TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Wirtschaftswissenschaften Lehrstuhl für BWL, insb. Betriebliches Rechnungswesen/Controlling

DISSERTATION

ACCOUNTING AND INNOVATION: EVIDENCE FROM EXTERNAL DISCLOSURE AND INTERNAL MANAGEMENT CONTROL SYSTEMS

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geboren am 09. Oktober 1982 in Mailand (Italien)

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Disputation:	04. Juni 2013

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List of abbreviations

ACCA	Association of Chartered Certified Accountants
AGFI	Adjusted goodness of fit index
AIC	Akaike's information criterion
AICPA	American Institute of Certified Public Accountants
AMOS	Analysis of moment structures
ANOVA	Analysis of variance
BMS	Between-targets mean square
CAIC	Consistent Akaike's information criterion
CEO	Chief Executive Officer
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CFO	Chief Financial Officer
CTO	Chief Technology Officer
EBIT	Earnings before interests and taxes
ECVI	Expected cross-validation index
EIASM	European Institute for Advanced Studies in Management
EM	Expectation-maximization
Eurostat	Statistical Office of the European Union
GAAP	Generally Accepted Accounting Principles
IAS	International Accounting Standard
IASB	International Accounting Standard Board
IC	Intellectual capital
ICAEW	Institute of Chartered Accountants in England and Wales
ICC	Interclass correlation coefficient
ICS	Intellectual capital statements
INC	Innovation capital

INCD	Innovation capital disclosure
INCDQUAL	Innovation capital disclosure quality
INCDQUANT	Innovation capital disclosure quantity
IFRS	International Financial Reporting Standards
IPO	Initial public offering
K	Number of judges
LOC	Levers of control
MCAR	Missing completely at random
MCS	Management control systems
METI	Japanese Ministry of Economy, Trade and Industry
ML	Maximum likelihood
N	Number
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NHKI	Nordic Harmonized Knowledge Indicators
OECD	Organization for Economic Co-operation and Development
PD	Product development
PIIP	Putting IC into Practice
R&D	Research and development
RICARDIS	Reporting Intellectual Capital to Augment Research, Development and Innovation in SMEs
RMSEA	Root mean square error of approximation
S.D.	Standard deviation
SEM	Structural equation modeling
SFAS	Statement of Financial Accounting Standards
SKE	Australian Society for Knowledge Economics
SME	Small and medium enterprises

SRMR	Standardized root mean square residual
TSTI	Three-step test-interview
WMS	Within-targets mean square

I Framework of the dissertation

This dissertation deals with the topic of "accounting and innovation" and provides evidence for the area of innovation from two accounting perspectives, i.e., the external disclosure perspective and the internal management control system perspective. The present section introduces the dissertation by providing the main definitions, drawing a brief state of the art of the research areas, and summarizing the three papers that build the main part of this cumulative dissertation. The first chapter of this introduction provides the basic definitions from the area of innovation research and clarifies the macro- and microeconomic importance of innovations. The second chapter addresses the accounting perspectives on the topic of innovation and summarizes the papers of this dissertation.

1 Innovation

About sixty years ago, Schumpeter (1943) provided the basis for today's macro- and microeconomic interest in innovations. He described the business process of the substitution of old products and processes with new ones as "creative destruction". Furthermore, he argued that this process, carried out by creative entrepreneurs, is the basis for economic growth. Innovations allow firms to gain competitive advantage and thus temporal monopolistic returns (Schumpeter, 1943). Until today, researchers (e.g. Capon, Farley, & Hoenig, 1990; Griliches, 1981; Hall & Mairesse, 1995) and institutions (e.g. OECD, 2010b) agreed on the positive effect of innovations for the performance and growth of firms and economies. Politicians and economists praise innovations for their positive effects on employment and quality of life. Firms seek diversification from their competitors through innovations. This is the reason why issues such as the enhancement, measurement, and disclosure of innovations are still a topic of concern for research, institutions, and firms (e.g. Balachandra & Friar, 1997; Damanpour, 1991; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; OECD, 2010a).

The increasing importance of innovations is reflected in numerous statistics. For example, the share of governmental expenditures on research and development (R&D) relative to total governmental expenditures increased between 2006 and 2010 (1.51% to 1.56% on average in all the 17 countries in the Euro-region, 1.68% to 1.90% in Germany, 1.33% to 1.61% in Austria). The percentage of R&D expenditures from business firms relative to GDP also experienced a rapid growth between 2006 and 2010 (1.19% to 1.27% on average in all the 17 countries in the Euro-region, 1.78% to 1.90% in Germany, 1.72% to 1.88% in Austria). In the same timeframe, the number of employees engaged in research in both the private and

public sectors increased (from 933,491 to 1,086,772 in all the 17 countries of the Euro-region, from 279,822 to 327,500 in Germany, from 291,999 to 354,942 in Austria) (Eurostat, 2011). However, the overall increased input into innovation processes does not always lead to increased innovation performance, making the issue of the management of these processes one of the key interests of firms. For example, the percentage of total turnover generated by innovations decreased between 2006 and 2008 (from 13.4% to 13.3% on average in all the 27 European Union countries, from 19.2% to 17.4% in Germany, from 13.6% to 11.2% in Austria; data for 2010 not yet available) (Eurostat, 2011).

