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DESIGNING MANAGEMENT CONTROL SYSTEMS IN PRODUCT DEVELOPMENT: INITIAL CHOICES AND THE INFLUENCE OF PARTNERS

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Abstract

Management control systems can hinder innovation. However, recent theoretical and empirical work indicates that these systems can also enhance it. Using two sequential empirical studies, this paper investigates this question. The first uses a field research design to examine the adoption of management control systems in the product development function of entrepreneurial firms. The data comes from questionnaires and interviews with the CEOs, financial officers, and business development managers of 69 firms. Analysis of the qualitative data indicates that managers adopt these systems not so much to fulfill a particular role as to solve particular needs that they face. These needs range from external contracting and legitimizing the process with external parties to internal drivers such as managers' background, learning by doing, need to focus, or reaction to problems. Furthermore, these reasons are associated with faster adoption of these systems and with product development performance. The objective of the second study is to extend and generalize the finding regarding the influence of external parties on management control system adoption to a population of mature firms. Using a survey design, the study finds an association between the importance of partners to product development and the level of formalization of management control systems..

Keywords: management control systems, product development, innovation

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Introduction

The role of formal management control systems within innovation processes remains ambiguous. Traditionally, these systems have been associated with mechanistic organizations (Burns & Stalker, 1961) that repeatedly perform the same routines with little if any changes. In contrast, their relevance to the innovation process, a process associated with organic structures, has been repeatedly questioned. Ouchi (1979) used a research department to illustrate clan control where social norms substitute formal management systems. Tushman and O'Reilly (1997) echo the same idea: "with work requirements becoming more complex, uncertain, and changing, control systems cannot be static and formal. Rather, control must come in the form of social control systems that allow directed autonomy and rely on the judgment of employees informed by clarity about the vision and objectives of the business" (page 108). The overall conclusion is that innovation processes are managed through informal mechanisms and that formal systems can only be detrimental to their performance.

However, recent work questions the validity of this relationship (Davila, 2005a). In the theory field, the distinction between coercive and enabling bureaucracies (Adler & Borys, 1996) suggests that formal management control systems (MCS) may be required to support innovation. Gavetti and Levinthal (2000) present a learning model where companies that jointly rely on planning and learning-by-doing are predicted to perform better in uncertain environments compared to alternative learning strategies. Zollo and Winter (2002) argue that the essence of dynamic capabilities is adaptive routines. The objective of Simons' (1995) interactive systems is to spark innovation. For the most part, recent empirical evidence also indicates that innovation processes may gain from the presence of MCS. Abernethy and Brownell (1999) use Simons' model to examine the use of budgets "as a dialogue, learning and idea creation machine" during episodes of strategic change. However, Bisbe and Otley (2004) find that interactive systems hurt innovation in high-innovation firms. Cardinal (2001) reports that more control was associated with improved radical as well as incremental innovation in the pharmaceutical industry. Ditillo (2004)

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describes MCS as a key element in knowledge intensive firms. Similarly, Chapman (1998) presents evidence consistent with this alternative view of the relevance of these systems in uncertain environments.

The objective of these empirical studies is to capture the association between performance and the use of MCS. However, their research designs are less powerful to study the underlying mechanisms driving this association. This paper extends these empirical findings by further understanding the roles that MCS have in a highly innovative setting: new product development. In particular, we examine two related questions: (1) w*hy* companies adopt MCS in their product development processes, and based on the findings to the first question, (2) *what* is the relevance of partners in the design of these systems.

Yin (1988) proposes experiments, histories, and field research as research strategies to address these exploratory questions. We designed a two-stage research process to address and partially generalize these questions. In the first stage, we use a field research design based on survey and interview data from 69 young high-technology firms. Guided by the literature, we develop a grounded theory (Glasser & Strauss, 1967) that identifies a typology of drivers for management systems in product development. Our findings indicate that these systems not only stimulate dialogue and idea creation; nor are they exclusively used as diagnostic systems to control execution; rather, an important objective is to stabilize an environment that, by the nature of the innovation process, is already rich in opportunities. MCS provide the infrastructure to anchor the innovation process to its objectives. We then use the typology developed to examine adoption decisions with time to adoption of MCS and product development performance.

In the second stage of the research, we use a survey-based research design to generalize one of the findings from the first stage. In particular, we extend the argument that the presence of external partners affects the design of MCS to a larger population of firms. Consistent with this conjecture, the empirical results indicate that the presence of external partners is associated with more detailed plans, and more intense use of MCS during the project execution.

The paper brings a new perspective to the growing evidence on the relevance of MCS to enhance the performance of organic structures (Kalagnanam & Lindsay, 1999) and in particular to innovation processes (Bisbe et al., 2004). The paper pursues this objective combining rich field-based and survey-based data in a two-stage research design. It diverges from prior research on several dimensions. First, the multi-case, multi-method field research design provides a depth and richness of data unique to this study. Second, the research design provides the quality and detailed data needed to propose a grounded theory (Glasser et al., 1967) to tentatively answer why MCS are adopted in innovation processes. Third, the study examines patterns between the drivers of MCS adoption and the organizational context in which the phenomenon happens. These insights advance our knowledge about the relevance of formal control procedures to enable innovation. Field research designs have proven to be effective in examining related research questions (Abernethy & Lillis, 1995; Ahrens & Chapman, 2004). Finally, the survey-based research design generalizes a subset of the field research findings to a larger population (Chenhall, 2003).

Conceptual framework

1. Limitations of management control systems

A sizeable body of literature has examined how informal processes such as culture (Tushman et al., 1997; Amabile, Conti, Coon, Lazenby, & Herron, 1996), communication patterns (Dougherty, 1992), team composition, and leadership (Clark & Fujimoto, 1991) impact the process of innovation. The conclusions from these studies are unambiguous. Innovation processes such as product development benefit from a rich information environment built through multi-disciplinary teams that create the abrasiveness (Leonard-Barton, 1992) required for ideas to spark, intense communication inside the organization and with outside parties to nurtures ideas (Dougherty, 1992), a supportive organization that rewards experimentation (Tushman et al., 1997), and a strong leader with the authority to execute on the vision (Clark et al., 1991).

In contrast, the role of MCS has received less attention and the conclusions are uncertain. On the one hand, these systems are viewed as stifling innovation (Tushman et al., 1997; Amabile, 1998; Ouchi, 1979). They constrain cross-functional interaction, limit communication to established patterns, penalize deviations, and diffuse leadership. Damanpour's (1991) meta-analysis of empirical work on organizational determinants of innovation reports a negative association between innovation and formalization. The prevalence of the cybernetic control model reflected in the thermostat metaphor (Anthony, 1965) may account for this conclusion. This model views MCS as static, with the purpose of eliminating variation within organizational processes, and lacking the adaptability to fit the dynamics of innovation. They are viewed as action control mechanisms (Merchant, 1982) dictating the actions that organizational members have to follow and punishing deviations from rules and procedures. These systems reinforce the extrinsic, contractual relationships of hierarchical organizations. In high-innovation environments, they kill the intrinsic motivation and freedom that innovation requires (Amabile, 1998). According to this view, MCS are most useful when task analyzability is high and the number of exceptions is low (Perrow, 1970) such as low innovation settings. Empirical studies have confirmed these predictions. Abernethy and Lillis (1995) find that "spontaneous contact and "integrative liaison devices" which allow regular, personal and intensive contact" are more prevalent in flexible manufacturing firms while traditional performance measurement systems are de-emphasized. Abernethy and Brownell (1997) report higher reliance on personnel control in research and development departments. Rockness and Shields (1988) echo these conclusions.

2. Empirical evidence on the role of management control systems in innovative settings

In spite of the previous arguments, evidence is accumulating that suggests a positive effect of MCS in uncertain settings. Formalization is positively related to satisfaction in a variety of settings (Jackson & Schuler, 1985; Stevens, Philipsen, & Diederiks, 1992). Environmental uncertainty has repeatedly been associated with MCS (Khandwalla, 1972; Chenhall & Morris, 1986; Simons, 1987). Directly investigating the role of accounting in highly uncertain conditions, Chapman (1998) used four case studies and concluded, "the results of this exploratory study strongly support the idea that accounting does have a beneficial role in highly uncertain conditions" (page 738). Howard-Grenville (2003) used an ethnographic approach in one high-technology company to document the relevance of organizational routines to confront uncertain and complex situations.

Within product development, prescriptive recommendations to practitioners emphasize the importance of MCS (McGrath, 1995). Several research studies have found that planning and well-coordinated project execution are associated with product success (Cooper, 1995; Zirger & Maidique, 1990). These studies hint to a relevant role of MCS although they fail to provide a theoretical justification for their findings (Brown & Eisenhardt, 1995). Using a control framework, Cardinal (2001) found that the three types of control systems—input, behavior, and output control—enhance radical innovation—

arguably the most uncertain type of innovation. Dávila (2000) reports a positive association between the use of management accounting information and product development performance. Brown and Eisenhardt (1997) describe successful product innovation as blending "limited structure around responsibilities and priorities with extensive communication and design freedom" so that "this combination is neither so structured that change cannot occur nor so unstructured that chaos ensues" (page 1).

These studies give several instances where innovation settings rely on MCS to succeed. While they do not attempt to explain this association, their descriptions suggest a very different interpretation than the traditional cybernetic model.

3. Theoretical justifications for the role of MCS in innovative settings

The empirical evidence in the previous sub-section hints at potential explanations as to why MCS may be relevant to innovation. Conceptual work has elaborated these explanations and developed concepts to capture them.

