Dealing with uncertainty in knowledge-intensive firms: the role of management control systems as knowledge integration mechanisms

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Abstract

Little research on knowledge-intensive firms has focused specifically on management control issues. This paper aims to consider such issues. Starting from the limitations of the definition of uncertainty, especially when applied to contexts characterised by knowledge intensity, this study investigates the relationship between knowledge complexity and management control systems. This relationship is analysed in the realm of knowledge-intensive firms’ teams where it is particularly critical due to the double coordination and knowledge integration role played by management control systems. A field research conducted in three project teams of a software firm supports the relevance of knowledge complexity in explaining the variation of management control systems. The paper concludes with some avenues for future research.

Introduction

The understanding of how a firm can manage knowledge is an issue that has received increasing attention in both theory and practice over the past ten years: on the one hand, we have seen the emergence of the knowledge-based theory of the firm, on the basis of which, knowledge and the capability to create and utilise such knowledge are the most important sources of competitive advantage (Prahalad & Hamel, 1990; Nelson, 1991; Henderson & Cockburn, 1994; Nonaka & Takeuchi, 1995; Boland & Tenkasi, 1995; Grant, 1996; Kogut & Zander, 1996; Nonaka et al., 2000); on the other hand, there has been an attempt to define knowledge-intensive firms and explain their organizational and management features (Bernardi & Warglien, 1989; Greenwood, Hinings, & Brown, 1990; Hinings, Brown, & Greenwood, 1991; Starbuck, 1992; Winch & Schneider, 1993; Alvesson, 1993, 1995, 2000; Nurmi, 1998). In general terms, knowledge-intensive firms refer to those firms that provide intangible solutions to customer problems by using mainly the knowledge of their individuals. Typical examples of these companies are law and accounting firms, management, engineering and computer consultancy organizations, and research centres. The category overlaps with

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the concept of professional service firms, but is broader, and does not focus on the features ascribed to a typical profession, such as a code of ethics, a strong professional association, monopolization of a particular market through the regulation of entry and so on (Raelin, 1985). In this paper I will discuss some central aspects of the management control systems of this kind of organizations. To date contributions on both knowledge-intensive firms and management control systems have almost completely neglected this issue.

The literature on knowledge-intensive firms has focused mainly on the reasons for, and consequences of, the distinctiveness of this type of firms from other kinds of organizations and has mostly devoted its attention to the more obtrusive mechanisms of management such as the professional control of tasks, culturally based forms of co-ordination, and ideological modes of control (e.g. Smigel, 1963; Hall, 1968; Alvesson, 1993, 1995; Abernethy and Stoebländer, 1995; Cooper et al., 1996; Dirsmith et al., 1997; Montagna, 1968; Morris & Empson, 1998). Management control mechanisms have not been explicitly addressed in the relevant contributions on the topic (Alvesson, 1995) or even have been considered, under certain conditions, counterproductive (Raelin, 1985; Nelson, 1988; Van Maanen & Kunda, 1989; Winch & Schneider, 1993; Alvesson, 1993).

Much of the management control thinking has concentrated its attention on the specifics of control systems design in manufacturing settings, where the activities are considered to be well suited to the use of such mechanisms. Only recently, has some attention been devoted to understanding their role in other contexts where the tasks differ substantially from the physical production of goods and are likely to include some tasks which are relatively extreme in terms of task uncertainty, as in knowledge-intensive firms. Some instances of the contributions included in this stream of research refer to the design of control systems in research and development organizational units (Abernethy & Brownell, 1997; Birnberg, 1988; Brownell, 1985; Hayes, 1977; Kamm, 1980; Rockness & Shields, 1984, 1988)² and the use of these mechanisms in product innovation projects (Koga & Davila, 1998; Nixon, 1998; Davila, 2000).³ Yet,

¹ The definition of management control systems has evolved over the years from one focusing on the provision of more formal, financially quantifiable information to assist managerial decision making to one that embraces a much broader scope of information (Chenhall, 2003). Here, the term management control systems is used to name the design as well as the use of coordination mechanisms based on the standardization of either input, action or results (Thompson, 1967; Mintzberg, 1979, 1983). In this we follow Merchant (1985), according to whom, the array of controls available for coordinating and controlling tasks spans from the use of result, to action and personnel/cultural controls.

² The studies on research and development mainly suggest that management control systems constrain or are irrelevant in R&D settings. Some contributions focus on how R&D departments use accounting controls (Hayes, 1977; Brownell, 1985; Rockness & Shields, 1988) and show that financial indicators do not assume specific relevance in these departments other than signalling the commitment of the organization to its R&D efforts. Other contributions, by adopting a wider definition of control systems, find only limited relationships between them and project characteristics. For example, Abernethy and Brownell (1997) demonstrate that “reliance on accounting controls has significant positive effects on performance only where task uncertainty is lowest” while “behavior controls appear to contribute to performance in no situation” (p. 245). This evidence seems to suggest that management control systems have a minor role to play in contexts characterised by a high level of uncertainty (Hirst, 1983; Brownell & Hirst, 1986; Brownell & Dunk, 1991).

³ The literature on product development suggests that when management control systems provide information directed to coordination and learning, they affect performance in a positive way (Koga & Davila, 1998; Nixon, 1998). But alternative arguments and evidence (Eisenhardt & Tabrizi, 1995) propose that such a relationship does not exist or is negative. Management control systems, by imposing rules and constraints on behaviour, reduce the level of creativity necessary to develop new products and, thus, negatively affect performance (Ambile, 1998; Davila, 2000). These arguments are in line with the traditional view of product development, according to which, successful new products derive from avoiding control procedures that could restrict the level of freedom available to researchers (Lothian, 1984; McNair & Leibrfried, 1992). The effect of the use of management control systems on product development performance is, therefore, unclear. So far, only Davila (2000) has tried to explain this lack of clarity by suggesting that these contradictory results might be the result of a different interpretation of the role of management control systems that should be considered as information tools to face uncertainty rather than control mechanisms to reduce goal divergence (Hirst, 1983; Brownell & Hirst, 1986; Brownell & Dunk, 1991; Hartman, 2000).
the evidence contained in these contributions is still sparse, and that which does exist is mixed.

