms are classed as "small" or "micro" based on the number of employees and revenues: all employed less than fifty people (ranging from 5 to 47) and all had less than € 10 million in revenues (the highest being € 6 million). Third, for comparability, all were in manufacturing industries (Delta only developed and sold products, but outsourced production), since manufacturing firm innovation behaviour differs significantly from that of service companies (Ettlie and Rosenthal 2011; Hoffman et al. 1998). Finally, each product represented an incremental innovation of relatively low complexity that had been in development for 8 to 16 months. All of the five product innovation projects involved external designers at some point, enabling us to tap multiple perspectives. Table 1 provides project and firm descriptions, anonymized as Alpha, Beta, Gamma, Delta, and Epsilon.

=== INSERT TABLE 1 ABOUT HERE ===

Data collection

The firms' innovation projects were explored via extensive interviews with informants including the project leader, the external designer, plus on average one other person from within each small company. Within small firms, the project leader of innovation efforts is often the owner/director, who is sometimes the only one involved in the project, thus restricting the number of potential interviewees. In total 15 persons were interviewed, several of them twice, in interviews lasting 90 minutes on average. The interviews, which took place late 2008 and early 2009, were recorded and fully transcribed, yielding 468 pages of interview text; interviews were conducted and transcribed in Dutch; quotes are authors' translations.

Interviews followed a semi-structured protocol to elicit a detailed timeline of the NPD project, identifying important events affecting the project from its initiation to its endpoint in the product innovation trajectory (prior to launch). The narrative of an innovation trajectory emerges naturally in such a discussion, as participants are asked for the history, with queries for clarity, identifying marker events, links among events and so on. Focusing the interviews on specific events and facts facilitated accuracy of the participants' memory (Huber and Power 1985; Miller et al. 1997).

To triangulate interview data, additional project documentation (such as project proposals, drafts of offers, and drawings or photos of the products being designed) was also consulted. Further, contemporaneous emails among project participants were reviewed, which also suggested and corroborated events (see Table 1 for company descriptions and an overview of all data sources). By collecting data from knowledgeable informants with different perspectives, likely to offset each other's potential biases, and by triangulating interview data with e-mail exchanges and project documentation, this study followed key procedures to mitigate potential retrospective biases and enhance accuracy (Huber and Power 1985; Miller et al. 1997; Schwenk 1985).

Process analyses

Following Langley's (1999) advice, multiple strategies for data analysis were combined (see Table 2 for an overview). As a first step, based on the interviews and documentation, a detailed process reconstruction of each innovation project was made in the form of an event sequence file (Poole et al. 2000). One member of the research team distinguished separate events in the innovation process and discussed this with another member of the team until consensus was reached on the identification of events. For each event, they recorded the date of occurrence, the action, the actors involved, the effect of the action, and the reasons for the action. Additionally, they noted the data source(s) for each event, thereby maintaining the chain of evidence (Yin 2003). For validation, the event sequence file was subsequently communicated to all interviewees, who were asked to correct or supplement the data where necessary. This feedback, communicated by phone or e-mail, resulted in minor changes only. The five sequences of finalized reconstructions ranged from 49 to 108 events.

Second, to investigate sequences of goal setting, idea development and resource commitment, events were coded using a scheme that distinguished goal events, idea events and resource events. To develop reliable coding procedures for these events, first, an initial coding scheme was created, building upon Poole et al. (2000). Following the literature on effectuation, resources are interpreted broadly, to include funds, equipment and personnel, as well as external partners (Sarasvathy 2001; 2008). Resource events consist of changes in these resources (e.g., initiating collaboration) or in the commitment of resources to the product innovation project. Goal events consist of formulation or changes in the objectives of product development activities. Idea events consist of the generation, modification or dismissal of product and design ideas. The coding scheme included an option for events that could not be assigned to one of these event types. As second sub-step, one pair of researchers coded the event sequences of Alpha and Epsilon; one of those two researchers coded the event sequence of Epsilon with a third member of the research team. As third sub-step, differences in codes were discussed in both coding teams and ambiguities in the coding scheme were resolved where necessary. This resulted in refining the coding rules and finalizing the coding scheme, which is displayed in Table 3. As fourth sub-step, this refined coding scheme was applied to the remaining event sequences, thus testing for interrater reliability on other parts of the data. Two members of the research team independently applied the coding scheme to the Delta event sequence. Cohen's Kappa was used to calculate interrater reliability, resulting in a score of .740. Additionally, one of the original two researchers and another member of the research team independently coded the event sequence of Beta, resulting in a score of .662. Both scores indicate substantial agreement (Landis and Koch 1977). As a fifth sub-step, after having determined reliability based on independent coding, differences were discussed until agreement was reached on the coding of all events.

As the third step in the analysis, the event codings were used for gamma analyses to establish quantitatively whether effectual or causal logic underpinned the innovation projects. Gamma analysis determines the extent to which event types tend to precede one another and the extent to which event types are separated from one another in an event sequence (Poole et al. 2000: 250). Gamma analysis was developed for a study of product development processes by Pelz (1985) and has been applied in strategy (Rindova et al. 2010), software development (Kemerer and Slaughter 1999), and decision making (Poole and Roth 1989). Gamma analysis is based on Goodman-Kruskal's (1963) gamma, a non-parametric statistic that is a measure for ordinal relationships (Pelz 1985). In gamma analysis of event sequences, gamma indicates the degree to which type A events precede type B event. A gamma score is calculated as (P-Q)/(P+Q), where P is the count of A events preceding B events and Q is the count of B events preceding A events. Gamma scores range from 1 to -1 and are symmetrical so that the gamma score for B events preceding A events is the same number but with the opposite sign as the score for A events preceding B events. If multiple types of events exist, pairwise gamma scores are calculated for each pair of event types. Based upon the resultant matrix with pairwise gammas, precedence and separation scores are calculated for each type of event. A *precedence score* is given by the mean of an event type's pairwise gamma scores. Consequentially, precedence scores for event types also range from 1 to -1, and these scores indicate the location of an event type in the overall ordering of event types: event types with higher precedence scores generally come earlier in the sequence of events. The set of pairwise gamma scores is also used to calculate *separation scores*, which indicate whether event types form distinct phases. Separation scores are calculated as the mean of the absolute value of pairwise gamma scores. Separation scores can range from 0 to 1 and indicate the distinctness of phases. According to the methodological guidelines for gamma analysis (Holmes 1995; Pelz 1985; Poole et al. 2000), separation scores below .25 indicate overlap where events of a particular type cannot be considered as a distinct phase; separation scores between .25 and .50 indicate somewhat distinct phases, and separation scores above .50 indicate clear separation of phases. Low separation scores also imply that precedence scores are low. All gamma analyses were conducted using WinPhaser software (Holmes 1995).

The gamma analyses proceeded in two stages. First, a test of the overall sequences examined whether, taken as a whole, each sequence exhibited effectual or causal logic (based on the sequence of goal, idea, and resource events). Next, in a more fine-grained analysis to test for changes in effectual and causal processes over time, each innovation project was divided in three equal length sequences of events, and gamma analyses were conducted on these partial event sequences by the same procedure as for the complete sequences.

The event sequences were further analyzed using qualitative methods (Langley 1999; Strauss and Corbin 1998) to provide more detailed insight in how the logics of effectuation and causation were used in these small firms' product innovation processes. To support the analysis, a visual mapping strategy was used (Langley 1999), which summarized innovation trajectories by depicting a selection of key events in a timeline. Then, specific events were analyzed as well as relations among events (e.g., among resource, goal, and idea events), using causation and effectuation as sensitizing concepts. Interview data pertaining to events were coded using QSR NVivo 8 qualitative analysis software. First, qualitative evidence was found that the firms used both causal and effectual logics, and differentiated the application of these logics to small firm product innovation in terms of the role of goals, resources, ideas, and additionally process management. Because the application of effectual logic differentiates these firms from common approaches to NPD, the effectual logic was investigated in more detail. Eight different tactics were identified that together explain the effectual approach to small firm product innovation as *resource-driven*, *stepwise* and *open-ended*.