The longstanding interest in the topic of innovation reached accounting research about one decade ago (see the survey of the literature presented in tables I - 1 and I - 3). This dissertation works at the crossroads of these two areas of research by considering the topic of innovation from different accounting perspectives: the external disclosure perspective and the internal management control system perspective (see section 2). Before describing these perspectives, this section clarifies the definitions about innovation and related terms that will become relevant in the course of the dissertation.

According to the OECD (2005) definition, an "[…] innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46). The distinction made within this definition can be found largely in Schumpeter's work when he argues that there are five types of innovations, i.e., the introduction of new products, the introduction of new production methods, the opening of new markets, the development of new sources of supply for materials, and the reorganization of the market structure within an industry (Schumpeter, 1943). Similarly, the above OECD definition discriminates among product, process, marketing, and organizational innovation (OECD, 2005).

> "A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics" (OECD, 2005, p. 48).

In contrast, when a "[…] new or significantly improved production or delivery method" (OECD, 2005, p. 49) is generated, then a process innovation is put in place. A marketing innovation requires "[…] the implementation of a new marketing method involving signifi-

cant changes in product design or packaging, product placement, product promotion or pricing" (OECD, 2005, p. 49), while "[…] the implementation of a new organisational method in the firm's business practices, workplace organization or external relations" (OECD, 2005, p. 51) identifies organizational innovations.

In particular, product innovations are generated through R&D (OECD, 2005). Indeed, according to the OECD,

> "research and experimental development […] comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2002, p. 30).

While basic research is not intended for the generation of new products and processes, applied research and development activities are aimed at producing new products or at improving those that are already produced substantially. While applied research draws on investigations to achieve new knowledge, development relies on knowledge already available in the firm (OECD, 2002).

In accounting research, one additional, innovation-related term emerged with the advent of intellectual capital research: innovation capital. Innovation capital describes the renewal abilities of a firm and related results in the form of intellectual property rights and other tangible, intangible, and financial assets (Edvinsson & Malone (1997)). This definition thus encompasses innovations in terms of the OECD definition, i.e., the result of the renewal process that leads to new products, processes, marketing, or organizational methods. However, it also requires the investigation of the procedures needed to obtain these results, e.g., in terms of employees and the training they received (human capital), the involvement of the customers (customer capital), and the corporate culture and managerial processes required (structural capital).

The first paper in this cumulative dissertation (see section 2.1.2) addresses innovation capital and its disclosure, while the second and third papers (see section 2.2.2 and 2.2.3) are focused on product innovations and on the systematic work required for their creation and based on knowledge already available in the firm, i.e., product development.

2 Accounting

The discipline of accounting can be categorized into two sub-dimensions: external disclosure on the one hand and management accounting and control on the other hand (Johnson & Kaplan, 1987). While external disclosure investigates the mandatory and voluntary reporting of performance information needed to reduce the information asymmetry between managers and stakeholders, management accounting and control deals with the formal processes taken by management in order to direct the behavior of organizational members toward the achievement of organizational goals (Chenhall, 2007). This cumulative dissertation aims at answering multifaceted research questions, from both perspectives, on the area of innovation.

Innovation is relevant both for external disclosure and for internal management accounting and control. Section 2.1 discusses the degree of external disclosure (both mandatory and voluntary) as well as antecedents and consequences of disclosure, while the design of management accounting and control systems for innovation efforts and its performance effects is addressed in section 2.2.

2.1 External disclosure

The last decades have experienced a dramatic increase in market-to-book ratios for some firms (Lev, 2001). One of the defensible justifications for the huge gap between market and book values is the existence of intellectual capital, which cannot be reflected in book values owing to restrictive financial standards regulations (Stewart, 1997). According to Lev, 2001, the terms "intellectual capital", "intangibles", and knowledge assets" can be used interchangeably to describe "[…] a non-physical claim to future benefits […]" (Lev, 2001, p. 5). Edvinsson (1997) categorizes intellectual capital in three dimensions: human (e.g., employee knowledge or the training of the workforce), internal (i.e., structural, e.g., the corporate culture or the management processes), and external (i.e., relational, e.g., the firm's customers and reputation) capital.

This change in market-to-book ratios reflects the shift from an industrial to a knowledge-based structure of our Western economies. In turn, this implies changes in the information required for decision-making by participants in economic life. For example, financial analysts and other stakeholders consider information on the innovation capital of a firm among the major information when making investment decisions (Eccles, Phillips, & Herz, 2001; Lev, 2001; Tasker, 1998). These changed requirements may exercise pressure on both standard setters and firms to adapt the mandatory and voluntary disclosure provided. Section 2.1.1 describes the state of the art of mandatory rules for financial statements and of

voluntary disclosure channels, while section 2.1.2 summarizes the results of the previous section by identifying the research questions on voluntary disclosure of innovation efforts addressed in paper 1.

2.1.1 Mandatory and voluntary disclosure of innovation efforts

Corporate mandatory and voluntary disclosure have been the focus of research since the 1960s (Ahmed & Courtis, 1999). Since then, researchers have analyzed the level of disclosure and its antecedents (e.g. Ahmed & Courtis, 1999) as well as its consequences (e.g. Leuz & Wysocki, 2008). Within voluntary disclosure there is a great degree of variability of the level of disclosure that is provided owing to the lack of obligation by law, while however mandatory disclosure often also leaves space for managerial discretion and thus for meaningful between-firm differences. As a result, researchers try to explain the antecedents and consequences of this variability.