One of the possible explanations of the contradictory results reported in these earlier contributions may be related to both the variables that have been used to describe uncertainty and the role assigned to management control systems. The concept of uncertainty adopted in the management accounting literature mainly refers to either Perrow’s model of technology and structure (Perrow, 1970)—which considers task analysability and the number of exceptions as the relevant dimensions of analysis—or “the difference between the amount of information required to perform a task and the amount of information already possessed by the organization” (Galbraith, 1973, p. 5) (e.g. Hirst, 1981; Rockness & Shields, 1984; Abernethy & Brownell, 1997; Davila, 2000). Yet, more recent contributions, mainly in the organization field of research, have enlarged the meaning and extension of this concept by including new dimensions in its definition, like for example the nature of the knowledge used to carry out a specific task (Mintzberg, 1979; Williamson, 1985, 1993; Grandori, 1997). Therefore, in this study, these additional dimensions are incorporated into the analysis of knowledge-intensive firms and the nature of uncertainty is assumed to be much more complex and fine-grained than the traditional models allow. Uncertainty is seen as being related to the specific characteristics of the knowledge applied to work activities and determining the way in which knowledge is transferred and controlled. As a consequence, the understanding of its impact on management control systems needs to be further explored.

In addition, this paper, in contrast to previous contributions in the literature, assumes that one of the relevant roles of management control systems is to coordinate activities by integrating different sources of knowledge expertise instead of simply to either supply information to deal with uncertainty (e.g. Khandwalla, 1972; Gordon & Narayanan, 1984; Simons, 1987; Davila, 2000) or to reduce goal divergence (Ouchi, 1979; Vancil, 1979). This alternative perspective may help re-interpret the existing contradictory empirical results related to the control of activities characterized by different levels of uncertainty.

Given these premises, the objective of this paper is to develop a conceptual model of the role of management control systems in knowledge-intensive firms by considering a new variable that expresses the level of uncertainty, here called knowledge complexity. More specifically, the aim is to analyse the way in which knowledge complexity affects coordination and knowledge integration and, in turn, management control systems. The relationships of these variables are examined in the realm of knowledge-intensive firms’ teams (considered as the level of analysis), where the greatest problems of consistency between the coordination and knowledge integration modes occur. In this way this study addresses the issues associated with the manner in which uncertainty is defined and provides a more complete understanding of how knowledge activities are controlled and integrated. Based on a review of the literature on management control systems, the likely influences of the type of uncertainty on the use of different control mechanisms are explored. For this purpose we consider a wide range of tools available for co-ordinating knowledge-intensive activities by examining the use of result, action and personnel/cultural controls (Merchant, 1985).

The present contribution has a number of different purposes. The general aim is to advance the understanding of knowledge-intensive firms by analysing the contingency features of the management control systems of their teams. In addition, by introducing a new variable (knowledge complexity), new insights concerning the relationship between uncertainty and management control systems are provided. Finally, because the knowledge-intensive setting is neither particularly well understood, nor extensively researched in the field of management accounting, exploratory case studies are used to illustrate the arguments.

The remainder of the paper is organized into four sections. First, drawing together existing strands of research on knowledge-based organizations and on knowledge in organizations, the relevance of knowledge integration and the role of teams in knowledge-intensive firms are presented. Second, by means of a brief review of the relevant prior research, the revised concept of uncertainty and its implications for the design of management
control systems are illustrated. Third, the methodology and data analysis are described and the results shown. The last section is dedicated to presenting conclusions and an agenda for future research.

Knowledge-intensive firms and knowledge integration: the role of teams

The analysis of the literature on knowledge-intensive firms reveals a remarkable heterogeneity between the various contributions that have appeared in books, reviews and journals. These contributions differ in terms of theoretical approaches and empirical investigation in a way that prevents a homogeneous framework and the generalisation of empirical results. For example, Winch and Schneider (1993) and Starbuck (1993) examine respectively the strategic management issues facing the architectural practices and the elements of exceptional success in a law firm. Bernardi and Warglien (1989), Ekstedt (1989) and Starbuck (1992) analyse the processes of learning and knowledge renewal. But, while the former study a research centre and a computer firm, the latter analyses mainly professional service organizations. Furthermore, other contributions examine specific management issues concerning knowledge-intensive firms. In particular, Alvesson devotes his attention to both the cultural-ideological modes of control (Alvesson 1993a), and the relevance of social identity and loyalty in preventing the (unwanted) exit of personnel (Alvesson, 2000).4

Knowledge-intensive firms have been defined in different ways by the various contributions as: firms that use, more than the average, employees in fields that require a sophisticated knowledge and whose expertise is the source of a competitive advantage (Bernardi & Warglien, 1989; Ekstedt, 1992; Winch & Schneider, 1993); firms “in which ... experts are at least one-third of the personnel” and experts are “those with formal education and experience equivalent to a doctoral degree” (Starbuck, 1992). Thus, in general, according to these definitions, knowledge-intensive firms’ capital consists predominantly of human capital, their
critical elements are in the minds of individuals and heavy demands are made on the knowledge of those who work in them (Ekstedt, 1989, p. 7). Alternatively, such a type of firms also has been characterized as those that deploy their “assets in a distinctive way, for they sell a capacity to produce, rather than a product” (Winch & Schneider, 1993, p. 923) and finally those that process what they know into unique knowledge products and services for their customers, or possibly goods in combination with services. They are less capital-intensive than companies in the manufacturing industries and more learning-intensive than those operating in other service industries (Nurmi, 1998).

The diversity of perspectives and definitions provided in the literature makes the concept of knowledge-intensive firm—and the related notion

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4 There is also an alternative institutional-constructivist perspective to study knowledge-intensive firms. According to this approach, ‘Knowledge-intensive firms can be viewed as providers of institutionalised myths’ (Alvesson, 1993b) because they incorporate ambiguities and uncertainties involved in their work and results. As a consequence knowledge-intensive firms have to put a great effort, both internally and externally, to emphasise, for employees as well as for customers and other actors, that their experts should be relied upon. In addition, according to this perspective, an aspect that differentiates knowledge-intensive firms from non-knowledge-intensive firms is ‘the degree of elaboration of the language code through which one describes oneself, one’s organization, regulates client-orientations as well as identity’ (Alvesson, 1993b, pp. 1007). Furthermore, knowledge plays roles such as (a) a means for creating community and social identity through offering organizational members a shared language and promoting their self-esteem; (b) a resource for persuasion in, for example, public relation work and interactions with customers; (c) providing the company with a profile (an intended image targeted at the market); (d) creating legitimacy and good faith regarding actions and outcomes; and (e) obscuring uncertainty and countering reflection. With these knowledge roles in mind, management is much more a matter of influencing employees on a broader scale, including securing and developing work and organizational identities (Alvesson, 1993b). However, this institutional-constructivist perspective is not considered here. This is because in this paper we use a functionalist approach that considers the utility of management control systems in achieving purposeful outcomes and ‘caution must be directed at any approach providing some unification between functionalist and “alternate” approaches’ (Chenhall, 2003, p. 160).
of knowledge\textsuperscript{5}—problematic.\textsuperscript{6} In brief, it is difficult to characterise knowledge-intensive firms as a distinct, uniform category. The difference between knowledge-intensive firms and other companies is not self-evident because all organizations involve knowledge. In addition, it becomes even more opaque if these firms are substantiated with reference not only to formal, science-based knowledge but also to other more embedded and encultured versions of it (Blackler, 1995; Alvesson, 2000). Nevertheless, there are many crucial differences between many professional service and consultancy companies on the one hand, and more routinized service and manufacturing firms on the other. It is therefore useful to refer to knowledge-intensive firms as a vague but meaningful category. The category per se does not lead to a precise definition or delimitation, as in any case often happens in social science; it includes organizations which are neither unitary nor unique. Yet, it draws attention towards phenomena that are beyond the single case without aspiring to describe organizations in general, loosely focusing on an organizational category about which new insights may be developed (Alvesson, 2000).