Fiol (1996) in her summary of the innovation literature uses the sponge as an analogy of the innovation process. The capability of an organization to innovate depends on its ability to assimilate, accumulate and exploit knowledge. This ability depends not only on its informal processes, but also on the formal mechanisms that support them, such as MCS. Simons' typology (Simons, 1995) identifies interactive systems as information-based routines to identify knowledge required to address strategic uncertainties. They provide the infrastructure to engage organizational members in the communication pattern required to nurture Fiol's first stage of innovation. One of the attractive features of the concept of interactive systems is that it allows top management to guide the search stage of the innovation process, without falling into the cybernetic model. Thus, the concept provides one of the first rationales to explain the relevance of MCS to innovation. Recent empirical studies (Abernethy et al., 1997; Bisbe et al., 2004) rely on interactive systems to examine MCS in uncertain environments, reflecting the relevance of the concept.

However, interactive systems only address the front end of the innovation process. The concept of enabling bureaucracy (Adler et al., 1996) addresses the role of MCS throughout the stages of assimilation and exploitation of knowledge in Fiol's analogy. Enabling bureaucracy is designed to "enhance the users' capabilities and to leverage their skills and intelligence" (page 68) rather than with "a fool-proofing and deskilling rationale" typical of a cybernetic model. Thus, organizations assimilate and exploit the knowledge accumulated in the first stage through flexible, transparent, user-friendly routines. Ahrens and Chapman (2004) apply the concept of enabling bureaucracy to analyze the role of MCS in a field study setting. They describe how managers rely on an enabling use of these systems to cope with the uncertainty of day-to-day operations.

Another line of research offers additional arguments through the concept of adaptive routines. Weick, Sutcliffe, & Obstfeld (1999) describe routines as resilient because of their capacity to adapt to unexpected events. This concept portrays routines as flexible to absorb novelty rather than rigid to suppress it. They offer organizational members a stable framework to interpret and communicate when facing unexpected events. They "usefully constrain the direction of subsequent experiential search" (Gavetti et al., 2000) (page 113). Reliability rather than replicability identifies routines in uncertain settings.

Feldman and Rafaeli (2002) extend this argument to include routines as drivers of key patterns of communication among organizational members. Miner, Bassoff, & Moorman (2001) describe the constant interaction between routine activities and improvisation in new product development. Routines provide the substrate for improvisation to happen and learning to accumulate. Zollo and Winter (2002) argue that dynamic capabilities are "routinized activities directed to the development and adaptation of operating routines" that organizations can purposefully manage through experience accumulation, knowledge articulation, and knowledge codification.

These concepts highlight the positive effect that MCS may have on innovation. They contrast with the command-and-control view of the cybernetic model. Rather than viewed as a rigid mold that rejects the unexpected, MCS are flexible and dynamic frames adapting and evolving to the unpredictability of innovation, but stable to frame cognitive models, communication patterns, and actions.

4. Roles and adoption of MCS in product development

In addition to the theoretical concepts supporting the relevance of MCS, the literature also offers various roles of MCS in innovative settings:

1. Amabile (1998) indicates that innovation thrives when people are granted freedom to achieve goals that are clear and stable for a sufficiently long period of time. She states "it is far more important that whoever sets the goals also makes them clear to the organization and that these goals remain stable for a meaningful period of time" (page 80). Uncertainty provokes a constant shift of priorities that may undermine the innovation process. MCS explicitly state goals, thus increasing their stability and visibility, facilitating convergence in meaning across organizational actors, and providing the steadiness and clarity that creativity requires.

2. Lundberg (1995) indicates that procedures help innovation by coding learning from past experience (Levitt & March, 1988). Coded routines facilitate the diffusion of organizational capabilities across the organization and over time (Nelson & Winter, 1982; Powell, 1998). Coded learning also avoids incurring mistakes that have been experienced in the past and increases organizational efficiency. Information-based routines allow comparisons across sequential enactments of the routine and gauge progress over time. Benchmarking progress has been identified as a key element in the learning process (Gavetti et al., 2000).

3. Lundberg (1995) also points out the importance of coordinating different innovation efforts across the organization. MCS decouple the efforts of organizational actors and reduce coordination cost through the explicit negotiation of local goals.

4. Similarly, process planning clarifies the sequence of steps to achieve certain organizational goals and provides a blueprint for coordinating the innovation effort over time (Cohen et al., 1996).

5. MCS facilitate control by exception (Simons, 1995) where managerial attention is required only if innovation results deviate from expectations.

6. MCS may also respond to external demands. External constituencies, such as partners, may impose these systems to enhance their monitoring within the firm. These intermediate milestones also facilitate contracting with outside

partners (Powell, 1998). Pfeffer and Salancik (1978) highlight the relevance of the external context in explaining how firms are organized.

7. Finally, new institutionalism (Powell & DiMaggio, 1991; Carruthers, 1995) views cognitive processes as relevant to explain management systems. It identifies formal processes as symbolic to externally legitimize the organization through an appearance of competency. Innovation processes may require the rational symbol associated with formal systems to legitimize the work of the organization. Management systems do not fulfill as much a technical need as conforming to external demands decoupled from technical needs.

The previous list (summarized in Table 1 and illustrated with quotes from this study) details the roles that the literature identifies for MCS. However, current knowledge or evidence on why these systems are adopted is limited. Moores and Yuen (2001) find that, as they expected, management systems are adopted in the growth stage of the firm. Davila (2005b) finds that, within the human resource function, the adoption of these systems is associated with the presence of external funding, size, age of the firm, and the replacement of the founder as CEO. These results suggest that external constituencies may affect adoption (to fulfill the last two roles identified); moreover the significance of size and CEO turnover might be related to failures in meeting the goals associated with the first six roles identified (Flamholtz, 2000).

Research method

This study comprises two stages. In the first stage, we use a field research design to investigate why companies adopt MCS in their product development process. To answer this question we sample from a population of young high-technology firms with a size between 50 and 150 employees. To capture the detail needed to answer the question, our data collection combines questionnaire and interview methods. The second stage of the research adopts a survey design approach. Its objective is to generalize beyond the initial sample a novel finding from the first stage. In particular, we examine whether technology-related partnerships in product development impose more structured MCS. In this second stage, we sample from a broader population of firms to generalize the findings beyond young high-technology firms.

1. Field research design

To capture the richness needed to explore the initial research question, we adopt a cross-sectional, multi-method, multi-case field research design. The aim of the cross-sectional multi-case design is to gather a large enough variance to document our research question, to capture the detail required to answer the questions, and to link contextual variables to the adoption of MCS. The multi-method design relies on qualitative data to identify patterns of behavior and quantitative data to examine covariates that may inform the research question. Our data includes questionnaire and semi-structured interviews on the adoption and role of MCS in young technology companies. Capturing the quality, depth, and richness to understand the experience of the actors (Seidman, 1998) demands detailed descriptions of the phenomena (Marshall & Rossman, 1995; Kvale, 1996). The focus of the study on product development as a relevant aspect of innovation processes drives the decision to sample among a population of technology companies. We expect product development to be a significant enough aspect of their strategy to have received management attention. The sampling of a population of young firms is intended to capture the point in time when formal systems, if any, are adopted. This transition point is likely to be a recent event in the life of these firms and thus managers are expected to be able to better articulate the reasons for the research question.

2. Data sources

For each company we collected as much information from public sources as possible—such as company web pages and press releases from Lexis-Nexis. This information was used to familiarize the research team with the characteristics and products of each company before the actual data collection. Next, each company received three questionnaires—one for the CEO, another for the CFO, and a third one for the business development manager. The purpose of the questionnaire was to collect quantifiable information about the company and its processes. Appendix A reproduces the relevant questions.

The final phase of the data collection included semi-structured interviews with each of the three managers. The objective of these interviews was to gain detail about the company, its history, its strategy and the adoption, design, and use of MCS. Each interview lasted between forty-five and ninety minutes. The interviews relied on a detailed protocol listing the questions to be addressed. The protocol insured that the main topics of the research were systematically covered during the conversation, but the semi-structured nature of the interview gave the flexibility of follow-up questions to clarify the particular practices at each company (Marshall et al., 1995). The relevant protocol questions are reproduced in Appendix B. Interviews were conducted in person or by phone and at least two researchers were present in every interview. Interviews were taped and then transcribed. The questionnaire, sent prior to the interview, facilitated focusing the interview around the key aspects of interest. The interview was also instrumental in clarifying answers to the questionnaire.

3. Sample description

The final sample includes 69 young, high technology companies. The data collection started in September 2002 and finalized in December 2003. Periodically during the data collection, we contrasted the incremental learning. By the end of the data collection, we felt that the sample captured a large variation in the population, reaching theoretical saturation (Glasser et al., 1967), and the sample was large enough to allow preliminary generalizations of the results.

We construct the sampled population using the following selection criteria: 1) high technology, 2) less than 10 years old, 3) between 50 and 150 employees, 4) independent, and 5) in a limited geographic area.[1] These criteria identify companies where product development is likely to be the foundation of their competitive advantage. They also identify companies more likely to have recently and independently transitioned through the stage of formalizing product development processes, rather than companies that have had systems in place for a long time or systems imposed by a parent company. We did not require firms to be public or private, foreign owned, or venture funded; however the majority of firms were private, domestically owned, and venture funded. The population of firms was sourced from the *CorpTech Internet directory of technology companies*. We

[1] The main reason for the geographic criterion was research funding (more than fifty percent of the interviews were done at the companies' premises). This decision also reduces the potential impact of omitted variables that may vary with geography and limits the generalizability of results.

accessed the database in January and June 2002 and built our sample from the following industries (using *CorpTech* industry classification): biotech (BIO), computer hardware (COM), manufacturing (MAN), medical equipment (MED), pharmaceuticals (PHA), photonics (PHO), computer software (SOF), subassemblies (SUB), test & measuring equipment (TAM), and telecommunications (TEL).[2] We also purposefully over-sampled biotechnology firms because of their potential relevance as a growth industry. This sub-sample was extended using three additional databases particular to the industry: *Rich's high-tech business guide to Silicon Valley and Northern California* (2000/2002), *BioScan* (Oct. 2001), and the *U.S. Business Browser* (c. 2001).

