What Do We Really Mean by Interactive Control Systems? The Risks of Theoretical Misspecification[+]

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Abstract

This paper stresses the need for a sound theoretical specification of the construct interactive use of control systems (ICS) prior to fitting it to explanatory models. In particular, two areas related to the theoretical specification of ICS are highlighted: 1) the delineation of the construct's domain, and 2) the selection of the appropriate measurement model for specifying the relationships between the construct, its dimensions and its indicators (i.e. reflective versus formative; latent versus non-latent models). Based on a review of the conceptual underpinnings of ICS, five constitutive dimensions are identified to represent its domain. Furthermore, and in contrast with the reliance of prior research on reflective models, it is suggested that ICS should be modelled as a non-latent multidimensional construct formed from its constitutive dimensions.

Introduction

The concept of interactive use of management control systems (or interactive control systems, ICS) was first proposed by Simons (1987b, 1990, 1991, 1995a, 2000) to describe a style of use of formal management control systems (MCS) whereby, among other features, top managers use formal MCS to involve themselves regularly and personally in the decision-making activities of operating managers and to focus organizational attention on strategic uncertainties. Although relatively new, Simons' concept has rapidly become popular in qualitative field studies (e.g. Marginson, 2002; Osborn, 1998; Vaivio, 2004) as well as in quantitative cross-sectional studies (e.g. Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Bonner, Ruekert & Walker, 2002; Davila, 2000; Tani, 1995; Van der Stede, 2001). Both streams of research have provided ample evidence that ICS has relevant effects on a series of organizational variables such as innovativeness, competitive adaptation and strategic change.

Nevertheless, substantial discrepancies have been reported across studies. These discrepancies are likely to emerge from the fact that different researchers have examined slightly different subsets of the ICS construct domain. While some prior studies have used some of Simons' ICS characteristics, others have used some other characteristics (e.g. Tani, 1995 versus Bonner, Ruekert & Walker, 2002). Furthermore, and as far as theory-based quantitative research into ICS is concerned, while prior literature has focused on testing relationships between ICS and other variables, there has been less attention paid to the rigorous specification of the relationships between the construct ICS and its observable indicators or its dimensions (i.e. the measurement model). As a result, the measurement instruments proposed in the extant literature present potential validity problems regarding both the definition and the operationalization of ICS, which complicates the interpretation and the replication of the findings.

As is the case for all theory-driven quantitative studies, the building of a rigorous theory regarding ICS will only be possible if the concepts have sound conceptual foundations, the measurement model is correctly specified, and measurement instruments are valid and reliable (Fisher, 1995; Luft & Shields, 2003; Otley, 1980). Conceptual misspecification and inappropriate measurement models may lead to severely biased estimates and severely flawed conclusions regarding the existence, magnitude and directions of the relationships between ICS and other constructs (Bergh & Fairbank, 2002; Edwards & Bagozzi, 2000). The potential severity of these consequences has been illustrated by Jarvis, Mackenzie & Podsakoff (2003).

Indeed, various calls to develop valid and robust measures of the elements of MCS, particularly where there is ambiguity in the meaning of constructs, have been made in the MCS literature (Chenhall, 2003; Otley, 1980; Otley & Fakiolas, 2000; Van der Stede, 2001). We argue that, as is the case for many other constructs in MCS research, ICS is one of these ambiguous constructs. Although several studies have attempted to define and operationalize ICS, no unifying definition or measurement has yet emerged and the proper justification of the adopted measurement model is often missing. While these limitations are typical in the early stages of the evolving process of developing a novel practice-defined construct such as ICS, we believe that as quantitative studies that incorporate the ICS construct gain importance in management accounting research, it is time to examine carefully and systematize the theoretical modelling of ICS (Segars, 1997).[1]

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[1] The approach we take follows Segars' (1997) adaptation of the traditional paradigms for scale development (Saris & Stronkhorst, 1984), which proposes a sequence incorporating a theoretical modelling process and a statistical modelling process. The first phase, theoretical measurement modelling, is concerned with deriving accurate descriptions of complex phenomena (e.g. through literature reviews, field studies or formal interviews), and involves two sub-phases: a) specifying the definitional domain and the theoretical network of the research constructs, and b) generating items for each construct of interest, based on an analysis of existing measurement scales, relevant literature and expert opinion. A second phase involves examining collected data by employing statistical measurement modelling to assess the consistency and accuracy of items in representing the construct of interest. This paper focuses

In this paper, we argue that previous literature on ICS tends not to be precise in at least two specific aspects related to theoretical modelling: 1) in delineating what is included and what is not included in the definition of ICS, and 2) in justifying the theoretical measurement model that relates the construct ICS, its dimensions and its observable indicators. Lack of attention to these factors can lead to considerable ambiguity regarding the meaning of the construct under consideration. Consequently, the aim of this paper is two-fold. First, we attempt to explicitly delineate the definitional domain of ICS and decompose the construct into its properties. Second, and in contrast with most prior literature, we present arguments in favour of the definition of ICS as a non-latent construct on the grounds that each of its properties is a constitutive facet rather than a mere manifestation. Finally, while the paper is motivated by a concern with defining and measuring ICS, we suggest that the discussion can be extended to other areas, so that empirical management accounting research as a whole can be enhanced by paying more attention to theoretical specification (i.e. the delineation of definitional domains and the justified selection of theoretical measurement models) before getting into empirics.

The remainder of the paper is divided into six sections. A first section reviews the definitions of ICS as proposed in prior research, both in Simons' work (1987b, 1990, 1991, 1994, 1995a, 2000) and in subsequent literature. In order to overcome the ambiguities of these definitions, Section 2 proposes an explicit delimitation of the definitional domain of ICS on the basis of an in-depth content analysis. Section 3 moves from definitional issues to measurement model issues, highlighting the potential validity problems that arise from an uninformed choice regarding the measurement models used to represent ICS, and pointing out that the implicit choices made in prior literature do precisely conduce to these validity problems. In order to overcome these problems, we argue in Section 4 for a measurement model that specifies ICS as a non-latent multidimensional construct

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specifically on the first sub-phase of theoretical modelling, that is, specifying the definitional domain and conceptual network of ICS (Segars, 1997).

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formed from its constitutive properties. A fifth and final section concludes by commenting on the implications of a sound theoretical specification and a justified selection of measurement models for future research.

The definitions of interactive control systems: a literature review

The definitions of "interactive control systems" in Simons' work

Since its introduction by Simons (1990, 1991, 1994, 1995a), the concept interactive use of control systems (ICS) has evoked considerable interest. ICS is a significant component of the "levers of control" framework, which aims to provide insight into how managers exercise appropriate control in organizations demanding flexibility, innovation and creativity (Simons, 1995a, 1995b, 2000). For Simons, a key point for the effectiveness as well as the effective analysis of formal management control systems (MCS) is not only the presence and the technical design of certain mechanisms of control, but also the manner in which management uses the available MCS. On the basis of the different patterns of attention of CEOs and other organization members, Simons distinguishes two styles of use of feedback and measurement systems: a diagnostic use (and hence, diagnostic control systems) and an interactive use (and hence, interactive control systems, ICS) (Simons, 1990, 1991, 1995a).

In this paper, we concentrate only on ICS. Diagnostic uses of feedback and measurement systems have already been extensively documented in previous literature (Anthony, 1988; Anthony & Govindarajan, 2004; Merchant & Van der Stede, 2003). More interesting and under-researched, because of its novelty, is Simons' characterization of ICS.[2] Precisely because his is one of the significant

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[2] The in-depth elaboration of the features of ICS provided in this paper is expected to be helpful for future studies interested in researching the role of ICS within the wider context of overall control packages (Otley, 1980) and the interplay between ICS, diagnostic control systems,

contributions of this framework, it is not surprising that Simons' studies provide ample reference to the attributes and effects of ICS. In doing so, rather than offering a sole nominal definition that represents the precise meaning of the concept, Simons characterizes ICS by enumerating or pointing out an array of inherent properties, implications and outcomes that are associated with this style of use of formal MCS. Table 1 illustrates some of the different enumerations of the features which characterize ICS that can be found in Simons' work.

Table 1
Instances of enumerations of features that characterize ICS in Simons' work

Simons, 1987b, p. 351	"1) Staff specialists have limited roles in preparing and interpreting information; 2) The process requires frequent and regular attention from operating managers at all levels of the organization; 3) Data are interpreted and discussed in face-to-face meetings of superiors, subordinate and peers; 4) Information generated by the process represents an important agenda to be addressed by the highest levels of management; 5) The process relies on the continual challenge and debate of underlying data, assumptions and action plans; and 6) The process is fuelled by a reward of effort rather than results".
Simons, 1995a, p. 97	"All interactive control systems have four defining characteristics: 1. Information generated by the system is an important and recurring agenda addressed by the highest levels of management; 2. The interactive control system demands frequent and regular attention from operating managers at all levels of the organization; 3. Data generated by the system are interpreted and discussed in face-to-face meetings of superiors, subordinates and peers; and 4. The system is a catalyst for the continual challenge and debate of underlying data, assumptions and action plans".
Simons, 1995a, p. 108-109	"To be used interactively, 1) A control system must require the re-forecasting of future states based on revised current information (...); 2) the information contained in a control system must be simple to understand (...); 3) a control system must be used not only by senior managers but also by managers at multiple levels of the organization (...) and 4) a control system must trigger revised action plans". "The four conditions listed above are necessary but not sufficient conditions for senior managers to use a control system interactively. To be used interactively, 5) a control system must collect and generate information that relates to the effects of strategic uncertainties on the strategy of the business" [our italics].
Simons, 2000, p. 220.	"The information contained in an interactive control system 1) must be simple to understand (...); 2) must provide information about strategic uncertainties (...); 3) must be used by managers at multiple levels of the organization (...) and 4) must generate new action plans".

