Knowledge Stocks and Information Flows in New Product Development

Journal of Management Studies 41:8 December 2004
0022-2380

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ABSTRACT Although firms increasingly invest in systems (e.g. ISO, knowledge centres, IT systems) for utilizing stored knowledge and acquiring market information during new product development, few manage to benefit from these investments. To explore this issue, we suggest that firms rely on two distinct types of *knowledge stocks* – procedural and declarative memory – that affect new product short-term financial performance and creativity in distinct ways. Additionally, we suggest that internal or external *information flows* can have distinct moderating impact on the memory types–product outcomes relationship. Our empirical study of product development activities indicates that there is an inverted U-shaped relationship between procedural memory and product outcomes as well as a positive relationship between declarative memory and financial performance. Also procedural and declarative memory may work in a *complementary* fashion enhancing both outcomes. Finally, procedural memory is found to reduce the value of internal or external information flows for product creativity. These findings have important implications for the organizational knowledge, capabilities, and product development literatures as well as for practice and they open ways for future research.

INTRODUCTION

Knowledge resources (i.e. knowledge stocks and information flows) are instrumental to innovative activities according to a number of research streams (e.g. Allen, 1971; Cohen and Levinthal, 1990; Henard and Szymanksi, 2001; March, 1991; Moorman and Miner, 1997; Starbuck, 1992). Firms, paying lip service to this claim, invest relentlessly in IT systems, knowledge centres, ISO systems or process management to leverage own experience and acquire better market information (Hammer and Stanton, 1999; Olivera, 2000). However, research and anecdotal evidence on the value of knowledge resources in new product

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development (NPD) provide mixed findings. On the one hand, they reduce waste, accelerate processes, and increase customer satisfaction (e.g. Hammer and Stanton, 1999). On the other hand, they can 'blind' team members and stifle innovativeness (e.g. Benner and Tushman, 2003). Specifically, students of innovation have 'lamented' the failure of companies in the disc drive (Christensen and Bower, 1996) or photolithographic aligner equipment industries (Henderson and Clark, 1990) to break away from entrenched routines or 'obsolete' information channels.

These failures coupled with the increasing capacity of NPD teams to utilize firm experience and acquire market information underscore the importance of understanding how firms can benefit from these knowledge resources. To explore this research problem, we first suggest that firms rely on two distinct types of memory[1] – procedural and declarative. Specifically, we propose that *procedural* (routine knowledge) and *declarative* memory (fact knowledge) affect new product outcomes i.e. financial success and creativity in distinct ways. We focus on these two knowledge types for several reasons. Firms increasingly routinize new product activities into best practices (procedural memory) and store prior product designs or customer specifications in intranets (declarative memory) for future use (Griffin, 1997; Olivera, 2000). In addition, by examining the direct effect of memory *types* on conflicting new product outcomes, we seek to extend empirical studies on product development, which are limited to examining the effects of levels and dispersion of organizational memory (Moorman and Miner, 1997) or declarative memory on procedural one (Lynn and Akgün, 2000; Lynn et al., 1997). Finally, we seek to contribute to discussions of memory as an important firm resource or capability (Grant, 1996; March et al., 1991) beyond more 'traditional' resources (e.g. financial ones).

Second, we examine the *joint* effect of these two memory types. Our focus builds on the notion of combinative capabilities (Kogut and Zander, 1992) resulting from reconfiguring prior knowledge and routines. While prior research has explored the simultaneous use of distinct functional knowledge e.g. marketing and R&D (Dutta and Narasimhan, 1999; Leonard-Barton, 1992), this is the first study to empirically explore the simultaneous use of procedural skills and theoretical knowledge.

Third, we focus on how sources (i.e. external vs. internal) of *information flows* interact with the memory types to affect product outcomes seeking to extend the information processing view of product development that has focused on the direct effect of the amount and types of information teams acquire from their environment (e.g. Ancona and Caldwell, 1992; Katz and Tushman, 1981; Moorman, 1995). This is an important issue as prior research claims that sources of information can impact the NPD outcomes (Cohen and Levinthal, 1990; von Hippel, 1988). Research, for example, notes that information from internal parties enhances speed and cost efficiency (Bierly and Chakrabarti, 1996) while direct

information from customers or supply chain partners enhances novelty (von Hippel, 1988). In a broader way, our focus on the joint effect of knowledge stocks and information flows can help us integrate these two research fields (i.e. memory and information processing), whose cross-fertilization has been limited.

To address these issues, this paper is organized as follows. First, building on resource-based view, organizational learning, capabilities and information processing, we introduce the types of knowledge stocks and sources of information flows. Then, we propose a conceptual framework that encompasses new product outcomes, knowledge stocks as antecedents, and information flows as moderators. Next, we report the empirical investigation of this conceptual model on the basis of a study of new product development activities among food companies. Finally, we conclude the paper with the implications of the key findings for marketing theory and practice.

KNOWLEDGE STOCKS AND INFORMATION FLOWS

Stored knowledge and information flows are central issues to a number of literatures ranging from the resource-based view (e.g. Barney, 2001) to capabilities (e.g. Eisenhardt and Martin, 2000; Grant, 1996), information view of NPD (e.g. Ancona and Caldwell, 1992; Katz and Tushman, 1981), organizational learning (e.g. Huber, 1991; March et al., 1991), or socio-cognitive approaches (e.g. Akgün et al., 2003). These literatures conceive information flows and memory as related concepts within the broader organizational learning framework. Though there are many definitions, for the purpose of this paper, we follow a cognitive approach to consider organizational learning as the process of developing or changing the state of knowledge (Akgün et al., 2003; Day, 1994; Huber, 1991). Knowledge stocks and information flows are both inputs to the processes (information acquisition, dissemination, interpretation, utilization, and storing) of organizational learning (see Figure 1). They exhibit, however, three key differences. First, following Huber (1991), information is 'data that give meaning by reducing ambiguity, equivocality, or uncertainty' whereas knowledge involves 'more complex products of learning, such as interpretations of information, beliefs about cause-and-effect relationships or more generally know-how' (Huber, 1991, p. 89). If organizational learning is to occur, information should be converted into knowledge following the learning processes and partly stored in organizational memory (Akgün et al., 2003; Day, 1994). Second and related, though both form an input to the learning process for the NPD team, knowledge stocks carry 'worldviews' or assumptions (Hedberg, 1981) about how the world around and within a firm works and, thus, they are imbued with legitimacy (Walsh and Ungston, 1991) whereas information is open to interpretation typically conditioned by these 'worldviews'. A third difference is tied to our particular focus of information on market developments. Specifically, our definition of information flows refers to recent or ongoing issues in the market

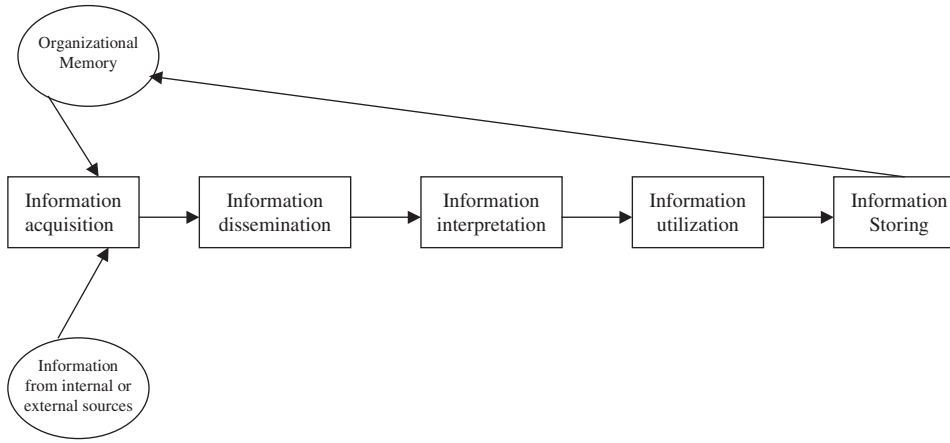

Figure 1. The position of our focal variables within the organizational learning framework

while memory describes past experience in general. To better understand the nature of memory and information flows we briefly review the pertinent theories.

Organizational Memory

It is rather recently that research on firm capabilities has renewed interest on the importance of stored experience and routines (Grant, 1996; Kogut and Zander, 1992; March et al., 1991) in explaining heterogeneity in firms' performance. This stream, building on earlier views of memory, extends the 'standard' resource-based view of the firm, which is limited to examining tangible (e.g. equipment) and intangible (e.g. brand equity) assets (Barney, 2001). Specifically, the capabilities approach focuses on the processes of combining assets and knowledge into competences (e.g. product design skills) and capabilities (e.g. new product development) (Amit and Schoemaker, 1993; Day, 1994).

Parallel to this research on organizational memory in strategy, there is more fine grained research focusing on the processes (Hargadon and Sutton, 1997), the 'storage bins' (Walsh and Ungson, 1991) or the retention forms associated with memory (Moorman and Miner, 1997). This research also points to the consequentiality of memory, stressing the falling search and experimentation costs manifested in the learning curve (Argote, 1996) and the expedited decision taking and implementation because new decisions are imbued with tradition and legitimacy (Walsh and Ungson, 1991). Other research, however, stresses the blinding effect of past schemata or beliefs (March, 1991; March et al., 1991) as they restrict definition on new challenges and problems (Walsh and Ungson, 1991). We seek to extend this view by focusing on two types of memory: procedural and declarative (Anderson, 1983; Cohen, 1991).