A letter addressed to the CEO was sent to every firm in the sample. The letter described the purpose of the research, the research process, and the benefits of participating—a half-day conference where participating companies were invited to a presentation of the managerial implications of the research project and a written document of the findings. The letter was followed up with a phone call to entice participation; a company was dropped from the sample if it had not accepted or declined participation after five phone calls. We carefully documented the sample selection process as detailed in Panel A, Table 2. Excluding companies that were acquired, went out of business or are ineligible, the response rate is 20%. Companies acquired or that went out of business were significantly younger than the eligible sample but comparable in terms of sales and number of employees. Within the eligible sample, we compared companies that participated to those that did not, in order to assess potential self-selection bias; we found no significant differences in sales, number of employees and age.[3] The final sample includes eleven biotechnology companies, 48 information technology companies, and ten companies in other industries; in addition, 62 received venture capital. Panel B, Table 2 provides additional descriptive statistics on the sample.

4. Data analysis

The data analysis was structured in two stages. In the first stage, interview data was coded—to summarize, interpret, and classify the information. To limit the potential bias inherent in the analysis of qualitative data, three researchers coded each one of the interviews. To systematically proceed through the coding process, each researcher used the Nvivo qualitative coding software. This software details the analysis from the raw data to the theoretical propositions, thus providing an auditable trail of the analysis. Because of the exploratory nature, each researcher may potentially identify different constructs that explain the observed patterns. To identify common constructs, the coding was done following a structured process. The sample was divided into two groups. The three researchers independently identified the main topics covered in each interview for one of the groups. The result was the dissection and reorganization of the original transcripts into broad topics. Then, the researchers met to contrast the topics that each one identified, agree on a common set of terms to identify them, and discussed any differences in interpretation of the transcripts. Next, the second group of interviews was independently coded using the common terminology. Finally, at the end of the process the team met to contrast the results of this second coding effort and discuss differences and new topics, if any. The objective of sub-dividing the sample into two groups is to contrast the model that emerges from the first

[2] We excluded from these lists any companies that were also listed as "Energy," "Environment," "Chemical," "Defense", "Transportation" or "Non". "Non" companies are not primarily high-tech companies. The other industries are excluded because they face a different regulatory and/or institutional environment. We also excluded organizations cross-listed in these industries.

[3] We compared means and medians of sales, employees, and age (variables available from the databases that we accessed) for both groups in our sample. We also use the non-parametric Mann-Whitney test on these variables with identical conclusions.

analysis using a hold-up sample. The same process was iteratively used to analyze with increasing detail each of the topics until a stable set of constructs were identified that explained the phenomenon examined. The process evolved in an iterative and non-linear fashion, where the topics and constructs were revised to better capture the insights of the independent analyses. The end result is a set of typologies that describe different aspects of the adoption of MCS in new product development (Marshall et al., 1995).

The second stage of the analysis is intended to establish patterns leading to a tentative formulation of a grounded theory (Strauss & Corbin, 1990). It combines survey data with the variables identified in the coding of the qualitative data to propose relationships among these variables (King, Keohane, & Verba, 1994). The findings reported in the paper are the end process of the analysis; however the audit trail documentation allows tracking the conclusions to the raw data.

Results

1. Adoption of management control systems in new product development

Panel C in Table 2 provides descriptive statistics on the percentage of companies adopting each of the product development systems identified for this research and the time-to-adoption since the founding of the company (Appendix A reproduces the relevant questionnaire items). Panel D in Table 2 gives the frequency distribution of the types of measures used to track product development and how often they are updated. These types of measures were coded based on the open-ended question to the questionnaire item about the three most important measures. The measures were coded by two researchers independently.

The iterative analysis of interview data identified six different drivers of the adoption of MCS as well as unique experiences not significant from a statistical perspective, but relevant to understand how MCS can be used and to grasp the richness of the phenomenon examined. Panel A in Table 3 provides descriptive statistics and illustrative quotes for each of the drivers. These drivers are not exclusive of each other, and more than one can be present at different stages or for different systems within a company. For each driver, we report the number of observations where it was the main driver and the number of observations where it was a secondary driver.[4]

In certain observations, systems are adopted to *legitimize* the company vis-à-vis external partners (Carruthers, 1995). They are not required from a management perspective, but they are adopted as a symbol (Macintosh, 1994) (chapter 9) to enhance the credibility of the company towards external parties—usually customers, partners, and investors. This role is consistent with the theoretical role summarized in Table 1 as number seven. Establishing a framework for the interaction with external parties is another external driver of MCS. External parties require visibility into the organization's processes to monitor, coordinate, and control them (Pfeffer et al., 1978). Intra-organizational agreements lack the constant interactions required to ground informal management and the need to formalize the interface is enhanced in these situations. We labeled this situation as *contracting* to indicate the relevance of formal systems to implement the contract between the players (Otley & Berry, 1994; Dekker, 2004) and consistent with the role identified as number six in Table 1.

We also found evidence consistent with internal drivers of MCS adoption. Managers may be proactive in that the systems are implemented ahead of the company

[4] For each company we identified at least one driver (except if the process was still informal) and at most two drivers (a main one and a secondary one).

requiring them. We distinguish two different drivers: *background* and *focus*. *Background* captures those systems put in place when a particular manager comes to the firm because of this person's prior experience. It is closely associated with congenital learning, where "individuals (…) have knowledge about (…) the processes the organization can use to carry out its creator's intentions" (Huber, 1991) (page 91). These managers, usually with significant prior experience, perceive MCS as management infrastructure required to facilitate growth. Their behavior can be interpreted as mimetic (Powell et al., 1991), where they emulate practices from other organizations to reduce the cognitive uncertainty, although the narratives suggest a strong functionalist aspect. The second driver, *focus*, reflects managers who implemented systems because they perceived an emergent need. In contrast to the *background* drivers that are implemented regardless of their immediateness, *focus* drivers respond to a particular need—such as to coordinate a geographically dispersed workforce, increase organizational efficiency, or improve communication.

MCS may be adopted as a reaction to unexpected events, mistakes, or recurring problems (Simons, 1995) (we label it as reactive to *chaos*). Lack of skills or lack of resources may delay the adoption of systems until constant failures in the informal processes force it (Flamholtz, 2000). In most circumstances, chaos was unintended and managers were ill-prepared to deal with it; in one of our observations, however, the manager purposefully used chaos to drive the need for change.

A final category that we labeled as reactive to *learning* was the outcome of the enactment process (Weick, 1995). While the outcome was a more efficient organization, this category is different from the proactive *focus* category in that formal systems emerged as the outcome of a learning process. It was not managers who decided to implement systems because of a particular need, but systems emerged to code existing practices. In some cases, the coding was triggered by certain events. For instance, in one of the companies the growth associated with the economic boom of the late nineties triggered the coding of processes: "we developed (the systems) over the years doing them ourselves, we know what we need to have; we have a project binder that has sections in it. (…) It came into existence in '99 during the boom; we needed better managed projects because we had so many things going on. We were forced to execute these projects efficiently so we could get to the next one." But in most cases, the formalization grew out of the periodic enactment of an informal routine.

Panel A in Table 3 also identifies cases where an informal management approach was used. We limit the count to companies that explicitly mentioned this approach. The reasons for maintaining an informal approach include: (1) team has worked together for a long time and their informal interactions are well-understood but not coded, (2) management team believed that formal systems would kill creativity, (3) the organization was not considered to be large enough to grant MCS, and (4) management team did not have the knowledge to implement these systems.

In contrast to external drivers of adoption, internal drivers do not directly map into the roles identified in Table 1. During the coding process, the categories that appeared to better describe the data were not so much the particular roles that the systems adopted were intended to fulfill as the reasons why they were adopted (the situation that led to the adoption). While this coding better reflects the underlying data, the interviews provide illustrations of MCS' roles consistent with Table 1. Relevant quotes are included in Table 1 to exemplify each of the theory-based roles.

Once adopted, MCS remain as part of the management infrastructure and evolve. Frequently, interviewees described the systems as "becoming more and more sophisticated." In a few settings, MCS can be a time-bounded solution to achieve a certain objective. For example, a new CEO in the sample formalized the product selection process to focus the organization and then dropped it as the organization understood the new strategy. Managers also gave instances of MCS stifling innovation (Panel B, Table 3 for illustrative quotes) and the need to adapt MCS "within the context of a company of our size (…) the minimum that we need to accomplish without putting artificial requirements, barriers, or roadblocks that slow us down."

Panel C in Table 2 presents the descriptive statistics related to the source of knowledge used in designing management systems. Internal managers designed MCS in the majority of cases. Typically, the design is a process of knowledge creation where tacit knowledge (Nonaka, 1990), spread over various people in the organization, is codified. In some cases, the knowledge is "hired" together with a person—a process labeled "grafting" (Huber, 1991). One of the companies in the sample hired a product development manager from one of the largest semiconductor companies in the world, who designed the systems based on "(the large company's) way of doing things." External designers are rarer and usually reflect the contracting process with partners or buying external technology (software) to manage processes.