Beyond the enumerations listed in Table 1, Simons explicitly mentions further characteristics which describe other constitutive

beliefs systems, boundary systems (Simons, 1995) as well as the interplay with informal control systems.

facets of ICS. For instance, he remarks that while personal involvement of senior managers is a defining feature of ICS, the type of involvement needed "differs fundamentally from hands-on management. Interactive control does not usurp the decision rights of subordinates; it involves senior management at critical phases in the decision process to ensure that decisions are being made within a defined framework. (... It) requires (senior managers) to heat up periodically the process and then to withdraw so that they affect outcomes without overtly intervening" (Simons, 1987b, p. 353). For the use of control systems to be interactive, senior managers' personal involvement must be done in a way that "generate(s) dialogue" (Simons, 1995a, p. 151) and create "a positive informational environment that encourages information sharing" (ibid., p. 158).

As is obvious from the preceding sample of quotations, the enumerations and descriptions do not fully coincide, and none of the enumerations or descriptions appears to exhaustively represent in itself the concept's domain, even though overall they depict a plausibly coherent configuration of characteristics. Simons opts to characterize the construct ICS by listing a series of inherent characteristics and implications, which as a whole portray the different facets of the domain of the construct.[3]

Although Simons' framework is triggered by the findings of a seminal quantitative study (Simons, 1987a), the development of his framework and in particular his conceptualization of ICS is achieved through a series of subsequent in-depth field studies (Simons, 1987b, 1990, 1991, 1994). Consequently, Simons' research programme does not in itself propose any operational definition of ICS. Operational definitions and measurement instruments are found in subsequent studies by other researchers.

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[3] Although the concept of ICS is dynamic and has been developed progressively and on the basis of practice, we consider the fundamental defining traits such as the ones listed in this section to be stable in Simons' framework.

The definitions of "interactive control systems" in subsequent studies

Since Simons (1990, 1991, 1994, 1995a) introduced ICS, several recent studies have shown interest in testing the alleged explanatory power of the construct and in investigating its relationships with other variables. Overall, these studies provide evidence of the significance and the relevance of ICS, insofar as it appears to have meaningful consequences for an array of organizational outcomes such as generation of ideas for product development and cost reduction (Tani, 1995), competitive adaptation (Osborn, 1998), strategic change (Abernethy & Brownell, 1999), strategy formation (Marginson, 2002) and successful product innovation (Bisbe & Otley, 2004). However, while most of the above-mentioned studies reinforce the plausibility of the relevance of Simons' framework, they also evidence some inconsistencies and contradictory findings. For example, Bonner, Ruekert & Walker (2002) suggest that the use of interactive controls during new product development project execution is negatively related to project performance. This contrasts with Tani's (1995) findings suggesting a contribution of ICS towards effective project performance.

These inconsistencies may be associated with imprecisions in the delineation of the definitional domain of ICS. To assess how the emergent strand of management accounting research has defined ICS, we conducted a content analysis of the quantitative studies appearing in nine top accounting journals in which ICS was included as a variable of interest. For the period 1995-2004, the review[4] revealed

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[4] The nine reviewed journals were *Accounting, Organizations and Society*, *The Accounting Review*, *Contemporary Accounting Research*, *Journal of Accounting and Economics*, *Journal of Accounting Research*, *Journal of Management Accounting Research*, *Accounting Horizons*, *European Accounting Review* and *Management Accounting Research*. The first six journals are the same used in Shields' (1997) review. The first five were also identified by Brown & Huefner (1994), Ballas & Theoharakis (2003) and Lowe & Locke (2005) as the top five accounting journals, whereas JMAR, AHO, EAR and MAR were also identified in Ballas & Theoharakis (2003) as leading journals in the specific research interest area of management accounting.

four quantitative papers (Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Davila, 2000; Van der Stede, 2001) (see Appendix A).

Probably as a result of the broad characterization proposed by Simons, all these studies define ICS using some of the characteristics of these control systems as mentioned by Simons, usually quoting some of the (non-exhaustive) enumerations or attributes such as the ones listed in Section 1.1. On the basis of this definition, each of the studies under review selects one or more items that aim to measure the characteristics captured in the selected definition[5] (see Appendix A). As a result, slightly different subsets of the construct domain are tapped in these studies.

Two examples can illustrate this partial coverage of the construct domain. Abernethy & Brownell (1999) define ICS on the basis of several of the defining features suggested by Simons. However, in their definition they do not take into account other inherent features such as those related to the collection and generation of information about strategic uncertainties, a feature that Simons explicitly regards as a necessary condition for considering that senior managers use a control system interactively (Simons, 1995a, pp. 108-109). Given the definition of strategic uncertainties as "the emerging threats and opportunities that could invalidate the assumptions upon which the current strategy is based" and given the contrast between this and critical performance variables embedded in plans and goals (Simons, 2000, p. 215), none of the measures included in Abernethy & Brownell (1999) can be considered a surrogate for focus on strategic

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[5] Two alternative approaches to operationalization of interactive control systems have been adopted in these studies. On the one hand, Abernethy & Brownell (1999) and Davila (2000) propose measuring interactive controls on scales that set interactive control systems against diagnostic control systems. On the other hand, and on the grounds that a high interactive use of a specific MCS does not necessarily preclude its diagnostic use (Simons, 1995a: 120; 2000: 224) and that low levels of diagnostic use do not necessarily imply a high interactive use, Bisbe & Otley (2004) argue that diagnostic use and interactive use (ICS) should not be captured as two poles of one single variable, bur rather as two distinct variables, and consequently opt to measure interactive control systems on scales that set interactive use against lack of interactive use.

uncertainties. A second example can be found in Van der Stede (2001) and Bisbe & Otley (2004), where personal and regular involvement by top managers is captured as a property of ICS, but no attempt is made to look at the extent to which this involvement is not invasive or hands-on. It is noteworthy in this regard that Van der Stede (2001) explicitly identifies interactive use of budgets with intensity of budget-related communication, hence excluding attributes of use other than intensity and therefore limiting the domain of ICS. Thus, neither Van der Stede (2001) nor Bisbe & Otley (2004) capture an inherent feature of ICS, insofar as they ignore whether control systems are not invasive, do not usurp the decision rights of subordinates and do not overtly intervene (Simons, 1987b, p. 353), or whether they instead create a positive informational environment that encourages information sharing (Simons, 1995a, p. 158).

Similar partial coverage of the attributes mentioned by Simons can be found in all the studies reviewed. The fact that prior literature has not as yet engaged in an exhaustive content analysis of the construct has resulted in different studies tapping different partial subsets of the intricacies of ICS.

A delineation of the definitional domain of interactive control systems

Following the calls to pay primary attention to the rigorous theoretical specification of constructs (Edwards & Bagozzi, 2000; Otley & Fakiolas, 2000), in this section we develop a first crucial component of theoretical modelling (Segars, 1997) of ICS, that is, the delimitation of its definitional domain. The features of ICS as presented in Simons' framework are examined though an in-depth content analysis and are subsequently organized by distinguishing a) its inherent attributes or properties, b) its implications for strategic activities and c) the strategic outcomes of ICS. We then argue that only the inherent

attributes or properties should be used for operationalizing the construct.

The properties of interactive control systems

Simons' framework characterizes the construct ICS on the basis of an array of enumerations and descriptions of its characteristics and implications. For clarification purposes, and following Marginson (2002), a distinction can be drawn (Fig. 1) between three types of features of ICS as conceptualized by Simons: 1) properties or qualities that the style of use of control systems should comprise, e.g. "(it) demand(s) frequent and regular attention from operating managers at all levels of the organization" (Simons, 1995b, p. 87); in order to 2) have implications for strategic activities around decision processes and mobilization of resources, e.g. "to guide the experimentation and learning" (Simons, 1995a, p. 107); 3) thereby leading to desirable outcomes at firm level, e.g. "to provoke the emergence of new initiatives and strategies" (Simons, 1995a, p. 180). While it is acknowledged that in some cases the borders between the three types of features may be fuzzy, this distinction may help sort out the rich intricacies of the construct under consideration.
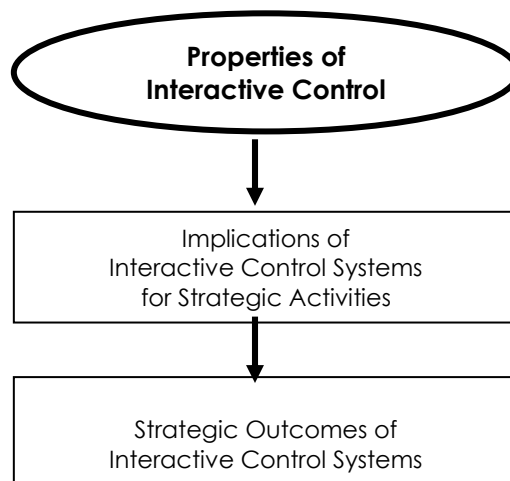

Fig. 1. Types of features of interactive control systems

A thorough examination of Simons' studies (Simons, 1987b, 1990, 1991, 1994, 1995a, 1995b, 2000) resulted in the detection of at least 108 quotations in which either properties, implications or outcomes of ICS are defined. We used thematic analysis procedures (Boyatzis, 1998; Lonkilla, 1995) for the purpose of systematically identifying patterns that organize the available information in a meaningful way.[6] ATLAS/ti was used as a software tool to help carry out this thematic analysis (Weitzman & Miles, 1995). In the first stage, individual quotes were assigned to codes merely on the basis of textual features (e.g. coincidence of keywords, use of synonyms). This encoding process resulted in the reduction of the 108 quotes to 26 codes (see Appendix B for an example of code assignment).

On the basis of Marginson's (2002) distinction, the resulting codes were classified as related to either properties of ICS (18 codes), implications for strategic activities (4) or strategic outcomes (4). This is illustrated in Appendix C. In order to operationalize ICS for quantitative research, this distinction between properties on the one hand and implications and outcomes on the other hand is crucial. Properties refer to the inherent attributes of a construct whereas implications and outcomes refer to the effects of this construct (Edwards & Bagozzi, 2000). In this paper we are interested in this paper in measures that refer to the construct itself, i.e. measures that describe the inherent attributes of a construct, and therefore we focus our attention on the analysis of themes related to properties.