Quantitative gamma analysis and qualitative process analysis were complementary in this study. Gamma analysis provided a quantitative estimation of the presence of causation and effectuation, while qualitative research procedures provided additional and in-depth insight into how causation and especially effectuation were used. First, gamma analysis reveals the overall precedence and separation of types of events, but not whether there is a direct connection between events. Qualitative research allows a more fine-grained analysis of how specific events are related. Second, gamma analysis reveals overall relations among events, here including developments and changes in goals, ideas, or resources. Yet, effectuation and causation may also build upon states (pre-existing resources, goals, or ideas), and not only upon prior events. Such relations among states and events may also be captured by qualitative analysis. Finally, qualitative research enables investigation of other aspects of effectuation and causation, besides the means-driven versus goal-driven principle investigated in gamma-analysis. The conclusions thus combined insights derived from both quantitative and qualitative research approaches. The findings section starts with the results of the gamma analyses, and then continues with discussing in detail the themes and tactics that emerged from the qualitative analysis.

=== INSERT TABLE 2 AND TABLE 3 ABOUT HERE ===

FINDINGS

Sequences of goal setting, idea development and resource commitment

Gamma analyses provided quantitative empirical examination for the presence of either causal or effectual processes. Resource events would precede goal events in effectual processes, whereas by contrast, goal events preceding resource events offer evidence of causal processes. Precedence and separation scores for each innovation trajectory taken as a whole are presented in Table 4. Overall precedence scores for goal events are higher than for resource events for Alpha, Beta, and Gamma, but Delta and Epsilon exhibited higher precedence scores for resource events than for goal events. These precedence scores suggest that causal processes prevailed in Alpha, Beta, and Gamma, and that effectual processes prevailed in the other two trajectories. However, the separation scores indicate that goal, idea, and resource events are highly interwoven across overall product innovation trajectories: all separation scores, except one, are below 0.5, and most of them are below 0.25, indicating significant overlap among event types. Hence, the sequences taken as unitary wholes do not support an unequivocal categorization of the individual process sequences as either causal or effectual, inviting further inquiry.

For a more fine-grained analysis, each event sequence was split in three parts of equal length (see Table 5). Analysis of these partial sequences does reveal a clear pattern: product innovation in small firms starts according to effectuation logic, but over time turns increasingly towards causation logic. Resource events precede goal events in the first part of each of the five trajectories (evidenced by a higher precedence score for resource events). In contrast, only one of the five cases ends with a partial sequence in which resource events precede goal events. Several partial sequence separation scores exceed 0.5, and most of these scores exceed 0.25 – partial sequences are thus much more readily categorized as having distinct phases. These analyses suggest that the product innovation processes observed in these small firms exhibit a combination of effectual and causal logics, with effectual logic prevalent in the earlier phases and emphasis shifting towards causal logic in later phases.

Idea events have the lowest precedence score in the overall analysis of each case, yet separation scores do not exceed 0.5 in any case. This means that idea events occur throughout the whole event sequence, though more dominantly at the end. This can be explained in the first place by the fact that ideas not only include product ideas as these are conceived early on in a product innovation process, but also ideas for more detailed product design and development decisions. A closer look at later ideas shows that these indeed concern product details such as colours and materials, and the operationalization, refinement, and changing of earlier ideas. The early idea events more often concern invention concepts or basic product ideas. Because the later detailed developments outnumber initial inventions, overall, ideas tend to occur later in a sequence.

=== INSERT TABLE 4 AND TABLE 5 ABOUT HERE ===

Qualitative analysis of causation and effectuation

With evidence in hand for the presence of both effectuation and causation - with effectuation dominance in the early stages of small firm product innovation and causation more dominant in later stages - we now turn to a qualitative analysis of how these small firms used effectual and causal logics. These logics differ with regard to the role of *goals* pursued, the *resources* used, *ideas* development, and *process management*. To provide a background to these qualitative analyses, Figures 1a to 1e represent a selection of key events in each of these trajectories.

Causal logic was visible at several moments in the innovation trajectories, especially in later stages. With regard to *goals*, as stated in the theory section, causal logic applied to NPD involves setting product innovation objectives and product definitions early in the process. Such a dominance of early-formulated goals was visible in the innovation trajectory at Delta, which started causally with the objective to solve mechanical problems with the current version of the product, as reported by customers (Summer 2004; see Figure 1d). *Resources* were committed aimed at this goal, for example where Delta and its design agency allocated time to find a solution for the medicine cabinet door-closing problem experienced by their lead customer (Winter 2004). In other trajectories, goals crystallized over time; once matured, these goals could then guide subsequent causal action. Investments in resources were made to achieve emergent product development objectives, as when Alpha invested in the development of molds for manufacturing its cooling unit covers (October 2008). In this causal logic*, ideas* are linked primarily to goals, as they serve to formulate goals or concern potential ways to realize objectives (e.g., to find a solution for the cabinet door problem in Delta), to which resources can be committed later. In this way, ideas may form a bridge from goals to resources. The application of causal logic can also be recognised to some degree in managing the *process* of product innovation, whereby small firms engage in planning at several moments in the trajectories, thereby guiding actions to attain objectives. For example, after Beta decided on the basics of product design in October 2004, they set a target to introduce the product in January 2009 and roughly planned the steps to attain that objective, though such planning was neither detailed nor strictly adhered to (see below).

At other moments, and especially early on the innovation processes, the small firms applied effectuation. In effectual logic, *resources* shape the innovation strategy, whereas in causal logic firms acquire and invest resources to attain goals. Substantiating the finding of early effectuation logic, several of the trajectories are triggered by resource events or start from resource states. At Alpha, the actual innovation trajectory kicks off in September 2007 after the owner / director is informed of an upcoming subsidized design workshop, offering resources to start working on the product innovation (Figure 1a). At Beta, it was the accidental acquisition of a patent and design for a hydraulic stirrup suspender as part of the inventory of an acquired company, a product not commercially successful because of high costs; after Beta left this resource on the shelf for a number of years, a Beta engineer with a personal interest in horse riding started tinkering in his free time to reinvigorate this product (Figure 1b). At Gamma, it was the existing relation with an external designer, and an existing product that served as a basis for joint experimentation toward product renewal (Figure 1c). Epsilon started with the question where else to apply their capabilities in processing Silestone, a solid natural quartz engineered material (Figure 1e). In effectual logic, *ideas* often concern how to use resources creatively for new products, thus forming a bridge from resources to goals. Furthermore, the *process* is not pre-planned, but stepwise. The development trajectory occurred through steps yielding concrete outcomes, such as prototypes, while limiting risk and costs at each step, where outcomes drive resource commitments by feedback (not prediction). This allowed firms to regularly reflect on outcomes so far, and to incorporate changes, customer feedback, or additional resources and opportunities as these emerged in their environment. Correspondingly, whereas causal logic sets bounded goals and product definitions, effectual logic is open-ended, with *goals* and *ideas* crystallizing over time.

Qualitative analysis thus corroborates the use of both logics in small firms – thereby also confirming Sarasvathy's (2001) expectation – but at different moments and for different events. Whereas the causal logic resembles the logic that underlies mainstream best practices advocated in the NPD literature, effectual logic differentiates the small firm approaches, inviting closer inquiry. Therefore, the effectual dimension is analyzed in more depth. Following from the analysis reported above, the effectual approach to small firms' product innovation efforts is conceptualized as *resource-driven*, *stepwise*, and *open-ended*. The next section discusses specific tactics associated with these characteristics.

=== INSERT FIGURES 1a TO 1e ABOUT HERE ===

Effectuation tactics in small firm product innovation

Further qualitative analysis identified eight tactics associated with the resource-driven, stepwise and open-ended nature of small firms' effectual approach to product innovation (see Table 6). Specifying the small firms' effectual approach to product innovation into detailed tactics also shows how the other principles of effectuation – besides the core principle of starting from one's resources – come into play, providing a rich picture of small firm product innovation processes.