2. Time to adoption of management control systems and impact on performance

This section examines whether the typology is relevant in explaining management processes in new product development. We address two issues.

First, we test whether the various drivers identified as being associated with the adoption of MCS in product development are associated with different timing of adoption. The six drivers described in Table 3 are event-driven—whether an external party demands to see the processes in place, a partnership is entered into, a new manager is hired, needs emerge, problems arise, or the informal practices are formalized. Therefore, the adoption depends on whether a particular event happens and there is no clear directional expectation. However, we expect that companies that still keep an informal approach will report adopting systems later than the rest of the companies in the sample. It is also plausible that companies adopting because of learning-by-doing will adopt later than the rest of companies, as long as any of the events that trigger the adoption of the systems are likely to happen early in the life of a company. We examine the potential effect of the various drivers on the time to adoption of MCS in product development using a Cox specification (Davila, 2005b; Hellmann & Puri, 2002). This specification models the time to an event (for instance, adopting a particular system). In this particular case, we report the time to adoption of product development milestones, which is the system adopted most often in our sample. We asked both the CEO and the business development person for the adoption date and the kappa statistic of inter-rater agreement was significant at the 1% level. Table 4 reports the results. Our dependent variable is the time to adoption of product development milestones as reported by the business development manager.[5] Our independent variables are dummy variables that take the value of one for those companies where a particular driver for adoption was identified (during the interview coding), regardless of whether it is the main or secondary driver. The coefficients reported are hazard ratios. A coefficient on the independent variables greater (or less) than one means that higher values for the independent variables are associated with shorter (longer) time to adoption.[6] Except for learning and contracting, the other four drivers are associated with significantly faster adoption than the reference group, which still uses an informal approach. However, we find

[5] The conclusions are unchanged if we use the date of adoption reported by the CEO or we use time to adoption of product development progress or product development budgets, which are the next two systems in terms of popularity in the sample.
[6] The hazard ratio is e^{β}. The reported standard error is the one associated with the hazard ratio.

no significant differences among the various groups (other than *background* being significantly faster than *legitimize*). This result suggests that the description in the interviews is consistent with informal approaches taking longer to adopt a particular system; and that no particular driver is associated with faster adoption—consistent with these drivers being associated with random events.

Our second test examines the association between product development performance and the six drivers described in Panel A, Table 3. If MCS are relevant to performance (and assuming that the ones adopted are designed for the specific needs of the company—in other words, the MCS adopted are not dysfunctional), then we expect different drivers to be associated with performance. In particular, we expect proactive drivers (*background* and *focus*) and learning by doing to be associated with better performance. Companies in these groups adopt MCS as a way to facilitate product development management, in contrast with firms in the other groups—external drivers, chaos and informal—where firms are forced into adopting MCS. The dependent variable takes a value of 0 for companies where product development projects are late (43 observations) and 1 if they are on-time or early (21 observations). We lost five observations for companies that chose not to disclose product development performance. We chose a dummy variable because companies have very different types of projects running at the same time—large projects to develop a new platform, medium projects to develop particular functions, and shorter projects to adapt the product to a particular customer—and respondents often left blank the questionnaire item on how late projects are because, as they explained during the interview, it varied across types of projects and within particular types of projects. The dependent variables are as in Table 4. Table 5 reports the results. *Background* driven companies perform significantly better than companies adopting as a reaction to *chaos* and *focus*. *Learning* by doing companies perform better than *contract* and *chaos*. Contrary to expectations, *focus* companies perform worse than informal management firms (which perform better than *contract*, *focus*, and *chaos*) and do not perform significantly better than any of the other categories.

Partners and management control systems in new product development

Among the conclusions from our field research, we identified external constituencies—mainly customers and partners—as relevant to understand the adoption of MCS. This finding is consistent with the role of external control (Pfeffer et al., 1978), signaling (reputation and symbolism and institutionalism) (Macintosh, 1994), and economics (facilitate contracting) (van der Meer-Kooistra & Vosselman, 2000). The hypothesis that these various theories put forward is that the relevance of external constituencies leads to more structured processes (governed through MCS): “there is increased monitoring and control between organizations” (Otley et al., 1994) (page 293). While theory is clear-cut in its predictions, empirical evidence on the relevance of MCS in inter-organizational settings is limited (Dekker, 2004). Our field research findings provide initial support to theoretical predictions. However, these findings rely on extending theory to the adoption rather than the design of MCS. In an effort to generalize our conclusions beyond the original sample of small firms to a population of larger firms and from adoption to MCS design, we extend the study to a different sample of firms using a survey-based research methodology.

1. Design of the survey research

The research design that we adopted to extend this study is a survey-based design. While this approach sacrifices the detail that we were able to capture in our field research, it better fits the objective of this second stage of the research project. Namely, generalizing one of our findings—which is consistent with existing theory—to a larger population. In particular, the survey addresses the following research question: is the involvement of partners associated with more formalized MCS? The question extends our conclusions about the adoption of MCS in growing firms to the design of MCS in larger firms.

The population sampled is the list of contacts of a large innovation management consulting firm. This population was selected because companies in contact with this type of consulting firm are likely to be large companies with significant innovation efforts. The survey was sent to the contact person in each firm, who was asked to forward it to the person most knowledgeable if required. Two weeks later a reminder was sent. Also, we informed the participants that they would receive a summary of the results of the survey. A total of 490 questionnaires were sent for a response rate of 18%. Table 6 describes the industry composition of the sample.

We examine three different aspects associated with the formalization of MCS: 1) the level of detail in the product development project plan, 2) the use of the project plan during the execution of the project, and 3) the use of metrics during the execution of the project. Factor analysis identified three different factors associated with the level of detail of the project plan. The first factor is the actual level of detail in the plan (*Plan detail*), the second factor is the stability of project objectives as detailed in the project plan (*Plan risk*), and the third factor is the detail in the project plan about the future of the product being developed (*Future detail*). The use of the project plan during the execution loaded into one factor (*Use plan*). The use of metrics loaded into two factors, one consistent with an interactive use of the metric system (Simons, 1995), labeled *Metric inform*, and another one consistent with a diagnostic use, labeled *Metric control*. Each item was measured using a 5-point scale anchored between fully disagree (1) and fully agree (5) and the variables were constructed as the sum of the questionnaire items. Panel A in Table 7 presents the wording of the various questionnaire items, their descriptive statistics, and the reliability index (Cronbach alpha).

We measured involvement of partners in new product development with a seven-item instrument (Heide & John, 1992; Zaheer, McEvily, & Perrone, 1998), using a 5-point scale anchored between fully disagree (1) and fully agree (5). The seven items are detailed in Panel B of Table 7. In addition, we controlled for four additional variables that may affect the formalization of MCS: 1) technology uncertainty, measured using six items (Dávila, 2000); 2) the logarithm of the number of projects that the organization executes each year; 3) the logarithm of the length of a typical product development project (in months); and 4) the number of functions included in cross-functional teams. Formalization may be less useful for more uncertain projects where an organic structure may be a better fit (Chenhall, 2003) and for projects managed through cross-functional teams where informal communication may replace formal systems. Conversely, formalization may be more significant for companies that develop more projects through the codification of learning and the increase in efficiency and for companies with larger projects that require more coordination.

Table 8 presents the correlation table. Higher partner involvement is positively and significantly correlated with the various variables associated with increased formalization. As expected, the various measures of control system formalization are positively correlated among them.

2. Research findings

To test the relevance of partner involvement in the formalization of MCS, we relied on a cross-sectional latent variable regression model estimated using Partial Least Squares (PLS) (Wold, 1985). PLS allows the joint evaluation of the measurement and structural models. The use of a latent variable model is intended to mitigate the impact of measurement error in the structural equation coefficients, thus enhancing the power of the tests (Ittner, Larcker, & Rajan, 1997). PLS iteratively estimates the measurement and structural coefficients using OLS regressions (Anderson, Hesford, & Young, 2002). Bootstrapping (300 samples with replacement) is used to assess the significance of the model coefficients.

Our first model examines the association between partner involvement and our various proxies of MCS—*Plan detail*, *Plan risk*, *Future detail*, *Use plan*, *Metric inform*, and *Metric control*—after controlling for additional variables that may affect the design of MCS: uncertainty, project length, use of cross-functional teams, and number of projects. Specifically, we estimate the following structural model:

Formalization of MCS = β_0 + β_1 *Partners* + β_2 *Technology uncertainty* + β_3 *Ln(Project length)* + β_4 *Cross-functional team* + β_5 *Ln(Number of projects)* + *Industry controls* + ε

If partners have any influence on the design of MCS, we expect β_1 to be positive and significant. We estimate a different model for each of the six MCS formalization variables. Table 9 presents the results. The coefficients in the measurement model (Panel A) are significant and in the expected direction. Panel B presents the results for the structural model. Partner involvement is significant in each of the structural models except for *Metric inform*. This result is broadly consistent with the expectations derived from the conclusions of the field research and theoretical predictions: A higher degree of partner involvement is associated with various constructs associated with formalization of MCS. In addition to significant industry effects (not reported), technology uncertainty is positively associated with two measures of formalization: *Future detail* and *Metric inform*. These associations suggest that formalization may be beneficial in uncertain environments, in line with the idea of enabling bureaucracies (Adler et al., 1996) and consistent with previous findings (Gordon & Narayanan, 1984; Simons, 1987). As an alternative statistical specification, we built the latent variables as the sum of the item scores and ran the structural model using an OLS specification. The results were comparable.