The 18 themes (i.e. codes) related to properties were clustered into a limited number of super-codes determined by organizing the codes on the basis of theory (Boyatzis, 1998, p. 136). Codes were theoretically

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[6] Thematic analysis allows the researcher to use a wide variety of information, such as interviews, life histories, essays, transcripts of speeches and literature, among many others. In this paper, the unit of analysis used was Simons' literature, identified as one single unit, and consequently the type of raw information used corresponds to published material. The analysis was carried out at the manifest level, code development and formation of cluster themes were theory-driven and samples of thought defined as quotes of no more than one paragraph long were selected as the units of coding (Boyatzis, 1998).

clustered into one super-code when they shared a common theme, had similar contents or were conceptually closely related. This procedure led to the identification of five super-codes which relate to properties of ICS (see Appendix C for the ATLAS/ti network output organizing codes into super-codes). The resulting five super-codes or theoretical dimensions are: 1) an intensive use by senior management; 2) an intensive use by operating managers; 3) the pervasiveness of face-to-face challenges and debates; 4) the focus on strategic uncertainties; and 5) a non-invasive and facilitating involvement. Each of these theoretical dimensions is discussed below.

Intensive use by senior management refers to the degree to which top management devote a significant part of their limited time and attention span (Merchant & Van der Stede, 2003; Simons, 1995a; Van der Stede, 2001) to issues related to inputs, processes or outputs of the formal management control systems. In contrast with the occasional, non-intensive use that characterizes management by exception, an intensive use of control systems by top management is manifested, for instance, by a regular pattern of frequent personal attention by top managers, by a strong personal involvement by top managers in subordinates' activities through the use of these systems or by the use of control systems as a recurring agenda addressed by top managers.

A second property of ICS refers to its intensive use by operating management. As with intensive use by senior managers, this property refers to the degree to which operating managers throughout the organization are involved in an intensive and frequent use of control systems, devoting a significant amount of time and effort to issues related to formal controls (Merchant & Van de Ven, 2003; Miller & Friesen, 1982; Van der Stede, 2001).

ICS is characterized by an intensive use at both the top and middle levels of the organization. In addition, both sides must regularly and frequently meet and interact, resulting in face-to-face challenge and debate. Face-to-face challenge and debate is manifested, for instance,

by frequent face-to-face meetings of superiors, subordinates and peers and by regular presentations that generate serious debate concerning assumptions, arenas of operation and suitable risk levels (Simons, 1987b, p. 347) and in which there is ample room to challenge aspects of organizational life such as the implementation of the current action plans or the assumptions on which these plans are based.

While intensity of use and intensity of communication are relevant in characterizing styles of use of control systems, these properties are not sufficient to capture the complexity of styles of use such as ICS. Contents and nature of the communication are also relevant (Ahrens & Chapman, 2004; Chenhall, 1995). In fact, Simons makes it clear that a necessary feature of an ICS is that it collects and generates information that relates to the effects of strategic uncertainties on the strategy of the business (Simons, 1995a, pp. 108-9). A fourth property of ICS refers, therefore, to the contents of the information dealt with, namely its focus on strategic uncertainties. Strategic uncertainties are the uncertainties and contingencies that could pose threats or present opportunities as circumstances change and that could invalidate the current strategy of the business (Daft et al., 1988). They relate to changes in competitive dynamics and internal competencies that must be understood if the business is to successfully adapt over time. In contrast with critical performance variables, which are embedded in plans and goals and are followed up by diagnostic control systems, strategic uncertainties cannot be known in advance and emerge unexpectedly over time (Simons, 2000, p. 215). Manifestations of this fourth property of ICS are the monitoring and making sense of changing conditions and the collection and communication of information about strategic uncertainties.

Finally, a fifth property relates to top managers' non-invasive and facilitating involvement. Strong participation, questioning and probing by top managers in subordinate activities can take different forms. At one extreme, a senior manager's participation and involvement may be associated with greater centralization of authority and decision-

making. Through regular and frequent interventions, senior managers may invade the autonomy of subordinates, replace team consensus-building and decision-making with hierarchical directives, and impose their own decisions at critical junctures or even override team decisions (Bonner, Ruekert & Walker, 2002). At the other extreme, a higher senior manager's involvement may be associated with a facilitative and integrative role. Through this role, management interventions are not perceived by the members of the organization as invasive, but rather as catalysts that encourage and ensure that people will search for, consider and share new information. While both scenarios are consistent with an intensive use of MCS by top management and with intense face-to-face challenge and debate, what characterizes ICS is the non-invasive, facilitating type of involvement. According to Simons, for the use of control systems to be interactive, a senior manager's personal involvement must be carried out in a way that "generate(s) dialogue" (Simons, 1995a, p. 151) in "a positive informational environment that encourages information sharing" early (ibid., p. 158). The resulting type of involvement "differs fundamentally from hands-on management. Even though it involves senior management at critical phases in the decision process to ensure that decisions are being made within a defined framework, interactive control does not usurp the decision rights of subordinates" (Simons, 1987b, p. 353). Through ICS, top managers force issues on the subordinates´ agendas and demand their attention, but nevertheless top managers' involvement through ICS is empowering rather than overtly intervening.

The five properties identified above represent a wide spectrum and collectively define ICS as introduced by Simons (1987b, 1990, 1991, 1995a, 2000). Although the usual trade-off between homogeneity and manageability along with the usual concerns about subjectivity of the categorizations are apparent here, the five properties resulting from thematic analysis are believed to cover the domain of Simons' ICS. This is illustrated in Appendix C, which provides an overall graphic representation of the network that links the themes related to the

inherent attributes, implications and outcomes of ICS. As research progresses, the conception of ICS may need reinterpretation, and future refinements such as the inclusion of new properties may be justified. However, it is important to emphasize that this reinterpretation should rest primarily on a sound theoretical justification. Ensuring a theoretically comprehensive coverage of the domain of ICS is crucial for content validity. This must be undertaken at the stage of theoretical modelling (e.g. through further development of thematic analysis) and has to be theory-driven and established prior to data collection. In contrast, it is also plausible that future empirical studies might recommend the reduction of indicators to a smaller number of dimensions. Again, in this case it is crucial to ensure that the data-driven procedures used for that purpose are applied on a theoretically meaningful and sufficiently inclusive selection of items derived from an in-depth thematic analysis.

The context-specific nature of interactive control systems

The thematic analysis procedures we have engaged in rest on the assumption that we can conceptualize the properties of ICS in a comprehensive and relatively unambiguous way. This conceptualization has relied explicitly on the work of Simons (1987b, 1990, 1991, 1995a, 2000). This focus on Simons' work as a whole suggests a universalistic definition of the ICS. This may be criticised on several counts.

First, the framework we propose does not capture the dynamics of the development of ICS as an evolving concept in Simons' work. Rather, it takes Simons' contributions as an integrated body that essentially defines ICS. Second, although there is probably an infinite variety of meanings and conceptualizations of styles of use of controls and Simons is one among many, our framework reduces the complexity of the concept ICS to ICS as conceptualized by Simons.

Furthermore, it might be claimed that the nature and meaning of interactive control systems depends on the purpose of the use of MCS (e.g. attention focusing, learning, searching) (Henri, 2005). One set of properties may be required for being used interactively for certain purposes (e.g. learning), while another set of properties are required for being used interactively for certain other purposes (e.g. attention focusing). This would indicate that ICS has a context-specific nature and that there is no comprehensive, universal construct of ICS. However, a context-specific nature of ICS would reinforce even more the argument that the conceptualization of ICS requires the proper delineation of a definitional domain, which now refers to the purposes or contexts of interest.

The measurement models of interactive control systems: a literature review

Having reviewed issues associated with the delineation of the definitional domain of ICS, we now consider the potential content validity problems associated with the second aspect of theoretical modelling, that is, the specification of the measurement model. Since, in contrast with other fields of management research, little attention has been paid in management accounting research to the distinction between alternative measurement models, this section introduces their fundamental traits. We first introduce the distinction between reflective and formative models for representing relationships between measures and constructs. We then extend the rationales behind this distinction to the analogous distinction between latent and non-latent models for representing relationships between dimensions and multidimensional constructs.

The key point here is that as long as there is a theoretical justification for viewing items as reflections or manifestations (i.e. as reflective measures) of a latent construct and for viewing dimensions as reflections or manifestations of a higher-order latent construct,

selecting a narrow and incomplete set of items or a narrow and incomplete set of dimensions may undermine reliability, but does not necessarily undermine content validity. However, content validity would be undermined and serious misspecification problems would arise if a narrow and incomplete set of measures or dimensions were captured while a model in which measures are constitutive facets of a non-latent construct (i.e. a formative or non-latent model) was warranted (Blalock, 1964; Bollen & Lennox, 1991; Edwards & Bagozzi, 2000; Fornell & Bookstein, 1982; Jarvis, Mackenzie & Podsakoff, 2003). An incorrect specification in this regard (e.g. an incorrect specification of a construct as reflective when it should have been formative) would severely bias structural parameter estimates, prevent meaningful estimation and testing of relationships between constructs and lead to inappropriate conclusions about hypothesized relationships between constructs (Edwards & Bagozzi, 2000). Jarvis, Mackenzie & Podsakoff (2003) have illustrated the severity of the implications of such incorrect specifications of measurement models. Applying this framework to the prior empirical literature on ICS, this section highlights the fact that all prior quantitative studies on ICS have implicitly assumed reflective or latent measurement models, which potentially threatens validity.

Specification of measurement models: reflective vs. formative indicators

The distinction between reflective and formative measurement models has been developed by Bollen (1989), Bollen & Lennox (1991) and Edwards & Bagozzi (2000), although it can be traced back to Blalock (1964) and Fornell & Bookstein (1982). The basic guidelines for determining whether a construct is formative or reflective are summarized in Table 2.