=== INSERT TABLE 6 ABOUT HERE ===

Resource-driven

Analysis of the event sequences showed a variety of tactics in the small firms' product innovation processes that exhibit their resource-driven nature, each helping the small firms to make do with limited resources. First, to deal with resource limitations, the small firms *made creative use of existing resources*, including technologies at hand, existing competences, and already accessible external relations. For example, Epsilon was the largest European processor of Silestone, a compound of natural quartz with anti-bacterial properties. Having previously produced kitchen worktops of this material, Epsilon's innovation trajectory naturally started with the question of where else they might apply this material (see Figure 1e). The initial idea that emerged in September 2007 was to construct modular plates for walls and floors, which subsequently expanded into a broad goal: finding additional domestic applications of Silestone to complement existing capabilities in kitchen applications. After considering multiple options, Epsilon decided in December 2007 to focus on bathroom products, where Silestone's hygienic properties would offer added value, and to design bathroom equipment manufacturable with Epsilon's existing production technology. Table 6 also displays examples from other firms using this tactic of making creative use of what is available, thereby illustrating aspects of bricolage (Baker and Nelson 2005) – making do.

A second aspect of resource-driven small-firm product innovation is that activities were scaled to be *realizable within and limited by available resources*. Only a few staff were involved (limited to just one or two persons in several of these companies), and in-house capabilities were paramount. A Beta respondent observed:

> "Our advantage is that we can produce it all by ourselves. We have the equipment, and the materials cost next to nothing. If I make a thousand of them, that will cost me 500 Euros for materials. Well, I have the people. If there is nothing else to do, they can either do nothing, or use their time to lathe [the stirrups], so let them lathe."

Similarly, many of the decisions reported concerning materials, product design, and product boundaries were based on what the company was currently able to do, or had in hand. At Alpha, for example, product design was changed after prototypes were built in February 2008. It appeared that the owner/manager himself, with many years of practical experience, had been able to finish the main component without problems; his employees, however, were less skilled, and before they finished, the polymer being used started to dry; product design was adapted to match the skills of the employees. Such decisions are clearly linked to existing practices of design for manufacturing (Ulrich and Eppinger 1995), yet here it is not manufacturability in general at issue, but firm specific capabilities. Moreover, the firms were not willing to spend much during the innovation trajectory. For example, when Gamma was accused of patent infringement in Summer 2005, they decided to change their product to avoid paying "tens of thousands of Euros of legal fees" even though they expected that they would win a possible lawsuit. Thus, the product innovation projects rooted in specific labor, production capacity, skills and equipment already available in house, and personal connections, limiting investments to what the firms could afford (Sarasvathy 2001).

Third, as part of their approach of making do with available resources and limiting additional resource commitments, these small firms *leveraged external resources whenever and wherever these became available,* particularly where they could do so without creating additional risks. For example, the Alpha sequence starts with a fuzzy initial idea lurking in the back of the mind. The innovation trajectory is triggered by the announcement in September 2007 of newly available external resources, via a subsidized design workshop, which stimulated a goal setting event: formulating requirements for a cooling unit cover. The owner / manager of Alpha commented on participation in the design workshop, which provided his firm with cheap access to a professional designer:

> "For me, money was the issue. Well, this was only 650 Euro, so I thought: we can afford that, let's give it a try."

When Alpha won the design contest in November 2007, its prize money of 5000 Euro was used to hire the external designers for further work:

> "I told them: Well, this means that you can use this as your budget to design the product."

They set the goal to finish development before Christmas 2007; moreover, the goals were extended to include brand identity as a complementary objective for designers to work on. An initial goal was triggered by new resources (the workshop), then expanded when still more resources became available (the prize). This tactic also reflects the effectuation principles of exploiting contingencies as they arise and building alliances with partners who also commit resources (Sarasvathy 2001).

A fourth tactic further exemplified the resource-driven nature of these firms' product development activities: they *prioritize existing business over product innovation projects*, since they could not afford shortfalls in ongoing activity (and thus ongoing cash flow). At least three of the trajectories reported here were delayed at some point because the person(s) responsible for product innovation had to divert attention back to ongoing business. For example, at Beta, when the lead engineer got absorbed in other demanding tasks in December 2008, product innovation was postponed there, too. Beta's managing director commented:

> "Look, Carlo has his other responsibilities as well, so you cannot force him to work on the project."

This decision criterion clearly reflects the limited resources of these companies, and implies that slippage for NPD projects is preferable to losses in ongoing business: the delivery of existing products was not to be compromised, even if product innovation projects suffered delays. Faced with a choice between diminishment of a future possibility by delaying the new product or immediate loss in current business, these small firms chose the affordable loss.

Stepwise Progress

A second theme emerging from the event sequences is that the small firms took an iterative, stepwise approach. Each of the trajectories was based on *loose project planning,* rather than the tight, linear, formal procedures and sequences of activities and milestones prescribed for big firm product development (cf., March-Chorda et al. 2002). Although the owner / managers had ideas about needed actions to be undertaken, these were not specified in advance, nor formally mapped or monitored over time. Nevertheless, their NPD processes were not devoid of planning: occasionally a plan was conceived, for instance by external designers who were involved, displaying some degree of causal logic aiming to control the process through planning and prediction. Yet, such plans concerned only fragmentary parts of the trajectories, and were not strictly adhered to in any case. Further, although Alpha, Beta and Epsilon all set target dates for launching the product, none of these was met (see also Table 6). The small firms accepted such delays as a consequence of their way of working, and most especially of resource constraints (such as personnel limitations and the paramount demands of ongoing business).

Instead of formal planning, the small firms followed a flexible, stepwise approach. They *worked in steps toward tangible outcomes*, such as the development of a new concept, a prototype, or subsequent variants of the same product. Individually, these steps contained little risk of financial loss, or at worst would result in affordable losses only. Such steps were punctuated by recurrent reconsideration on how to proceed further, in light of emergent circumstances. Such an iterative approach allowed firms to reexamine a project and to move it forward (or delay or terminate it) from moment to moment, with the latest information, as options and possibilities arose, while limiting the risks associated with any step. As part of this stepwise approach, activities were undertaken sequentially, not simultaneously: After each step, the small firm innovators reconsidered the project before embarking on another step, with the path forward emerging from results of prior action. For example, one source commented:

> "I want to have it technically fixed, before we want to initiate cooperation with them [an outside partner]."

As part of working in steps towards tangible outcomes, resources were allocated gradually over time, depending upon the progress of the project and as resources became available. Commenting upon product launch, one of the project leaders said:

> "That's why we have chosen – also for financial reasons – not to do everything at once, but to wait and see whether it will take off. Thus, [we] start small and expand gradually."

Such gradual commitment of resources to projects made it possible to advance promising projects despite limited resources. This stepwise approach shares the pattern of intermediate decision points with a stage-gate process (cf., Cooper 2001), but here decision moments and criteria, as well as sequencing of activities, are far less predefined, and far more emergent. Positive feedback, particularly from potential clients, rather than meeting predefined milestones, drove additional resource allocation and next-step commitment. This exemplifies the effectuation principle of non-predictive control.

Not surprisingly, small firms' lack of planning and absence of a sequential approach resulted in frequent delays, so new activities often took more time than expected. For example, supplier approval of the cooling unit design cover developed by Alpha took much longer than anticipated. Some of these delays could have been avoided if activities had been set in motion earlier, or if more activities were performed in parallel. Yet both planning and simultaneity would increase resource demands or increase risk by committing the firms definitively to their innovation instead of (or in addition to) existing business, while stepwise processes preserved flexibility and limited risk, taking uncertainty into account.

Open ended

A third theme, related to the other two, is the open-endedness of small-firm innovation. Projects were driven by a broad strategic intent, rather than specific goals for future sales or market share, or by any initially well-defined product definition. Instead, projects proceeded by the *ongoing generation, selection, and modification of goals and ideas*. The iterative approach allowed project goals and ideas to evolve in response to circumstances over time. Epsilon's project began in October 2007 with the idea of using Silestone, previously used only in kitchens, to applications elsewhere in the house, exploiting Epsilon's modular manufacturing capability. After some time, the idea of developing products for the bathroom emerged, and all attention focused on Silestone's hygiene advantages for bathrooms from that moment on. As the project leader reported:

> "There was no pre-existing plan. In a few days I imagined what novelty we could develop for a new market and there the modular parts for bathrooms emerged."

Next, Epsilon started thinking about objects in a bathroom, like the toilet, shower, bath, sink, and cabinets. The designer created two proposals, each with four or five bathroom objects. Epsilon chose one proposal and decided which aspects were desirable and which not for each specific bathroom object. Several times during the project, the designer created three or more alternative ideas for one of the objects, like three possibilities for a Silestone sink. Each time, the most attractive emergent option was chosen to move forward, with "attractive" defined in terms of current manufacturing capabilities, among other criteria. In the other cases too, goals and product designs were held open, to respond to experience, new insights and facts in the environment as these emerged (see Table 6).