Procedural memory. This refers to memory 'for how things are done' (Cohen and Bacdayan, 1994, p. 404) or 'things you can do' (Berliner, 1994, p. 102), and it is also known as motor memory (Cohen, 1991). Its *routine* nature is manifested in 'patterned sequences of learned behavior involving multiple actors' (Cohen and Bacdayan, 1994, p. 557) and it has two broad implications. First, procedural memory takes the form of skills *tied to* the particular domain in which they are exercised (Moorman and Miner, 1998a). For instance, in the context of new product development, it includes routines for team cooperation, project milestones (Moorman and Miner, 1997), or skills in predevelopment market assessment, prototyping, concept testing and market launch (Lynn and Akgün, 2000). Second, it is automatic and inarticulate (Cohen and Bacdayan, 1994), that is, procedural memory is often available to its users even without the underlying substantive knowledge (Tsoukas and Vladimirou, 2001). Brazilian street vendors, for example, could correctly calculate the cost of five lemons at 35 cruzeiros apiece, while they could not answer the matching arithmetic problem of $5 \times 35 = ?$ (Cohen and Bacdayan, 1994).

Declarative memory. Declarative memory is 'memory for facts, events, or propositions' (Anderson, 1983; Cohen, 1991, p. 137) including know-that, know-why or know-when (Huber, 1991; Kogut and Zander, 1992). For example, the procedural memory of riding a bike can be contrasted to the declarative memory of the mechanics principles underlying riding a bike (Cohen, 1991). In the NPD context, it includes, for example, accumulated knowledge of customer preferences (Lynn and Akgün, 2000), products features (e.g. product drawings, packaging) or when to use a positioning approach depending on the customer or competitive context (Moorman and Miner, 1998b). Unlike procedural memory, declarative is general i.e. not committed to a specific use, having two implications. First, it can be consciously and intentionally recollected (Anderson, 1983), allowing its users to analyse new problems: see causes and effects, draw similarities with past events, and choose a suitable response to the problem (Moorman and Miner, 1998b). Second, it can be used in a *variety* of applications (Singley and Anderson, 1989). Prototyping skills (procedural knowledge), for example, can be useful in product development while knowledge of market dynamics can be used both in NPD *as well as* other firm processes (i.e. order fulfilment, service delivery, or strategy development).[2]

Information Flows

In addition to stored knowledge, gathering and using information during the innovation process is equally important according to the information view of product innovation (e.g. Allen, 1971; Ancona and Caldwell, 1992; Moorman, 1995) and

research on adoption of innovations (e.g. Rogers, 1983). The information view builds on the general thesis that NPD teams should match their information processing capability to the information processing demands of the task environment (Allen, 1971; Tushman, 1977). Building on this thesis, researchers have mainly focused on the role of boundary spanning activities and gatekeepers (Katz and Tushman, 1981) or the types and effects of external communication of teams (Ancona and Caldwell, 1992). Building on these insights, the last years have witnessed an explosion of studies into how NPD teams can acquire better market information (e.g. Brown and Eisenhardt, 1997; Imai et al., 1985; Moorman, 1995; Olson et al., 1995). We seek to extend this information point of view by focusing on two broad sources of market information flows: internal and external.

Internal information flows. These occur when a project team relies on market information from internal sources in the focal firm including internal experts, concurrent projects, the R&D department or sales force department (Huber, 1991). Research has studied the transmission of information to the project team from internal parties, finding a positive impact on firm performance (e.g. Katz and Tushman, 1981; Jaworski and Kohli, 1993; Moorman, 1995).

External information flows. These refer to the extent to which the project team relies *directly* on external sources involving customers or lead users (von Hippel, 1988), supply chain partners (Day, 1994), alliances (Inkpen and Dinur, 1998), and outside experts or consultants (Huber, 1991). Research has shown that information from external parties has a positive impact on financial performance (Kohli and Jaworski, 1993) or innovativeness (Katz and Tushman, 1981; Moorman, 1995).

The distinction between internal and external information flows is a matter *relative* to the focal team. Information, for example, from the sales force department, has originated from contact with customers. For the sales force department, it represents external information flows. For the NPD members, however, it represents an internal information flow, because they rely on an *in*direct access to customers. Though this point might appear trivial, its implications are important. Information from internal sources mirrors existing assumptions and, thus, the scope of information will be probably confined to the firm's established set of customers/competitors, or supply chain partners (Day, 1994; Huber, 1991). Direct access to external sources, instead, could provide new and context-rich information (von Hippel, 1988) that challenges the established assumptions (e.g. redefine customer needs, identify new competitors).

CONCEPTUAL FRAMEWORK

Having discussed the knowledge resources and their types, this section first discusses the focal new product outcomes followed by three sets of hypotheses about

the direct effect of memory types, their joint effect, and the moderating effect of external and internal sources of information flows on memory–new product outcomes relationship.

New Product Outcomes

Within the product development context, we focus on two outcomes: short-term financial performance and creativity.

New product short-term financial performance refers to the degree to which financial targets such as new product profit, sales, and market share have been accomplished within the *first year* after the product launch. Speed (Griffin, 1997), adherence to budget (Olson et al., 1995), technological and marketing synergies (Gerwin and Barrowman, 2002; Henard and Szymanksi, 2001), meeting customer needs (Henard and Szymanksi, 2001), and product quality (Cooper and Kleinschmidt, 1986) have been found to be important drivers of short-term financial performance.

New product creativity refers to the extent to which the new product challenges current market ideas and practice (Moorman, 1995) or 'differs from conventional practice within the domain of interest' (Sethi et al., p. 75), or the perceived originality or uniqueness (Henard and Szymanski, 2001). Product creativity is driven by diverse viewpoints (Ancona and Caldwell, 1992), strong expertise in a specific domain (Cohen and Levinthal, 1990; Sethi et al., 2001), and an ability to challenge past knowledge schemata (Dougherty, 1992; Sethi et al., 2001) or reconfigure prior knowledge through novel linkages (Nelson and Winter, 1982).

The above mentioned definitions of product outcomes as well as their determinants provide the conceptual foundations on which we build our model. Specifically, we explicate how procedural and declarative memory directly, jointly, as well as in the presence of internal and external information flows are expected to play a critical role in giving rise to these determinants of new product outcomes.

The Direct Effects of Memory on New Product Outcomes

Fine-tuned routines and processes can hurt financial performance. One reason is that routines act as perceptual filters (Hedberg, 1981) that may foreclose the ability to understand and meet changes in customer needs or competitive reactions, thus leading to poor market acceptance (Day, 1994). Dougherty (1992), for example, describes how a computer firm failed to meet customer expectations and its sales objectives, as strong technology skills (proven successful in its original high quality, durable word processor) 'blind' its engineers in the follow-up product extensions where user features were more important than technology. Second and related, routines are automatic or habitual which could be detrimental for creativity. For example, Hewlett Packard relied on its instrument division strength in 'next-bench'

design routines (designers relied on their colleagues on the next bench to solve problems) during the HP 150 project (PC linked to a high-end computer). Unlike in the case of instrument products, these routines hampered product creativity, as designers were not representative of PC users (Leonard-Barton, 1992).

Yet, routines and standard approaches are argued to generate some positive outcomes. First, they can lead to financial success because they speed up execution, reduce costs, and ensure reliable organizational action. This idea is well entrenched in evolutionary models (Nelson and Winter, 1982), theories of bounded rationality (Cyert and March, 1963) and studies on organizational memory (Walsh and Ungson, 1991). In support, there is rich literature providing strong evidence that stable, well-exercised processes increase product quality and customer satisfaction (e.g. Cooper and Kleinschmidt, 1986; Griffin, 1997). Routines can also boost creativity as they provide a degree of structure, crucial for novel NPD projects, which is typically associated with unclear priorities, muddy markets, and high uncertainty (Brown and Eisenhardt, 1997). Under these conditions, routines have psychological benefits. 'It is also important to create structure and motivate pace in these settings, because the uncertainty can create paralyzing anxiety about the future' (Eisenhardt and Tabrizi, 1995, p. 91). Additional to emotional benefits, structure has cognitive benefits as shared practices and procedures could improve exchange and mutual understanding across functions which is crucial for developing novel linkages among different 'thought worlds' (Dougherty, 1992).

Taken together, these arguments imply an inverted U-shaped relationship between procedural memory and financial performance and creativity. Too much procedural memory could impede creative thinking as well as the ability to perceive changes in the market. Too low procedural memory, however, could make the innovative process inefficient as well as throw members at chaos and paralysis. Hence, moderate levels of procedural memory promote the highest levels of both product outcomes because new product team members benefit from accumulated experience and structure. Thus, we posit:

> *Hypothesis 1*: Moderate levels of procedural memory produce (a) the highest levels of new product short-term financial performance and (b) the highest levels of new product creativity.