The level of disclosure provided is dependent on a comparison of costs and benefits of disclosure (Depoers, 2000; Leuz & Wysocki, 2008). Costs of disclosure are classified into direct costs, i.e., preparation, certification, and dissemination costs, and indirect costs, i.e., opportunity costs and proprietary costs arising from the risk that disclosed information may be used by competitors to the firm`s disadvantage (Leuz & Wysocki, 2008). Benefits from disclosure arise in terms of reduced information asymmetries between managers and investors and thus lower costs of capital (see the arguments in agency theory, e.g. Botosan, 1997; Healy & Palepu, 2001; Jensen & Meckling, 1976; Leuz & Wysocki, 2008), in terms of an improved reputation as a "good corporate citizen" (see the arguments in legitimacy theory, e.g. Dowling & Pfeffer, 1975; Parsons, 1960; Pfeffer & Salancik, 1978; Weber, 1978), and in terms of benevolent behavior by stakeholders such as employees or banks (see the arguments by stakeholder theory, e.g. Clarkson, 1995; Freeman, 1984).

This general reasoning can be transferred to the area of disclosure about innovation efforts for both completely voluntary disclosure and for disclosure where managerial discretion is induced by legal regulations. Direct costs of disclosure of innovation efforts arise from the need to collect data which are probably not yet available in the required form in the firm, such as the distinction of expenses for each R&D project, the development and gathering of key performance indicators for the entire innovation portfolio of the firm, etc. Indirect costs may arise, for example, when disclosure on innovation suggests that a firm becomes active in certain new markets and this is imitated by competitors, thus diminishing the monopolistic returns that the firm can gain as a pioneer in this market. Besides these costs, a number of bene-

fits may arise from innovation disclosure. According to agency theory, innovation efforts carry high risks that increase the information asymmetry between managers and investors (Aboody & Lev, 2000). Thus, voluntary disclosure on innovation activities may contribute to a reduction in the insecurity of investors and, therefore, reduce the cost of capital and facilitate the provision of financial support for innovation projects. According to legitimacy theory, innovative actions are considered socially desirable as they can be expected to bring progress to society (Gardberg & Fombrun, 2006). Therefore, firms will benefit in terms of the inflow of capital, labor, and customers when informing the public about innovation efforts. Similarly, the stakeholder approach addresses the benefits arising from satisfying the manifold information interest by a number of stakeholders, who in turn affect the performance of the innovation positively or negatively, e.g., by purchasing the innovation or by providing funds for R&D projects.

Firms will increase their disclosure level to the point where the benefits from disclosure equal the costs. When the costs surpass the benefits, no (additional) disclosure is provided, unless some legal regulation (without room for discretionary decisions) is set up (Leuz & Wysocki, 2008). The following section (2.1.1.1) sketches the disclosure required by law for innovation capital according to IFRS (International Financial Reporting Standards), U.S. GAAP (United States Generally Accepted Accounting Principles), and German GAAP. In contrast, section 2.1.1.2 presents the media used to disclose innovation capital voluntarily, as well as related research.

2.1.1.1 Mandatory disclosure of innovation efforts

Mandatory disclosure in financial statements has been criticized widely for its inability to deliver adequate, value-relevant information about innovations (e.g. Lev & Sougiannis, 1996; Lev & Zarowin, 1999). Innovations and related efforts represent the basis for future value creation (Lev & Sougiannis, 1996). Like assets such as machines used in the production process, innovations generate returns over many years, and thus it seems sensible to capitalize related expenses in the balance sheet and amortize them over their useful lifetime (Lev & Sougiannis, 1996), instead of expensing them immediately in the profit and loss statement.

Depending on the financial reporting regime applied in the firm, different but internationally converging regulations (Schipper, 2005) delineate the boundaries for the treatment of innovation expenses in the mandatory financial statements.

The consideration of innovations in mandatory disclosure is restricted mostly to the discussion on R&D expenses. Until 2009, the German GAAP required full expensing of R&D

expenses, thus forbidding the recognition and subsequent amortization of these investments in the firm. In 2009, in the course of efforts for convergence between national and international financial reporting standards, the German GAAP created opportunities for the partial recognition of R&D expenses in the balance sheet, as already allowed by the IFRS. Thus, the chance to show investments in intangibles in the financial statement was no longer restricted to large capital market oriented firms.

The recognition of all types of intangible assets following IFRS is regulated in the IAS 38 (International Accounting Standard 38). It distinguishes the treatment of intangible assets mainly on the basis of the way in which the intangible asset is obtained by the firm, i.e., if is generated internally, acquired separately, or acquired in a business combination. Overall, the recognition of an intangible asset (and thus of innovation capital assets) requires the demonstration of (1) the fulfillment of the criteria for the definition of an intangible asset; and (2) the fulfillment of the criteria for recognition in the balance sheet (IAS 38.18). (1) requires the identifiability of the asset, firm control over the resource, and future economic benefits from the asset (IAS 38.10). (2) requires that the expected future economic benefits will probably flow to the firm and that the costs incurred for the acquisition or generation of the asset (the basis for initial valuation) can be measured reliably (IAS 38.21 and 38.24). Thus, in terms of innovation capital, acquired patents or licenses can be recognized based on the aforementioned criteria at the purchase price (IAS 38.27). Furthermore, for internally generated intangible assets, the IFRS requires a distinction between research expenses and development expenses, dictating that the former cannot be recognized, while the latter can be recognized if the firm can demonstrate (1) the technical feasibility of completing the intangible asset; (2) its intention to complete the intangible asset; (3) its ability to use or sell the intangible asset; (4) how the intangible asset is intended to generate future economic benefits; (5) the availability of adequate resources to complete the development of the intangible asset; and (6) its ability to measure reliably the expenditures attributable to the intangible asset during its development (IAS 38.54-38.57). The costs of internally generated development expenses also encompass the fees to register a legal right, e.g., a patent (IAS 38.66).