Another tactic associated with the open-endedness of the product innovation trajectories was firms' *reliance on own customer knowledge and market probes instead of upfront market research* in each of the five development projects. Although early market research is conventionally seen as a key element of best practice in big firm product innovation, we did not find it in the small firms. The owner / manager of Alpha commented, posing experience against market research:

> "There are lies, even bigger lies, and there is market research and statistics. (…) I see the numbers of the RAI [a trade organization] …. and I see an incredible discrepancy between what should be the case, according the calculations, and what I see in practice. You just need a gut feeling, like: it's heading in that direction, I feel comfortable with that. (…) And in practice, it is such a specific market, if you would ask something [of] a client, my potential clients, well, they won't answer market research questions, no way. A market salesman, a butcher, a caterer, they won't make time for that. They'll say: "I am busy with my work," and they'll throw the telephone on the hook. That's the way I know my clients. So you won't get any reliable data from them."

Lack of upfront market research does not indicate deficient dedication to customers, nor indifference to useful insight; instead, it reflects unwillingness to spend resources to predict sales early on, when the project itself was open-ended. Respondents claimed to have intimate knowledge of their customers and their needs, including not-yet-articulated and potential needs. Moreover, most of the firms did engage in ongoing market testing with prototypes – not in any systematic formal way, but ad hoc, for instance by having local horse riders try the newly developed stirrup suspender (Beta); by placing a prototype of new bathroom equipment in a showroom, sending pictures to potential dealers, and soliciting comments (Epsilon); or by offering prototypes to potential customers for testing (Alpha). The small firms' intent was product relevant information, not prediction: the firms involved customers to evoke responses to prototype features, and they adapted products to incorporate such feedback. There was no effort to predict potential demand early on.

DISCUSSION AND CONCLUSIONS

This study's process research approach uncovered the underlying logic of small firms' product innovation processes in five product innovation trajectories. Analysis establishes that these small firm product innovation processes follow effectuation logic, especially during the earlier development phases, in combination with causation logic, especially in later stages. Small firms' partial reliance on effectuation logic provides a theoretical explanation for prior findings in the literature on product innovation, that small firms seldom adhere to formalized new product development approaches, engage in little planning, and omit activities often advocated as best practice in large firms, such as upfront market research (e.g., March-Chorda et al. 2002). While our study largely confirms these observations, our findings also suggest that product innovation in small firms cannot be dismissed as merely unplanned, chaotic, improvisational, or ad hoc. Instead, where product innovation does not conform to a goal directed approach to NPD management, there may still be an underlying logic: effectuation.

The logic of effectuation fits well with the characteristics of small firms, in particular their limited resources, leading to focus on one or a few projects, and their flexibility. Limited resources stimulate small firms to make do with what is available, maintain alertness to emerging new resources, and to focus on short-term success and real feedback, rather than betting on predictions or long term plans. Their single project focus renders decision making based on expected returns too risky a bet for small firms: they prefer short-term developments they can control, and incremental resource commitments and risks they can afford. Further, the flexibility of small firms allows them to benefit from such a flexible, iterative approach; they can adapt more readily than bigger firms. Moreover, a meta-analysis showed that the logic of effectuation is associated with superior performance in start-up firms (Read, Song, and Smit 2009). These observations offer grounds for reconsidering the assumption that small firms' product innovation practices are flawed where they fail to mimic large firms' best practices.

The findings suggest that the canon of best practices in product innovation (e.g., Kahn et al. 2006) needs to differentiate between large firms and small firms. What is traditionally considered best practice (e.g., Kahn et al. 2006; Cooper and Kleinschmidt 1995), derived from the context of larger firms, presupposes causal logic – and contradicts small firms' constraints. For example, formalized project selection based on market research and calculations of expected returns (cf., Terwiesch and Ulrich 2008) presupposes clear objectives and control through prediction. By contrast, instead of attempting to predict what will be successful, small firms' effectual approaches design ongoing projects primarily to limit downside risks, adapting these in light of ongoing feedback. As a result, small firm innovation product definitions are not as stable as usually advocated (e.g., Cooper and Kleinschmidt 1995). Further, in contrast with formalized large-firm NPD processes, the small-firm effectual approach does not plan project activities in advance, instead leaving multiple paths open until circumstances determine the emergent path forward. Thus, imposing large firms' practices on small firms is unlikely to succeed if small firms' unique characteristics are not taken into account. Also, the failure of many policy interventions targeted at small- and medium-sized enterprises (e.g., Massa and Testa 2008; Kaufmann and Tödtling 2002), may arise because policy makers assume causal principles in their assessment criteria. For instance, small firms are often required to provide detailed project descriptions, planning, and budgets to policy and funding organizations - requirements antithetical to the small firms' limited resources and effectual logic.

A challenge for future research is to find ways to enhance product innovation performance in small firms that incorporate effectuation logic. The tactics discerned in this study may form a starting point. Simultaneously, however, firms need to accept or address potentially adverse consequences of an effectual approach. A first potential downside is longer NPD lead time, due to delays caused by unanticipated problems and lack of parallel activities (both exacerbated by small firms' resource limits and their sequential approach to product innovation). While small firms tend to innovate in less crowded domains (Almeida and Kogut 1997), longer lead times may threaten success in more competitive domains where the timing of market entry is critical. A second downside is that prioritizing existing business risks postponing innovation activities indefinitely, or cancelling projects altogether. Third, by focusing on existing resources, firms may unduly constrain their innovation prospects, although small firms' openness to external resources can mitigate this risk. Elements from the best practices of large firms may be helpful to overcome such barriers. As individual projects jell, causal logic becomes more useful; and especially as small firms grow, they will likely need increasingly structured approaches, since effectuation eschews the formality so useful for orchestrating multiple simultaneous product innovation efforts.

While the case study projects concerned incremental innovations approached in an incremental way, they share similarities with radical innovation approaches. The small firms' decision making resembles the iterative strategy of uncertainty reduction (Terwiesch and Ulrich 2008), less stable product definitions (Seidel 2007), less emphasis on early market analysis (Song and Montoya-Weiss 1998), more flexible and learning-oriented approaches (Cooper 2008; MacCormack et al. 2001; Lynn et al. 1996) that are associated with radical, long term innovations. Further, the phased, emergent nature of effectuation shares characteristics of spiral approaches to product development, which similarly do not plan and predict the whole process upfront, but instead address forward action in recurring cycles (Cooper and Edgett 2008). This study reflects the importance of such concepts in an integrated perspective on product innovation in small firms. Moreover, it suggests that effectuation logic might have implications for radical innovation trajectories in large firms as well (Brettel et al. 2012): where degree of innovation increases risk, effectuation approaches may diminish it.

Besides contributing to the literature on product innovation, this article also contributes to the burgeoning literature on effectuation. First, it expands effectuation research's scope from its prior primary focus on individual entrepreneurs and start-ups to include product innovation in established small firms. Further, ours is the first study to test for the presence of causation and effectuation using quantitative analyses of process data, thus offering a very direct test of the effectuation perspective in a real life context. Finally, this study extends the dynamic model of effectuation, making it specific for product innovation in small firms. In particular, ideas were included in the analysis because ideas are a core feature of product innovation and may form a bridge between goals and resources, in both directions. Interestingly, ideas came on average last in the gamma analyses of the sequences, suggesting that idea development also continues after goals are set and resources committed.

This study's limits invite further research. A key issue that warrants additional research attention are the consequences of effectuation and causation approaches for product development in small firms. This study examined only small Dutch manufacturing firms, all of which had been involved in a government-sponsored design workshop, so this study's findings cry out for replication in other settings. Studies of product innovation trajectories across settings (e.g., EU versus non-EU firms; matched large-firm and small-firm comparisons across industries; consumer and industrial product innovation activities in small versus large firms, and manufacturing firm innovations versus service innovations) are promising possibilities. A key question is how organizational size affects the degree to whether causation and effectuation are used in product innovation, and which other organizational or environmental characteristics are indicators for the application of effectuation or causation principles. A potential line of inquiry concerns the use of effectuation in large firms. For example, do radical innovation processes exhibit effectual characteristics, or should they? If so, what does that imply for the management of these trajectories?