We propose that declarative memory will tend to produce financially effective outcomes because it helps teams identify patterns in external events and select actions producing outcomes that are coherent and suitable to market conditions (Moorman and Miner, 1998a). For example, expertise in matching marketing mix to the preferences of a customer segment could improve customer satisfaction. Consistent with this, new product development studies have found that marketing and technological expertise improve financial success (e.g. Cooper and Kleinschmidt, 1986; Henard and Szymanski, 2001). Alternatively, the application

of declarative knowledge could be slow because, compared to procedural memory, it is not committed to a specific use. Accordingly, researchers note that considerable effort is required to covert declarative memory into organizational action (Cohen and Bacdayan, 1994; Moorman and Miner 1998a). Scholars have tended to consider this difficulty of declarative memory as part of the split between design engineers and production engineers. For example, production engineers believe design engineers with strong theoretical knowledge create problems by drawing on abstract knowledge, instead of drawing on heuristics that can be deployed rapidly (Dean and Susman, 1989). In sum, despite the mixed arguments about the relationship between declarative memory and financial success, we follow empirical studies that suggest that declarative memory should have a positive effect (see the meta-analysis of Henard and Szymanski, 2001).

Regarding the declarative memory–creativity relationship, the conscious application of declarative memory increases the chances of using prior knowledge in a less standard fashion, using general principles to find innovative solutions. For example, Hargadon and Sutton (1997) observed that when designers accessed past projects on how to design new products, they relied on analogies between past solutions and current design problem 'to view old technological solutions from a new frame of reference that allows them to recognize certain useful characteristics, such as material, design, or flexibility, and to ignore other less transferable features, such as shape, size or original use' (p. 738). This feature of declarative knowledge informs the widely established insight that new discoveries are sustained by investment in R&D and basic research (Cohen and Levinthal, 1990). Thus:

> *Hypothesis 2*: The greater the level of declarative memory, (a) the higher the new product short-term financial performance and (b) the higher the new product creativity.

The Complementary Effect of Memory Types on New Product Outcomes

In addition to their direct effects, we argue that declarative and procedural knowledge stocks can be complements that cancel one another's drawbacks. In describing the mechanisms associated with this complementary relationship, we first examine how declarative memory can facilitate the effective and novel use of procedural memory. There is ample conceptual work (e.g. Henderson and Clark, 1990) arguing that innovations and combinative capabilities (Kogut and Zander, 1992) are largely new combinations of existing knowledge and routines (Nelson and Winter, 1982). These combinations can take various forms: 'applying pre-existing routines to new contexts, recombining subunits within pre-existing routines, and recombining entire routines in new ways' (Moorman and Miner, 1998a,

p. 712). Quinn (1988), for example, observes that managers with the ability to identify patterns in the events (a declarative stock) are more likely to perform well, which is knowing which processes and tools to employ given certain problem conditions.

Turning now to how procedural memory may facilitate the value of declarative memory, we also suggest that firms can use procedural skills to apply rapidly declarative memory. Knowledge-intensive firms (e.g. consultancies) often maintain multiple mechanisms through social networks (Hansen et al., 1999) and information locating tools – directories, search engines, listings – (Anand et al., 1998) to speed up access to expertise and diverse viewpoints. Based on his study in a multinational consulting firm, Olivera (2000) found that consultants benefited from routinizing memory into electronic or social systems (e.g. knowledge centres and social networks), because they could quickly apply expert knowledge in new projects. Therefore, we propose:

> *Hypothesis 3*: Using high levels of both procedural *and* declarative memory enhances (a) new product short-term financial performance and (b) new product creativity.

Information Flows as Moderators of the Effectiveness of Memory

Whereas past research has examined the role of knowledge stocks and information flows separately, we propose that the value of knowledge stocks is not fixed but it depends on information flows.

The moderating impact of internal information flows. Considering the relationship between procedural memory and creativity (Hypothesis 1b), we suggest that internal information flows shift the positive effect of procedural memory from its intermediate to low levels for two reasons. First, the scope of the information search of other internal functions or units is confined by established 'worldviews' to existing customer or competitors (Hedberg, 1981) and it is rarely targeted at the needs of the focal NPD project. Thus, the resulting information flows reflect limited diversity in input (familiar sources of information) and converge with entrenched assumptions reinforcing routine thinking and behaviour (Cohen and Levinthal, 1990). Second, as internally accessed information about market developments is indirect, it typically provides context free information and, thus, it is unlikely to capture *un*articulated customer needs, which is crucial to product creativity (e.g. Hamel and Prahalad, 1991). This informs the standard insight from research on innovative products that market research in indirect forms fails to capture rich contextual information, uncover latent customer needs (e.g. von Hippel, 1988) and, therefore, it is unlikely to lead to novel use of prior skills. Thus:

Hypothesis 4: The greater the level of internal information flows, the more the likelihood that procedural memory will hamper new product creativity.

Still, NPD projects could benefit from internal information in presence of declarative knowledge. Because declarative knowledge can imply alternative uses increasing anxiety, meaningful internal information has cognitive and emotional benefits. Specifically, internal parties share a unified frame of reference (firms purpose, strategy, customer benefits, etc) that provides a context within and priorities by which the team applies prior expertise and knowledge (Tsoukas and Vladimirou, 2001). Information on customer complaints from the sales force function, for example, could provide a concrete direction on how product designers can utilize their design expertise to address these complaints, and increase client satisfaction. Furthermore, this feature of internal information can boost a team's motivation to focus on execution resulting in increased speed, as team members feel confident that their actions are connected to the firm's strategy. Additionally, internal information, due to its ease of access and comprehension, is cost efficient in guiding the application of declarative knowledge. Consistent with these arguments, Imai et al. (1985) found that product development projects could effectively leverage prior expertise when team members had communication with internal parties. Thus, we propose:

Hypothesis 5: The greater the level of internal information flows, the more the likelihood that declarative memory will promote new product short-term financial performance.

The moderating impact of external information flows. External information can mitigate the tendency of procedural stocks to stifle innovation. First, the direct nature of external information increases the chances of using prior skills and routines to meet market changes as team members see these market changes emerge in their context. Consistent with this argument, the famous 'Honda effect' provides an example of using procedural routines creatively in presence of hands-on experience with the market. The initial plan of Honda for entering the US market followed the industry convention: targeting the high-end 'black leather jacket' segment with emphasis on heavyweight motorcycles (250cc, 350cc). After observing non-conventional motorcycle customers trying to buy the lighweight 50cc Supercub motorcycles ridden by Honda reps in Los Angeles (external information flows), the Honda entry team challenged their original plan and targeted the product at the medium-income leisure class customers (Mintzberg et al., 1996). Consequently, they recombined their marketing, distribution, and technological routines and skills in Japanese market to redefine the US motorcycle industry.

Second and related, direct contact with external parties allows a firm to be open to multiple viewpoints – not just new information but more importantly *new ways*

to 'see' the market (Inkpen and Dinur, 1998; Tushman, 1977). Consistent with this, the innovation literature, for example, suggests that innovative products require direct contact with the customer in the form of lead user (von Hippel, 1988) as a guide to the use of internal strength and skills. We, therefore, propose:

Hypothesis 6: The greater the level of external information flows, the lower the likelihood that procedural memory will hamper new product creativity.

Finally, we argue that external information and declarative knowledge display synergistic effects, boosting financial effectiveness in two ways. First, market information from external parties grounds the transformation of general knowledge into concrete facts (e.g. customer needs, competitive behaviour; Jaworski and Kohli, 1993), rather than in abstractions. RCA, for example, experimented with alternative video technologies. Because its engineers were isolated from market trends and competitors' innovations, however, the company's product only played videotapes, missing the emerging customers' need to record and watch programmes at their leisure (Hamel and Prahalad, 1991). JVC and Sony had, instead, direct customer feedback to their early versions, which allowed their engineers to use their technical expertise to make a more profitable play-and-record form of video.

Second, declarative knowledge can accelerate the utilization of externally sourced market information due to absorptive capacity (Cohen and Levinthal, 1990), that is, the ability to recognize, absorb, and use external information. Specifically, firms need a critical mass of internal knowledge in order to understand and assimilate external information. In support, Cockburn and Henderson (1998) report that firms whose researchers are connected to their public sector colleagues increase their productivity. Thus:

Hypothesis 7: The greater the level of external information flows, the higher the likelihood that declarative memory will promote new product short-term financial performance.