More specifically, for the purposes of this paper, knowledge-intensive firms are viewed as organizations that use mainly the knowledge of their individuals to develop and trade immaterial responses\textsuperscript{7} to customer requirements. The one feature such firms possess is that their expertise is used to solve varied problems by offering a differentiated range of innovative responses to customers (Ekstedt, 1989; Starbuck, 1992). In addition, their knowledge is mainly embedded in human capital, even if this knowledge may be partially institutionalised and localised at the organisational level in the form of collective frames of reference, systematised methods of work, sophisticated routines and processes (Starbuck, 1992; Alvesson, 1995; Morris & Empson, 1998).

Knowledge-intensive firms have become more prevalent and more important as the business services sector has grown equally over the last twenty years (Winch & Schneider, 1993) and the world has been moving toward the so-called “post-industrial” economy (Drucker, 1993; Nonaka, 1994). Yet, research has only just started to scratch the surface in this area of business and most of the existing writings have suggested simplistically that managing these organizations is mainly based on both attracting and keeping the key professional workforce—the most significant ‘resource’ of knowledge-intensive companies—and developing organization-specific knowledge of an informal nature, inscribed in organizational culture and a certain style of working (Maister, 1982; Alvesson, 2000).

However, the management of knowledge-intensive firms is definitely more difficult than suggested. This is because knowledge-intensive firms need not only to attract the right individuals with the right expertise, but also to integrate the knowledge of those recruited in order to carry out activities mostly characterized by uncertainty, knowledge asymmetries and resulting observability problems (Winch & Schneider, 1993; Austin & Larkey, 2002). In fact, uncertainty comes from the fact that work in this type of firm tends to be oriented toward innovation and problem solving, and may require efforts on dimensions that are unanticipated and whose criticalness often evolves dynamically (Ekstedt, 1989). In addition, activities generate pronounced asymmetries—based not only on information, but also on knowledge disparities—between a manager and those (s)he manages. A manager who has the same information as a

\textsuperscript{5} An analysis of the concept of knowledge is outside the scope of this study. Yet, in the discussion that follows we are consistent with the definition provided by Morris and Empson (1998) when they say that ‘knowledge is viewed as information which professionals acquire through experience and training, together with the judgement which they develop over time which enables them to deploy that information effectively in order to deliver client service. Thus, knowledge is not limited to technical or product based expertise (professional know-how as Svieby & Lloyd, 1987, call it) but may also be knowledge of clients or industries and how they operate (managerial know-how). In turn, knowledge takes particular forms as it accumulates over time depending on the historical development of the firm (Dodgson, 1993)’.

\textsuperscript{6} For a review of the difficulties related to the definition of this concept see, for example, Starbuck (1992) and Alvesson (1992, 1995).

\textsuperscript{7} These solutions are immaterial in that they refer to value-creating transformations occurring in the realm of ideas or symbols, or, alternatively, in which a substantial amount of productive activity is intellectual rather than physical (Austin & Larkey, 2002).
worker can still lack the expertise needed to understand, attribute, evaluate, and act on what (s)he observes. This leads to observability problems that are particularly severe and persistent in knowledge-intensive firms due to the immaterial nature of their activities (Austin & Larkey, 2002). Moreover, the same problems of uncertainty, asymmetry and observability occur not only in the manager-subordinate relationship but also with reference to individuals possessing different kinds of expertise and operating together at the same level. To reduce uncertainty and overcome both asymmetry and observability problems, they need to integrate the many types of knowledge they have (Grant, 1996; Boland & Tenkasi, 1995; Austin & Larkey, 2002). Integration of knowledge helps overcome uncertainty and reduce knowledge disparities making visible what the other individuals think and do (Boland & Tenkasi, 1995).

The literature on the topic has mainly analysed only one way of integrating knowledge, by means of formal knowledge transfer (e.g. Kay, 1979; Levitt & March, 1988; Boisot, 1995), and has made only limited progress in dealing with this issue when most of the relevant knowledge is tacit (Polanyi, 1966). Some notable exceptions to this void are represented by Nonaka (1994) who describes the conversion of tacit into explicit knowledge (and vice versa) and other authors who emphasize the role of codification and diffusion processes in making tacit knowledge visible and available (Boisot, 1998).

However, the knowledge-based theory of the firm has suggested that knowledge transfer is not always an efficient approach to integrating knowledge. According to the same theory, when work requires the combination of many individuals’ specialist knowledge, the key to efficiency is to achieve effective integration while minimizing knowledge transfer through cross-learning by organizational members. Such processes of cross-learning takes place within teams that directly involve individuals (Lave & Wenger, 1991, Brown & Duguid, 1991; Cohen, 1993; Mohrman, 1993; Wenger, 1998; Scott & Tiessen, 1999; Easterby-Smith, Crossan, & Nicolini, 2000; Ancori et al., 2000).

Teams create synergy to increase the integrated application of specialized knowledge, so that the performance of the whole is greater than the sum of its parts (Cohen, 1993). In fact, complex tasks require the search for and evaluation of various alternatives, and this is likely to require more information than is possessed by a given individual (Bamber & Bylinski, 1982; Ismail & Trotman, 1995; Scott & Tiessen, 1999). This additional information may be provided by groups which generally should have greater collective knowledge than individuals (Burton, 1987; Hare, 1976; Stein, 1975; Taylor, Berry, & Block, 1958; Yetton & Bottger, 1982; Scott & Tiessen, 1999). Prior research suggests that groups benefit from the combination of different backgrounds, competencies and perspectives of their members (Ismail & Trotman, 1995; Shaw, 1976). Even if one individual has more knowledge and experience, the specific knowledge of the less informed individuals can integrate the knowledge of the group as a whole (Burton, 1987; Maier, 1970). The group can combine the knowledge of different group members and reach judgements of higher quality as a result of exchanging and sharing information and perspectives (Casey, Gettys, Pliske, & Mehle, 1984; Stocks & Harrell, 1995). Accordingly, teams which have this knowledge integrative function tend to be widely used in complex environments requiring the use of differentiated knowledge and the provision of novel and multidimensional solutions (Grant, 1996, 1997; Scott & Tiessen, 1999).