Table 2
Guidelines for determining whether a construct is formative or reflective

	Reflective model	*Formative model*
Alternative labels	Effect indicator models (Bollen & Lennox, 1991)	Causal indicator models (Bollen & Lennox, 1991)
Direction of causality implied by the conceptual definition *Indicators are ...* *Causes of changes*	Direction of causality is from constructs to items Indicators are reflections or manifestations of the construct Changes in the construct necessarily cause changes in the indicators	Direction of causality is from items to constructs Indicators are defining characteristics of the construct Changes in the indicators should cause changes in the construct
Covariation among the indicators *Should a change in one of the indicators be associated with changes in other indicators?*	Indicators are expected to covary Yes	Indicators do not necessarily covary Not necessarily
Are indicators / items interchangeable? *Do indicators have similar content? Do they share a common theme?* *Would dropping one of the indicators alter the conceptual domain of the construct?*	Yes Indicators should have the same or similar content/ should share a common theme Dropping an indicator should not alter the conceptual domain of the construct	Not necessarily Indicators need not have the same or similar content/ need not share a common theme Dropping an indicator may alter the conceptual domain of the construct
Nomological net of the construct indicators *Are the indicators/items expected to have the same antecedents and consequences?*	Nomological net for the indicators should not differ Indicators are required to have the same antecedents and consequences	Nomological net for the indicators may differ Indicators are not required to have the same antecedents and consequences

(Adapted from Jarvis, Mackenzie & Podsakoff, 2003)

Classical measurement theory (Nunnally & Bernstein, 1994) relies on reflective models in which an underlying latent construct is measured through a series of reflective indicators that are reflections or manifestations of the latent variable (Fig. 2a). The direction of causality is from the construct to the items, since changes in the construct cause changes in the indicators. In this model, variance in each measure Y is explained by a construct common to all measures (η_1) and by a unique factor from each measure (which includes its specificity and random measurement error). Covariation among the measures is attributed to their common cause η_1 (i.e. the latent

construct). As a result, reflective measures covary and a change in the construct is expected to result in a simultaneous change in all measures. Consequently, under a reflective measurement model, equally reliable measures are essentially interchangeable and removing specific reflective indicators does not alter the conceptual domain of the construct and does not cause dire consequences. Rather, an incomplete sample of reflective indicators may present the advantage of being parsimonious while serving as a valid measure of the construct, even though it may be less reliable than a larger sample of indicators. Finally, since all of the indicators reflect the same underlying construct and are assumed to be interchangeable, they should all have the same antecedents and consequences and share the same nomological net (Bollen, 1989; Bollen & Lennox, 1991; Edwards & Bagozzi, 2000; Jarvis, Mackenzie & Podsakoff, 2003).
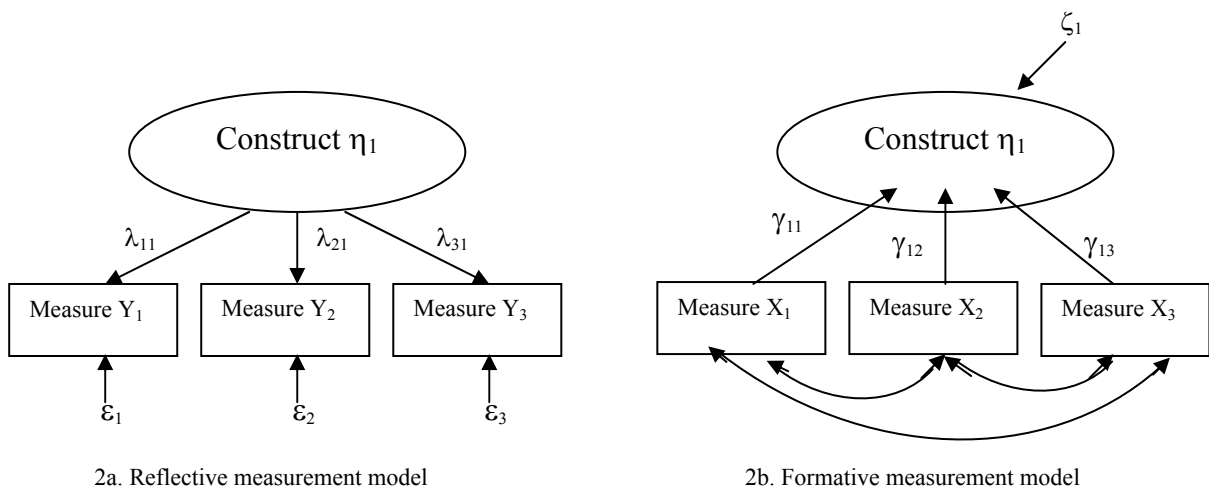

2a. Reflective measurement model   2b. Formative measurement model

Fig. 2. Path diagrams of reflective and formative measurement models for the relationship between measures and constructs

Alternatively, if a construct is formed or induced by measures that describe its inherent attributes, and therefore the measures are not driven by an underlying construct but instead are separate measures that define the construct, a formative measurement model applies (Fig. 2b). In Fig. 2b, the formative model views measures X_{1-3} as causes of the construct and the observed indicators are separate facets that

define the construct. The direction of causality flows from the indicators to the latent construct. The indicators as a group jointly determine the conceptual and empirical meaning of the construct.[7] Because causality runs from the measures to the construct, the construct is not presumed to explain the variances-covariances of the measures. In formative models, attributes need not covary. Consequently, classical reliability estimates (e.g. Cronbach's α) based on internal consistency are irrelevant for formative measures, as are tests of convergent and discriminant validity (Bagozzi, 1994; Bollen, 1989).

An essential trait of formative models is that leaving out constituent facets of the construct may provoke severe misspecification and construct validity problems. Omitting an indicator that represents a facet has serious repercussions because it means omitting a crucial part of the construct and giving an incomplete picture of it. With formative indicators, what is needed is a census of indicators, not a sample. Finally, formative indicators should not be expected to have the same antecedents and consequences and therefore their nomological net may differ (Bollen, 1989; Bollen & Lennox, 1991; Edwards & Bagozzi, 2000; Jarvis, Mackenzie & Podsakoff, 2003).

Specification of measurement models of multidimensional constructs: latent vs. non-latent constructs

So far, we have focused the discussion about measurement models on the relationships between measures and first-order, unidimensional constructs. However, a construct may be defined as multidimensional when it refers to several distinct but related dimensions that can be connected parsimoniously and meaningfully into one single holistic

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[7] A disturbance term ζ_1 is associated with the construct and represents the part of the construct that is not explained by the measures (although this disturbance term may be omitted and measurement error ignored in some cases, such that the construct is a linear combination of its measures). In contrast, the measures are conceived as error-free causes of the construct.

theoretical concept (Edwards, 2001; Law, Wong & Mobley, 1998). There are various possible ways a multidimensional construct can relate to its dimensions, and a necessary condition for a multidimensional construct to be well defined is that this relationship be clearly specified (Edwards, 2001; Jarvis, Mackenzie & Podsakoff, 2003). A first basic distinction regarding the possible ways a multidimensional construct can relate to its dimensions concerns the relational level (Law, Wong & Mobley, 1998) and the direction of the relationship. Thus, mirroring the disjunction between reflective and formative indicators, two alternative models of relationship between a multidimensional construct and its dimensions may be proposed, namely latent and non-latent models. Table 3 presents the guidelines for determining whether a multidimensional construct is latent or non-latent.

In terms of relational level, a latent multidimensional construct exists at a deeper and more embedded level than its dimensions, and it is understood as a non-observable underlying construct of higher order ξ_I which is manifested in different forms through its dimensions (Fig. 3a).[8] The causal relationship flows from the construct ξ_I to the dimensions η_i and the dimensions are effects of the latent higher-order construct. In this model, each of the dimensions is influenced by the latent higher-order construct and measures the multidimensional construct with different degrees of accuracy according to the magnitude of its specific component, S_i. Hence, variances and covariances among dimensions are explained by a higher-order multidimensional construct common to all dimensions (i.e. the latent higher-order construct).[9] As a result, a change in the higher-order latent construct is expected to result in changes in all dimensions. Consequently, under a latent model, equally reliable dimensions are essentially interchangeable and removing specific dimensions does

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[8] The dimensions represent unobservable variables manifested in turn through a series of observable indicators.

[9] While it is a necessary condition, high correlation among dimensions is not sufficient evidence that a latent model applies. Conceptual justification is needed to interpret a construct as latent.

not cause dire consequences. Rather, an incomplete sample of dimensions may present the advantage of being parsimonious while serving as a valid measure of the multidimensional construct even though it may be less reliable than a larger sample. Finally, since the dimensions are simply different forms manifested by the underlying construct, they are assumed to be interchangeable.

Table 3
Guidelines for determining whether a multidimensional construct is latent or non-latent

| | *Latent model* | *Non-latent model* | |
		Aggregate Model	*Profile model*
Alternative labels	Reflective second-order (Jarvis, Mackenzie & Podsakoff, 2003) Superordinate (Edwards, 2001)	Formative second-order (Jarvis, Mackenzie & Podsakoff, 2003)	n/a
Direction of causality implied by the conceptual definition	Direction of causality is from construct to dimensions	Direction of causality is from dimensions to construct	Does not apply
Dimensions are ... *Causes of changes*	Dimensions are reflections or manifestations of the construct Changes in the construct necessarily cause changes in the dimensions	Dimensions are defining facets of the construct Changes in the dimensions should cause changes in the construct	
Covariation among dimensions *Should a change in one of the dimensions be associated with changes in other dimensions?*	Dimensions are expected to covary Yes	Dimensions do not necessarily covary Not necessarily	
Are dimensions interchangeable? *Would dropping one of the dimensions alter the conceptual domain of the construct?*	Yes Dropping a dimension should not alter the conceptual domain of the construct	Dimensions need not be interchangeable Dropping a dimension may alter the conceptual domain of the construct	
Relational form	Does not apply	Construct can be formed as algebraic function of its dimensions	Levels of the construct are determined by profiling levels of each of the dimensions

(Based on Law, Wong & Mobley, 1998 and Jarvis, Mackenzie & Podsakoff, 2003)