To conclude, small firms' product innovation efforts are guided by the entrepreneurial logic of effectuation as well as the managerial logic of causation. Thus, the use of effectuation theory enabled us to show how small firm product innovation processes resemble as well as differ from mainstream, big-firm conceptions of best practice. To advance normative implications, more research is needed to investigate the consequences of effectual versus causal logic approaches, and to examine how causation-based product innovation practices are, or might be integrated with effectual approaches. Such research will bring us closer to improving small firm product innovation processes, while acknowledging their distinct nature.

REFERENCES

Acs, Z.J. and Audretsch, D.B. 1988. "Innovation in large and small firms: an empirical analysis." *American Economic Review* 78(4): 678-690.

Almeida, P. and Kogut, B. 1997. "The exploration of technological diversity and geographic localization in innovation: start-ups in the semiconductor industry." *Small Business Economics* 9(1): 21-31.

Audretsch, D., Van der Horst, R., Kwaak, T. and Thurik, R. 2009. *Annual Report on EU Small and Medium-sized Enterprises*. EIM Business & Policy Research, EU, DG Enterprise and Industry.

Baker, T. and Nelson, R.E. 2005. "Creating something from nothing: resource construction through entrepreneurial bricolage." *Administrative Science Quarterly* 50(3): 329-366.

Barczak, G., Griffin, A. and Kahn, K.B. 2009. "Trends and drivers of success in NPD practices: results of the 2003 PDMA best practices study." *Journal of Product Innovation Management* 26(1): 3-23.

Biazzo, S. 2009. "Flexibility, structuration, and simultaneity in new product development." *Journal of Product Innovation Management* 26(3): 336-353.

Bougrain, F. and Haudeville, B. 2002. "Innovation, collaboration and SMEs internal research capabilities." *Research Policy* 31(5): 735-747.

Brettel, M., Mauer, R., Engelen, A. and Küpper, D. (2012). Corporate effectuation: entrepreneurial action and its impact on R&D project performance. *Journal of Business Venturing* 27(2): 167-184.

Brouwer, E. and Kleinknecht, A. 1996. "Firm size, small business presence and sales of new products: a micro-econometric analysis." *Small Business Economics* 8(3): 189-201.

Carland, J.W., Hoy, F., Boulton, W.R. and Carland, J.A.C. 1984. "Differentiating entrepreneurs from small business owners: a conceptualization." *Academy of Management Review* 9(2): 354-359.

Chandy, R.K. and Tellis, G.J. 2000. "The incumbent's curse? Incumbency, size, and radical product innovation." *Journal of Marketing* 64(3): 1-17.

Cooper, R.G. 2001. *Winning at new products: accelerating the process from idea to launch* (3rd ed.). Cambridge: Perseus.

Cooper, R.G. 2008. "Perspective: The Stage-Gate® idea-to-launch process - update, what's new, and NexGen systems." *Journal of Product Innovation Management* 25(3): 213-232.

Cooper, R.G. and Kleinschmidt, E.J. 1986. "An investigation into the new product process: steps, deficiencies, and impact." *Journal of Product Innovation Management* 3(2): 71-85.

Cooper, R.G. and Kleinschmidt, E.J. 1995. "Benchmarking the firm's critical success factors in new product development." *Journal of Product Innovation Management* 12(5): 374-391.

Cooper, R.G. and Edgett, S.J. 2008. "Maximizing productivity in product innovation." *Research-Technology Management* 51(2): 47-58.

Damanpour, F. 1992. "Organizational size and innovation." *Organization Studies* 13(3): 375-402.

Dew, N., Read, S., Sarasvathy, S.D., and Wiltbank, R. 2009. "Effectual versus predictive logics in entrepreneurial decision-making: differences between experts and novices." *Journal of Business Venturing* 24(4): 287-309.

Eden, L., Levitas, E., and Martinez, R.J. 1997. "The production, transfer and spillover of technology: comparing large and small multinationals as technology producers." *Small Business Economics* 9(1): 53-66.

Edwards, T., Delbridge, R., and Munday, M. 2005. "Understanding innovation in small and medium-sized enterprises: a process manifest." *Technovation* 25(10): 1119-1127.

Eisenhardt, K. 1989. “Building theories from case study research.” *Academy of Management Review* 14(4): 532-550.
Ettlie, J.E. and Rubenstein, A.H. 1987. “Firm size and product innovation.” *Journal of Product Innovation Management* 4(2): 89-108.
Ettlie, J.E. and Elsenbach, J.M. 2007. “Modified Stage-Gate regimes in new product development.” *Journal of Product Innovation Management* 24(1): 20-33.
Ettlie, J.E. and Rosenthal, S.R. 2011. “Service versus manufacturing innovation.” *Journal of Product Innovation Management* 28(2): 285-299.
Fiegenbaum A. and Karnani, A. 1991. “Output flexibility: a competitive advantage of small firms.” *Strategic Management Journal* 12(2): 101-114.
Filson, A. and Lewis, A. 2000. “Cultural issues in implementing changes to new product development process in a small to medium sized enterprise (SME).” *Journal of Engineering Design* 11(2): 149-157.
Freel, M.S. 2000a. “Do small innovating firms outperform non-innovators?” *Small Business Economics* 14(3): 195-210.
Freel, M.S. 2000b. “Barriers to product innovation in small manufacturing firms.” *International Small Business Journal* 18(2): 60-80.
Goodman, L.A. and Kruskal, W.H. 1963. “Measures of association for cross classifications III: approximate sampling theory.” *Journal of the American Statistical Association*, 58(302): 310-364.
Hoffman, K., Parejo, M., Bessant, J., and Perren, L. 1998. “Small firms, R&D, technology and innovation in the UK: a literature review.” *Technovation* 18(1): 39-55.
Holmes, M.E. 1995. *WinPhaser: Sequence Analysis and Comparison*, Version 1.1, User Manual.
Huang, X., Soutar, G.N., and Brown, A. 2002. “New product development processes in small and medium-sized enterprises: some Australian evidence.” *Journal of Small Business Management* 40(1): 27-42.
Huber, G.P. and Power, D.J. 1985. “Retrospective reports of strategic-level managers: guidelines for increasing their accuracy.” *Strategic Management Journal* 6(2): 171-180.
Jick, T.D. 1979. “Mixing qualitative and quantitative methods: triangulation in action.” *Administrative Science Quarterly* 24(4): 602-611.
Kahn, K.B., Barczak, G., and Moss, R. 2006. “Establishing an NPD best practices framework.” *Journal of Product Innovation Management* 23(2): 106-116.
Kaufmann, A. and Tödtling, F. 2002. “How effective is innovation support for SMEs? An analysis of the region of Upper Austria.” *Technovation* 22(3): 147-159.
Kemerer, C.F. and Slaughter, S. 1999. “An empirical approach to studying software evolution.” *IEEE Transactions on Software Engineering* 25(4): 493-509.
Laforet, S. 2008. “Size, strategic, and market orientation affects on innovation.” *Journal of Business Research* 61(7): 753-764.
Landis, J.R. and Koch, G.G. 1977. “The measurement of observer agreement for categorical data.” *Biometrics* 33(1): 159-174.
Langley, A. 1999. “Strategies for theorizing from process data.” *Academy of Management Review* 24(4): 691-710.
Ledwith, A. and O’Dwyer, M. 2009. “Market orientation, NPD performance, and organizational performance in small firms.” *Journal of Product Innovation Management* 26(6): 652-661.
Leiponen A. and Byma, J. 2009. “If you cannot block, you better run: small firms, cooperative innovation, and appropriation strategies.” *Research Policy* 38(9): 1478-1488.
Leitner, K.H. 2011. “The effect of intellectual capital on product innovativeness in SMEs.” *International Journal of Technology Management* 53(1): 1-18.