In order to be able to attribute the correct amount of costs to a specific intangible asset created in the firm for recognition in the balance sheet, there is a clear demand for a management accounting and control system which allows the verification of the fulfillment of the criteria mentioned above (see section 2.2 for the discussion of management accounting and control systems for product development). For example, management accounting should make sure that each development project is assigned all direct costs such as materials, sala-

ries, and wages, but also those indirect costs such as the rent for the product development building that can be attributed reliably to the project. Thus, for this area, firms seem to experience a convergence of financial and management accounting.

Finally, the costs of intangible assets acquired during a business combination have to be recognized based on the fair value of these assets (IAS 38.33).

It must be noted that the opportunity to recognize expenses for intangible assets in general, as well as innovation capital, is used to very different degrees by firms from different as well as the same industries (Hitz, 2007). This reflects the managerial discretion behind this regulation and also related earnings management potential.

European firms that aim to enter the U.S.-American capital market are required to prepare financial statements according to the U.S. GAAP. For innovation capital, the U.S. GAAP prescribes in SFAS2 (Statement of Financial Accounting Standards 2) the immediate expense of internally generated research as well as development costs related to a specific innovation project when incurred. In turn, intangible assets (e.g., patents or licenses) that are acquired individually or with other assets are recognized in the balance sheet based at their fair value (SFAS 142).

In summary, financial accounting standards only allow a very restricted view to firms' innovation efforts. Even if, given certain prerequisites, a part of R&D expenses can be recognized in the balance sheet according to IFRS and German GAAP, investors and other stakeholders may miss information about the entire product pipeline, applications for patents, the innovation culture put in place in the firm, etc. (Eccles, et al., 2001; Lev, 2001; Tasker, 1998). Furthermore, the managerial discretion behind the IFRS and local GAAP regulations reduces further the information content of both expensed and recognized development costs.

However, this information regarding potential future economic benefits of the firm, and thus the value creation process, can be presented by the media of voluntary disclosure, which are addressed in the next section.

2.1.1.2 Voluntary disclosure of innovation efforts

Disclosure about innovation is investigated in the broader research area of intellectual capital disclosure. Innovation capital occupies one particular position within the different types of intangibles. In addition to the macro- and micro-economic importance of innovations described in section 1, innovation capital is the result of the efforts given to the main intellectual capital categories (i.e., human, internal, and external capital) (Lev, 2001; Mouritsen, Bukh, &

Bang, 2008). At the same time, innovation capital is the basis for the increase in future benefits through the enhancement of the main intellectual capital categories (Lev, 2001). For example, good customer relations allow the firm to obtain new impetus with regard to customer needs and expectations (i.e., external capital) and, thus, the fundament for new products and services. At the same time, innovative products may lead to an increase in the number of customers or to better customer retention. Similarly, highly qualified and motivated employees (i.e., human capital) will increase the innovativeness of the firm. At the same time, the resulting commitment to innovation will attract properly qualified and motivated workforce. Finally, an innovative culture (i.e., internal capital) will encourage the innovativeness of the firm. This innovativeness will simultaneously create the chance to revise the processes in the firm regularly and adapt them to new requirements.

Given this interwoven relation of innovation capital on the one hand and human, internal, and external capital on the other hand, it is reasonable to start the analysis of the voluntary disclosure of innovation capital by an investigation of the research on voluntary intellectual capital disclosure. Table I - 1 summarizes the most prominent studies dealing with the disclosure of different forms of intangible assets, i.e., studies that are published in the English language in academic double-blind review journals. The studies in table I - 1 use the method of content analysis to collect data about the disclosure on intellectual capital (or parts of it) in different media. Content analysis is a methodology which codifies text into categories and, in the case of a quantitative approach, quantifies the frequency of occurrences within each category (Krippendorff, 2004).

Table I - 1: Previous studies on intellectual capital disclosure (in chronological order)

Study	n	Country	Media used	Type of study	Intellectual capital categories
Subbarao & Zeghal (1997)	120	U.S.A. (20), Canada (20), Germany (20), U.K. (20), Japan (20), South Korea (20)	Annual report	Descriptive (quantitative)	Human capital
Entwistle (1999)	113	Canada	Annual report	Drivers	R&D
Guthrie & Petty (2000)	20	Australia	Annual report	Descriptive (quantitative)	Internal, external, human capital
Brennan (2001)	11	Ireland	Annual report	Descriptive (quantitative)	Internal, external, human capital
Olsson (2001)	18	Sweden	Annual report	Descriptive (quantitative)	Human capital
Williams (2001)	31	U.K.	Annual report	Drivers and effects	---
Mouritsen, Larsen, & Bukh (2001a)	1	Sweden	Intellectual capital statement	Descriptive (qualitative)	Human capital and structural capital
Mouritsen, et al. (2001b)	17	Denmark	Intellectual capital statement	Descriptive (qualitative)	Employees, customers and publics, process, technology
Ordóñez de Pablos (2002)	13	Austria (1), Denmark (3), India (1), Israel (2), Spain (5), Sweden (1)	Intellectual capital statement	Descriptive (qualitative)	Internal, external, human capital
April, Bosma, & Deglon (2003)	20	South Africa	Annual report	Descriptive (quantitative)	Internal, external, human capital
Bontis (2003)	10,000	Canada	Annual report	Descriptive (quantitative)	---
Bozzolan, Favotto, & Ricceri (2003)	30	Italy	Annual report	Drivers	Internal, external, human capital