METHODS AND ANALYSIS

Research Setting

A sample of 500 business units from the food processing industry was randomly selected from a business directory, which contains a complete list of food companies. Choosing a random sample from a single industry is a widely used approach (e.g. Jaworski and Kohli, 1993) to ensure that the sample is not biased. One hundred and sixty firms that did not engage in product development activities (but instead were retailers or distributors) were eliminated from the sample, leaving 340

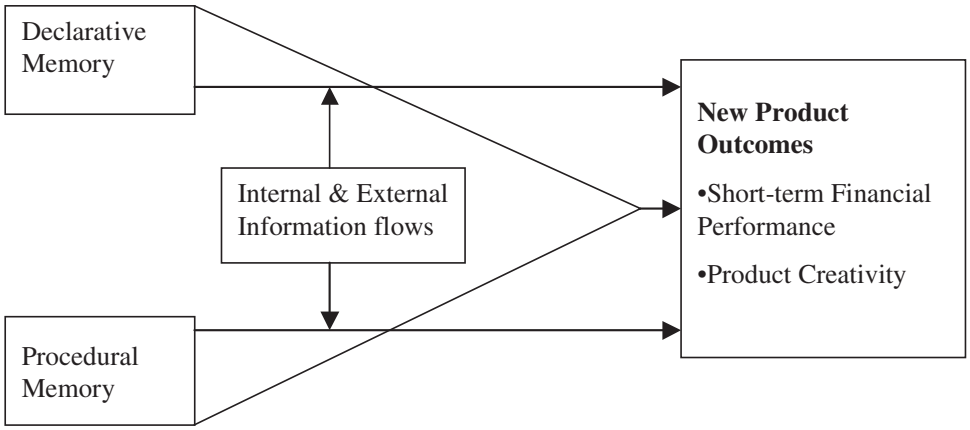

Figure 2. Conceptual framework

firms to participate in the study. Our choice of a single industry limits problems that result from a sample of firms from different industries. Different industries increase extraneous sources of variance and thus require the inclusion of many inter-industry factors to account for heterogeneity of estimates.

The marketing managers were selected as key informants as prior research has indicated that they are involved with new product development activities (e.g. Jaworski and Kohli, 1993; Moorman, 1995; Olson et al., 1995). The marketing managers were mailed a questionnaire, a letter explaining the purpose of the study and requesting their participation, and a monetary incentive of approximately €2.5. In addition, they were promised a summary of the results if they returned their business cards with the completed questionnaire. A reminder postcard with a replacement copy of the questionnaire was mailed approximately three weeks after the first mailing. Two weeks following the second mailing, non-respondents were telephoned and encouraged to complete and return the questionnaire. Using a chi-square difference test, no systematic differences between those responding before and after the second mailing were found, reducing concerns about non-response bias.[3] Of the eligible sample of 340 firms, 136 returned the questionnaire for a response rate of 40 per cent.

The questionnaire asked participants to focus on a product development project for which their business unit was responsible over the last twelve months. We asked respondents to identify the project type by utilizing an ordinal scale developed by Hultink (1997, see Appendix) that builds on well-known categorizations of NPD projects. Seventeen per cent described it as a completely new product with a new market, 24.5 per cent as a new product line, 38.3 per cent as an addition to an existing line, 9.6 per cent as a repositioning of an existing product, and 10.6 per cent improvement of an existing product, indicating a variety of project types.

Measures

While the study relied on existing scales of short-term financial performance and creativity (Moorman, 1995), we used prior studies to develop the scales of memory types and information flows.

Memory types. Measures of the memory types were based on the literature. Scales in the literature, however, use *in*direct measures (Lynn and Akgün, 2000; Lynn et al., 1997), i.e. the antecedents of both memory types. We decided to adapt a pool of items from Moorman and Miner (1997, 1998b) because the scale of Moorman and Miner (1998b) is biased towards procedural memory (e.g. 'well-defined procedures', 'a standard approach'), whereas the scale of Moorman and Miner (1997) is biased towards declarative knowledge (e.g. 'a great deal of knowledge', 'experience'). Thus, their scales do not allow us to isolate the unique effect of each memory type but they may generate confounded results. The adapted items were then presented to academic experts who judged their precision, representativeness, and specificity. On the basis of these comments, the scales were revised to enhance their clarity. The revised scales were then administered to ten marketing managers whose responses were used to further modify the scales. All final items were measured using a seven-point Likert scale.

Given the focus of procedural memory (Anderson, 1983; Cohen, 1991; Moorman and Miner, 1998b) on well-exercised routines and processes taking the forms of skills, in order to evaluate procedural memory, informants were asked to rate the extent to which, 'For this project, my team relied on: well-defined procedures, a standard approach, strong skills'. To measure declarative memory, we began with its formal definition. Because early pretesting indicated that managers might experience difficulty in rating declarative memory if we used the criteria of 'facts, events, and propositions', we asked, instead, our respondents to evaluate the extent to which, 'For this project, my team relied on: a great deal of knowledge, strong expertise, knowledgeable people'. Using these criteria gave managers a clearer basis for evaluating declarative memory, as our pretesting revealed. A general advantage of our measures of procedural and declarative knowledge is that they build on prior conceptual definitions (Cohen and Bacdayan, 1994; Kogut and Zander, 1992). For instance, our measures parallel the distinction between 'knowing *how* to do something' and 'knowing *what* sometimes means' as types of knowledge stocks (Kogut and Zander, 1992, p. 386; emphasis in original).

Information flow sources. We relied on the literature of market orientation, and specifically, on the scales of intelligence generation and dissemination (Jaworski and Kohli, 1993) and information acquisition and transmission (Moorman, 1995) to generate a pool of items for the scales of external and internal information flows respectively. To make sure that internal information flows are distinct from firm

stored knowledge, we asked our respondents to focus on information about market *developments* received during the project from various internal sources. In addition, given the focus of external information flows on direct information from external parties, we asked our respondents whether they contacted or discussed with various external parties.

Control variables. We control for well-known alternative explanations regarding why a project is successful. Specifically, we control for the size of the business unit's resources to rule out the possibility that large size is contributing to new product outcomes, an important tenet of resource-based view. This was measured by asking informants to compare their R&D, marketing, distribution, and sales resources to those of their competitors. We also control for market turbulence and technological turbulence utilizing Jaworski and Kohli's (1993) measures.

Common method bias tests. Since the dependent and independent variables were obtained from a single key informant, we tested for common method variance (CMV) using the Harman one-factor test. The result of the principal components factor analysis revealed nine factors with eigenvalues greater than 1.0. This corresponds to the nine variables in our model. Further, the results indicated that there is no general factor in the unrotated factor structure. In addition, following Lindell and Whitney (2001), we partial out the smallest correlation of the remaining correlations in order to remove the effect of CMV. Given that all unadjusted correlation coefficients remain statistically significant at $p < 0.05$ after adjusting for CMV even under to most strict conditions applied in our sensitivity analysis, we feel more confident that the findings of our analysis are not due to CMV.

Measure Purification

Following the data collection, the scales were purified according to recommendations (e.g. Bagozzi and Yi, 1988). Forming subsets of theoretically related variables, we first ran two confirmatory factor models: one with memory types and information flows variables and another with the two product outcomes and three control variables. Following recommendations of the literature, we chose to delete items with large modification indices or very weak loadings or loaded on more than one factor (see Appendix), if doing so does not reduce domain coverage. Overall, the results demonstrate adequate levels of fit for both the first model ($\chi^2_{(59)} = 167.6$, NNFI = 0.91, CFI = 0.88, SRMR = 0.077) and the second model ($\chi^2_{(109)} = 126.31$, NNFI = 0.89, CFI = 0.96, SRMR = 0.076). In addition, the average variance extracted by each measure exceeded the recommended cut-offs (Bagozzi and Yi, 1988), which together with the high reliabilities evidenced by all measures (Table I), establishes the internal consistency of our measures.

Table I. Measure characteristics and correlation matrix

	Mean	*S.D.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. Procedural memory	3.88	1.60	*0.75*								
2. Declarative memory	5.07	1.32	0.16*	*0.85*							
3. Internal information flows	4.50	1.20	0.12	0.20*	*0.76*						
4. External information flows	4.45	1.26	0.23**	0.39**	0.19*	*0.75*					
5. Short-term new product financial performance	4.69	1.40	0.08	0.26**	0.26**	0.29**	*0.88*				
6. New product creativity	5.42	1.56	−0.02	0.06	0.06	0.32**	0.38**	*0.82*			
7. Firm resource level	4.36	1.56	0.02	0.27**	0.01	−0.03	0.22*	0.09	*0.64*		
8. Market turbulence	4.37	1.30	0.19*	0.03	0.20*	0.32**	0.22**	0.15	0.03	*0.74*	
9. Technological turbulence	4.03	1.38	0.14	0.18*	−0.01	0.19*	0.16*	0.08	0.02	0.38**	*0.79*

Notes: The alpha associated with multi-item reflective measures is on the diagonal and in italics.
*$p < 0.05$, **$p < 0.01$.

We checked the external (concurrent) validity of our memory measures by examining their correlations with other variables that are distinct from, but theoretically related to, our memory types. Specifically, we utilized the scale of organizational culture from Moorman (1995) that tapped the firm culture in terms of whether it is formalized or organic. We measured formalized cultured by asking informants to rate the extent to which their firm was a hierarchy and a market culture. Organic cultures were measured by asking respondents to rate the extent to which their firm was clan and adhocratic culture. It has been argued that mechanistic structures tend to be associated with routines and formal procedures while organic cultures are high on knowledge exchange (Moorman, 1995; Quinn, 1988). We expect, thus, that procedural memory is more likely to correlate with formalized cultures whereas declarative memory is more likely to correlate with organic cultures. The procedural memory was positively correlated with formalized cultures ($p < 0.05$) but not with organic cultures ($p > 0.10$). Likewise, the declarative memory was positively correlated with organic cultures ($p < 0.05$), but not with formalized cultures ($p > 0.10$).