Lynn, G. S. and Akgün, A.E. 2001. “Project visioning: its components and impact on new product success.” *Journal of Product Innovation Management* 18(6): 374-387.
Lynn, G.S., Morone, J.G., and Paulson, A.S. 1996. “Marketing and discontinuous innovation: the probe and learn process.” *California Management Review* 38(3): 8-37.
MacCormack, A., Verganti, R., and Iansiti, M. 2001. “Developing products on "Internet Time": the anatomy of a flexible development process.” *Management Science* 47(1): 133-150.
MacCormack A. and Verganti, R. 2003. “Managing the sources of uncertainty: matching process and context in software development.” *Journal of Product Innovation Management* 20(3): 217-232.
March-Chorda, I., Gunasekaran, A., and Lloria-Aramburo, B. 2002. “Product development process in Spanish SMEs: an empirical research.” *Technovation* 22(5): 301-312.
Massa, S. and Testa, S. 2008. “Innovation and SMEs: misaligned perspectives and goals among entrepreneurs, academics, and policy makers.” *Technovation* 28(7): 393-407.
Miller, C.C., Cardinal, L.B., and Glick, W.H. 1997. “Retrospective reports in organisational research: a reexamination of recent evidence.” *Academy of Management Journal* 40(1): 189-203.
Millward, H. and Lewis, A. 2005. “Barriers to successful new product development within small manufacturing companies.” *Journal of Small Business and Enterprise Development* 12(3): 379-394.
Moultrie, J., Clarkson, P.J., and Probert, D. 2007. “Development of a design audit tool for SMEs.” *Journal of Product Innovation Management* 24(4): 335-368.
Pelz, D.C. 1985. “Innovation complexity and the sequence of innovating stages.” *Knowledge: Creation, Diffusion, Utilization* 6(3): 261-291.
Poole, M.S. and Roth, J. 1989. “Decision development in small groups IV: A typology of group decision paths.” *Human Communication Research* 15(3): 323-356.
Poole, M.S., Van de Ven, A.H., Dooley, K., and Holmes, M.E. 2000. *Organizational change and innovation processes: theory and methods for research*. Oxford: Oxford University Press.
Qian G. and Li, L. 2003. “Profitability of small-and-medium-sized enterprises in high-tech industries: the case of the biotechnology industry.” *Strategic Management Journal* 24(9): 881-887.
Radas, S. and Bozic, L. 2009. “Antecedents of SME innovativeness in an emerging transition economy.” *Technovation* 29(6/7): 438-450.
Read, S., Dew, N., Sarasvathy, S.D., Song, M., and Wiltbank, R. 2009. “Marketing under uncertainty: the logic of an effectual approach.” *Journal of Marketing* 73(3): 1-18.
Read, S., Song, M., and Smit, W. 2009. “A meta-analytic review of effectuation and venture performance.” *Journal of Business Venturing* 24(6): 573-587.
Rindova, V., Ferrier, W.J., and Wiltbank, R. 2010. “Value from gestalt: how sequences of competitive actions create advantage for firms in nascent markets.” *Strategic Management Journal* 31(13): 1474-1497.
Romijn, H. and Albaladejo, M. 2002. “Determinants of innovation capability in small electronics and software firms in southeast England.” *Research Policy* 31(7): 1053-1067.
Roper, S. 1997. “Product innovation and small business growth: a comparison of the strategies of German, U.K. and Irish companies.” *Small Business Economics* 9(6): 523-537.
Rosenbusch, N., Brinckmann, J., and Bausch, A. 2011. “Is innovation always beneficial? A meta-analysis of the relationship between innovation and performance in SMEs.” *Journal of Business Venturing* 26(4): 441-457.

Sarasvathy, S.D. 2001. “Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency.” *Academy of Management Review* 26(2): 243-263.
Sarasvathy, S.D. 2008. *Effectuation: elements of entrepreneurial expertise.* Northampton, MA: Edward Elgar.
Sarasvathy, S.D. and Dew, N. 2005. “New market creation through transformation.” *Journal of Evolutionary Economics* 15(5): 533-565.
Schumpeter, J.A. 1934. *The theory of economic development*. Cambridge, MA: Harvard University Press.
Schumpeter, J.A. 1942. *Capitalism, socialism and democracy.* New York: Harper.
Scozzi, B., Garavelli, C., and Crowston, K. 2005. “Methods for modelling and supporting innovation processes in SMEs.” *European Journal of Innovation Management* 8(1): 120-137.
Schwenk, C.R. 1985. “The use of participant recollection in the modelling of organizational decision processes.” *Academy of Management Review* 10(3): 496-503.
Seidel, V.P. 2007. “Concept shifting and the radical product development process.” *Journal of Product Innovation Management* 24(6): 522-533.
Song, X.M. and Montoya-Weiss, M.M. 1998. “Critical development activities for really new versus incremental products.” *Journal of Product Innovation Management* 15(2): 124-135.
Strauss, A. and Corbin, J. 1998. *Basics of qualitative research: techniques and procedures for developing grounded theory.* London: Sage.
Stuart, T.E. 2000. “Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry.” *Strategic Management Journal* 21(8): 791-811.
Terwiesch, C. and Ulrich, K.T. 2008. *Innovation tournaments: creating and selecting exceptional opportunities.* Boston, MA: Harvard Business Press.
Terziovski, M. 2010. “Innovation practice and its performance implications in small and medium enterprises (SMEs) in the manufacturing sector: a resource-based view.” *Strategic Management Journal* 31(8): 892-902.
Ulrich, K.T. and Eppinger, S.D. 1995. *Product design and development*. New York: McGraw-Hill.
Van de Ven, A.H. 1986. “Central problems in the management of innovation.” *Management Science* 32(5): 590-607.
Van de Ven, A. H., Polley, D. E., Garud, R., and Venkataraman, S. 1999. *The Innovation Journey.* Oxford: Oxford University Press.
Van de Ven, A.H. 2007. *Engaged scholarship: a guide for organisational and social research.* Oxford: Oxford University Press.
Van de Vrande, V., De Jong, J.P.J., Vanhaverbeke, W., and De Rochemont, M. 2009. “Open innovation in SMEs: trends, motives and management challenges.” *Technovation* 29(6/7): 423-437.
Verhees, F.J.H.M. and Meulenberg, M.T.G. 2004. “Market orientation, innovativeness, product innovation, and performance in small firms.” *Journal of Small Business Management* 42(2): 134-154.
Welsh, J.A. and White, J.F. 1981. “A small business is not a little big business.” *Harvard Business Review* 59(4): 18-32.
Wiltbank, R., Dew, N., Read, S., and Sarasvathy, S.D. 2006. “What to do next? The case for non-predictive strategy.” *Strategic Management Journal* 27(10): 981-998.
Wiltbank, R., Read, S., Dew, N., and Sarasvathy, S.D. 2009. “Prediction and control under uncertainty: outcomes in angel investing.” *Journal of Business Venturing* 24(2):116-133.

Wolff, J.A. and Pett, T.L. 2006. "Small-firm performance: modelling the role of product and process improvements." *Journal of Small Business Management* 44(2): 268-284.

Woodcock, D.J., Mosey, S.P., and Wood, T.B.W. 2000. "New product development in British SMEs." *European Journal of Innovation Management* 3(4): 212-221.

Yap, C.M. and Souder, W.E. 1994. "Factors influencing new product success and failure in small entrepreneurial high-technology firms." *Journal of Product Innovation Management* 11: 418-432.

Yin, R.K. 2003. *Case study research: design and methods,* 3rd ed. Thousand Oaks: Sage.