Table I - 1 (continued): Previous studies on intellectual capital disclosure (in chronological order)

Study	n	Country	Media used	Type of study	Intellectual capital categories
Ordóñez de Pablos (2003)	5	Spain	Intellectual capital statement	Descriptive (qualitative)	Internal, external, human capital
Abeysekera & Guthrie (2004a)	30	Sri Lanka	Annual report	Descriptive (quantitative)	Internal, external, human capital
Abeysekera & Guthrie (2004b)	30	Sri Lanka	Annual report	Descriptive (quantitative)	Human capital
Goh & Lim (2004)	20	Malaysia	Annual report	Descriptive (quantitative)	Internal, external, human capital
Oliveras & Kasperskaya (2004)	13	Spain	Annual report	Descriptive (quantitative)	Internal, external, human capital
Seleim, Ashour, & Bontis (2004)	38	Egypt	Annual report	Descriptive (quantitative)	Internal, external, human capital
Abdolmohammadi (2005)	58	U.S.A.	Annual report	Drivers and effects	Brand, competence, culture, customers, IT, intellectual property, partnership, personnel, proprietary process, R&D
Abeysekera & Guthrie (2005)	30	Sri Lanka	Annual report	Descriptive (quantitative)	Internal, external, human capital
Bukh, Nielsen, Gormsen, & Mouritsen (2005)	68	Denmark	IPO prospectus	Drivers	Employees, customers, IT, processes, R&D, strategic statements

Table I - 1 (continued): Previous studies on intellectual capital disclosure (in chronological order)

Study	n	Country	Media used	Type of study	Summary of results
García-Meca, Parra, Larrán, & Martínez (2005)	257	Spain	Report to analysts	Drivers	Strategy, processes, customers, technology, human capital, R&D and innovation
Ordóñez de Pablos (2005)	3	India	Intellectual capital statement	Descriptive (qualitative)	Internal, external, human capital
Vandermaele, Vergauwen, & Smits (2005)	60	The Netherlands (20), Sweden (20), U.K. (20)	Annual report	Drivers	Internal, external, human capital
Vergauwen & van Alem (2005)	89	France (37), Germany (28), The Netherlands (24)	Annual report	Descriptive (quantitative)	---
Guthrie, Petty, & Ricceri (2006)	150	Hong Kong (100), Australia (50)	Annual report	Drivers	Internal, external, human capital
Bozzolan, O`Reagan, & Ricceri (2006)	60	Italy (30), U.K. (30)	Annual report	Drivers	Internal, external, human capital
Cordazzo (2007)	86	Italy	IPO prospectus	Drivers	
Jones (2007)	119	U.S.A.	Annual report	Drivers and effects	R&D
Lee, Neilson, Tower, & Van der Zahn (2007)	128	Australia	Website	Drivers	Human resources, patient, IT, process, innovation, strategic capital
Singh & Van der Zahn (2007)	334	Singapore	IPO prospectus	Effects	---
Vergauwen, Bollen, & Oirbans (2007)	60	Sweden (20), U.K. (20), Denmark (20)	Annual report	Drivers	Internal, external, human capital

Table I - 1 (continued): Previous studies on intellectual capital disclosure (in chronological order)

Study	n	Country	Media used	Type of study	Summary of results
White, Lee, & Tower (2007)	96	Australia	Annual report	Drivers	Employees, customers, IT, processes, R&D, strategic statement
Zeghal, Mouelhi, & Louati (2007)	150	Canada	Annual report	Drivers	R&D
Abeysekera (2008)	20	Sri Lanka	Annual report	Drivers of disclosure	Internal, external, human capital
Gerpott, Thomas, & Hoffmann (2008)	29	(international)	Annual report and website	Drivers and effects	Human, customer, supplier, investor, process, location, innovation capital
Kamath (2008)	30	India	Annual report	Descriptive (quantitative)	---
Mouritsen, et al. (2008)	1	Australia	Annual report	Descriptive (qualitative)	Internal, external, human capital related to innovation capital
Oliveras, Kasperskaya, & Fargas (2008)	12	Spain	Annual report	Drivers	Internal, external, human capital
Schneider & Samkin (2008)	82	New Zealand	Annual report	Descriptive (quantitative)	Internal, external, human capital
Sonnier, Carson, & Carson (2008)	141	U.S.A.	Annual report	Drivers	Internal, external, human capital

Table I - 1 (continued): Previous studies on intellectual capital disclosure (in chronological order)

Study	n	Country	Media used	Type of study	Summary of results
Striukova, Unerman, & Guthrie (2008)	15	U.K.	Website, annual report, annual review, interim report, report to analysts, preliminary report, corporate social responsibility report	Descriptive (quantitative)	Internal, external, human capital
Whiting & Miller (2008)	70	New Zealand	Annual report	Effects	Internal, external, human capital
Campbell & Abdul Rahman (2010)	1	U.K.	Annual report	Descriptive (quantitative)	Internal, external, human capital

I identified 44 studies, the majority of which deal with voluntary disclosure in the annual reports. Indeed, annual reports not only provide financial data, but also a number of voluntary narratives, such as the introductory remarks, the chairman's statement, the chief executive's statement, any operating and financial review content, the directors' report, and some social/environmental content (Campbell & Abdul Rahman, 2010). Other disclosure instruments encompass the IPO (initial public offering) prospectus, websites, or intellectual capital statements (ICS). ICS are documents issued on a voluntary basis, enabling companies to present their intangible assets – and thus their innovation efforts – in a narrative, visual, and numeric form (Mouritsen, et al., 2001b).