We conducted a final set of analyses to assess the discriminant validity. Examining first the correlation matrix (Table I), the correlations did not appear to suggest problems of discriminant validity. Within each subset, pairs of constructs were assessed in a series of two-factor confirmatory factor models using LISREL 8.3. Each model was run twice, first constraining the correlation between the two latent variables to unity and then freeing this parameter (Bagozzi and Yi, 1988). Results provide evidence of discriminant validity.[4] Furthermore, discriminant validity is indicated by the fact that all φ's are statistically different from 1. Finally, examining the memory types, the sources of information flows, and the new product outcomes, we find that the average variance extracted for each construct is higher than the squared correlation between the construct and any other construct.[5] In addition, because the measures of memory types and the sources of information flows are new, discriminant validity was also assessed between our measures and measures of market orientation (Jaworski and Kohli, 1993), suggesting that our constructs are independent.[6]

Analysis

To test the direct effect of memory types, their joint effect, and the moderating effect of information flows, we used two tests. First, we utilized two three-step linear multivariate regression models with new product short-term financial performance and creativity as dependent variables. Step 1 contained the control variables (see Table II). Step 2 contained the terms of Step 1 as well as the *direct* effects of the memory types and sources of information flows. Step 3 contained the terms of Step 2 as well as the *two-way interactions* comprising: the two types of memory, the quadratic term of procedural memory, each memory type with each infor-

mation flow source. All variables were mean-centred before forming interactions in order to avoid multicollinearity (Irwin and McClelland, 2001). Variance inflation factors were estimated to examine collinearity levels and results (<1.5) were found to be below harmful levels. Following standard practice, interactions of Step 3 are only considered if the change-in-F associated with their entry is significant.

Second, planned contrasts were then used to examine the significant two-way interactions in more depth utilizing procedures[7] recommended by Irwin and McClelland (2001) that retain the data in their original form and do not collapse it into median split groups. The advantage of these procedures, compared to split analysis, is twofold – they do not reduce statistical power and they do not induce spurious relationships (Irwin and McClelland, 2001).

RESULTS

New Product Short-Term Financial Performance

Results indicate that Step 1 control variables (see Table II) account for a significant amount of variance in short-term financial performance ($R^2 = 0.14$, $F_{(3,121)} = 6.91$, $p < 0.01$) with two significant predictors: firm resources ($b = 0.50$, $p < 0.00$) and market turbulence ($b = 0.22$, $p < 0.03$). Results indicate that Step 2 predictors account for a significant amount of variance in short-term financial performance ($R^2 = 0.28$, $F_{(7,117)} = 5.516$, $p < 0.01$). Four predictors are significant: declarative memory ($b = 0.30$, $p < 0.00$), external information flows ($b = 0.15$, $p < 0.07$), firm resources ($b = 0.25$, $p < 0.05$), and market turbulence ($b = 0.19$, $p < 0.07$). Step 3 involving the two-way interactions is also significant (Change-in-$F_{(13,111)} = 2.59$, $p < 0.05$). Hypothesis 1a predicts an inverted U-shaped relationship between procedural memory and new product financial performance, which the results support ($b = -0.09$, $p < 0.04$).

Hypothesis 2a predicts that there is a positive[8] relationship between declarative memory and financial performance, which the results confirm ($b = 0.29$, $p < 0.00$). Hypothesis 3a predicts that the joint effect of the two memory types on short-term financial performance is positive. The results indicate a positive two-way interaction of procedural memory and declarative memory ($b = 0.14$, $p < 0.03$), supporting the hypothesis. Follow-up analysis to examine this interaction shows that this relationship between declarative memory and financial performance is insignificant ($b = 0.06$, $p < 0.33$) at low procedural memory *but* it becomes significantly positive at high procedural memory ($b = 0.48$, $p < 0.00$).

Hypothesis 5 predicts that internal information flows have a positive moderating effect on the declarative memory–new product financial performance relationship, which the results do not support ($b = -0.10$, $p < 0.16$). Hypothesis 7 predicts that external information flows have a positive moderating effect on the relationship between declarative memory and short-term financial performance.

Table II. Memory types and information flows: direct, joint, and moderating effects on new product outcomes

	Short-term new product financial performance			*New product creativity*		
Step 1 (control variables)						
Total R^2		0.14			0.03	
F-level (p-value)		6.91, $p < 0.01$			0.84, n.s.	
Degrees of freedom		(3,121)			(3,133)	
		b	*p*		*b*	*p*
Firm resources		0.50	0.00		0.07	0.49
Market turbulence		0.22	0.03		0.10	0.18
Technological turbulence		0.09	0.31		–0.01	0.86
Step 2 (Step 1 and main effects)						
Total R^2		0.28			0.11	
F-level (p-value)		5.516, $p < 0.01$			3.27, $p < 0.02$	
Degrees of freedom		(7,117)			(7,129)	
		b	*p*		*b*	*p*
Procedural memory (PM)		–0.05	0.49		–0.03	0.61
Declarative memory (DM)		0.30	**0.00**		0.08	0.28
Internal information flows (IIF)		0.18	0.16		–0.04	0.59
External information flows (EIF)		0.15	0.**07**		0.23	**0.00**
Firm resources		0.25	**0.05**		0.03	0.75
Market turbulence		0.19	**0.07**		0.06	0.44
Technological turbulence		0.02	0.86		–0.05	0.52
Step 3 (Step 2 and 2-way interactions)						
Total R^2		0.35			0.23	
Change-in-F (p-value)		2.59, $p < 0.05$			3.19, $p < 0.01$	
Degrees of freedom		(13,111)			(13,123)	
	Hypotheses	*b*	*p*	*Hypotheses*	*b*	*p*
Internal information flows		0.25	**0.02**		0.04	0.61
External information flows		0.21	**0.04**		0.28	**0.00**
Firm resources		0.33	**0.01**		0.04	0.67
Market turbulence		0.14	0.18		0.08	0.99
Technological turbulence		0.03	0.79		–0.03	0.75
PM		–0.11	0.17		–0.07	0.25
PM × PM	(H1a, ∩) accepted	–0.09	**0.04**	(H1b, ∩) accepted	–0.07	**0.03**
DM	(H2a, +) accepted	0.29	**0.00**	(H2b, +) rejected	0.02	0.79
PM × DM	(H3a, +) accepted	0.14	**0.03**	(H3b, +) accepted	0.10	**0.04**
PM × IIF	–	–0.09	0.17	(H4, –) accepted	–0.12	**0.01**
DM × IIF	(H5, +) rejected	–0.10	0.16	–	–0.02	0.63
PM × EIF	–	–0.05	0.44	(H6, +) rejected	–0.13	**0.00**
DM × EIF	(H7, +) rejected	–0.01	0.84	–	–0.02	0.70

Results show no significant interaction ($b = -0.01$, $p < 0.84$), which fail to support Hypothesis 7. Some non-hypothesized effects are also significant: internal information flows ($b = 0.25$, $p < 0.02$), external information flows ($b = 0.21$, $p < 0.04$), and firm resources ($b = 0.33$, $p < 0.01$).

New Product Creativity

Step 1 involving the control variables (Table II) does not account for a significant amount of variance in creativity ($R^2 = 0.03$, $F_{(3,133)} = 0.84$, *n.s.*). Results indicate that Step 2 predictors account for a significant amount of variance in new product creativity ($R^2 = 0.11$, $F_{(7,129)} = 3.27$, $p < 0.02$). One predictor is significant: external information flows ($b = 0.23$, $p < 0.00$). Step 3 involving the two-way interactions is also significant (Change-in-$F_{(13,123)} = 3.19$, $p < 0.01$). Hypothesis 1b predicts an inverted U-shaped relationship between procedural memory and new product creativity, which the results support ($b = -0.07$, $p < 0.03$). Hypothesis 2b predicts that there is a positive relationship[9] between declarative memory and creativity, which the results fail to confirm ($b = 0.02$, $p < 0.79$). Hypothesis 3b predicts that the joint effect of the two memory types on new product creativity is positive. The results indicate the two-way interaction of procedural memory and declarative memory is significant ($b = 0.10$, $p < 0.04$), supporting the hypothesis. Follow-up analysis to examine this interaction shows that this relationship between declarative memory and new product creativity is insignificant ($b = -0.17$, $p < 0.10$) at low procedural memory *but* it becomes significantly positive at high procedural memory ($b = 0.23$, $p < 0.05$).

Hypothesis 4 proposes that internal information flows have a negative moderating effect on the procedural memory-creativity relationship, which the results support ($b = -0.12$, $p < 0.01$). Follow-up analysis examining this interaction shows that this relationship between procedural memory and new product creativity is insignificant ($b = 0.47$, $p < 0.12$) at low internal information flows *but* becomes significantly negative at high levels ($b = -0.35$, $p < 0.01$). Hypothesis 6 predicts that external information flows have a positive moderating effect on the procedural memory–creativity relationship. Results show, however, there is a significant but negative interaction ($b = -0.13$, $p < 0.00$), which fails to support Hypothesis 6. Follow-up analysis probing this interaction shows that this relationship between declarative memory and new product creativity is insignificant ($b = 0.01$, $p < 0.19$) at low external information flows *but* becomes significantly negative at high external information flows ($b = -0.31$, $p < 0.05$). In addition, the non-hypothesized direct effect of external information flows is positive ($b = 0.28$, $p < 0.00$).