Unlike latent constructs, non-latent constructs exist at the same level of abstraction as their dimensions and are defined as combinations of

their dimensions. Within non-latent models, a further subdivision can be made depending on the relational form whereby dimensions combine to form the multidimensional construct. As depicted in Table 3, a researcher will typically face two options to describe the relational form of non-latent models: an aggregate model and a profile model (Law, Wong & Mobley, 1998). Under an aggregate model (Fig. 3b), the causal relationship flows from the dimensions ξ_i to the non-latent higher-order multidimensional construct η_1 and the multidimensional construct may be formed as an algebraic composite of its dimensions, i.e. as a linear or a non-linear, stochastic or not, function of its dimensions (Jarvis, Mackenzie & Podsakoff, 2003). As far as profile models are concerned, these are applicable when it is considered theoretically meaningless to algebraically combine the constitutive dimensions of a construct. In this case, researchers can specify various levels of their dimensions, crossing combinations of these levels of the dimensions, and interpret the construct by profiling the levels (Law, Wong & Mobley, 1998).
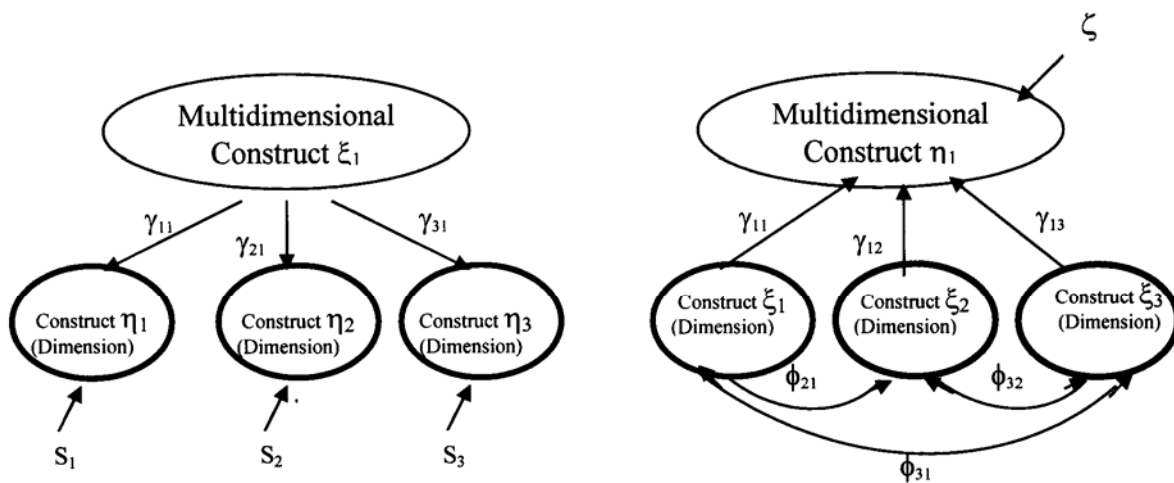

Fig. 3a. Latent model

Fig. 3b. Non-latent aggregate model

Fig. 3. Path diagrams of latent and aggregate models for the relationship between dimensions and multidimensional constructs[10]

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[10] Fig. 3b is a non-latent model in which the aggregate construct is not an exact combination of its dimensions. More restrictive models may drop the error term for the aggregate

For non-latent constructs, be they aggregate or profile, the dimensions are separate facets that define the construct and which constitute relatively independent sources of influence. Because causality does not run from the higher-order construct to the dimensions, the higher-order construct is not presumed to explain the variances-covariances of the dimensions. In non-latent models, dimensions are rarely correlated (ϕ_{kl} of low magnitude may be expected) given the suitable and inherent dimension heterogeneity. Therefore, internal consistency estimates or validity strategies based on classical test theory do not apply for non-latent multidimensional constructs (Bagozzi, 1994; Bollen, 1989; Jarvis, Mackenzie & Podsakoff, 2003).

Another essential implication of the heterogeneity of the dimensions of a non-latent multidimensional construct is that these dimensions are not interchangeable. While in the latent model an appropriate sample of dimensions is sufficient, an essential trait of non-latent models is that leaving out constitutive dimensions of the higher-order construct may provoke severe specification and construct validity problems. Omitting a dimension that represents a facet has serious repercussions because it means omitting a part of the multidimensional construct itself (Nunnally & Bernstein, 1994). With non-latent multidimensional constructs, what is needed is a census of dimensions, not a sample. Excluding a dimension gives an incomplete picture of the higher-order construct, missing a crucial part of it. Consequently, a high content validity achieved through a proper delineation of the domain of the multidimensional construct is particularly crucial when a non-latent model applies (Diamantopoulos & Winklhofer, 2001).

Implicit choices in prior literature on ICS

Whether a reflective or a formative model is specified for relating measured items and constructs has fundamental repercussions on the suitability of the model specification and, consequently, on the bias of

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multidimensional construct (Edwards, 2001).

the estimates, the validity of the tests and the flawlessness of the conclusions drawn. Whether a latent or a non-latent model is specified for relating dimensions and multidimensional constructs has analogous implications (Jarvis, Mackenzie & Podsakoff, 2003).

However, specifying which type of measurement model is appropriate should not be based on post hoc empirical evidence. In particular, researchers should refrain from invoking a formative or non-latent measurement model just as an explanation for low reliability estimates. Rather, the specification of measures as formative or reflective and the specification of multidimensional constructs as latent or non-latent should be regarded as a crucial step and grounded on a priori substantive theoretical reasoning and on the conceptual underpinnings of measures, dimensions and constructs (Edwards & Bagozzi, 2000). Researchers should be familiar enough with this theory-driven specification problem to anticipate the need for either additional items or constructs during the research design phase (Jarvis, Mackenzie & Podsakoff, 2003).

Nevertheless, in contrast with what is an increasing practice in other fields of management research, so far this issue has rarely been addressed in empirical management accounting studies (see Maalmi, Raulas, Gudergan & Sehm, 2004 for an exception; Luft & Shields, 2003 for an overview). In particular, none of the four studies regarding ICS under review explicitly states whether and why a particular measurement model has been chosen. All four studies define ICS as a unidimensional construct and uncritically test unidimensionality on the implicit basis of reflective models. Factor analysis procedures are applied to an incomplete sample of observed variables and used to isolate dimensions and (should this be the case) higher-order constructs. Implicitly, all of the reviewed studies consider the items as reflective measures of latent constructs, that is, the chosen measures are viewed as a sample of reflections or manifestations of common underlying latent constructs. In consequence, as long as the non-exhaustive sample ensures sufficient

reliability, it is considered unnecessary to verify that all items or dimensions of the domain of the constructs of interest are captured. Analogously, should higher-order factors surface, lower-order factors are viewed as a sample of reflections or manifestations of common underlying higher-order factors. Consequently, in the analysed studies, the alleged unidimensionality and reliability of the construct of interest is based on classical test theory, which is in fact pertinent only if reflective indicators (for which, for example, EFA, CFA and Cronbach's α would be suitable) or latent constructs are warranted (Bollen & Lennox, 1991; Edwards & Bagozzi, 2000). Although each of the reviewed papers implicitly specifies a reflective or latent model, this is neither explicitly stated nor theoretically justified.[11]

Following on from this, it may be argued that, given the novelty of ICS, prior studies have had difficulty in justifying the chosen measurement models. However, at the current stage of research, the essential attributes of ICS are identifiable from Simons' work and the guidelines for determining whether a construct is either reflective or formative, either latent or non-latent, are relatively well established. In this context, it is reasonable to expect future studies to justify explicitly their support for the measurement model they adopt, and to evaluate its implications. Incomplete samplings of observed variables should only be defended on the basis of reflective or latent models. If, however, reflective indicators and latent multidimensional constructs appeared to be unwarranted for capturing ICS, an incomplete, non-exhaustive sampling of the defining features indicated by Simons would cause serious misspecification of the construct, thwart validity

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[11] Interestingly, and even though all these studies base unidimensionality and reliability tests on an incomplete sampling of items and on implicit reflective or latent models, a detailed review of these studies does in fact reveal some indications of unidimensionality and reliability problems. For instance, Bisbe & Otley (2004) unexpectedly find that two factors stand out from a factor analysis of the four items expected to relate to ICS. The first factor, with three items loading, is retained as representing interactive use, and the second factor, with one item loading, is ignored. Abernethy & Brownell (1999) claim unidimensionality, yet they do not report the factor analysis results and report Cronbach's $\alpha < 0.6$ below the recommended lower limits of acceptability.

tests and invalidate findings and conclusions about the association between ICS and other variables.

A theoretical measurement model for interactive control systems: ICS as a non-latent multidimensional construct

In order to advance a theoretical measurement model (Segars, 1997) of ICS, we now move to the specification of the relationships between ICS, its properties and its observable measures. Grounded on a priori substantive conceptual reasoning rather than on post hoc empirical evidence (Edwards & Bagozzi, 2000, p. 171), we first discuss the specification of a suitable measurement model for representing the relationship between the ICS construct and its properties. Following this, we discuss the specification of the measurement model that is appropriate for representing the relationship between the properties of ICS and the observable indicators.

The relationship between ICS and its properties

Concerning the choice of the theoretical measurement model (Segars, 1997) that relates properties to the overall ICS construct, we argue that a multidimensional non-latent model is warranted. First, we believe that modelling ICS as a multidimensional construct is justified. The salient properties of ICS – intensive use by top management, intensive use by middle management, face-to-face challenge and debate, focus on strategic uncertainties and non-invasive, facilitating involvement – have distinct natures and do not collectively respond to one single theoretical concept, as would be needed in the case of unidimensional constructs. Moreover, and in contrast with a set of unrelated unidimensional constructs, the properties can be conceptualized as separate but integral parts of a meaningful abstraction that represents the overall construct of ICS (Law, Wong & Mobley, 1998). To enhance the content validity of ICS measurement and to ensure that

the full domain of the concept is covered, it is then argued that the interactive use of MCS should be conceptualized as a multidimensional construct comprising five dimensions (i.e. its properties).

Second, we think it justified to specify ICS as a non-latent multidimensional construct since ICS exists not at a deeper but at the same conceptual level as its properties. It is not an unobservable higher-order abstraction underlying its dimensions at a more embedded level, but rather it exists as a combination of these dimensions. The five dimensions form an overall meaningful representation of ICS but there is no latent construct that can be manifested solely as any one of the single dimensions. No property alone can represent ICS and the construct exists only as the combination of its properties, from which it is formed (Law, Wong & Mobley, 1998).