The focus of intellectual capital disclosure research on publicly available annual reports restricts the analyses mostly to large firms, since small firms whose financial statement values fall below certain thresholds do not have to publish a detailed annual report. In contrast, ICS have been shown to be a disclosure instrument which is of particular interest for small and medium firms (Mouritsen, et al., 2001b).

Most of the studies restrict their focus of analysis to one country, not allowing the inspection of nation-based differences in the disclosure behavior. While half of the studies confine their analyses to a mere quantitative or qualitative description of the disclosure, the remaining half investigates its drivers and/or its effects.

Of these 44 studies dealing with intellectual capital disclosure, only three investigate some disclosure that is directly related to innovation capital (see Entwistle, 1999; Jones, 2007; Zeghal, et al., 2007). The remaining studies either consider only one category type of intellectual capital (mostly human capital), or analyze the entire intellectual capital disclosure, thus missing a detailed picture of how the renewal abilities of a firm are generated and what are the related results, in the form of intellectual property rights and other tangible and intangible assets. For example, disclosure of the financial impact of new products, customers gained through innovations, changes in firm reputation as a result of innovations, or the innovation culture, is not investigated. Entwistle (1999), Jones (2007), and Zeghal, et al. (2007) analyze R&D disclosure, but miss to collect data on disclosure on, e.g., process and marketing innovations as well as the process required for the their achievement. Therefore, to the best of my knowledge, I did not find any study dealing explicitly with innovation capital in the depth and breadth required by the definition of innovation capital, its micro- and macroeconomic importance, and the prominent role within the different categories of intellectual capital.

Table I - 2: IC disclosure guidelines (sorted chronologically)

Guidelines	IC categories
Skandia Navigator (Edvinsson & Malone, 1997)	Financial focus; renewal and development focus; customer focus; human focus; process focus
Intangible Assets Monitor (Sveiby, 1997)	External capital; internal capital; competences
Modelo Intelect (Euroforum, 1998)	Human capital; structural capital; relationship capital
Dutch Ministry of Economics (Backhuijs, Holterman, Oudman, Overgoor, & Zijlstra, 1999)	Human capital; customer capital; process capital; innovation capital
Austrian Research Centers (Austrian Research Centers, 2000)	Human capital; structural capital; relationship capital; core research projects; financial and intangible outcome
Meritum project (Meritum, 2000)	Human capital; structural capital; relational capital
Danish Ministry of Science Technology and Innovation (2003)	Customers/users; employees; processes; technology
Nordika (Nordic Industrial Fund, 2001); Frame (Nordic Industrial Fund, 2003); Nordic Harmonized Knowledge Indicators (NHKI); and the follow-up project "Putting IC into Practice" (PIIP) (Thorleifsdottir & Claessen, 2006)	Human capital; structural capital; relational capital
Schmalenbach working group "Accounting and Reporting of Intangible Assets" (Schmalenbach working group "Accounting and Reporting of Intangible Assets", 2005)	Innovation capital; human capital; customer capital; supplier capital; investor capital; process capital; location capital
German Federal Ministry of Economics and Technology (2008)	Human capital; structural capital; relationship capital

Notes: While the others guidelines set up their own disclosure principles, Nordika, Frame, Nordic Harmonized Knowledge Indicators (NHKI), and the follow-up project "Putting IC into Practice" (PIIP) attempt to summarize already existing IC disclosure guidelines.

Interestingly, concerning the disclosure media used, on the one hand ICS are the disclosure media that, based on their scope and definition, seem to be the ones that should provide the most space for disclosure about intangible assets. However, on the other hand, the research on these disclosure media is very limited, restricted to a small number of countries, and entirely qualitative. Table I - 2 provides an overview of different European guidelines suggesting areas of disclosure. The differences are confined mostly to the way in which the disclosure to be addressed is classified, rather than to the content to be disclosed.

This research on disclosure about intellectual capital and in particular about innovation capital leads to the first bundle of research questions of this cumulative dissertation, which are addressed in the first paper. This paper is outlined in the next section.