DISCUSSION

Based on previous research, we have conceived and tested the direct and joint effect of procedural and declarative memory as well as the moderating impact of

internal and external sources of information flows on the relationship between memory and new product outcomes. The empirical investigation has produced three key findings grouped along our three sets of hypotheses. First, regarding the direct effects of memory types, we found an inverted U-shaped relationship between procedural memory and financial performance and creativity as well as a positive relationship between declarative memory and financial performance. Second, procedural and declarative memory work in a *complementary* fashion to improve both financial performance and creativity. Third, procedural memory, however, hinders the value of internal or external information flows for product creativity. Although our results should be considered suggestive due to some empirical and conceptual limitations, they provide a platform for further theorizing on new product development practices, capabilities, and organizational memory as well as informing management practice.

Implications for Theory

A first key finding is that there is a curvilinear relationship between procedural memory and new product outcomes as well as a positive relationship between declarative memory and financial performance. This provides a complement to the work of Moorman and Miner (1997) who investigated organizational memory, *in general*, utilizing a measure mixing both routines and general knowledge. Our approach allows isolating the effect of two different *types* of memory.

We also extend prior empirical studies on the role of memory (Lynn and Akgün, 2000; Lynn et al., 1997) in three ways. First, our measures assess *directly* the memory types whereas these studies use detailed, yet, indirect measures, i.e. the antecedents of both memory types. For example, recording-reviewing, filing, past product review, goals, and management support as measures of declarative memory are not tied to prior conceptual definitions of declarative memory. Second, their empirical study (Lynn et al., 1997), in fact, does not examine the effect of both knowledge types on product success but a different set of relationships: declarative memory → procedural memory → new product success. Third, they utilize a single measure of new product success, while our approach contains two somewhat contradictory outcomes (i.e. financial performance and creativity), and, thus, we paint a richer portrait of memory's effects.

This result also joins the more recent resource-based view that stresses the importance of knowledge assets over traditional resources (Barney, 2001; Grant, 1996). Our study corroborates empirically the nuanced portrait of the value of knowledge assets in NPD (Levitt and March, 1988; March et al., 1991). Especially, the inverted-U relationship between procedural knowledge and both new product outcomes diverge from an entrenched dichotomy in the area of product development. Research, specifically, asserts that a structured approach – procedural memory – stifles creativity (i.e. Gupta et al., 1986; Olson et al., 1995) but promotes

efficiency (e.g. Cooper and Kleinschmidt, 1986). In contrast, our results, converging with other research (e.g. Brown and Eisenhardt, 1997), suggest that neither is creativity a result of organic processes nor are strict procedures a recipe for financial efficiency; rather, moderate use of routines (e.g. well-defined priorities and means) promotes *both* product outcomes.

A second key finding is that combining procedural and declarative knowledge stocks can boost both new product financial performance and creativity. This result relates to the knowledge and memory literature. While previous literature has introduced similar (Kogut and Zander, 1992) or the same types of knowledge (Cohen, 1991; Moorman and Miner, 1998a; Singley and Anderson, 1989), this is, to our best knowledge, the first study to provide empirical evidence on this complementary relationship across two different new product outcomes.

This finding also relates to an emerging literature emphasizing a firm's combinative capabilities (Grant, 1996; Kogut and Zander, 1992). This finding suggests that the nature and value of combinative capabilities may lie in integrating diverse functional knowledge (Dutta and Narasimhan, 1999; Leonard-Barton, 1992) *as much as* in integrating procedural skills and theoretical knowledge (Grant, 1996; Nelson and Winter, 1982). Such integration could have the potential for easing the tradeoffs between adaptability and short-term efficiency, a central issue in current strategy research (e.g. Benner and Tushman, 2003; Brown and Eisenhardt, 1997). Future research could conceptualize the integration mechanisms and empirically explore their effects at a project portfolio level.

Third, our results on the moderating impact of information flows provide a first step for examining the capabilities and information processing approach to NPD in a more integrated way. For example, our approach extends the work of Moorman and Miner (1997) who examined the moderating role of environmental factors while we generate some interesting results on the sources of information flows as moderators of memory. Specifically, we found that while internal information flows strengthen the financial success, they also restrict creativity *in* presence of strong procedural memory. In addition, while external information flows promote both financial success and creativity, they also detract from creativity *in* presence of strong procedural memory. Thus, *both* information flows have negative moderating role of comparable size.

Although the former moderating effect was expected, the latter is somewhat surprising. Two explanations may account for this unexpected finding. First, routines, apparently, dominate or 'filter' information flows to fit the entrenched assumptions and hamper the ability of project members to take a 'new' perspective *even* after their direct contacts with external parties. Second, given that our external information flows measure did not discriminate between *current* and *future* customers and markets, we believe, following other research (Chandy and Tellis, 1998; Kyriakopoulos and Moorman, 2004), that the latter may have a positive impact on the effectiveness of procedural as well as declarative knowledge. Consistent with this,

Christensen and Bower (1996) illustrate how dominant firms in the worldwide disk-drive market missed the wave of new generation products because their information channels were biased to their existing customers' needs, missing the emergence of new users.

Implications for Practice

Companies have been formalizing new product development activities, following ISO certification programmes, or project management models (e.g. phase review, stage gate process) promulgated by the industry (Griffin, 1997). In pursuit of this effort, they try to codify successful own or others' practices and experience into a set of rules and recipes (e.g. blueprints and best practices) to speed up activities and build up skills. One implication of our findings for product development practitioners is that companies need to exercise moderation in these practices. Given that formalization and codification make available more the rules and recipes, and *less* the underlying substantive knowledge, their excessive and automatic use can lead to opposite results, hurting financial success and creativity. Instead, companies could benefit from a combination of formalizing certain *higher-order* aspects (e.g. milestones, processes for transferring knowledge) and 'freeing' other aspects (e.g. cross-functional knowledge integration) of NPD.

Another implication of our research for practitioners is to underscore the importance of designing memory systems that allow less standard use of procedural memory as well as fast deployment of declarative memory. First, by infusing declarative knowledge into choosing and recombining prior procedures, firms can avoid the pitfalls of routines misfiring in inappropriate situations. Second, firms can utilize procedural memory to access prior general knowledge and quickly use it into new applications. For example, for more creative use of procedural knowledge, Shaw et al. (1998) explain how 3M's strategic planers use 'strategic narratives' in business planning in order to transmit critical contextual knowledge (e.g. implicit assumptions, historical context, cause-and-effect relationships) in choosing prior routines. In addition to 'soft' memory systems, advances in IT systems (internal electronic communication systems, search engines, etc) allow employees to retrieve quickly declarative knowledge such as drawings, modules specifications, or product designs (Olivera, 2000). For example, Markus (2001) explains how expert systems with case-based reasoning enhance and speed up knowledge use by customer support personnel. The difficulty associated with computerizing certain forms of declarative knowledge (analytical or rationale knowledge), however, is remarkably consistent with prior research underscoring the importance of social networks and other informal routines (Amand et al., 1998) as an important form of storing and re-using expertise. Our suggestions, finally, build on but also go beyond practitioner-oriented taxonomies of knowledge strategies, e.g. codification or personalization (Hansen et al., 1999). In contrast to the recommendations that

firms should not 'straddle', our findings imply that firms need to devise systems and processes for using *both* strategies to harness the benefits of their stored knowledge.

Study Limitations

An important conceptual limitation of our paper is that we do not account for the content of memory types. Routines for brainstorming, for example, can increase the potential for creativity as team members become more competent in generating and discussing new ideas (Hargadon and Sutton, 1997) while routines seeking to standardize behaviour could hinder creativity. Likewise, knowledge about customer preferences vis-à-vis knowing why a market behaves in a certain way are two different types of declarative knowledge with potentially diverse effect on creativity or financial performance. Future research should explore more deeply how more refined types of procedural memory such as overlap/interaction routines and tool/formal methods (Gerwin and Barrowman, 2002) or routines for each NPD phase (e.g. prototyping, concept testing, launch routines) (Henard and Szymanski, 2001; Lynn and Akgün, 2000) affect new product outcomes. Similarly, research could measure the distinct effect of factual knowledge, beliefs about cause-and-effect relationships, or conditional knowledge (Huber, 1991).

Because our sample is limited to a set of food firms, it would be interesting to examine whether our results extend to different industries or firm activities. First, there may be industries, i.e. biotechnology where declarative memory is more frequently used and low levels of procedural memory can be beneficial (e.g. Henard and Szymanski, 2001). Second, other firm processes may exhibit different emphasis on procedural and declarative memory. Research could select, for example, from among firm processes that are procedural memory-dominated (e.g. integrated logistics) and that are declarative memory-dominated (e.g. technology development).