These conclusions are especially appropriate for knowledge-intensive firms. In fact, as argued in the literature (Boland & Tenkasi, 1995), integration

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8 Nevertheless, even within team-based processes, hierarchy is still necessary in order to link different sub-systems (e.g. the various project teams) together. The principles of hierarchical design are fundamental to ‘modular’ design in organizational structures. Critical to the design of modular structures is the separation of the total system into a number of modular sub-systems and then to design and standardize the interfaces between these sub-systems. A key distinction here is between the ‘component knowledge’ required by the sub-systems and the ‘architectural knowledge’ required for the linking of the various sub-systems (Grant, 1997, p. 453). Knowledge-intensive firms include both kinds of knowledge. In this paper, however, we mainly devote attention to the ‘component knowledge’ related to project teams considered as the main locations where knowledge activities take place.
through teams is particularly suitable to deal with a dynamic environment that requires fast and innovative responses (Cohen, 1993; Scott & Tiessen, 1999), as is the case of knowledge-intensive firms (Boland & Tenkasi, 1995). In this type of environment, teams allow a process of distributed cognition in which multiple communities of specialised knowledge workers, each dealing with a part of an overall organizational problem, interact to create the patterns of sense-making and behaviour displayed by the organization as a whole. This distributed cognition is necessary because the critically important processes and the diversity of environments and technologies to face are too varied and complex for an individual to understand in its entirety (Boland & Tenkasi, 1995).

Yet, as suggested in the introduction, the issue of control has received only fragmented and unsystematic attention in the knowledge-intensive firms’ literature. Few contributions have been focused on the questions related to what controls are used in the teams of knowledge-intensive firms and on how these controls guarantee the necessary integration of knowledge. This study has the objective to fill this void.

The main research questions are: How are knowledge-intensive firms’ teams controlled? And how does uncertainty affect management control systems? Additional questions are: How does uncertainty influence knowledge integration? How do management control systems act as knowledge integration mechanisms?

To be informed as much as possible by the existing writings, we start our explorations of the research questions by reviewing the published management control literature. We then analyse these questions with a field study of three software development project teams in order to provide some tentative explanations on the existing management control systems differences. We conclude with an agenda for future research.

### Uncertainty and management control systems in knowledge-intensive firms

#### Literature review: uncertainty and management control systems

Contingency-based research has a long tradition in the study of management control systems (Hayes, 1977, 1978; Tiessen & Waterhouse, 1978; Otley, 1980; Hopwood, 1989; Chapman, 1997; Chenhall, 2003). Researchers have attempted to explain the effectiveness of management control systems by examining designs that best suit the nature of the context in which they operate. Perhaps the most widely researched aspect of the context is uncertainty (Chenhall, 2003) and its relevance has been reaffirmed recently by many commentators who have stressed its fundamental role in the management control systems design (Chapman, 1997; Hartmann, 2000; Chenhall, 2003).

In the literature, the concept of uncertainty has been mainly associated with environment and technology (e.g. Burns & Stalker, 1961; Woodward, 1965; Lawrence & Lorsch, 1967; Thompson, 1967; Perrow, 1967). More specifically, on the one hand, environmental uncertainty has been captured in terms of dynamism, heterogeneity (Gordon & Miller, 1976; Amigoni, 1978), predictability (Waterhouse & Tiessen, 1978), controllability (Ewusi-Mensah, 1981) and equivocality (Daft & Macintosh, 1981). On the other hand, technology has been expressed with reference to complexity (Woodward, 1965), task uncertainty (Perrow, 1967; Ouchi, 1979) and interdependence (Thompson,
These three latter concepts are normally considered as separate constructs but they are common because they include some overlapping themes concerning uncertainty. It seems likely that conversion of inputs into outputs within less complex, mass production technologies is more programmable and predictable than in job or batch styled technologies servicing customized products (Chenhall, 2003).

Typically, the arguments supporting uncertainty-related expectations have not always discriminated clearly between these various types and sources of uncertainty leading to some indistinctness of the different dimensions of the concept (Hartmann, 2000; Chenhall, 2003). As a result, while the relevance of this construct is still widely recognized in extant management control systems research, its ambiguity has been advocated as one of the main reasons for the vagueness in capturing the impact of uncertainty over management control systems. This ambiguity may produce even more severe problems in understanding if the same variables are applied to completely different contexts, without any specific caution.

In this respect, it is worth noting that many of the dimensions related to uncertainty have been developed with reference to the physical production setting [see for example Woodward (1965)], and that many of the contingency-based management control systems contributions have considered manufacturing organizations (Chenhall, 2003). Yet, the extent to which the same dimensions of uncertainty maintain their relevance in other more knowledge intensive contexts is questionable. It is doubtful, for example, that two of the most common variables used to describe uncertainty—task analysability/programmability and the number of exceptions—represent discriminatory dimensions to study management control systems in knowledge-intensive firms. In fact, in such type of firms, on the one hand, analysability is prevented, in part, by the lack of observability of action and, on the other hand, the number of exceptions is by definition high due to the high level of innovation involved in executing tasks. In addition, knowledge-intensive firms are characterized by a more complex and multidimensional environment. As compared with the physical activities of manufacturing organizations, knowledge-intensive processes involve an extra dimension of uncertainty because they require the application of a wide range of differentiated knowledge that needs to be integrated effectively to produce appropriate responses to customers’ needs. As already suggested, this integration mainly takes place within teams. Therefore, to study the impact of uncertainty over management control systems in knowledge-intensive firms, the nuances of the project teams and the dimensions of knowledge need to be better expressed. More specifically, advances could be made by giving a specific theoretical meaning to the concept of uncertainty when applied to tasks characterised by knowledge intensity.

The purpose of the section that follows is to provide a concept of uncertainty that takes into consideration the specifics of knowledge-intensive firms’ teams and to suggest a framework that represents the impact of this variable on both the coordination and knowledge integration modes, and in turn on management control systems.