The previous specification treated each of the formalization variables as separate dimensions of formalization. An alternative view suggests that these variables represent two distinct phases of the control process: planning and execution (Anthony, 1965). From this perspective, the variables *Plan detail*, *Plan risk*, and *Future detail* capture the formalization of the planning process—before the actual operational process is executed. The variables *Use plan*, *Metrics inform*, and *Metrics control* reflect the formalization of MCS during the execution of the operational process. The effectiveness of the execution variables may depend on the planning variables. In other words, the ability to control the execution of a process depends on the formalization of the planning process (Anthony, 1965; Simons, 2000). If the planning variables mediate the relationship between the exogenous variables and the execution variables, the significant effect of *Partners* upon *Use plan* and *Metric control* may be due to the relevance of *Partners* in explaining the planning variables.

We model the mediating effect of planning variables as described in Figure 1. We model partners' relevance as affecting both the three planning MCS variables and the execution MCS variable. To model the effect of the control variables in a parsimonious way, we rely on the results from Table 9. In particular, we include the most significant exogenous variables as a path to the endogenous variables in the PLS model. Table 10 reports the results for the structural model. Panel A examines the effect on the execution MCS variable *Use plan*; column (1) reports the path coefficients from the exogenous and planning variables to this execution MCS variable; columns (2) to (4) report the path coefficients from planning variables to the execution variable. Panel B looks at *Metrics inform* and Panel C at *Metrics control*. The direct effect of *Partners* is only significant for *Metrics control*. *Plan detail* is significantly associated with all three MCS execution variables, suggesting that more detail in the plan allows this planning effort to be used during the execution of the innovation projects. This result provides evidence on the association between the levels of formalization during the planning and execution of a product development project. In contrast, *Plan risk* is not significant, while *Future detail* is significant for *Use plan* but negative and significant for *Metric control*.

Table 11 examines whether the previous findings have any relevance to the perceived performance of the firm. To assess this relationship, we regressed each of the formalization variables, the relevance of partners and the interaction of the formalization variables with *Partners* to explain innovation performance. This *Performance* variable is the sum of three questionnaire items (reported in Appendix C) where respondents were asked to evaluate, on a 5-point scale, the gap between their company's current position and where it should be for derivative, new and breakthrough products. This gap measure was subtracted from the maximum gap in the sample to have higher values of the variable being associated with a smaller gap and therefore better performance. If higher level of formalization leads to better relationships with partners, we expect the interaction term to be positive and significant. The first column examines the direct effects without interactions. Only *Technology uncertainty* and *Number of projects* are positive and significant, indicating that companies that see themselves as facing more technological uncertainty and those with more product development projects perceive themselves as performing better. None of the formalization variables or the MCS variables is significant. The rest of the columns report the effect of interaction terms. The presence of partners and plan detail has a negative impact upon performance. A potential explanation for this observation is that plan detail constrains the relationships with partners. However, the interaction of another planning variable—*future detail*—with partners is positive and significant. The interaction of two execution variables—*metric inform* and *metric control*—with partners is positive and significant. Overall, these results suggest that MCS have a positive effect on leveraging partners in product development.

Conclusions

The aim of this paper is to bring detailed evidence on the enabling role that MCS may have in innovative settings. The paper presents two sequential studies. The first one, a multi-case, multi-method field research design, examines how MCS are adopted in the product development process of young firms. Data includes detailed descriptions of the phenomenon including quantitative and qualitative information. The analysis indicates that in contrast to the theory approach—which describes MCS in innovative settings as fulfilling a set of roles—the variance in the adoption of MCS is not driven as much by certain roles that need to be fulfilled as by events that trigger the adoption. We identify external drivers of adoption when firms adopt MCS because of external pressures—consistent with the external control concept (Pfeffer et al., 1978), the concept of legitimizing (Powell et al., 1991), and the contracting process (van der Meer-Kooistra et al., 2000). We also identify internal drivers, including proactive ones, as when systems are adopted because of a manager's background—frequently systems are brought to the firm with the hiring of a particular manager, or when a manager with systems knowledge decides to implement the system because the organization has reached a certain maturity point. Internal drivers also include reactive drivers, when systems are adopted as a reaction to a mistake or failure or when systems emerge as the formalization of an ongoing informal routine. The paper also examines the impact of these drivers on the management of product development.

The second study aims at generalizing a particular finding from the first study—the relevance of external parties to the adoption of MCS. This second study extends the argument from the influence of these parties on the adoption process to their influence on the detail of MCS in larger firms—an argument more in line with theoretical predictions. Using a survey-based design, the study finds that the presence of technological partners is associated with a higher degree of formalization and that the presence of these partners and a higher degree of formalization is associated with improved perceived performance.

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Table 1.
Theoritical roles of MCS in innovative settings

	MCS roles in innovative settings	Illustrations of these roles
1.	Make goals explicit, stable and visible to provide convergence in meaning across actors	"Myself and a couple of the other folks here thought we'd better put a structure in place where we write a specification (…) and at some point we freeze it and then we develop against it. (…) And it's a challenge because you have a moving target most of the time, but the reality is if that specification changes on too dynamic a basis, there's no way really a technology team to execute against it."
2.	Code learning from past experience to avoid past mistakes and increase efficiency	"It is very important that the process is followed because we have done terrible when we don't follow the process, so we are now very meticulous about following it."
3.	Help in coordinating innovation efforts across different parts of the organization	"The company was somewhat more contentious and more fractured, and (putting in place product development processes) was the only way to get everyone unified on a common plan of attack."
4.	Plan the sequence of steps that lead to stated goals, help coordination over time	"The focus is on understanding reporting progress towards achieving an important milestone; what the underlying causes are for what we're seeing and what the plans are, next steps that are being taken. (…) Schedule is important, but it is only the start of the conversation."
5.	Facilitate control by exception when innovation results deviate from expectations	"The benefits of (product development process) formalization is that you get more accountability. I think it is very easy from an engineering perspective to say I can do that. (…) What you get is (a) you can hit that expectation in a timely manner, and (b) develop features that meet the market on time. (…) As the company matures, people get more accountable."
6.	Coordinate and contract with external partners	"The first product road map was one specifically that we developed for sharing with Microsoft."
7.	Symbols to legitimize the organization in its environment	"What (our customer) said was 'I want to see what processes have you instituted in your system? We are going to buy version 5.0 of your product, I want to see what you did from version 3.0, 4.0, 5.0. What were the milestones? What bugs did you fix? What was the testing it went through?' We had done all those things but we didn't have the documentation. So we had to show them and to be candid (recreate it)."

Tabla 2.
Sample descriptive statistics

Panel A: Sample construction

Companies in the initial database	624
Minus	
Companies that went out of business	94
Companies acquired	88
Companies ineligible in some other way[1]	102
Companies that did not respond[2]	158
Companies that declined participation	113
Final sample of companies	**69**

[1] These companies are too small, too old, or subsidiaries of other companies.
[2] These are companies that did not respond to the five telephone contacts.

Panel B: Sample descriptive statistics

	Mean	**Std. Dev.**	**Q1**	**Median**	**Q3**
Number of CEOs	1.73	0.80	1	2	2
Age	7.42	2.33	5	7	9
Employees[1]	119	62.6	72	114	160
R&D intensity (%)[2]	0.39	0.26	0.16	0.38	0.61
Revenues (‘000)[3]	10,691	11,711	2,468	7,14	15,156
Profit (‘000)[3]	-10,175	15,598	-12,139	-5,4	-18
Funding[4]	52,441	59,865	8,963	39,3	72,75

[1] Number of employees is calculated at the peak of each company’s size.
[2] R&D employees are estimated as a percentage of total employees defined as the sum of R&D employees for each of the years reported divided by the sum of total employees for those same years. Only companies that reported R&D employees are included.
[3] Revenues and profits are for the last year of data available.
[4] Funding is the total external funding for each company.

Table 2 (continued)
Sample descriptive statistics

Panel C: Descriptive statistics on product development systems

	Companies adopting	Time-to-adoption
Project milestones	80%	2.65
Reports comparing progress to plan	70%	2.88
Budget for development projects	66%	3.00
Project selection process	63%	3.42
Product portfolio roadmap	59%	3.33
Product concept testing process	44%	2.71
Product team composition guidelines	39%	3.00

Companies adopting each system are the percentage of companies that had adopted the system at the point of data collection. *Time-to-adoption* is the mean number of years since founding to the adoption of the particular system for those companies that adopted each system.

Panel D: Descriptive statistics on product development measures

Type of measures	Respondents	Updating frequency
Time	62	2.81
Budget/financial	30	2.36
Product functionality	30	2.08
Customer	24	1.78
Quality	15	2.90

The table reports the number of *respondents* that listed each type of measure among the three top measures for managing product development and the *frequency* (times per month) that the measures are updated.