The current work can be also improved by addressing some methodological limitations related to our cross-sectional, primary data from single key informants. Common method bias, likely to arise from relying on the same source for both the antecedent and outcome variables, could lead to erroneous relationships. Though the Harman-factor test and the Lindell and Whitney (2001) approach mitigate our concerns, relying on multitrait–multimethod analysis can be a more effective approach. Finally, multiple informants are necessary to reflect different aspects of collective processes such as memory and information flows.

CONCLUSION

Do firms really benefit from own prior experience as well as market information? We argued, overall, that depending on the *type* of their experience and *sources* of information flows, firms could develop profitable and creative products. Our find-

ings, specifically, suggest that a firm should utilize moderate levels of procedural as well as high levels of declarative memory. Firms could also benefit from mechanisms for recombining procedures and general knowledge. Too much reliance on prior procedures, however, reveals the 'classic' problems as observed in the extant literature; 'core rigidities' and 'not invented here syndrome' *even* in the presence of new information from external parties.

NOTES

*We appreciate the comments of Aric Rindfleisch, Cheryl Jarvis, Ad de Jong, the editor, and the three anonymous reviewers.

[1] We use the terms knowledge stocks and organizational memory interchangeably in this article.

[2] Having defined the two memory types and provided examples of associated activities, we hasten to caution that there is often no black-and-white distinction between declarative and procedural memory; however, it is also the case that the firm actions tend to exhibit a dominant emphasis. For example, a firm with prototyping competence contains both procedural skills as well as theoretical technical knowledge underlying these skills. Nevertheless, the procedural skills dominate the technical knowledge in the specific case. Patents, instead, exhibit dominant emphasis on knowledge rather than procedures.

[3] Comparing early respondents (ER) to late respondents (LR), no differences were found: procedural memory (ER = 3.88, LR = 3.88, $t_{(138)} = 0.01$, n.s.), declarative memory (ER = 5.08, LR = 5.03, $t_{(138)} = 0.23$, n.s.), internal learning (ER = 4.53, LR = 4.41, $t_{(138)} = 0.55$, n.s.), external learning (ER = 4.52, LR = 4.23, $t_{(138)} = 1.2$, n.s.), financial performance (ER = 4.75, LR = 4.52, $t_{(137)} = 0.84$, n.s.), creativity (ER = 5.51, LR = 5.39, $t_{(138)} = 0.84$, n.s.), market turbulence (ER = 4.49, LR = 4.15, $t_{(138)} = 1.57$, n.s.), technological turbulence (ER = 4.06, LR = 3.95, $t_{(138)} = 0.42$, n.s.), and firm resources (ER = 4.47, LR = 4.21, $t_{(138)} = 1.41$, n.s.). We also checked for non-response bias by examining the difference in firm size (a five-point ordinal scale measuring number of employees) between respondents (R) and non-respondents (NR) without significant results (R = 1.87, NR = 1.98, $t_{(338)} = 1.03$, n.s.).

[4] Results indicate that the critical value ($\Delta\chi^2_{(1)} = 3.84$) was exceeded in all tests: procedural memory and declarative memory ($\Delta\chi^2_{(1)} = 14.10$); procedural memory and internal information flows ($\Delta\chi^2_{(1)} = 5.68$); procedural memory and external information flows ($\Delta\chi^2_{(1)} = 6.79$); internal and external information flows ($\Delta\chi^2_{(1)} = 44.05$); declarative memory and internal information flows ($\Delta\chi^2_{(1)} = 12.04$); declarative memory and external information flows ($\Delta\chi^2_{(1)} = 16.45$); and financial performance and product creativity ($\Delta\chi^2_{(1)} = 29.58$).

[5] The squared correlations (ranging from 0.003 to 0.14) do not exceed the average variance extracted (ranging from 0.54 to 0.73), suggesting discriminant validity.

[6] Procedural memory and market orientation ($\Delta\chi^2_{(1)} = 45.65$); declarative memory and market orientation ($\Delta\chi^2_{(1)} = 30.14$); external information flows and market orientation ($\Delta\chi^2_{(1)} = 81.27$); internal information flows and market orientation ($\Delta\chi^2_{(1)} = 72.76$).

[7] First, we created a high level of the moderating variable (e.g. procedural knowledge) one standard deviation above its mean-centred level. Using this high level, we re-estimated our model and examined the significance of the term associated with the moderated variable (e.g. declarative knowledge). This told us whether there is significant effect of declarative knowledge when procedural knowledge is *high*. Second, we constructed a low level of procedural knowledge (one standard deviation below the mean-centred level). Using this low level, we re-estimated our model and examined the significance of the moderated variable (e.g. declarative knowledge). This told us whether there is significant effect of declarative knowledge when procedural knowledge is *low*. The benefit of this approach is that it allows researchers to use post-hoc probing to put the spotlight on the how one variable (z) is affecting the effect of another (x) on some outcome of interest (y).

[8] We have also tested an inverted U-relationship but the effect was not significant ($b = 0.08$, $p < 0.22$).

[9] We have also checked for an inverted U-relationship without significant results ($b = 0.07$, $p < 0.56$).

APPENDIX

I. Organizational Memory (adapted from Moorman and Miner, 1998b)

For this project, my team relied on:

Procedural memory

- well-defined procedures
- a standard approach
- strong skills*

Declarative memory

- a great deal of knowledge
- strong expertise
- knowledgeable people*

II. Sources of Information Flows (new)

Internal information flows

During this project, we:

- regularly received market information, i.e. customer needs, competitive action changes from other teams
- systematically received information about market changes from various departments
- systematically collected information on market developments from other concurrent projects
- were kept regularly informed from other sites of our company about market developments
- were regularly updated by customer service people
- were regularly updated by sales force people

External information flows

During this project, we:

- systematically discussed with our customers
- regularly consulted our supply chain partners
- systematically contacted our alliances
- regularly discussed with external consultants
- studied systematically successful companies outside our industry*
- consulted regularly outside experts*

III. New Product Outcomes (based on Moorman, 1995)

Rate the extent to which the product has achieved the following outcomes during the first twelve months of its life in the marketplace.

Short-term new product financial performance
- market share relative to its major competitor
- sales relative to its major competitor
- profit margin relative to its major competitor

New product creativity
- very novel for this category – very ordinary for this category
- creative – not creative
- interesting – uninteresting

IV. Control Variables

Market turbulence (Jaworski and Kohli, 1993)
Technological turbulence (Jaworski and Kohli, 1993)
Firm resources (NEW, 7 = high, 4 = moderate, 1 = low)
In comparison with the competition:
- our R&D resources
- our marketing resources
- our distribution resources
- our sales resources

V. Discriminating Variables

Market orientation (Jaworski and Kohli, 1993)
Organizational culture (Moorman, 1995)
Project type (Hultink, 1997)
Indicate the category into which the product best fits:
- completely new product, new market
- new product line
- addition to existing line
- improvement of existing product
- repositioning of existing product
- existing product produced at lower cost

* Items deleted during the measure purification process.

REFERENCES

Akgün, A. E., Lynn, G. S. and Byrne, J. C. (2003). 'Organizational learning: a socio-cognitive framework'. *Human Relations*, **56**, 7, 839–68.
Allen, T. J. (1971). 'Communication networks in R&D labs'. *R&D Management*, **1**, 14–21.
Amit, R. and Schoemaker, P. J. H. (1993). 'Strategic assets and organizational rent'. *Strategic Management Journal*, **14**, January, 33–46.

Anand, V., Manz, C. C. and Glick, W. H. (1998). 'An organizational memory approach to information management'. *Academy of Management Review*, **23**, 4, 796–809.

Ancona, D. G. and Caldwell, D. F. (1992). 'Bridging the boundary: external activity and performance in organizational teams'. *Administrative Science Quarterly*, **37**, 4, 634–65.

Anderson, J. R. (1983). *The Architecture of Cognition*. Cambridge, MA: Harvard University Press.

Argote, L. (1996). 'Organizational learning curves: persistence, transfer and turnover'. *International Journal of Technology Management*, **11**, 7–8, 759–70.

Bagozzi, R. P. and Yi, Y. (1988). 'On the evaluation of structural equation models'. *Journal of the Academy of Marketing Science*, **16**, Spring, 74–94.

Barney, J. B. (2001). 'Is the resource-based "view" a useful perspective for strategic management research? Yes'. *Academy of Management Review*, **26**, 41–56.

Benner, M. J. and Tushman, M. L. (2003). 'Exploitation, exploration, and process management: the productivity dilemma revisited'. *Academy of Management Review*, **28**, April, 238–56.

Berliner, P. F. (1994). *Thinking in Jazz: The Infinite Art of Improvisation*. Chicago, IL: University of Chicago Press.

Bierly, P. and Chakrabarti, A. (1996). 'Generic knowledge strategies in the U.S. pharmaceutical industry'. *Strategic Management Journal*, **17**, Winter Special Issue, 123–35.

Brown, S. L. and Eisenhardt, K. M. (1995). 'Product development: past research, present findings, and future directions'. *Academy of Management Review*, **20**, 343–78.

Brown, S. L. and Eisenhardt, K. M. (1997). 'The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations'. *Administrative Science Quarterly*, **42**, 1–34.