Dealing with knowledge complexity in knowledge-intensive firms’ teams: the role of management control systems as knowledge integration mechanisms

There is little understanding of how knowledge-intensive firms control their teams. This problem is
particularly multifaceted in such a type of organization because the selection of control mechanisms should take into consideration at the same time both the coordination and the knowledge integration aspects. A framework is needed to explore how the various forms of control act as complex knowledge integrative devices and how the contextual factors affect their selection and effectiveness.\textsuperscript{13}

In knowledge-intensive firms, one of the distinctive factors potentially affecting control system choices is the nature of knowledge and its complexity. Wood (1986) discusses three aspects of task complexity that are strictly interlinked to knowledge complexity: component complexity, coordinative complexity and dynamic complexity. The component complexity of a task is determined by the number of distinct information cues that must be processed and the number of distinct acts that must be executed in performing the task. The coordinative complexity is the result of the form and strength of the relationships between information cues and acts, including the content, timing, frequency, and location requirements for performances of demanded acts. Finally, the dynamic complexity relates to the need to adapt to changes occurring in the cause-effect relationships or means-ends chain during the execution of the task.

The task is afflicted by component complexity when knowledge is characterised by computational complexity, arising from the high number of agents and activities, and their interconnections (Grandori, 1997; Simon, 1962). In this case, organizational economic analyses and classic organization theory suggest the extension of the codification and formalization of information by using formal processing supports to manage operations (Galbraith, 1977; Mintzberg, 1979; Grandori, 1997). The management literature recommends the diffusion of codification as a mechanism to integrate the different pieces of knowledge (Cowan et al., 2000). Obviously, this is possible only when knowledge is characterized by codifiability, that is to say the possibility to formally articulate it in documents and software. This knowledge may be substantive, e.g. in blueprints, or it may be procedural, e.g. in a recipe for carrying out a task (Simon, 1979; Winter, 1987; Zander & Kogut, 1995; Cohendet & Steinmuler, 2000).

On this basis, we predict that when a task involves computationally complex knowledge it will be regulated by codifying procedures, actions, rules and instructions in order to both coordinate efficiently the complementary activities of many agents by adopting an action oriented approach to control and, at the same time, guarantee the effective integration of knowledge.

In contrast, a task may be subject to coordinative complexity, which is the result of using knowledge involving technical complexity, defined as the number of distinctive skills, or competencies belonging to many different (groups of) experienced people (Cohen & Levinthal, 1990; Iansiti & Clark, 1994; Zander & Kogut, 1995). The more knowledge is differentiated among agents, the more it fosters interactions and triggers mechanisms for knowledge integration due to the multiplicity of ways the problems are perceived and dealt with. In this case, integration is not achieved by the transmission of tacit knowledge (and by its formalisation) but through its coordination aimed at pursuing a common objective. In other words, in a context of diversified knowledge, the ‘constraint’ of tacit knowledge can be solved by means of coordination mechanisms more than codification processes (Grant, 1996; Cowan et al., 2000). In addition, coordination of actions is efficiently achieved by means of joint problem

\textsuperscript{13} Knowledge-intensive firms can use different mechanisms to control their teams. One effective and complete way to classify these mechanisms, according to the object of control, is by distinguishing between result, action and personnel/cultural control (Merchant, 1998). In the result oriented approach, control is mainly exercised via setting targets, reporting achievements, accountability, and reward structure that serve to foster output-directed behaviour, whereas control of action is based primarily on procedure guides, operating manuals, codification of actions and supervising observance of rules and instructions. On the contrary, personnel controls consist of helping individuals perform their tasks by building on the natural tendency to control themselves and cultural control represents a set of values, social norms and beliefs that are shared by members of the organization and that influence their actions. It is based on the belief that by fostering a sense of solidarity and commitment towards organizational goals individuals can become immersed in the interests of the organization (Merchant, 1998; Ouchi, 1979). The different controls tend to be usable in different contexts (Merchant, 1998; Ouchi, 1979).
solving, differentiation of decoupled specialized sub-systems and output exchange (Grandori, 1997, 1999), and needs to be further reinforced when the different specialized sub-systems are characterised by a diversity of interests, leading to potential competitive and hostile uses of knowledge (Ouchi & Bolton, 1988; Grandori, 1999).

Therefore, we predict that a task involving technically complex knowledge requires the use of result oriented control mechanisms hinging primarily on setting objectives and monitoring achievements with reference to content, timing, frequency, and location of required outputs. This allows at the same time an efficient control of action and an effective integration of knowledge.

Finally, in some other situations, the main feature of the task is dynamic complexity and knowledge is characterised by cognitional complexity. The processes are either new for the agents involved or entail innovative problem solving and are subject to many possible ‘serendipities’ and unexpected outcomes. This implies the discovery of cause-effect relations and relevant goals, and the transformation in explicit knowledge is expected to fail (Grandori, 1997; Perrow, 1967; Burns & Stalker, 1961). Therefore, such form of knowledge is communicated between individuals by means of common history, shared experiences and collective social and organizational frames—if these individuals have the time, the occasions for socialization, and the broader institutional incentives to perceive the game as basically integrative (Grandori, 1997; Ouchi, 1980; Ouchi & Bolton, 1988). In addition, in this setting coordination is achieved mainly by means of ‘professional or collegial’ structural arrangements (Perrow, 1970).

Thus, we predict that tasks that use cognitionally complex knowledge require regulation through self and group controls achieved with the use of selection and training policies which ensure that individuals have been exposed to appropriate training and socialization processes. In this way, by fostering a sense of community both control and knowledge integration are in place.

In brief, what is hypothesized here is that different types of knowledge complexity give rise to differing relations between reliance on each of the three kinds of controls, and management performance (see Fig. 1). Yet, in many instances, there will be no radical choice between the various forms of control because the task involves many pieces of knowledge, each characterised by a specific complexity, and more complex integrative devices need to coexist to assist control.

Tentative theoretical propositions

The preceding discussion can be reported in brief in the form of the following tentative theoretical propositions, which are, of course, subject to refinement:

P1: A context involving knowledge characterized by computational complexity will tend to be regulated through action oriented controls aimed to coordinate and guarantee the integration of knowledge.

P2: A context involving knowledge subject to technical complexity will tend to be regulated through result oriented control mechanisms allowing coordination and integration of knowledge.