Table 1: Company characteristics and data sources

Firm	Main activities	Employees	Product innovation	Duration	Events	Data Sources
Alpha	Modifying minivans into refrigerated vans	5	A new rooftop cover needed to place a condenser unit in a minivan.	September 2007-October 2008	69	- Interview with owner/manager in charge of the project - Interview with two designers involved in the project - E-mails concerning the project (19) - Documents (project proposals, product presentation, pictures/sketches of work in progress, letters) (19)
Beta	Producing steel products	5	A pneumatically suspended stirrup for horse riding.	June 2008 - February 2009	76	- Interviews with owner / manager in charge of the project (2) - Interview with technical engineer involved - Interview with external designer involved - E-mails concerning the project (6) - Documents (sketches, pictures and presentations of the product in various stages of development, letters from intermediary) (24)
Gamma	Developing and selling ergonomic office solutions.	21	Redesign of a laptop stand	February 2005-October 2005	49	- Interview with director in charge of the project - Interview with external designer - Emails concerning the project (4) - Documents (picture, sketches, letters from intermediary) (6)
Delta	Manufacturing plastic products with specialized production methods.	22	Redesign of a medicine cabinet	September 2004 - June 2005	50	- Interview with director of operations in charge of the project - Interview with engineer involved in the project - Interview with lead customer for whom the product was developed - Interviews with external designers (2) - E-mails concerning the project (2) - Documents (pictures, sketches, presentations of the product in various stages of development, video, letters from intermediary) (24)
Epsilon	Manufacturing stone (-based) products for kitchen applications.	47	Expansion of current product line to include bathroom products	September 2007 - January 2009	108	- Interviews with director of operations in charge of the project (2) - Interview with external designer - Emails concerning the project (71) - Documents (project proposal, personal notes, sketches, 3D images, presentations, letters from intermediary, subsidy application) (98)

Table 2. Steps in the process analysis

Steps in the analysis	Activities	Ensuring reliability
Create event sequence file	1. Identifying events 2. Incorporating changes based upon briefing and validity check	• Maintain chain of evidence by relating events to data sources • Debriefing second researcher • Validity check with respondents
Code event sequences for gamma analysis	1. Developing initial coding scheme based upon Poole et al. (2000) 2. Independent coding of events in event sequence file (by two pairs of researchers) 3. Discussing and refining coding scheme 4. Independent coding with refined coding scheme to determine Cohen's Kappa 5. Discussing differences and finalizing coding	• Independent coding by multiple researchers • Cohen's Kappa as measure for interrater reliability
Gamma analysis	1. Gamma analysis on complete sequences 2. Gamma analysis on partial sequences	• Adopt methodological considerations, e.g. concerning interpretation of values
Qualitative analysis of event sequences	1. Visual mapping 2. High level qualitative analysis of application of causation and effectuation 3. Identification of tactics of effectuation through open coding of interview data	• Joint coding • Maintain chain of evidence by coding interviews in NVIVO 8

Table 3. Coding scheme for gamma analysis of event sequences

Event category	Code	Description
Idea events	I	Changes to the ideas and concepts of the product innovation project, relating to the actual product. Ideas that are discussed but later discarded also fall into this category.
Goal events	G	Changes in goals or evaluation criteria, project schedules, and planning. Descriptions of goal events included the reasons why decisions regarding goal changes were made.
Resource events	R	Changes in the resources that are committed to the product. Resources include financial resources, knowledge, time, people, and partners. Thus, also changes in the people involved with the product innovation project or in the way they are related to each other or the project (for instance contract changes) count as resource events.

Table 4. Precedence and separation scores of gamma analyses, overall analysis

Case	Score	G	I	R
Alpha	Precedence	.270	-.435	.165
	Separation	.282	.435	.165
Beta	Precedence	.174	-.175	.001
	Separation	.174	.175	.101
Gamma	Precedence	.542	-.364	-.178
	Separation	.542	.393	.178
Delta	Precedence	.041	-.107	.066
	Separation	.112	.107	.066
Epsilon	Precedence	.076	-.265	.189
	Separation	.171	.265	.189

Table 5. Precedence and separation scores of gamma analyses of partial sequences

		Part I			Part II			Part III		
Case	Score	G	I	R	G	I	R	G	I	R
Alpha	Precedence	-.103	-.738	.841	-.100	-.617	.717	.415	-.169	-.246
	Separation	.675	.738	.841	.500	.617	.717	.415	.169	.354
Beta	Precedence	.051	-.340	.289	-.289	.444	-.156	-.426	.046	.379
	Separation	.251	.340	.289	.289	.444	.267	.426	.338	.379
Gamma	Precedence	-.370	-.450	.820	1.000	-.450	-.550	NA[1]	.190	-.190
	Separation	.470	.450	.820	1.000	.550	.550	NA[1]	.190	.190
Delta	Precedence	-.400	.425	-.025	.511	-.911	.400	.267	.100	-.367
	Separation	.400	.425	.025	.511	.911	.600	.267	.300	.367
Epsilon	Precedence	-.200	-.229	.429	.673	-.388	-.285	-.015	.456	-.441
	Separation	.200	.229	.429	.673	.388	.548	.265	.456	.441

[1]: Not applicable, because no such event was recorded in this part of the event sequence

Table 6. Examples of effectual tactics from each of the cases (not in chronological order)

TACTICS	Alpha	Beta	Gamma	Delta	Epsilon
Resource-driven					
Making creative use of existing resources (including technologies, competences, external relations)	Without budget to advertise, to attend trade fairs or work with sales partners, the owner wants a product that exploits free publicity: a prominent logo and name so drivers "can follow it with their eyes and say 'that's beautiful'" and later Google it.	Beta leveraged their network resources around December 2008 for market probing and promotion, approaching local professional horseback riders, including an Olympic gold medalist, to try out their new equipment and gain domain credibility.	Gamma re-used the folding principles developed for an earlier product, translating these into a new material and styling for its new laptop stand.	The designer involved draws upon his knowledge of elastic cords gained through sailing, and proposes a solution for the cabinet door closing problem that uses a specific cord that is quite wear resistant.	Epsilon considered where else they might apply Silestone and their processing capabilities; in September 2007 decided on modular plates for walls and floors, which subsequently expanded into domestic applications to complement prior kitchen products.
Scoping innovations to be realizable with available and affordable resources	Instead of designing the product with CAD/CAM techniques and wind tunnel testing (as proposed by a design agency), the Alpha owner/director worked with polyurethane foam models, that could be cheaply tested on dummy vans.	Beta utilized its employees' idle time and spare equipment capacity to manufacture their stirrup suspender as an additional product	When Gamma was accused of patent infringement in Summer 2005, they decided to change their product to avoid paying "tens of thousands of Euros of legal fees", despite expectation they would win a possible lawsuit.	Delta considers teflon to reduce friction in the cabinet closing mechanism, but to limit costs they decide on materials fit for existing production methods, styrene and thermoplastics.	When Epsilon decided to produce bathroom equipment in house instead of outsourcing, designs were adapted to fit production techniques (e.g. edges of five instead of three centimeters).
Use external resources whenever and wherever available	To test cooling unit covers, Alpha used contacts with two world leading suppliers of cooling units, who provided demo vans with measurement equipment for testing technical functionality (June 2008).	Beta used government subsidies and students to access external knowledge resources at universities. A small government grant covered tests at a university (December 2008).	Innovation was spurred in September 2007 by announcement of a subsidized design workshop. Availability of these external resources stimulated formulating new requirements,	Neither Delta nor its main client was willing to invest substantially to improve the medicine cabinet. A subsidized design workshop offered "a nice opportunity. Especially because it was paid for by others."	An SME innovation support agency helps Epsilon investigate subsidy opportunities and applies to a large regional development fund to support the development of sanitary equipment.
Prioritizing existing business over product innovation projects	Alpha's budget for external designers was depleted by February 2008, while the owner / manager devoted time to increasing demand for existing products, leading to postponement of the project and thus changes in the initial goals.	At Beta, in December 2008 the lead engineer got absorbed in other demanding tasks, thus postponing development.	Daily business pressures diverted Gamma from work on the project: "Big companies have a department and people who only have to focus on development. In SMEs it is an extra task for people and it may linger".	Delta employees initially spent some time on solving the cabinet door skewing problem, but decide not to continue if it takes to much time.	Because the sales of kitchen counter tops decreased in the economic crisis, Epsilon brings the production of bathroom equipment in house instead of outsourcing it, to keep employees at work.