Table 3.
Adoption of Management Control Systems in Product Development

Panel A: Typology of drivers of adoption

	Main[1] driver	**Secondary[1] driver**	
External drivers			
Legitimize	2	9	"We're also finding that the customers get a feeling of control when you give them more data (...). Now, between you and me, they're getting no more control at all; but, by seeing data that they've never seen before, we look good compared to the internal IT, which is one of our strong competitors." "That was almost the number one question (how do you go about developing this stuff) from both audiences—people we were bringing on, and our customers (…) and investors actually. Pretty almost everyone. If you don't have it, nobody's comfortable with it. So again, I think it's just like when you want to buy a house. The first thing you want to do is inspect the foundation of the house."
Contract	7	8	"Pfizer, as part of the agreement, put in place milestones that we had to achieve." "When we won the Motorola contract, Motorola forced us to get our act together and so that was a forcing function for all these (product development) processes. Motorola insisted on proper program management, proper change control, proper project reporting, monthly business reviews, monthly project reviews, etc. and they sent audit teams in to audit where we were and make specific recommendations." "We tie most of our payments to milestone payments."
Internal drivers: Proactive			
Backgrounds	24	11	"Both of us had come from big company backgrounds where we had used project tracking systems, it seemed natural (…), even though it was a very small amount that we were tracking, we were just used to it. That was the normal thing to do. I'd have to say that we've had project tracking systems, red-yellow-green status reports, and so forth, from the very beginning." "The founder and the initial engineering people knew engineering and knew that you can't just have a free-form, 'let's go be random', there has to be some real milestone way of tracking it. (…) So when I got there, the engineering team was a very competent team, very good architects, very hard-working. They had a real desire for process: code reviews and configuration management and that was good."

Focus	9	10	"Now we're getting to the place where the return is lower compared to the investment, right? Because we've already taken up the low hanging fruit. So now we're having to use stepladders to go get fruit. And now it makes more sense to be measuring exactly how many grapes am I getting for how much effort moving the stepladder." "I did it (formalization) more to share my thinking with a bigger team, six, seven people." "I think, looking back at it, and comparing it to other companies I've been working for, I think the toughest step for a company to go through is the step from going from a small company where pretty much everyone knows the main goals, the main focus and the main initiatives within the company, to the steps where you have to stop passing the whole business and some people will know some, some people will know other, but not everyone sees the big picture. And I think it's a very crucial, it's very easy to start having a lot of people running in many different directions. And the difficulty at that stage is to keep the whole energy focused. It's like moving from a two-person boat where it's easy to make sure you paddle in the same rhythm, to a 10-person boat where suddenly you have to spend more time on making sure it's the same rhythm than anything else."
Internal drivers: Reactive			
To chaos	11	3	"The original engineering team would give me dates when they were going to have certain things done and never make the dates. They didn't communicate amongst themselves, so even when they released something, it didn't do what they said it was going to do. There was no QA process, so when they did release it, it continued to be buggy, they would introduce more bugs than they would fix." "We were picking projects in such a strange way. Whatever came in, displacing something else. Sort of chaotic." "We wanted to formalize it, but the skill set wasn't there, and also the realization that we needed that wasn't there. So I couldn't push it too much. I said, okay, for now let's focus on the other areas. (…) The reason it's happening now, actually this month, is because the last release we did it dragged out to a month's cycle, and it was very painful." "I think generally you find that a big change occurs when something goes wrong, and something did, and so big change occurred."
To learning	7	0	"It was around here that things became less ad hoc because of experience and documentation of process, retaining history of what worked and didn't work, finally came to place. (…) By that time, we'd had enough experience with enough projects to say, "Okay, now we get what works and doesn't work. We can estimate accurately." And it just took doing it a number of times in this new industry and both succeeding and failing to understand okay now we can generalize, we can systematize, we can come up with methodologies that really work." "It was just sort of the solidification of what was a more informal sort of milestone assessment process."

Kept informal approach	8	"We can still afford to be fairly fluid and flexible and informal in our approach, because our development team has been with Kevin, every one of them, eight to 15 years." "I think we're not at that stage yet. I think we are a small company, where on the resources side, it's pretty clear from the onset, when we go into a product, we pretty much know how long it's going to take and how much it's going to cost us. And the biggest cost is usually in terms of resources involved, more than actual dollars." "We thought we were going to have to fire him because he was such a creative guy and would always work on something new. (…) Some people are prima donnas. And you have to put up with that, but they have to be able to sing. And so the worst thing that can happen in a company is prima donnas that don't deliver. But if you have people who deliver, it happens every year, what they do in between doesn't matter. And I know we've had managers that will fire that kind of person, because they come in late, and they do weird things, and they don't make the budget. But if you've been around long enough you know that 80% of your innovation will come from crazy people." "We tried to formalize it in '97, in '98, in '99, but we said it was not possible. So we left it at an informal level. Part of my job through most of my life has been doing stunt work things in bigger organizations. In a sense, that was kind of the flavor of what was going to work in the company."

[1] Main driver indicates number of companies where the particular driver was identified as the main one; secondary driver indicates if it was also identified. For each company, we identified at least one driver (except if the process was still informal) and at most two drivers (a main one and a secondary one). Quotes are particular examples of each of the drivers.

Panel B: The limitations of management control systems

"I think to a certain extent processes could slow things down, and so being slow to market is worse than being fast to market. The whole goal of a biotech firm is to bring a product to market. That's life or death. And anything that gets you closer to market is good and anything that keeps you from the market is bad."

"Fortunately, on the engineering side of it—given the amount of money we had, we did put in place a very formal development cycle with all the tools in place. So all the revision control systems for hardware and software, all those tool chains are in place, and have been in from day one in the company. And if anything, that's cost me six months of product development time, so now I have second thoughts about the so-called sophisticated tool chains. But, they've always been in place here actually from day one."

Panel C: Sources of management control system design

Source of MCS design	Number of companies	Illustrative quotes
Internal people	61	"Some of the systems were driven by key individuals with—given their experience and background, they drove those processes."
		"We have a guy who again brought the experience with him. Most of us that have been in big companies—and that's most of my senior staff—either had the PLC or a gate process. But in particular, our product line manager director brought the template. And the trick of bringing something that's been used in a different company is making it relevant and the steps involved relevant to the size of the company."
		"So I have one of my guys write the whole document, it's about an 80-page document, about the development process."
		"I give (Our VP of engineering) credit for designing (the plan of record) here."
		"Working with people who were experienced, like the sales guys were experienced in product development too, because it's their project being developed. (The founder) brought quite a bit of the infrastructure too. My support guy was an older guy in his 50s and he had 30 years of product development experience, so those guys all brought in a lot to the table."
		"I brought it from my previous experience. I've done product development for about twelve years and you kind of know what works."
External parties	3	"For example, there's a company that makes backup software. And I needed backup software because if the worst possible thing happens, I want to be able to put it back to the way it was, which means I need a backup. So I don't want to create my own backup system. This company had a backup system."
		"Pfizer, as part of the agreement, put in place milestones that we had to achieve."

Table 4.
Product development formalization

	Product development milestones		
	Hazard ratio		**Robust std. error**
External drivers			
Legitimize	2.425	***	0.66
Contract	2.032		0.65
Internal drivers—proactive			
Background	3.573	***, +	1.23
Focus	2.283	**	0.75
Internal drivers—reactive			
Learning	1.589		0.98
Chaos	2.496	**	0.90
Number of observations	388		
Number of companies	69		
Chi-sq.	16.89	***	

*, **, *** significantly different at 10%, 5%, and 1% respectively from reference category. + significantly different at 10% from *legitimize*. Table reports Cox proportional hazard model of the time to adoption of product development milestones. Dependent variables are the drivers of MCS adoption identified in the qualitative analysis. The category not included is “informal.”

Table 5.
Product development formalization and performance

	Project performance (0 = late, 1 = early or on-time)	
	Coefficient	**Standard error**
External drivers		
Legitimize	-0.203 ‡	0.61
Contract	-2486 **	2.22
Internal drivers—proactive		
Background	0.767 ++, +++	0.65
Focus	-1454 **	0.73
Internal drivers—reactive		
Learning	0.065 ‡	0.99
Chaos	-2.73 **, †, ††	1.12
Number of observations	64	
Pseudo- R^2	0.22	
Chi-sq.	13.57 **	

** significantly different at 5% from reference category; +++ significantly different at 1% from *chaos*, ++ 5% from *contract* and *focus*; † significantly different at 10% from *learning*, †† significantly different at 5% from *legitimize*; ‡ significantly different at 10% from *contract*. The table reports a logit model with product development performance as the dependent variable (1 if the project is early or on-time, 0 if it is late). Dependent variables are the drivers of MCS adoption identified in the qualitative analysis. The category not included is "informal."

Table 6.
Industry distribution of the sample

	Number of observations
Automotive	9
Chemicals and resources	18
Consumer goods	11
Engineering and medical products	31
Information and media	9
Other	10
Total	**88**

Table 7.
Descriptive statistics

Panel A: Planning variables

Construct		Mean	Std. dev.	Cronbach's α
Plan detail				0.87
1.	The project plan describes in detail who will be involved in the project and when	3.66	1.03	
2.	The project plan describes in detail the sequence of tasks that will be performed	3.67	1.05	
3.	The project plan describes in detail the timing of tasks that will be performed	3.72	0.96	
4.	The project plan is very specific about the expected outcomes of the project	3.81	1.02	
Plan risk				0.62
1.	Most of the technical risk that may exist is eliminated during the planning phase	3.01	1.09	
2.	The planning phase is key to translate customer needs into precise product specifications	4.15	0.94	
3.	Product specifications are frozen at the planning phase	2.76	1.18	
4.	The planning phase is key to eliminate market risk out of the project	3.23	1.03	
Future detail				0.80
1.	Changes in prices and volumes over the expected product's life	2.90	1.33	
2.	Marketing costs over the expected product's life	2.59	1.18	
3.	Analysis of targeted customers	3.68	1.08	
Use plan				0.63
1.	During the development phase the project plan is used as a benchmark to evaluate progress	3.93	0.92	
2.	During the development phase the project plan is discussed with management only when there are significant deviations *	2.98	1.28	
3.	During the development phase the project plan is modified to include new information	4.05	0.68	
4.	During the development phase the project plan is central to interact with management	3.86	0.92	
Metric inform				0.69
1.	Metrics are used to assess whether the project is advancing according to plan	4.16	0.75	
2.	Metrics are an important input to assess the innovation team's performance	3.64	1.09	
3.	Metrics are used to evaluate the impact of new events upon the project	3.36	1.06	
Metric control				0.64
1.	Metrics are used to update project expectations	3.72	0.98	
2.	Metrics are used to control project execution	4	0.81	
3.	Metrics are used to decide when to stop a project	3.77	0.95	

The scale for survey items is 1=fully disagree, 5=fully agree and 1=does not include; 5=includes to a very large extent for the *future detail* variable. * Indicates reverse coded.