Chandy, R. K. and Tellis, G. J. (1998). 'Organizing for radical product innovation: the overlooked role of willingness to cannibalize'. *Journal of Marketing Research*, **35**, 4, 474–87.

Christensen, C. M. and Bower, J. L. (1996). 'Customer power, strategic investment, and the failure of leading firms'. *Strategic Management Journal*, **17**, 197–218.

Cockburn, I. M. and Henderson, R. M. (1998). 'Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery'. *Journal of Industrial Economics*, **46**, June, 157–82.

Cohen, W. M. (1991). 'Individual learning and organizational routine: emerging connections'. *Organization Science*, **2**, 135–9.

Cohen, W. M. and Bacdayan, P. (1994). 'Organizational routines are stored as procedural memory: evidence from a laboratory study'. *Organization Science*, **4**, 554–68.

Cohen, W. M. and Levinthal, D. A. (1990). 'Absorptive capacity: a new perspective on learning and innovation'. *Administrative Science Quarterly*, **35**, September, 128–52.

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**, June, 71–85.

Cyert, R. and March, J. G. (1963). *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.

Day, G. S. (1994). 'The capabilities of market-driven organizations'. *Journal of Marketing*, **58**, 4, 37–52.

Dean, J. W. and Susman, G. I. (1989). 'Organizing for manufacturable design'. *Harvard Business Review*, **67**, 28–36.

Dougherty, D. (1992). 'Interpretive barriers to successful product innovation in large firms'. *Organization Science*, **3**, 2, 179–202.

Dutta, S. and Narasimhan, O. (1999). 'Success in high-technology markets: is marketing capability critical?'. *Marketing Science*, **18**, 4, 547–68.

Eisenhardt, K. M. and Martin, J. A. (2000). 'Dynamic capabilities: what are they?'. *Strategic Management Journal*, **21**, 10–11, 1105–21.

Eisenhardt, K. M. and Tabrizi, B. N. (1995). 'Accelerating adaptive processes: product innovation in the global computer industry'. *Administrative Science Quarterly*, **40**, March, 84–110.

Gerwin, D. and Barrowman, N. J. (2002). 'An evaluation of research on integrated product development'. *Management Science*, **48**, 7, 938–53.

Grant, R. M. (1996). 'Prospering in dynamically competitive environments: organizational capability as knowledge integration'. *Organization Science*, **7**, July–August, 375–87.

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

Gupta, A. K., Raj, S. P. and Wilemon, D. (1986). 'A model for studying R&D – marketing interface in the product innovation process'. *Journal of Marketing*, **50**, 2, 7–17.

Hamel, G. and Prahalad, C. K. (1991). 'Corporate imagination and expeditionary marketing'. *Harvard Business Review*, **69**, July–August, 81–92.

Hammer, M. and Stanton, S. (1999). 'How process enterprises really work'. *Harvard Business Review*, **77**, 6, 108–18.

Hansen, M. T., Nohria, N. and Tierney, T. (1999). 'What's your strategy for managing knowledge?'. *Harvard Business Review*, **77**, March–April, 106–16.

Hargadon, A. and Sutton, R. I. (1997). 'Technology brokering and innovation in a product development'. *Administrative Science Quarterly*, **42**, 716–49.

Hedberg, B. (1981). 'How organizations learn and unlearn'. In Starbuck, W. H. and Nystrom, P. C. (Eds), *Handbook of Organizational Design*. London: Oxford University Press, 3–27.

Henard, D. H. and Szymanski, D. M. (2001). 'Why some new products are more successful than others'. *Journal of Marketing Research*, **38**, 3, 362–75.

Henderson, R. M. and Clark, K. B. (1990). 'Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms'. *Administrative Science Quarterly*, **35**, March, 9–30.

Huber, G. P. (1991). 'Organizational learning: the contributing processes and the literatures'. *Organizational Science*, **2**, February, 88–115.

Hultink, E. J. (1997). 'Launch Strategies and New Product Performance: An Empirical International Study'. Doctoral dissertation, Technical University of Delft, Delft, NL.

Imai, K., Nonaka, I. and Takeuchi, H. (1985). 'Managing the new product development process: how Japanese firms learn and unlearn'. In Clark, K., Hayes, R. and Lorenz, C. (Eds), *The Uneasy Alliance*. Boston, MA: Harvard Business School, 337–76.

Inkpen, A. C. and Dinur A. (1998). 'Knowledge management processes and international joint ventures'. *Organization Science*, **9**, 454–68.

Irwin, J. R. and McClelland, G. H. (2001). 'Misleading heuristics and moderated multiple regression models'. *Journal of Marketing Research*, **38**, 1, 100–9.

Jaworski, B. J. and Kohli, A. K. (1993). 'Market orientation: antecedents and consequences'. *Journal of Marketing*, **57**, 3, 53–70.

Katz, R. and Tushman, M. L. (1981). 'An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility'. *R&D Management*, **11**, 103–10.

Kogut, B. and Zander, U. (1992). 'Knowledge of the firm, combinative capabilities, and the replication of technology'. *Organization Science*, **3**, 383–97.

Kyriakopoulos, K. and Moorman, C. (2004). 'Tradeoffs in marketing exploitation and exploration strategies: the overlooked role of market orientation'. *International Journal of Research in Marketing*, **21**, 3, 219–40.

Leonard-Barton, D. (1992). 'Core capabilities and core rigidities: a paradox in managing new product development'. *Strategic Management Journal*, **13**, Summer, 111–25.

Levitt, B. and March, J. G. (1988). 'Organizational learning'. *Annual Review of Sociology*, **14**, 319–40.

Lindell, M. K. and Whitney, D. J. (2001). 'Accounting for common method variance in cross-sectional research designs'. *Journal of Applied Psychology*, **86**, 1, 114–21.

Lynn, G. S. and Akgün, A. E. (2000). 'A new product development learning model: antecedents and consequences of declarative and procedural knowledge'. *International Journal of Technology Management*, **20**, 490–510.

Lynn, G. S., Simpson, J. T. and Souder, W. E. (1997). 'Effects of organizational learning and information-processing behaviors on new product success'. *Marketing Letters*, **8**, 1, 33–9.

March, J. G. (1991). 'Exploration and exploitation in organizational learning'. *Organizational Science*, **2**, February, 71–87.

March, J. G , Sproull, L. S. and Tamuz, M. (1991). 'Learning from samples of one or fewer'. *Organization Science*, **2**, February, 58–70.

Markus, M. L. (2001). 'Toward a theory of knowledge reuse: type of knowledge reuse situations and factors in reuse success'. *Journal of Management Information Systems*, **18**, 1, 57–93.

Mintzberg, H., Pascale, R. T., Goold, M. and Rumelt, R. P. (1996). 'The "Honda effect" revisited'. *California Management Review*, **38**, Summer, 78–117.

Moorman, C. (1995). 'Organizational market information processes: cultural antecedents and new product outcomes'. *Journal of Marketing Research*, **32**, 3, 318–35.

Moorman, C. and Miner, A. S. (1997). 'The impact of organizational memory on new product performance and creativity'. *Journal of Marketing Research*, **34**, 1, 91–106.

Moorman, C. and Miner, A. S. (1998a). 'Organizational improvisation and organizational memory'. *Academy of Management Review*, **23**, October, 698–723.

Moorman, C. and Miner, A. S. (1998b). 'The convergence of planning and execution: improvisation in new product development'. *Journal of Marketing*, **61**, 3, 1–20.

Nelson, R. R. and Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Olivera, F. (2000). 'Memory systems in organizations: an empirical investigation of mechanisms for knowledge collection, storage, and access'. *Journal of Management Studies*, **37**, 6, 811–32.

Olson, E. M., Walker, O. C. Jr and Ruekert, R. (1995). 'Organizing for effective new product development: the moderating role of product innovativeness'. *Journal of Marketing*, **59**, 1, 48–62.

Quinn, R. E. (1988). *Beyond Rational Management*. San Francisco, CA: Jossey-Bass Publishers.

Rogers, E. (1983). *Diffusion of Innovations*. New York: Free Press.

Sethi, R., Smith, D. C. and Park, C. W. (2001). 'Cross-functional product development teams, creativity, and the innovativeness of new consumer products'. *Journal of Marketing Research*, **38**, February, 73–85.

Shaw, G., Brown, R. and Bromiley P. (1998). 'Strategic stories: how 3M is rewriting business planning'. *Harvard Business Review*, **76**, May–June, 41–8.

Singley, M. K. and Anderson, J. R. (1989). *The Transfer of Cognitive Skill*. Cambridge, MA: Harvard University Press.

Starbuck, W. H. (1992). 'Learning by knowledge-intensive firms'. *Journal of Management Studies*, **29**, 7, 713–40.

Tsoukas, H. and Vladimirou, E. (2001). 'What is organizational knowledge?'. *Journal of Management Studies*, **38**, 7, 973–93.

Tushman, M. L. (1977). 'Special boundary roles in the innovation process'. *Administrative Science Quarterly*, **22**, 4, 587–605.

von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.

Walsh, J. P. and Ungson, G. R. (1991). 'Organizational memory'. *Academy of Management Review*, **16**, January, 57–91.