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<th>Knowledge integration</th>
<th>Management control (object)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational complexity</td>
<td>Documents/codification</td>
</tr>
<tr>
<td>Technical complexity</td>
<td>Outputs/Performance reports</td>
</tr>
<tr>
<td>Cognitional complexity</td>
<td>Informal/oral.face-to-face communication</td>
</tr>
</tbody>
</table>

Fig. 1. Knowledge complexity, knowledge integration and management control systems.
P3: A context involving knowledge characterized by cognitional complexity will tend to be regulated by means of personnel/cultural forms of control leading at the same time to coordination and knowledge integration.

Comparative case studies: management control systems in three software development project teams

To explore the tentative research propositions discussed above and, more generally, the whole area of control system choice in knowledge-intensive firms’ teams, we solicited the cooperation of a multinational software firm in the UK.14

Research design15

Because the existing contributions on management control systems in knowledge-intensive firms are still quite limited, I decided to do a case study as the preferred methodology to build knowledge about the phenomenon (Yin, 1988). In addition, as management control systems vary across firms of different industries and the organization’s hierarchical levels—and this variation in the research setting can be detrimental to the power of the research design—two specific decisions have been made: the first was to limit the study to a firm belonging to the software industry; the second was to select the project team as the unit of analysis, because it is in the project teams that ideas are transformed in executable software applications through the use of differentiated knowledge and where the greatest problems of knowledge integration and control occur.

Initial contact with the firm was through its Chief Financial Officer, with whom the purpose of the study was discussed and agreement to participate secured.

Data were collected through a combination of document analysis, direct observation and systematic interviewing. The analysis of documents spanned from the annual reports, to budget and reporting statements, to the specific project documentation. Observation was carried out within three software development projects in which I spent 20 days full time over a period of two months, analysing meetings, practices and documents. Interviews were administered to managers at different levels (15 h at the top management level and more than 20 h at the project team level). Interviews were structured around a set of questions about the management control systems and the software development process itself. The questions were open-ended in order to adapt the interview to the expertise of each interviewee without losing the overall direction. An average of six to seven people (managers, leaders and developers) were interviewed in each project team. The use of multiple informants and sources of evidence allowed for the triangulation of data.

The evidence collected was repeatedly analysed. At the very beginning it seemed that transcripts and notes were incoherent. But different ways of organising the material were considered and a pattern began to emerge. At each phase, the interpretations of the data collected were checked against the next round of data, in an attempt to verify the level of understanding gained. This process continued until succeeding data started to become predictable. All the data collected and their interpretation became part of a report discussed with the Chief Financial Officer. This discussion helped verify the correct understanding of the practices adopted in the firm and challenge the corresponding interpretations.

Next, I provide a description of three illustrative software development project teams dealing with knowledge complexity and the design and use of management control systems. The primary criterion for project teams selection was to ensure that the variety of knowledge complexity and control patterns would emerge. The paper concludes with

14 The name of the firm has been obscured to preserve confidentiality.
15 The case study is based on data gathered as part of a much broader research study into the management control systems in knowledge-intensive firms carried out during my Ph.D thesis. In the course of the study, a broad cross-section of managers and professionals were interviewed in the firm, from the chief financial officer to the most junior, least experienced staff.
an analysis of the similarities and differences in the software development control systems and some tentative theoretical conclusions.

The software development process

‘Computer software consists of any set of instructions and data which is read, interpreted and executed by the control units of a computer system’ (Grindley, 1988). It can be distinguished in three broad classes: operating systems, the basic software controls of the operations of a computer, including network controllers and compilers; application tools, which are software tools that support specific applications in software engineering or database management, among other areas; and applications solutions, which are software instructions that enable a computer to perform specific tasks of interest to the end user, such as accounting and word processing. All these three types of software can be provided in either ‘standard’ (packaged software) or ‘custom’ form (Mowery, 1996). It is, however, only the control of the development of this latter kind of software that is analysed here.

The process of software development is structured around a well-defined sequence of phases. The first phase is typically represented by the requirement specification phase to indicate the complete, validated set of required functions, interfaces and performance outcomes for the software product. The outcome of the initial phase is a project plan with a description of the software characteristics and project specifications: technological performance, customer interfaces, target costs, and organizational resources. The second phase—design—goes into more detail to specify the overall hardware-software architecture, control structure and data structure for the software product, along with such other necessary components as data user’s manuals and test plans. The third phase—software development—is the actual development of the set of instructions in terms of lines of code. It is in this phase when trade-offs get resolved and information is transformed into an executable programme. The last two phases—testing and implementation—confirm that the software meets the requirements and the customer’s needs.

Yet, even if described as apparently linear, the process is iterative in its nature: software specifications or even the design can be re-evaluated in light of new information generated throughout the process (Rook, 1986; Bohem, 1988; Bersoff & Davis, 1991).

Project team A

The first project analysed was a fixed-price project to develop software for the exploitation of meteorological satellites in space division to provide a system which enables the generation and enhancements of meteorological products from satellite data.

Because the project was a re-run of a previous similar project with the same client, few doubts existed regarding technology, client and management.

The software is developed on the basis of the previous experience and uses a lot of the ideas developed in the preceding project (Team leader of product quality monitoring).

In terms of technology there is nothing new (Team leader of the monitoring control and communication on-line subsystem).

Most of the ideas are the same, even if we have to write everything from scratch. There is a lot of use of experience. The advantage is also that the client is known (Team leader of algorithms).

The source of uncertainty came mainly from the project scope. Evidence of this emerges with reference to the duration of the project (24 months), the number of people involved (30), the number of project requirements (5000 classified in three different categories: the facilities, the algorithms, and the general ground requirements), and finally the wideness of project documentation (5000 pages only for the architectural design phase). The project is therefore characterized by what we have called computational complexity, due to the number of people, activities and inter-connections that need to be coordinated.

Due to its low level of newness, the project team possessed sufficient knowledge to decide in advance the way in which activities were to be
executed to achieve the objectives. The action and knowledge of many agents through a long period of time needed to be coordinated and integrated by means of efficient information carriers. To achieve these objectives, the management control system was authoritative and prescriptive in nature, centred around action, featuring rules of behaviour and focusing on compliance with pre-specified norms and plans.

In fact, the authoritative nature of the project was witnessed by a clear definition of lines of responsibility between the project manager, support staff (quality engineering, hardware procurement, computer system, system design), team leaders (algorithms, on-line systems, off-line systems, product quality monitoring, on-site support and assembly-integration-test) and developers.

The structure of the project is definitely hierarchical (A developer of the product quality monitoring team).

The structure is hierarchical. There is a clear definition of objectives, responsibilities and delegation (The team leader of monitoring control and communication on-line subsystem).