More specifically, a multidimensional construct should be modelled as non-latent if the following conditions prevail (Jarvis, Mackenzie & Podsakoff, 2003): (a) the dimensions are viewed as defining characteristics of the construct, (b) changes in the dimensions are expected to cause changes in the multidimensional construct, (c) changes in the multidimensional construct do not cause changes in the dimensions, (d) the dimensions do not necessarily share a common theme, (e) eliminating a dimension may alter the conceptual domain of the multidimensional construct, (f) a change in the value of one of the dimensions is not necessarily expected to be associated with a change in all of the other dimensions, and (g) the dimensions are not expected to have the same antecedents and consequences. As discussed in detail below, all seven conditions prevail in the case of ICS, which justifies its modelling as an aggregate multidimensional construct.

In the case of ICS, its dimensions cause the multidimensional construct, not the opposite. It does not make conceptual sense to argue

that there is an interactive use of control systems and so there is an intensive use by top management, a focus on strategic uncertainties, a non-invasive involvement and so on. On the contrary, it makes sense to argue that if a firm presents an intensive use of control systems both by top management and middle management, face-to-face discussions, a focus on strategic uncertainties, and a non-invasive involvement, then there is an interactive use of that control system. Dimensions are not driven by a higher-order latent construct; rather, the separate dimensions are the ones that define and form the construct. Consequently, changes in any of the constitutive dimensions of ICS may be expected to produce changes in the level of interactivity of the control systems rather than the opposite.

The dimensions of ICS are distinct in nature and do not share a common theme (hence, intensive use refers to frequency, while focus on strategic uncertainties refers to the object of attention and non-invasive involvement refers to leadership styles). Given these distinct natures, covariances among the dimensions of ICS are indeterminate. Firms may rank high for one property yet not for the other dimensions. If one dimension increases, ICS increases, but this does not necessarily imply simultaneous increases in all dimensions. A change in one dimension may result in a change in the construct even though the other dimensions remain constant. In fact, a review of the management control literature provides abundant examples of anecdotal evidence of control settings in which one property is present and a second property is not. For instance, Bonner, Ruekert & Walker (2002) depict a situation where intensive use of MCS by top management is not associated with non-invasive, facilitating involvement, but rather the opposite.

As a result, dimensions are not interchangeable. To enhance the content validity of the construct, a comprehensive coverage of the properties that form ICS as a non-latent multidimensional construct must be included in its operationalization. The dimensions of the multidimensional construct cannot be just a sample of different

manifestations but must be a census of all its facets or constituent parts (Bollen & Lennox, 1991; Law, Wong & Mobley, 1998). Excluding a constitutive dimension changes the composition of the non-latent construct. Failure to include any unique dimension of ICS would imply omitting an essential facet of the multidimensional construct, impairing its content validity. Finally, the dimensions of ICS do not necessarily share the same nomological net. Several studies (Bonner, Ruekert & Walker, 2002; Miller & Friesen, 1982; Simons, 1987a; Van der Stede, 2001) suggest that given their distinct nature, the five dimensions do not necessarily share the same antecedents and consequences.

To summarize, and to the extent that the seven conditions set forth by Jarvis, Mackenzie and Podsakoff (2003) apply to ICS, we think a non-latent measurement model is appropriate for representing the relationship between the dimensions of ICS and the multidimensional construct.

The relationship between indicators and properties of ICS

In the foregoing sub-sections we have specified the definitional domain of the higher-order construct ICS, delineating five specific properties, which correspond to dimensions of the multidimensional construct of interest. Each of these properties may be measured in turn through a series of multi-item observable indicators. Regarding the theoretical measurement model (Segars, 1997) that relates observable indicators to each of the five dimensions of ICS, a classical reflective model (Bollen, 1989; Bollen & Lennox, 1991; Edwards & Bagozzi, 2000) is warranted since each of the non-observable underlying latent dimensions (i.e. each of the properties of ICS) can be measured through a number of observable items which are manifestations of these dimensions.[12]

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[12] The resulting specification can be used in subsequent empirical research for the selection of sets of items that fully represent the domain of the construct. As an indication, we propose in

The properties of ICS are of a higher-order level of abstraction than the observable items, and although unobservable themselves, they cause the items (i.e. there is a non-invasive involvement and so there is dialogue, information-sharing and decision rights are not usurped). Furthermore, indicators within each dimension can be conceptually expected to covary and covariances follow a predictable pattern. Equally reliable indicators are essentially interchangeable and removing specific indicators does not imply dire consequences. Failure to include any unique indicator does not necessarily impair the construct validity of the measure. An incomplete sample of indicators can serve as a valid measure of the dimension even though it may be less reliable than a larger sample. Finally, the indicators of each of the dimensions have the same antecedents and consequences and share the same nomological network.

An integrative framework for specifying interactive use of management control systems

Thus far we have considered the theoretical domain and the conceptual underpinnings of ICS. We have suggested that a sound specification of the measurement model of ICS must include a series of observable reflective indicators. These indicators measure different manifestations of the five underlying latent constructs that represent a census of the inherent dimensions of ICS.[13] In turn, these latent constructs combine to form the higher-order non-latent multidimensional construct ICS. The five dimensions are relatively independent sources of influence but they are constitutive facets of the non-latent multidimensional construct which exists at the same

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Appendix D a measurement instrument based on Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Davila, 2000; Simons 1995a and Van der Stede, 2001 that captures the full census of constitutive dimensions of ICS.

[13] The enumeration of the five properties under consideration is undoubtedly subject to further refinement since future theory-driven developments might suggest the inclusion of additional properties, or future data-driven findings might recommend the reduction of the number of dimensions.

conceptual level as its dimensions and is defined as a combination of these dimensions.

On the basis of the current state of management control theory, we suggest that it is reasonable for researchers to define ICS according to either of the two types of non-latent models reported in the multidimensional constructs debate (Law, Wong & Mobley, 1998; Edwards, 2001), i.e. as an aggregate or as a profile construct. By opting for the theoretical specification of ICS as an aggregate construct, researchers define ICS as an algebraic function of its constitutive dimensions, and it is specified as a second-order non-latent factor that has first-order factors as formative indicators, while the first-order factors themselves have reflective indicators (Fig. 4a) (Jarvis, Mackenzie & Podsakoff, 2003). Alternatively, if ICS is defined according to a profile model (Fig. 4b), the researcher assumes that dimensions cannot be meaningfully combined in an algebraic form. Instead, the researcher will identify different profiles of style of use of MCS, grouping the firms into clusters with particular characteristics on the constitutive dimensions, and ICS will be identified as a meaningful cluster represented by a high intensive use by both top and operating managers, a high level of face-to-face discussions, a strong focus on strategic uncertainty and a non-invasive involvement. Although a thorough analysis of identification, estimation and validation issues is beyond the scope of this article, Appendix E provides some brief indications regarding the conditions for evaluation of both aggregate and profile multidimensional models.

In any case, we do not believe that it is appropriate to model ICS as a latent construct manifested through a series of reflective dimensions or indicators.[14] Rather, we believe that a non-latent multidimensional approach should be used. A context-specific nature of ICS (see

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[14] The implicit acceptance of latent models for ICS has been common practice in prior research (Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Van der Stede, 2001), mirroring the traditional practice in quantitative management accounting research (see Chenhall, 2003; Luft & Shields, 2003 for a review) of accepting the psychometric framework derived from classical test theory (Nunnally, 1978).

Section 2.2) would reinforce even more the argument that the conceptualization of ICS as a latent construct manifested through reflective measures or reflective lower-order constructs is not possible and therefore formative measures or formative lower-order constructs are suitable.
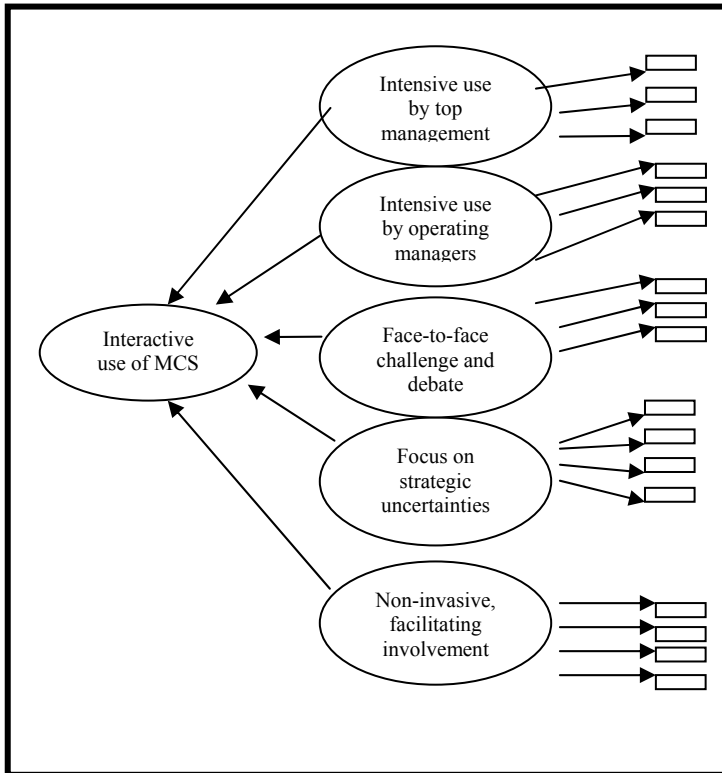