Stepwise					
Loose project planning	Alpha does not use strict and detailed planning. A rough plan in early November 2007 aimed to finish development before Christmas of that year, but the product was finalized only om summer 2008.	In October 2008, when the stirrup project is poised for launch, the project was delayed first January 2009, then to March and later to May, due to other priorities.	Gamma decides not to apply for a subsidy because this requires commitment to long term planning that they cannot provide: "If an SME has a need at this moment, he will not spend months on preparation".	After failed attempts to solve the problem, the project was put on the shelf, but revived by the design workshop. Once a design crystallized afterwards, a plan was proposed to finish the new design in three weeks (but it actually took two additional months).	An external designer involved in the project offers multiple plans, but these are treated loosely by Epsilon and the product launch date is postponed several times.
Working in steps towards tangible outcomes	Alpha did not aim to develop a "flawless" product, since the owner knows some clients will prefer a first version. He anticipates further honing with their feedback, and depending upon demand.	Beta works on two product versions. While they believe a pneumatic solution would be best, they want a mechanical product first: "We have a mechanical solution that will work, and this [pneumatic version] is not certain yet".	After Gamma had produced several thousands of its laptop stands, they invested in further improvements, to refine the product, avoiding big steps: "If we develop something, we need 95% certainty that it will sell."	Delta decides to create an improved product version of the 2-and 3-layered medicin cabinets first; and postpone a solution for the 4-layered cabinet because that appeared to be more difficult.	Epsilon produced a quick first version of their bathroom equipment, to check for manufacturability and get client input; the feed back received reassured them of the attractiveness of their product.
Open ended					
Iterative generation, selection, and modification of goals and ideas	Alpha broadened its project from its initial target, a cooling unit cover (October 2007), to using this project to renew its brand identity (November 2007).	Beta shifted focus from cost reduction of their hydraulically suspended stirrup (Spring 2008), to the development of a pneumatic and a mechanical stirrup, a stirrup adaptor, and revision of its exterior design (Autumn 2008).	Product definition had changed late in the trajectory (Summer 2005, due to an accusation of patent infringement), but the project continued and evolved in response.	Solutions shifted seeking to repair medicine cabinets in the field, to redesigning the closure mechanism, and even considered redesign of the whole product.	Epsilon's project started in October 2007 with the idea of expanding use of Silestone material to walls and floors. Next, the idea expanded to bathrooms, and later moved to bathroom furniture.
Relying on own customer knowledge and market probing instead of early market research	Alpha's owner / manager relied on his own insight into what customers would like: "I know my clients and I know what they like," rather than predicting sales targets in advance.	Beta did not engage in any systematic. formal market research, but instead probed the market with prototypes, by having local horse riders try their newly developed stirrup suspender.	Gamma was convinced that their new product - which would be more stylish and cheaper than it precursor - would sell, as well as their old plastic version had ("It has to succeed, I am convinced of that").	Neither Delta nor their main client did market research: "Practice will tell whether it works or not". Instead, a medicine cabinet was placed in a hospital to see whether it was "nurse proof". This revealed additional problems.	Epsilon's thinking was based on general insight into consumer trends ("It should have an expensive, Italian look"). A first set of new bathroom equipment was placed in a showroom, to solicit comments.

Figure 1a: Key events in the innovation trajectory at Alpha

Resource events

- *September '07*: Alpha informed about subsidized design workshop and introduced to external designer
- *November '07*: Alpha wins design contest prize of 5000 Euro, which is used continuing collaboration with designers
- *Feb '08*: No budget for external designers left, Alpha's owner / director commits own time
- *March '08*: Time scarce because of rise in orders and turnover of experienced personnel
- *May '08*: molds made in collaboration with existing supplier
- *June '08*: Suppliers provide demo vans for test drives

Goal events

- *October '07*: development of specifications for cooling unit cover
- *October '07:* Goals refined to include universality, premium styling, cost effectiveness, better aerodynamics
- *November '07:* Goal set to finish development before Christmas; brand identity added as goal for designers to work on
- *March '08*: Market introduction is postponed

Idea events

- *Before September '07:* idea emerges that cooling unit cover could be better styled
- *Oct '07*: external designer introduces idea of modular system and waterdrop shape
- *November '07*: Based on sketches, foam models are created and evaluated, final shape selected
- *November / December '07:* development of product name and logo
- *February '08*: work on manufacturability results in design changes
- *May '08*: changes in material (carbon fibre)
- *July '08*: changes in cassette and logo

Figure 1b: Key events in the innovation trajectory at Beta

Resource events

- *Around 2001*: Beta acquired company that patented a hydraulic stirrup suspender, which had sold little, because of high costs
- *October '08*: Beta informed about subsidized design workshop and introduced to external designer
- *December '08:* Funding for tests at university
- *December '08:* engineer absorbed in other work
- *December '08* seeking suppliers for materials (in particular rubber rings)
- *January '09:* prototypes provided to well-known riders from network for testing

Goal events

- *Spring '08*: emergence of intent to redesign hydraulic suspender to reduce its costs
- *October '08*: goals set for external designer, focusing on exterior
- *October '08:* Both stirrup and adapter, using same elements
- *October '08:* Goal set to introduce product in January 2009
- *December '08:* Introduction postponed to March 2009
- *January '09*: develop mechanical stirrup as alternative product (based on same principles) because it is still uncertain whether pneumatic solution will work

Idea events

- *September '08*: hydraulics replaced by pneumatical solution
- *October 08*: idea to develop adaptor instead of complete stirrup
- *October '08:* Design of exterior, styled as "technical" and "organic"
- *Nov '08:* Development of pneumatic system
- *December '08:* connection mechanism redesigned
- *December '08:* test outcomes require engineering changes
- *January '09*: design of lighter version for kids

Figure 1c: Key events in the innovation trajectory at Gamma

Resource events

- *2003:* development of relation with design agency and exploration of joint project, but no follow up because of high costs
- *February '05:* Gamma engages design agency through subsidized design workshop
- *March '05:* Designer is committed to the project and will cooperate with Gamma.
- *April '05:* During workshop, potential manufacturer evaluates folding mechanism
- *April '05:* Designer is involved again to evaluate first prototype

Goal events

- *2004:* development of strategic intent to broaden focus from selling ergonomic products to developing new products
- *March '05:* Gamma wants exclusive laptop stand with increased functionality: larger, portable, with integrated document holder and cable management.
- *March '05:* Designer makes project proposal. Simplicity is added to requirements
- *Summer '05:* Change of specifications: no integrated document holder, due to accusation of patent infringement

Idea events

- *March '05:* Product will be made of Hylite with an aluminum look
- *April '05:* Designing folding system, backside, and document holder for 2 A4 sheets
- *April '05:* Manufacturer adapts the product for manufacturing and creates first prototype
- *May '05:* Improvements are made based on tests of second prototype. More robustness.

Figure 1d: Key events in the innovation trajectory at Delta

Resource events	*Winter '04*: Delta and external designer commit time to design a solution to satisfy lead customer	*February '05*: financial support for participating in design workshop					
Goal events	*Summer '04*: Customers report mechanical problems with medicine cabinet produced by Delta; intent to repair these in the field	*Winter '04*: Struggles between Delta, lead customer, and external designer over responsibility	*Winter '04*: Adapted product is introduced, but especially for the 1 and 2 layer cassettes the skewing problem remains.	*March '05*: Requirements for redesign of medicine cabinet include solution for the skewing problem; low cost; applicable to existing products.	*April '05*: adaptation of requirements (e.g. cost level) after meeting with lead customer		
Idea events	*Autumn '04*: Delta delivers doors to fix the mechanical problems in the field	*Winter '04:* Modification of the sliding strips in order to improve closing the door	*March '05*: developing ideas (e.g.using teflon strips, adding pull mechanism)	*April '05*: elastic cord solution chosen for closing mechanisms	*May '05*: modifications based on prototyping and for cost saving	*Summer '05*: further modifications based upon outcomes in the field	

Figure 1e: Key events in the innovation trajectory at Epsilon

Resource events	*September '07:* Epsilon notified of subsidized designer workshop	*October '07:* participation in subsidized designer workshop	*December '07*: hiring external designers	*August '08*: application for subsidy	*September '08*: take share in Chinese furniture manufacturer	*October '08*: sales of luxureous kitchen products drop due to credit crisis	
Goal events	*October '07:* broad goal set to find domestic applications of Epsilon materials (in particular Silestone) to complement existing kitchen applications	*December '07:* goal to develop sanitary products (showercabin, bath, sink, fountain) for high market segment; when successful, this line will be extended with a bidet, toilet, and accessories late 2008.	*February '08*: based on reaction to prototypes extension with cupboards; deletion of bath; planning to be finished in July '08	*October '08*: project deprioritized; and delayed; decision to produce more in house			
Idea events	*October '07:* idea to expand product portfolio with modular stone plates for walls and floors	*October '07:* futuristic designs, which are liked but discarded	*January '08*: developing four concepts and selection of one best produceable in silestone	*May '08*: designs ready	*September '08*: final designs ready	*December '08*: design adapted because of composite characteristics	