Interviewees reported that control was exerted, on a regular basis, around activities which were weekly assigned to developers and monitored by specific metrics, such as the number of modules completed, the time spent on the modules, the time to go, the daily number of written lines of code and so on. These various pieces of information were communicated and integrated constantly in formal written documents and weekly formal meetings.

The detail of action control emerges by considering the words of some project members, who stressed the role of detailed plans (specifying time, modules and lines of codes) and the continuous monitoring of productivity by counting the number of lines of code generated:

At the end of the architectural design phase there was a plan with the number of modules and information about how long it would take to produce one. Then the modules were assigned to the different members of the team. Every week the project manager monitored which module was finished, how long it would still take and so on. At the end of the detailed design phase there was a redefinition of the plan (The team leader of product quality monitoring).

In a project like this we thought we would be able to achieve twenty lines of code per day and during this phase we have achieved forty. So the productivity has been higher (The project manager).

We started thinking that it was 260,000 lines of code, then gradually things changed over the project. For example, the algorithm team had overestimated the number of lines of code and the on-line and off-line teams had underestimated them. We ended up with more or less 260,000 fortuitously (The project manager).

As for the control of the work, the team leader reviews everything we do on a regular basis not only at the end, but incrementally. There is also a weekly monitoring concerning the time spent on a specific model and the time to go (A developer of the team of monitoring control and communication on-line sub-system).

In addition, the observation of the project showed that the same action control mechanisms (plans, schedules, forecasts, policies and procedures, and standard information and communication systems) were also the main channels for knowledge integration. Knowledge was integrated mainly through the codification of action in documents embodying both the content and the processes inherent in the application of technical knowledge. It was captured in project documentation and was made accessible to all the members of the project team.

In brief, the project was controlled in detail, on a continuous basis, by action control mechanisms which were at the same time means for integrating knowledge.

Project team B

The second project observed was a telecommunication division’s mobile billing and
customer care project for an Israeli mobile operator. The project was about the customisation of a specific product that was produced by another company. The product aimed to manage all the problems linked to the calls of a mobile phone, the invoices, the payments, and so on. Therefore, the kernel of the product needed some interfaces with other systems to manage all these activities. For these reasons, the firm had to integrate the activities of different work groups (sub-contractors), each providing software that formed part of the total solution.

The most important phase of the project will be
the integration phase (The delivery manager).

Each work group was characterised by specific knowledge and competencies: one work group knew the product very well and was in charge of making all the kernel changes; another work group was dedicated to making changes in the payment product; the third work group was aimed to the provisions; and finally, the firm under analysis had the knowledge to introduce all the non-kernel changes. In other words, the distinctive knowledge and competencies belonging to the different work groups represented what has been here called technical complexity.

Due to the participation of different autonomous work groups, the project was characterised, also, by a very demanding timeframe.

The project is time critical because the various phases are executed in parallel and there are a lot of dependencies (The delivery manager).

The strategy adopted for the project implementation was based on the firm’s previous experience of business support and control systems implementations.

Interviewees reported that the main task of control mechanisms was to coordinate the effort of work groups to meet the tight schedule. Each work group was working autonomously and what needed to be secured was that the groups’ outputs were presented in time and according to specifications. For this reason control was centred around results by using reporting and performance measurement mechanisms in which the outputs were presented and potential problems and exceptions illustrated.

The control mechanisms help coordinate the activities and manage the interdependencies of different groups. The project managers and the team leaders wanted also to know whether the outputs described in the plan were achieved, because a variance could have had an impact on other activities (The integration test team leader).

Apart from this, within groups, the work was left completely free and activities were carried out by the different individuals without a rigid hierarchy, with a lot of autonomy and self-coordination guaranteed by direct and informal communication.

The structure of the project is not rigid. I believe that developers can go to the project manager if they want to, and normally they would report to the line manager. So the developers would report to the delivery manager and the members of my team would report to me. But if they want they can go straight away for whatever specific matter they have (The acceptance test team leader).

As far as the team goes I talk to them everyday, I find what they have been doing and if they have any problems, questions, technical issues, I arrange for either find themselves the answer or I find the answer for them (The acceptance test team leader).

The observation of the project showed that the work groups were working autonomously according to the detailed objectives that were assigned to everyone, with a very limited formal and informal communication in between. In this case knowledge integration was achieved via exchanging performance measures and outputs, embodying the different group’s expertise, while minimizing knowledge transfer.

In summary, control was exerted via setting targets and reporting achievements and performance, and was not only a way to coordinate the
activities of different work groups, but also a means to guarantee the integration of different groups’ specialist knowledge.

**Project team C**

The last project analysed was a finance division’s initiative aimed to develop a solution for Visa cash card loading using mobile phones and short message service system. It was a completely new project with a lot of innovation. Neither the technology was known by the company nor the market in which the product would be introduced.

We look for what are the latest technologies and how they can be used via us to help our clients do things better. Technology innovation is the application of new things to do business better and the mobile commerce project comes as a part of this (The technical manager).

The project is innovative because it is in a market sector in which we have not built a product before (The technical manager).

With this project, we are in a situation of cognitive complexity because the processes are new for the agents involved and entail innovative problem solving leading to unknown outcomes and potential unexpected exceptions.

At the very beginning the objectives of the project were very general and this prevented the possibility to define specific targets to achieve.

The only requirement for the project was to load cash over the mobile phone...that was the total scope in the requirement at the start of the build in the project (The technical manager).

The time was not considered as a critical issue. Therefore, deadlines were self defined by the members of the team and were quite far in terms of time.

We didn’t have details about when to achieve results; we were saying to each other ‘Ok I will do that’ but we did not define formal cut-off dates to sort out when we would deliver the results, when we would complete the design (The technical manager).

Interviewees reported that the project manager was not part of the project from the very beginning and when he was involved, he played mainly a supportive role (reinforcing intentions, giving advice, questioning decisions, asking for explanations, contributing to solving problems, providing resources and so on). He was a “lightweight” project manager with no one reporting directly to him, but only coordinating the development effort of very competent and talented people.

In the first meetings there was no project manager...it was a group of peers (The technical manager).

They (the programmers) produced a very exceptional program...and this was a function of having a good team...The firm has a lot of talented people and part of my job was to turn talented individuals into a talented team...create the motivation, create the working atmosphere (The project manager).

My style was to let the technicians get on with the project...therefore I didn’t attend any of the meetings because having the project manager there I think it would stifle creativity ‘oooh my boss is in here I don’t want to appear foolish’...I have given them the job of designing...let them go into the design meetings, be creative (The project manager).