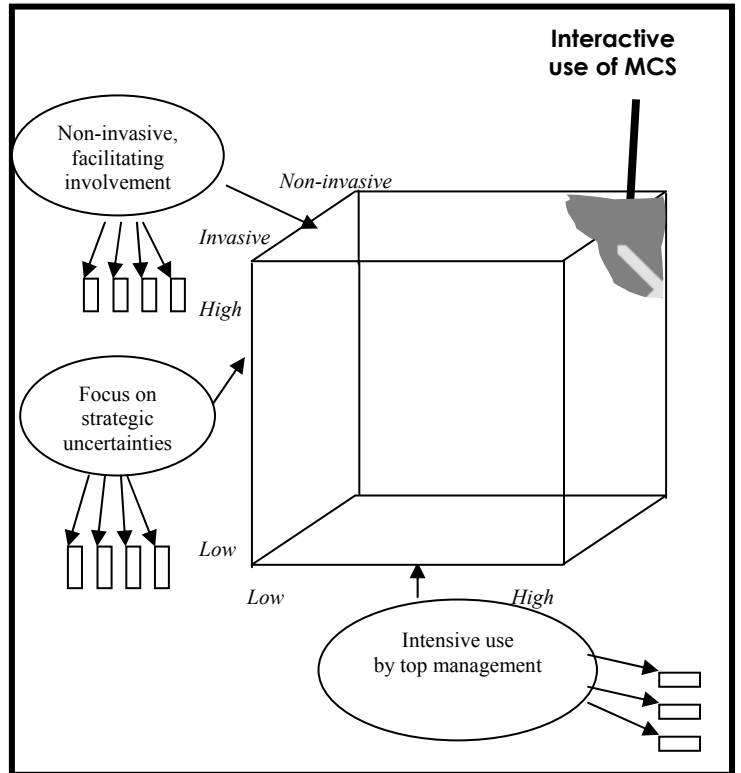<div align="center">

Fig. 4a. Aggregate model   Fig. 4b. Profile model
(only 3 dimensions represented)

**Fig. 4. Second-order factor theoretical specification
for interactive control systems**

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The conceptualization of ICS as a non-latent multidimensional construct as represented by its constitutive dimensions. In comparison with early research into ICS (e.g. Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Davila, 2000; Van der Stede, 2001), future empirical studies should pay special attention to the exhaustiveness of the inherent properties of ICS being measured. Furthermore, the conceptualization of ICS as a non-latent multidimensional construct

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establishes that the need for extra indicators covering the full domain of the construct, as represented by its dimensions, must be anticipated in the research process and taken into account at the questionnaire design stage (Bollen, 1989; Bollen & Lennox, 1991; Edwards, 2001; Edwards & Bagozzi, 2000; Jarvis, Mackenzie & Podsakoff, 2003; Law, Wong & Mobley, 1998). Another important implication for future research of the conceptualization of ICS as a non-latent multidimensional construct is that evaluation and validation of measurement instruments cannot be based on classical test theory procedures (Edwards & Bagozzi, 2000).

Conclusions

A central aim of theory-based quantitative research is to develop strong theoretical and conceptual foundations. The goal of this paper is to draw attention to the primary need for a sound theoretical specification of the construct interactive use of control systems (ICS) (Simons, 1995). This is required prior to fully developing measurement instruments and prior to fitting explanatory models that analyse structural relationships between ICS and other constructs. Our discussion suggests that two areas related to the theoretical specification of ICS deserve further attention in future empirical research: 1) the delineation of the construct domain, and 2) the selection of the appropriate measurement model for specifying the relationships between the construct ICS, its dimensions and its observable indicators. Inaccuracies in establishing the definitional domain of ICS and in specifying a suitable measurement model can lead to erroneous conclusions regarding the existence, magnitude and direction of associations between ICS and other constructs. We therefore argue for the field to progress towards a more careful theoretical specification.

Regarding the delineation of the domain of ICS, we suggest that in-depth analytical procedures such as thematic analysis are necessary to

make sure that the full definitional domain of a complex construct such as ICS is covered by the sample of indicators. This is a theoretical specification issue, based on a priori substantive theoretical reasoning and on the conceptual underpinnings. Therefore, it must be anticipated in the research process and taken into account prior to the questionnaire design stage. In the particular case of ICS, we first make a distinction between properties, expected implications and expected strategic outcomes of ICS. We argue that the definitional domain of ICS must be derived exclusively from themes related to properties. At this point in time the thematic analysis suggests that ICS is composed of five distinct inherent properties: 1) an intensive use by senior management; 2) an intensive use by operating managers; 3) the pervasiveness of face-to-face challenges and debates; 4) the focus on strategic uncertainties; and 5) a non-invasive, facilitating involvement. While intensity of use as captured by the first two properties is crucial in characterizing ICS, intensity in itself is not sufficient to capture the complexity of an interactive use of control systems. Contents and nature of the communication as captured by the remaining three properties are also relevant.

Furthermore, a correct theoretical specification needs to address explicitly the measurement model to be adopted (i.e. the nature and direction of the relationships between measures and constructs, and between dimensions and multidimensional constructs). Most recent management accounting studies, including those based on structural equation models, have placed great emphasis on explaining the nature and direction of causal relationships among constructs but surprisingly have devoted little attention to the specification of measurement models. With an uncritical reliance on classical test theory, measures are almost automatically accepted in this literature as reflections or manifestations of underlying latent constructs, and dimensions are viewed as different forms manifested by a higher-order latent construct. In contrast with this traditional practice in management accounting research, other fields of management research have increasingly become sensitive to the distinction between reflective

measurement models (in which indicators are manifestations of an underlying construct) and formative measurement models (in which indicators are constitutive facets of a construct) (Bollen, 1989; Bollen & Lennox, 1991; Edwards & Bagozzi, 2000) as well as to the analogous distinction between latent and non-latent models for relating second-order multidimensional constructs and their dimensions (Law, Wong & Mobley, 1998; Jarvis, Mackenzie & Podsakoff, 2003). We think it crucial for the sound cumulative progress of knowledge derived from MCS research to explicitly introduce this distinction into future empirical studies and to provide explicit arguments in favour of whatever measurement model is advocated by the researchers.

In the particular case of ICS, a review of its conceptual underpinnings suggests that, in contrast with the reliance on reflective or latent models that characterizes prior research, ICS should be modelled as a non-latent multidimensional construct formed from its constitutive dimensions. Rather than being manifestations of a common underlying construct, the five constitutive dimensions are separate facets of different nature that collectively define ICS and which are relatively independent sources of influence.

Specifying ICS as a non-latent multidimensional construct has important implications for future studies since it requires researchers to anticipate, early in the research process, the need to cover exhaustively the full domain of the construct as represented by a census of each of its constitutive dimensions. Omitting a dimension would be omitting a part of the construct. Furthermore, the conceptualization of ICS as a non-latent multidimensional construct implies that validation cannot be based on classical test theory (Nunnally, 1978) procedures. Rather, reliance on face, content and external validity criteria appears to be appropriate.

Finally, we believe that the discussion concerning the particular specification of ICS can be extended to other management accounting

constructs. Thus, it would seem appropriate for future research in management accounting to follow the increasingly common practice in other areas of management research by 1) clearly delineating the definitional domains of the constructs of interest and 2) making explicit whether formative or reflective indicators are warranted and whether latent or non-latent measurement models are applicable. It is our belief that an important element in the evolution towards more effective research into MCS is increased attention to the meaning and measurement of the constructs used to study systems' variables. Careful definition of these constructs and attention to their measurement will foster progress in understanding their effects within organizations.

Appendix A
Items in the measurement of interactive control systems (prior literature)

|	# items	Items in measure of the construct	Mgmt Control Systems under study
Abernethy & Brownell (1999)	4	1. I often use (MC) information as a means of questioning and debating the ongoing decisions and actions of department managers 2. The (MC) process is continuous- it demands regular and frequent attention from managers at all levels 3. There is a lot of interaction between top management and department/unit managers in the (MC) process 4. I use the (MC) process to discuss with my peers and subordinates changes occurring in the (organization)	Budgets
Davila (2000)	1	1. The information was used to monitor the project, but it was not discussed with my team except when it reported events that fell below plans or expectations vs. The information was used constantly in the interactions with my team. Frequently it was the main topic of our conversation	Product cost, Product design, Time-related, Customer-related, Resource input and, Profitability information
Van der Stede (2001)	6	1. Corporate superiors call me in to discuss budget deviations in face-to-face meetings 2. My corporate superiors, myself and my own subordinates often form a team to discuss and solve budgeting matters 3. Budget matters are discussed regularly with my corporate superiors even if there are no negative budgets deviations to report 4. I consult with my corporate superior on how to achieve my budget 5. Frequency of communication with the corporate parent for budget-related issues (formal / informal)	Budgets
Bisbe & Otley (2004)	4	1. The main aim of (MCS) follow-up is to force us to continually question and revise the assumptions upon which we base our plans 2. Whether there are deviations from planned performance or not, (MCS) follow-up reports are the main subject for face-to-face discussion with my executive team. 3. I pay regular and frequent attention to MCS. I use them permanently. 4. In my company, (MCS) require permanent attention from all managers	Budgets, Balanced scorecards, Project Management Systems,

Appendix B
Instance of assignment of quotes to codes

Quotes assigned to code "face-to-face discussions"