Table 7 (continued)
Descriptive statistics

Panel B: Project characteristics

Construct		**Mean**	**Std. dev.**	**Cronbach's α**
Partners				0.81
1.	Key partners are involved in the product definition phase	3.51	1.16	
2.	Key partners constantly bring new ideas to improve our product innovation	3.33	0.94	
3.	Our relationship with key partners is based on broad collaboration agreements	3.50	0.90	
4.	Contracts with key partners are specific about the expected deliverables	3.79	0.77	
5.	We have learned or acquired new and important information from our partners	3.84	0.77	
6.	We have learned or acquired a critical capability or skill from our partners	3.48	0.83	
7.	Our partnering has helped us to enhance existing capabilities and skills	3.91	0.72	
Tech. uncertainty				0.76
1.	The technology underlying the products of my company moves fast	3.42	1.19	
2.	When a company introduces a new product, it significantly increases its market share	3.62	0.94	
3.	Product performance is rapidly improving in our industry	3.65	0.98	
4.	The biggest challenge in product innovation is to quickly move technology to customers' hands	3.77	1.09	
5.	The product market that our company serves is considered to be mature	3.85	1.16	
6.	Customers' needs are stable over time	2.86	1.11	
Ln(Number projects)		3.06	1.36	
Ln(Length projects)		3.04	0.65	
X-teams	Number of business functions with representatives reporting to the product development manager	4.72	3.99	

Table 8.
Correlation table

	Tech. uncertainty	Project length	X-functional team	Number of projects	Partners	Plan detail	Plan risk	Future detail	Use plan	Metric inform	Metric control
Tech. uncertainty		-0.03	0.21***	0.20**	0.23**	0.17	0.15	0.33***	0.31***	0.19*	0.41***
Project length	-0.05		0.11	0.05	0.14	0.11	-0.02	0.05	0.24**	0.26**	0.25**
X-functional team	0.24***	0.12		0.05	0.10	-0.05	0.12	0.18	-0.03	-0.03	0.04
Number of projects	0.18**	-0.16**	0.05		0.24**	0.14	0.15	0.16	0.06	0.12	0.17
Partners	0.23**	0.16	0.17	0.22*		0.26**	0.33***	0.31***	0.19*	0.41***	0.23**
Plan detail	0.15	0.16	0.06	0.11	0.34***		0.40***	0.14	0.46***	0.22**	0.38***
Plan risk	0.10	0.02	0.33***	0.17	0.26**	0.39***		0.23**	0.17	0.15	0.29***
Future detail	0.36***	0.09	0.24**	0.17	0.31***	0.09	0.21*		0.32***	0.22**	0.16
Use plan	0.14	0.22*	0.00	0.03	0.28***	0.48***	0.19*	0.31***		0.29***	0.27**
Metric inform	0.17	0.04	0.64	0.02	0.14	0.26**	0.17	0.20*	0.23**		0.46***
Metric control	0.11	0.22*	0.28**	0.16	0.43***	0.50***	0.27**	0.13	0.29***	0.37***	

Pearson correlation in upper triangle, Spearman correlation in lower triangle. ***, **, * statistically significant at the 1%, 5%, and 10% level (two-tailed), respectively.

Table 9.
Project planning and new product development characteristics

Panel A: Measurement model—standardized loadings

Plan detail						
Item 1.	Item 2.	Item 3.	Item 4.			
0.879***	0.920***	0.894***	0.755***			
Plan risk						
Item 1.	Item 2.	Item 3.	Item 4.			
0.761***	0.822***	0.520***	0.568**			
Use plan						
Item 1.	Item 2.	Item 3.	Item 4.			
0.523***	-0.675***	0.671***	0.828***			
Future detail						
Item 1.	Item 2.	Item 3.				
0.854***	0.877***	0.812***				
Metric information						
Item 1.	Item 2.	Item 3.				
0.849***	0.690***	0.794***				
Metric control						
Item 1.	Item 2.	Item 3.				
0.745***	0.820***	0.719***				
Technology uncertainty						
Item 1.	Item 2.	Item 3.	Item 4.	Item 5.	Item 6.	
0.734***	0.697***	0.770***	0.607***	-0.566***	-0.539**	
Partners						
Item 1.	Item 2.	Item 3.	Item 4.	Item 5.	Item 6.	Item 7
0.638***	0.692***	0.581***	0.520***	0.826***	0.746***	0.725*

***, **, * statistically significant at the 1%, 5%, and 10% level (two-tailed), respectively (t-statistic in parenthesis). Loadings for explanatory variables are the average loading from the six models tested (as reported in Panel B).

Table 9 (continued)
Project planning and new product development charactristics

Panel B: Structural model—standardized structural coefficients

	Latent endogenous variable					
	Planning variables		Execution variables			
	Plan detail	**Plan risk**	**Future detail**	**Use plan**	**Metric inform**	**Metric control**
Latent exogenous variables						
Partners (β_1)	0.233**	0.305*	0.313***	0.331**	0.116	0.340***
	(2.20)	(1.76)	(3.01)	(2.57)	(0.80)	(2.94)
Technology uncertainty (β_2)	0.167	0.122	0.314**	0.244	0.275*	0.199
	(1.20)	(0.71)	(2.64)	(1.60)	(1.80)	(0.81)
Ln(Project length) (β_3)	0.072	-0.133	0.024	0.164	0.182	0.147
	(0.57)	(-0.90)	(0.20)	(1.19)	(1.14)	(1.24)
Cross-functional team (β_4)	0.036	-0.003	0.131	0.094	-0.061	-0.061
	(0.32)	(-0.02)	(1.20)	(0.80)	(-0.43)	(-0.32)
Ln(Number of projects) (β_5)	-0.205	0.038	0.024	0.053	0.080	0.066
	(-1.12)	(0.17)	(0.16)	(0.42)	(0.43)	(0.54)
Square multiple correlation (R^2)	0.25	0.20	0.29	0.32	0.25	0.28

Partial least squares estimations based on standard errors from 300 bootstrap samples (with replacement). ***, **, * statistically significant at the 1%, 5%, and 10% level (two-tailed), respectively (t-statistic in parenthesis). Industry controls included but not reported.

Table 10.
The use of planning and metrics during product development

Panel A: Use of plan

	Endogenous latent variable			
	(1) Use plan	**(2) Plan detail**	**(3 Plan risk**	**(4) Future detail**
Exogenous latent variables				
Technology uncertainty	**0.032**	0.131		0.322 ***
	(0.28)	(1.13)		(3.03)
Project length			-0.166	
Cross-functional team			(-0.90)	0.136
Number of projects		0.083		(1.53)
Partners	**0.179**	(0.68)		
	(1.43)	0.178	0.339 **	0.289 **
Endogenous latent variables		(1.40)	(2.07)	(2.51)
Plan detail	**0.378** ***			
	(3.81)			
Plan risk	**-0.102**			
	(0.85)			
Future detail	**0.251** **			
	(2.32)			
Squared multiple correlation (R^2)	**0.35**			

Panel B: Metrics for information

	Endogenous latent variable			
	(1) Use plan	**(2) Plan detail**	**(3 Plan risk**	**(4) Future detail**
Exogenous latent variables				
Technology uncertainty				
Project length	**0.197**	0.127		0.322 ***
	(1.51)	(1.06)		(3.05)
Cross-functional team			-0.178	
			(-0.95)	0.139
Number of projects		0.090		(1.57)
		(0.72)		
Partners	**0.058**	0.189	0.346 **	0.284 **
	(0.37)	(1.60)	(2.27)	(2.59)
Endogenous latent variables				
Plan detail	**0.222** *			
	(1.90)			
Plan risk	**0.019**			
	(0.12)			
Future detail	**0.052**			
	(0.33)			
Squared multiple correlation (R^2)	**0.19**			

Table 10 (continued)
The use of planning and metrics during product development

Panel C: Metrics for control

	Endogenous latent variable							
	(1) Metric control		**(2) Plan detail**		**(3 Plan risk**		**(4) Future detail**	
Exogenous latent variables								
Technology uncertainty			0.126				0.328	***
			(1.10)				(3.02)	
Project length	**0.180**	*			-0.189			
	(1.77)				(-1.19)		0.129	
Cross-functional team							(1.34)	
Number of projects			0.087		0.338	**	0.293	**
			(0.72)		(2.11)		(2.21)	
Partners	**0.293**	**	0.192*					
	(2.82)		(1.69)					
Endogenous latent variables								
Plan detail	**0.238**	***						
	(2.41)							
Plan risk	**0.153**							
	(1.21)							
Future detail	**-0.002**	**						
	(-0.02)							
Squared multiple correlation (R^2)	**0.33**							