People were defining their own deadlines and I was just reviewing what they were doing and support them one hundred percent providing them with the program, the desks, equipment...I had the role of facilitator...I didn’t have that much influence on the technical solution (The project manager).

Observation showed that control was mainly informal in nature, with diffuse responsibilities, a lack of explicit guidance and a predilection for frequent but ad hoc communication. Preplanning was not possible and so a greater need existed for
information acquisition on an ongoing basis. In addition, as the members of the project were reliant upon one another for the accomplishment of their tasks they tended to share information, cooperate, and continuously adapt to new insights as they were emerging.

We had technical meetings to discuss the technical architecture and everybody was saying ‘Ok this is what we need to do’, but the control of specifying those requirements and documenting the requirements was really loose ... we started with the general let’s talk about this and what sort of things do we need to do ... We didn’t define each of our responsibility ... there was a lot of informal communication (The technical manager).

This form of control was also the main knowledge integration channel. The project relied heavily upon interpersonal processes and communication-intensive forms of information exchange as the primary means for integrating knowledge, and placed little emphasis on codification. Individuals were combining their specialist knowledge through ‘personal’ and ‘group’ communication, the last taking the form of meetings. As the range of problems and decisions to be covered tended to be wide, hence a great volume of information was communicated among individuals, often at the peer level.

To sum up briefly, informal and intensive interaction and communication were the ways to exert cultural control and, at the same time, achieve effective knowledge integration between the individual specialists belonging to the project team.

Discussion of projects

The previous projects provide a diverse set of software development experiences and different roles and characteristics of management control systems. Each project team required different management control mechanisms depending on the knowledge complexity of the project.

Knowledge complexity spanned from the computational complexity of project A due to the size of the project, its duration and the number of requirements to consider, to the technical complexity of project B, resulting from the participation of different groups of specialists and, finally, to the cognitional complexity of project C, deriving from its level of innovativeness.

This variation affected the projects’ management control practices in terms of the detail of the definition of objectives, the level of detail of information reporting, the frequency of information updating and the usage of information. Project A was characterised by an extreme precision in terms of the definition of objectives, a frequent reporting of detailed and codified information, and the use of this information to keep track of the activities carried out (action control). By contrast, in project B, while there was still a detailed definition of targets, the information exchanged during the project was kept at a minimum and was mainly incorporated in both the outputs delivered and the performance reported at each of the main milestones (result control). Finally, project C had a completely different pattern. The scope of the project had a very broad definition, and information was continuously exchanged informally between the members of the team. The purpose was to sort out potential problems and exceptions as they were emerging over time (personnel/cultural control).

The same variation was also impacting the modes of knowledge integration: the codification of action in project A, output exchange and performance reporting in project B and informal information sharing in project C.

The comparison of the projects should highlight the impact of knowledge complexity on the coordination and knowledge integration modes consistently incorporated in the management control systems. Therefore, management control systems play a double role in knowledge-intensive firms in that, on the one hand, they help coordinate activities and, on the other hand, foster a specific mode of knowledge integration. It is therefore their capability to perform this double role that makes them effective mechanisms in knowledge-intensive firms.

To conclude, the theoretical discussion and the case descriptions suggest that knowledge complexity is a driving force in the design and use of management control systems.
Epilogue and agenda for future research

Very little is known about the control practices of knowledge-intensive firms. Past studies have mainly focused on their organization and management features, and have only partially addressed control issues. The present paper tries to overcome this limitation and examines the variables that affect the management control systems of such type of firms.

Starting from the limits of the definition of uncertainty, especially when applied to the context of knowledge-intensive firms, this study focuses on the impact of a new variant of uncertainty—knowledge complexity—on management control systems. This effect is evaluated through the intervening role of coordination and knowledge integration modes. In other words, it is investigated by examining how knowledge complexity affects coordination and knowledge integration, and in turn management control systems. These contingent relationships are analysed in the realm of knowledge-intensive firms’ teams, where the problems of consistency between coordinating individuals and integrating knowledge mostly occur.

More specifically, the analysis suggests that, according to the type of knowledge complexity faced by teams—whether computational, technical or cognitional—knowledge integration tends to be centred around documentary sources, output exchange or informal communication, and coordination around action, results or values/beliefs. Consistent with this framework, management control mechanisms are to be designed to coordinate individuals and support knowledge integration at the same time. It is, therefore, the capability to play both the coordination and knowledge integration roles that makes management control mechanisms effective in knowledge-intensive firms. If they were useful mechanisms only to coordinate individuals’ action but prevented the appropriate integration of knowledge they would be detrimental to the health and functioning of knowledge-intensive firms’ teams.

The analysis started with a review of the literature on knowledge-intensive firms and management control systems and proceeded on that prior knowledge to develop some tentative propositions. These propositions were further explored by means of a field study research method. In fact, as the study of management control systems in knowledge-intensive firms is at an early stage, we thought that the development and refinement of theory was definitely more desirable in this phase than testing pre-defined hypothesis. The evidence collected confirmed the expectations concerning the impact of knowledge complexity on management control systems.

This study contributes to the literature in several ways. First, it provides new insights concerning the control practices of knowledge-intensive firms. Second, by addressing some definition issues associated with the manner in which uncertainty has been normally described in the management control contributions, it contributes to a re-interpretation of the contradictory results reported in the literature on management control systems in research and development units. Finally, by analysing the relationship between knowledge complexity and management control systems, it suggests a framework that could be also fruitfully applied to other potentially knowledge-intensive environments like for example marketing departments, human resources units, and cultural organizations.

This study has only started to scratch the surface of the complex knowledge-intensive firms’ control practices. As research advances, certainly better classifications, descriptions and roles of management control mechanisms can be developed as well as implications of combinations of controls and their interactive effects examined. Further research can also enlarge the set of variables that affect both management control systems’ choices and their effectiveness in knowledge-intensive firms. It could also contribute to assessing the relative weight of the causal variables and their interactions. In addition, new insights could emerge by considering other industries and levels of analysis.

Notwithstanding these limitations, this study does provide some insights into the nature of controls in knowledge-intensive firms and illustrates how two complementary needs—coordination and knowledge integration—can be effectively satisfied by management control systems.
Acknowledgements

The author would like to thank M. Abernethy, M. Agliati, F. Amigoni, S. Beretta, A. Caglio, D. Cooper, A. Davila, A. Dosi, A. G. Hopwood, P. Miller, M. Power and M. D. Shields for their helpful comments and suggestions on earlier drafts of this paper. The paper benefited also from the discussion with the participants of the Conference ‘Information Flows in Knowledge-Intensive Firms’, L. Bocconi University, Milan, 2001.

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