- Data generated by the (interactive control) system are interpreted and discussed in face-to-face meetings of superiors, subordinates and peers (Simons 1995a, p. 97)
- (Through interactive control systems, top managers) participate in face-to-face meetings with subordinates (Simons 1995a, p. 180)
- The data generated by the interactive control systems are best interpreted and discussed in face-to-face meetings of superiors, subordinates and peers. (Simons 1995b, p. 87)
- The discussions (about interactive control systems) involve operating managers directly (Simons 2000, p. 218)
- The discussions (about interactive control systems) are always face-to-face (Simons 2000, p. 218)
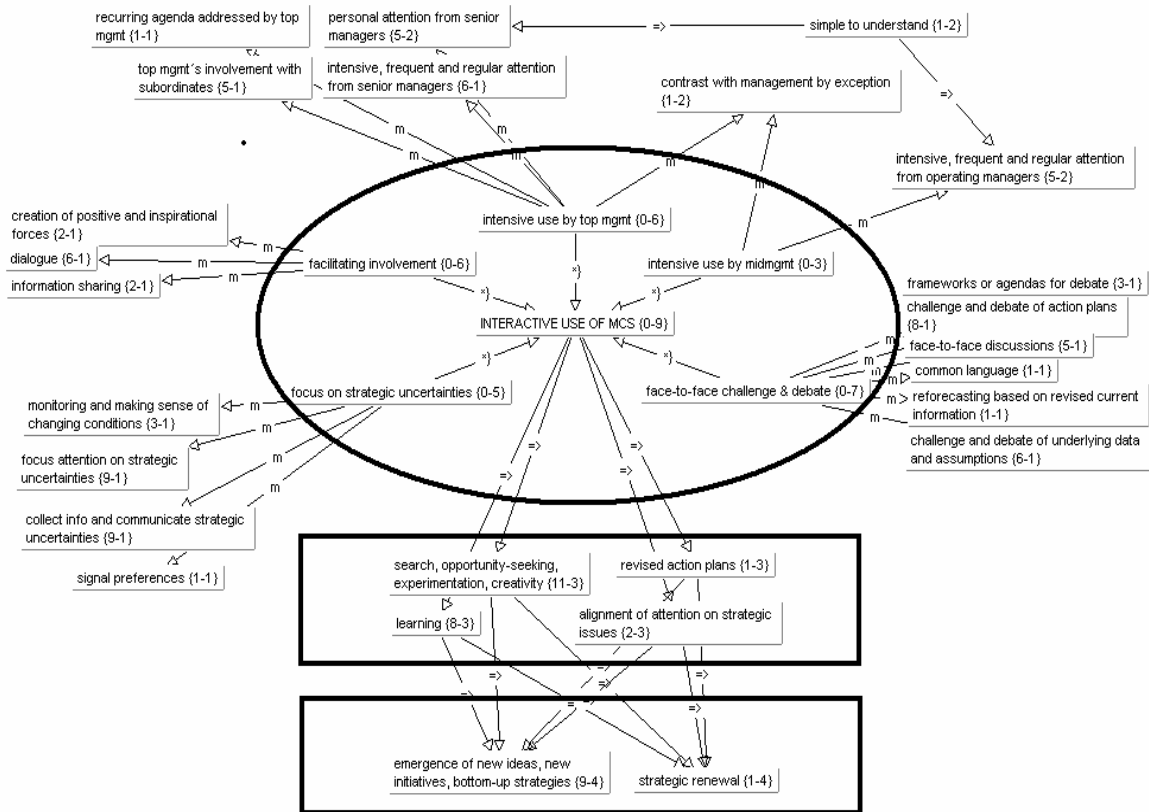
Appendix D
A measurement instrument for interactive control systems and its constitutive dimensions

For purposes of illustration, the following questions refer to one specific management control system, i.e. budgets. An initial version of the questionnaire was pre-tested with four academics in the areas of management control and business policy and twelve managers

Top managers are the target respondents, and are asked to rate on a Likert-type scale the extent to which they agree (1) or disagree (7) with the following statements. R after the statement means scores are reversed.

Intensive use by top management
- Budget-related issues demand my regular and frequent attention. I use budgets permanently.
- I pay attention to budget tracking reports only when there are deviations from planned performance (R).
- Through my personal attention to budgets, I get strongly involved with subordinates´ activities.

Intensive use by operating managers
- Budget-related issues demand regular and frequent attention from operating managers at all levels.
- Operating managers pay attention to budget tracking reports only when there are deviations from planned performance (R).
- In my company, budget information is used constantly by operating managers.

Face-to-face challenge and debate
- There are a lot of inter-personal interactions between top management and department/unit managers in the budget process.
- I often use budget information as a means of face-to-face questioning and debating the ongoing decisions and actions of operating managers.
- Budget matters are discussed personally between top managers and operating managers.

Focus on strategic uncertainties
- I use the budget follow-up process to review with my subordinates potential changes occurring in the conditions that could invalidate our current strategy.
- Budget reviews are primarily used to check whether we are on target regarding our critical performance variables (R).
- Budgets help us understand the competitive dynamics of our business.

Non-invasive, facilitating involvement
- Budget meetings create a positive environment that encourages information sharing rather than retaining private information.
- My interventions in the budget process are seen by operating managers as catalysts that encourage, inspire and facilitate new ideas for developing their own decisions.
- Because of my involvement in the budgeting process, I often have to invade the autonomy of operating managers and override their own decisions (R).
- When opportunities or problems occur, subordinates approach me to discuss budget matters without being asked to.

Appendix E
Evaluation of non-latent models

Researchers may opt for two approaches to define the relational forms whereby dimensions combine into a multi-dimensional non-latent construct (Law, Wong & Mobley, 1998). Under the first approach, aggregate models, it is considered that ICS is a composite that can be expressed as an algebraic function (i.e. linear or non-linear, stochastic or non-stochastic) of its dimensions. In this approach, the relative weights of each dimension in forming the final aggregate multidimensional construct are independent of the covariance structure and must be derived either theoretically or on the basis of the relations between the construct and other constructs in its nomological network. An alternative approach for specifying ICS as a non-latent construct is the profile model. Under a profile relational form, ICS is not modelled as an algebraic function of its dimensions but as one particular combination of levels of its dimensional characteristics. In this type of model, each dimension is dichotomized or artificially partitioned into discrete levels and different crossings or combinations of the dichotomized constitutive dimensions are used to form various theoretically meaningful profiles of the multidimensional construct. Below we introduce the conditions for evaluating models under each approach.

ICS as a non-latent aggregate construct

In some exceptional cases, the exact algebraic function of a non-latent composite, i.e. the relative weights, can be determined theoretically (Law, Wong & Mobley, 1998), but we do not think the current theoretical development of ICS is detailed enough at the current stage to prescribe such an exact algebraic function. Therefore, it is suitable to resort to structural equation models (SEM). There follows a brief discussion of identification, estimation and evaluation issues of non-latent aggregate models.

Before estimating an aggregate model, one needs to establish that all its parameters are identified, that is, that enough information is available for the estimation of every parameter in the model. Unfortunately, taken in isolation, non-latent aggregate models like the ones shown in Fig. 3b and Fig. 4a are statistically under-identified due to indeterminacies associated with the scale of measurement and the disturbance term of the multidimensional construct (Bollen and Lennox, 1991; Jarvis, Mackenzie & Podsakoff, 2003). Two conditions are necessary for the identification of ICS (MacCallum & Browne, 1993; Edwards, 2001). First, the scale of measurement of ICS must be established either by constraining a dimension's weight to be equal to one or by standardizing the variance of the multidimensional construct ICS. Second, the indeterminacy associated with the variance of the ICS disturbance term must be solved. Two particular specifications of SEM are often suggested for achieving this identification: PLS and MIMIC models. However, each of these has its own limitations and neither of the two is recommended for the specific case of ICS.

For its part, PLS imposes that ICS be an exact linear combination of its dimensions, eliminating error indeterminacy by removing or ignoring the error term (Garthwaite, 1994; Wold, 1982). Apart from imposing this restrictive condition, it must be noted that PLS bases its modelling procedures on the variance-covariance structure, which is inconsistent with the features of non-latent constructs. Alternatively, if the assumption of an exact linear combination is not imposed, MIMIC may be used. However, even though MIMIC models (Hauser and Goldberger, 1971) would be an optimal approach for solving error indeterminacy and achieving identification (Diamantopoulos & Winklhofer, 2001; Jarvis, Mackenzie & Podsakoff, 2003), MIMIC is not applicable in the case of ICS because MIMIC would require the inclusion of at least two observable reflective indicators of ICS which are not available on theoretical grounds, on the basis of the foregoing sections.

MIMIC not being applicable, a necessary condition for identifying the error term variance is that the measurement model be embedded within an extended model that captures the ICS nomological network and incorporates effects from ICS (Bollen, 1989) so that ICS emits at least two paths to other latent

variables measured with reflective indicators (Jarvis, Mackenzie & Podsakoff, 2003; MacCallum and Browne, 1993).

Once the measurement model is identified by capturing the nomological network, the following step in the statistical modelling is to estimate the model parameters. For example, if variables η_i and η_j are theorized as outcomes or consequences of ICS, the weights of the dimensions in forming the aggregate construct ICS can be estimated through the covariance structure of the five dimensions of ICS and η_i and η_j. Hence, the weights of the dimensions are influenced not only by the covariances among the dimensions that form ICS, but also by the relationships between these dimensions and the variables η_i and η_j caused by ICS. We can then estimate and test the multidimensional construct ICS in the SEM framework as a weighted composite of its dimensions plus a disturbance term and other additional unspecified variables (Bollen & Lennox, 1991; MacCallum & Browne, 1993).

ICS as a non-latent profile construct

Profile multidimensional constructs are derived from an artificial partition of each dimension into discrete categories. In this partition process, different profiles or configurations are identified by combining the various levels across the dimensions. In contrast with aggregate models, where ICS is a continuous variable which is an algebraic function of its dimensions, ICS under a profile approach would be modelled as a particular combination of levels of its constitutive dimensions.

Strictly speaking, in our case the profile construct being defined is styles of use of MCS, and ICS is one particular profile of the construct styles of use of MCS. Indeed, styles of use of MCS can be interpreted only under its various profiles (e.g. no use, diagnostic use, interactive use, dysfunctional use, interfering use and so on). A firm cannot rank high or low in styles of use of MCS. Instead, it will rank high or low in each of the captured dimensions and consequently will rank high or low in (be close to or far away from) one given style of use of MCS. On theoretical grounds, ICS would be identified as one theoretically meaningful profile that is characterized by the crossing of a very intensive use by top management, a very intensive use by middle management, a high level of face-to-face challenge and debate, a strong focus on strategic uncertainties and a strongly non-invasive, facilitating involvement.

In order to use such a profile multidimensional construct in quantitative analysis, Law, Wong & Mobley (1998) suggest as a general rule the computation of the profile centroid in the multidimensional space, whose coordinates are the averages of the data points within the profile. The score of each individual within a given profile is then computed as the reversed Euclidean distance of the individual's ratings to the profile centroid. In the particular case of ICS, we specifically suggest the computation of the individual scores as the reversed Euclidean distance from each firm to the ideal point of the ICS profile whose coordinates are the maximum value achievable in each of the constitutive dimensions.

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