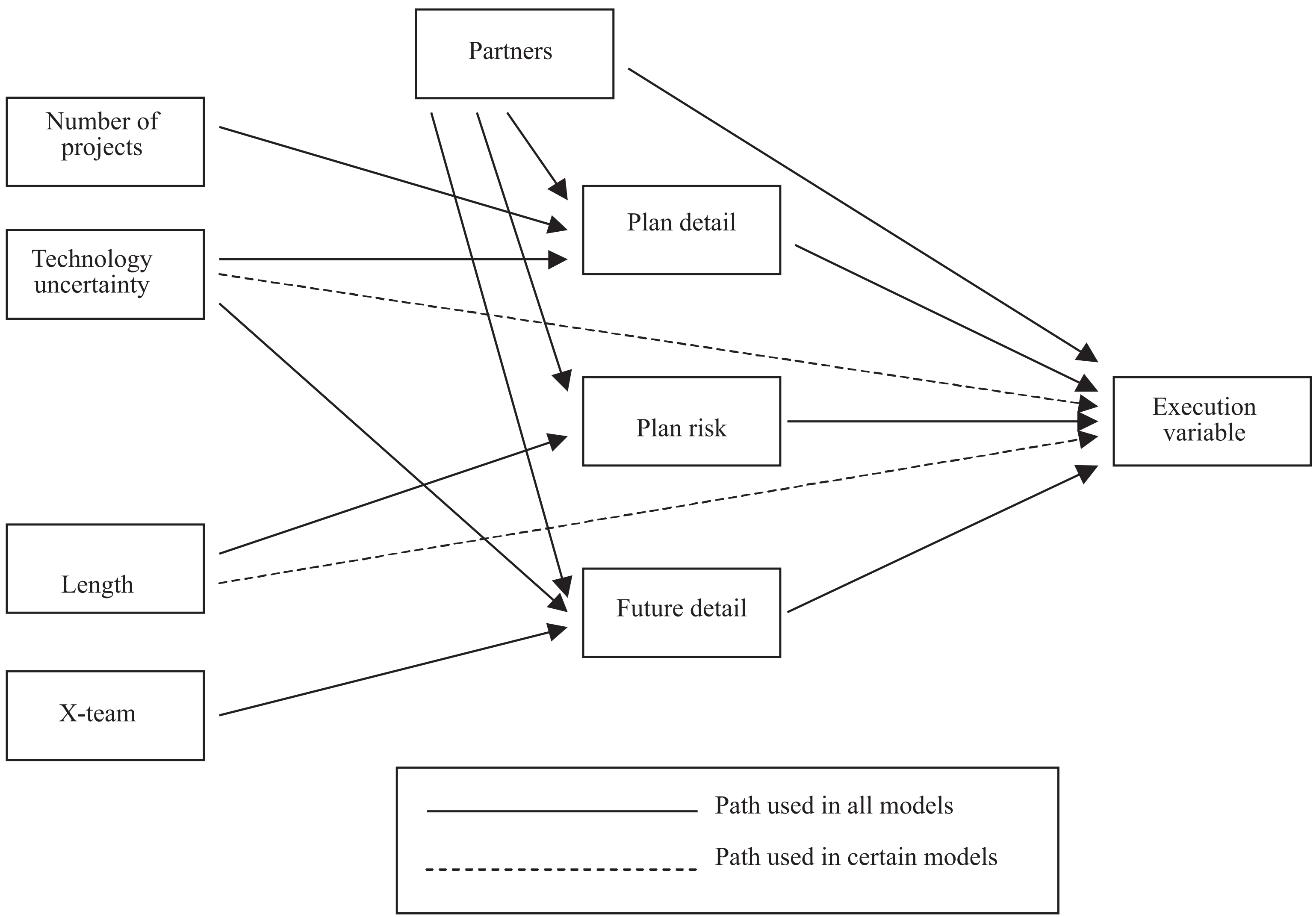
Standardized structural coefficients using partial least squares estimations based on standard errors from 300 bootstrap samples (with replacement). ***, **, * statistically significant at the 1%, 5%, and 10% level (two-tailed), respectively (t-statistic in parenthesis). Industry controls included but coefficients not reported.

Table 11.
Project performance and project characteristics

	Dependent variable: *Performance*						
Formalization variable		***Plan detail***	***Plan risk***	***Future detail***	***Use plan***	***Metric inform***	***Metric control***
Independent variables							
Technology uncertainty	0.363** (2.15)	0.185 (1.18)	0.218 (1.24)	0.270* (1.76)	0.234 (1.26)	0.250 (1.43)	0.320** (2.11)
Ln(Project length)	-0.239 (-1.47)	-0.475*** (-3.14)	-0.311*** (-2.05)	-0.261** (-2.01)	-0.333** (-2.01)	-0.203 (-1.50)	-0.279** (-2.01)
X-functional team	0.016 (0.83)	0.021 (1.26)	0.013 (0.69)	0.018 (1.19)	0.014 (0.86)	0.019 (1.41)	0.022 (1.56)
Ln(Number of projects)	0.224*** (3.47)	0.236*** (3.89)	0.221*** (3.48)	0.198*** (3.03)	0.221*** (3.48)	0.209*** (3.45)	0.203*** (3.15)
Partners	-0.265 (-1.55)	-0.074 (-0.45)	-0.128 (-0.71)	-0.054 (-0.41)	-0.059 (-0.37)	0.038 (0.25)	-0.208 (-1.46)
Plan detail	0.126 (0.90)	0.137 (1.32)					
Plan risk	0.171 (1.05)		0.082 (0.58)				
Future detail	-0.035 (-0.26)			0.049 (0.42)			
Use plan	-0.108 (-0.68)				-0.096 (-0.71)		
Metric inform	-0.098 (-0.79)					-0.011 (-0.09)	
Metric control	-0.081 (-0.57)						0.054 (0.48)
Interaction term		-0.171* (-1.91)	-0.020 (-0.27)	0.201* (1.99)	-0.037 (-0.37)	0.155*** (2.87)	0.183*** (3.04)
Adjusted R^2	0.11	0.15	0.14	0.16	0.16	0.19	0.21

The table reports OLS regressions with robust standard errors. The interaction term reports the coefficient for the interaction of variable partners and the corresponding MCS variable. ***, **, * statistically significant at the 1%, 5%, and 10% level (two-tailed), respectively (t-statistic in parenthesis).

Figure 1
Model for mediating variables



Appendix A

Questionnaire items

1. When was the company legally established? (Month / Year) ___________________
2. We are interested in mapping the evolution of your company in terms of number of equivalent full time employees and number of R&D employees. What were these measures for each of the dates specified below?

Date	**Total full time employees**	**Total full time R&D employees**
Dec. 2003		
(...)		
Dec. 1993		

3. How long is a typical product development project, from initial concept development to product launch? ___________________
4. Compared to the original target launch date for a typical product, is the actual date the product is launched generally (circle one) … Early / Late
   by an average of how much time _____________
5. Please indicate below when your company formalized each system. "Formalized" is defined as having documented a process and / or periodically and purposefully executing the process.

	Year formalized
Project milestones	
Budget for development projects	
Reports comparing actual progress to plan	
Project selection process	
Product portfolio roadmap	
Project team composition guidelines	
Product concept testing process	

6. What are the three most important measures that top management uses to evaluate the progress of a development effort (for example, schedule attainment or on-budget)?

	Measure	***How often does top management check it (weekly, monthly, …)?***
1		
2		
3		

Appendix B

Protocol questions for interviews

In this interview we are interested as much in current practices as in changes in these practices over time and the reasons for these changes. We want to understand the company's history, its chronology, and the evolution of its management practices. During the interview emphasize the idea of evolution and identify reasons why each of the variables in the research changed. (Italics are instructions for interviewers)

In this interview we want to better understand the challenges that your company faced (and is still facing) in moving from the start-up phase to the phase where professional management systems are required to manage the company. We are interested in your company's history and chronology as well. We already received your answers to the questionnaire, which were very useful to focus the questions in this interview.

Products

1. Can you provide a brief description of your company's products? *We are interested in the assessment of the technology behind the products and their manufacturing complexity.*

History

2. How has the business model of the company changed over time?
3. What were the main turning points?
4. What were the main phases in the history of the company?

Organization

5. How is the company organized? *(functional, business unit, matrix)*
6. Was it always this way? (*If it changed*) When / why did it change? Who proposed or structured the change?

Strategy

7. What does the competitive landscape look like? In terms of technology? Market participants? Any significant changes? If so, why?
8. What do your target customers value about your company compared to your competitors?

Product development

9. How do new product development projects get selected? How did this selection process evolve? Why?

Systems

10. Why did your company start to use the systems identified in the questionnaire?
11. What factors drove the need to adopt the systems?
12. Who designed the systems?
13. Has any been modified? Why?
14. What is the biggest challenge in using these systems?
15. Has any been dropped? Why?
16. How are the key performance dimensions measured? Why are they key?

Appendix C

Performance

How big is the gap between your company's current innovation performance for *derivatives* and *new products* and where should your company be to succeed in the marketplace

Derivatives

1	2	3	4	5
No gap (we are where we want to be)	**Small gap**	**Medium gap**	**Sizeable gap**	**Big gap (we need to improve a lot to succeed)**

New products

1	2	3	4	5
No gap (we are where we want to be)	**Small gap**	**Medium gap**	**Sizeable gap**	**Big gap (we need to improve a lot to succeed)**

Breakthrough products

1	2	3	4	5
No gap (we are where we want to be)	**Small gap**	**Medium gap**	**Sizeable gap**	**Big gap (we need to improve a lot to succeed)**