2.1.2 Drivers of innovation capital disclosure in intellectual capital statements: Evidence from Europe

Section 1 of the framework of this dissertation discussed the micro- and macroeconomic importance of innovations. Thus, there is great interest from the public, investors, and other stakeholders in information about the innovation efforts of firms. Section 2.1.1.1 showed the potentials, but also the limits of mandatory disclosure, therefore addressing the need for voluntary disclosure on innovation efforts to supplement mandatory disclosure. Voluntary disclosure for overall intellectual capital is found, for example, in annual reports, websites, IPO prospectuses, and ICS, as investigated by numerous researchers (see section 2.1.1.2). However, is remarkable that previous research does not address innovation capital disclosure in depth. Therefore, the paper entitled "Drivers of innovation capital disclosure in intellectual capital statements: Evidence from Europe" aims to close this gap. The disclosure media considered are ICS, since they are specifically designed to disclose on innovations (as well as on others intellectual capital areas) (European Commission, 2006). The research questions this paper answers are: (1) What kind, i.e., quantity and quality, of information is provided about innovation capital in ICS?; and (2) Are certain firm characteristics able to explain differences in the quantity and quality of innovation capital disclosure in ICS?

Data collection is carried out by manual content analysis of the ICS. The collection of ICS is based on an investigation of the ICS guidelines reported in table I - 2 for participating firms. The final sample of ICS available in English or German consists of 51 documents.

The disclosed innovation capital items are allocated to three categories: human, internal, and external capital. This allows the presentation on the one hand of the intersection between the main categories of intellectual capital and the efforts carried out to renew a firm,

and on the other hand the related results in terms of financial, tangible, and intangible capital. The quantity and quality of the innovation capital disclosure is measured according to indexes previously used and validated in the literature. Quantity addresses the frequency with which an innovation capital item is addressed in the ICS, while quality refers to the type of information conveyed in this disclosure (quantitative vs. qualitative, financial and non-financial, historical vs. forward-looking).

While the first research question is answered descriptively, analyses of variance and t-tests are used to address the second research question.

The analysis reveals a heterogeneous picture of the disclosure behavior across the 51 firms. With the intent to explain these differences, firm characteristics (size, industry, region of domicile, and disclosure guidelines adopted) were investigated. These four variables are found to be drivers of difference in the quantity of innovation capital disclosure, while differences in quality are only driven by the industry to which the firm belongs. Thus, there is a homogeneous disclosure quality for innovation capital for firms of different size, from different regions, and for firms adopting different disclosure guidelines.

This result is of particular interest for practitioners, since it shows, e.g., that small and medium firms also have the opportunity to disclose about innovation with the same degree of quality as large firms. Furthermore, guideline-setters and policy-makers can use these results to direct the disclosure in directions that are more fruitful for information-seekers, e.g., toward higher quality disclosure. The paper contributes to the research on intellectual capital disclosure by showing that ICS are used for innovation capital disclosure, thus inviting future research on that type of disclosure to investigate ICS as disclosure media. Furthermore, I find that information about innovation is more or less distributed equally throughout the human capital, internal capital, and the external capital categories. The paper shows that innovation can be fostered by accurately mixed investments in the different forms of intellectual capital and thus sheds some light on the interwoven relation between different intellectual capital categories.

The conceptual development of the paper, the data collection and the data analysis, as well as the interpretation of results and the formulation of the paper are based on the individual work by Lucia Bellora, the author of this cumulative dissertation. I am grateful for the support of my co-author Thomas W. Günther in providing feedback on the concept and formulation of the paper.

In order to participate in the research discourse on voluntary disclosure, earlier versions of this paper were at the following conferences: 3rd EIASM (European Institute for Advanced Studies in Management) Workshop on Visualising, Measuring, and Managing Intangibles and Intellectual Capital (Ferrara, Italy, October 2007), 15th International Product Development Management Conference (Hamburg, Germany, June 2008), 4th EIASM Workshop on Visualising, Measuring, and Managing Intangibles and Intellectual Capital (Hasselt, Belgium, October 2008). For a previous version of this paper, in 2007, I was awarded the European Investment Bank Prize for the Best Contribution on Performance Measurement and Valuation of Intellectual Capital. The paper was submitted to *The British Accounting Review* and is currently under revision for resubmission to this journal.

2.2 Internal management control systems

In section 2.1 on external disclosure of innovation data I addressed the issue of convergence between financial and management accounting. External reporting requires data that can only be obtained by a properly designed management accounting system. For example, detailed, project-based cost data for product development have to be provided by the management accounting system. Management accounting is embedded in the broader concept of management control systems (MCS). Their scope goes far beyond the mere provision of reliable data for management purposes and as input data for the financial statement. Per definition, MCS refer to all formal actions or activities taken by management in order to direct the behavior of organizational members toward the achievement of organizational goals (Anthony & Govindarajan, 1998; Flamholtz, 1983; Otley, 1994; Simons, 1995). MCS encompass also management accounting systems. Management accounting "[…] refers to a collection of practices such as budgeting or product costing" (Chenhall, 2007, p. 164), but also includes topics such as planning and performance measures (Luft & Shields, 2007).

The following section discusses the research on the relationship between MCS and innovation performance.

2.2.1 Management control systems and innovation

The traditional concept of MCS describes a system of "command-and-control", based on deviation analyses and aimed at reducing the unexpected to a minimum (e.g. Flamholtz, Das, & Tsui, 1985; Ouchi, 1979). Thus, the common assumption was that MCS are at odds with the nature of innovations, which are nurtured from the unexpected, from uncertainties, from deviations from traditional paths, and from exploration (Davila, Foster, & Oyon, 2009). This assumption was supported by numerous researchers on formal routines and innovation (e.g.

Amabile, Conti, Coon, Lazenby, & Herron, 1996), and Damanpour (1991) showed the detrimental effect of formalization in his meta-analysis of innovation determinants.

However, in the last few decades, new paradigms of MCS and organizational structure have emerged, allowing a reconciliation of formalization and innovation (see Davila, et al., 2009 for an overview). Simons (1995) provides one of the first proposals of how MCS can enhance innovation. He suggests that there are four levers of control (an interactive and diagnostic control system, and a beliefs and boundary system) that operate simultaneously, but in different ways. In particular, with the interactive control system, Simons (1995) proposes a lever that is specially designed to deal with uncertainties. Adler & Borys (1996) contrast enabling and coercive bureaucracies, and design enabling bureaucracies to support the adaption to uncertain environments. Weick, Sutcliffe, & Obstfeld (1999) theorize the need for adaptive organizational forms in order to avoid inertia. Zollo & Winter (2002) identify dynamic capabilities, i.e., formal routines that provide structure for learning and change processes. The roots of the research on formal structures useful to innovation can be seen in Burns & Stalker (1961) with their organic organizational forms, which include a network structure of control, knowledge-sharing, and a consultation relationship between individuals at different hierarchical levels instead of a command-and-control relationship.

All these frameworks reflect formal structures that are related positively to innovations. In the MCS literature, the levers of control framework was afforded particular attention. I revised the literature dealing empirically with the direct relationship between the design of MCS and product development performance, R&D performance, or innovation performance, and found a frequent consideration of the levers of control framework, as shown in table I - 3.

In the levers of control framework, the diagnostic control system stands for the adherence to standards or goals, while the interactive control system postulates the use of measures and instruments from management accounting (such as performance measures) in a manner that allows the emergence of innovations and change (Simons, 1995).

Table I - 3: Studies on the relation between management control systems and innovation performance (in chronological order)

Study	n	Country	Level of analysis	MCS concept	Innovation performance concept	Main results
Omta, Bouter, & Van Engelen (1994)	38	The Netherlands	Department	Personnel (effectiveness), resources (adequacy and administrative control), process (planning, frequency, and attendance mix), and external control (international communication)	Innovative performance (patent number and development length)	Significant positive correlation only between frequency of process control and patent number, as well as attendance mix in process control and development length.
Davila (2000)	56	Europe and U.S.A.	Project	Diagnostic and interactive control system (levers of control), frequency of information updating and level of detail of information (information: product cost, product design, time-related, cost-related, budgets, profitability)	New product development project performance	Significant negative direct effect of the use of time information on new product development project performance; significant positive effect of use of product design and cost information on new product development project performance; other MCS with non-significant effect.
Bonner, et al. (2002)	95	U.S.A.	Project	Interactive control system (levers of control, measured as team operational and team strategic control influence and management intervention) and formal control mechanisms (measured as process and output control, as well as team reward control)	New product development project performance	Significant negative direct relationship between process control as well as management intervention and new product development project performance; significant positive direct relationship between team operational control influence and new product development project performance; other control mechanisms with non-significant effect.

Table I - 3 (continued): Studies on the relation between management control systems and innovation performance (in chronological order)

Study	n	Country	Level of analysis	MCS concept	Innovation performance concept	Main results
Bisbe & Otley (2004)	40	Spain	Firm	Interactive control system (levers of control)	Product innovation performance	Non-significant direct relationship between interactive control and innovation performance; significant negative effect for high-innovative firms. The more interactive the control system, the greater the positive effect of product innovation performance on organizational performance.
Li, Li, Liu, & Wang (2005)	585	China	Firm	Strategic control and financial control	Product development performance	Significant positive direct effect of strategic and financial control on product development performance.
Henri (2006)	383	Canada	Firm	Diagnostic and interactive control system (levers of control)	Innovativeness	Significant positive direct effect of interactive control system on innovativeness; significant negative direct effect of diagnostic control system on innovativeness.
Dunk (2011)	74	Australia	Firm	Use of budget as a planning or as a control instrument	Product innovation performance	The more budgets are used as a planning instrument rather than as a control instrument, the greater the positive effect of product innovation performance on organizational performance.
Rijsdijk & van den Ende (2011)	148	The Netherlands	Project	Outcome, process, and clan control	New product development project performance (process performance and product concept effectiveness)	Significant positive direct effect of outcome control and clan control on process performance and product concept effectiveness; non-significant effect of process control on process performance and product concept effectiveness.

With the beliefs and boundary system, Simons (1995) introduced values and norms in his framework, i.e., formalized corporate culture, which are likely to foster innovation activities by communicating the relevance and the boundaries of innovativeness. All four levers of control are combined in firms in order to increase performance (Malmi & Brown, 2008; Simons, 1995). Especially owing to the introduction of the interactive control system, the levers of control framework has become a well-accepted framework to analyze MCS in innovative settings (e.g. Bisbe & Malagueno, 2009; Bisbe & Otley, 2004; Bonner, et al., 2002).

However, the levers of control framework has not yet been considered in its entirety. Most of the studies analyzed only one or two of the four levers. This contradicts the general agreement on the fact that MCS operate as a package and that MCS components should be considered jointly in order to avoid spurious findings owing to model underspecification (Chenhall, 2007; Fisher, 1998; Malmi & Brown, 2008; Otley, 1980).

Thus, the somewhat contradictory results of previous studies, as displayed in table I - 3 (e.g., interactive control systems impact innovation significantly positive in the study by Henri, 2006, but significantly negative in a sub-sample by Bisbe & Otley, 2004, and partially non-significantly in the study by Bonner, et al., 2002), may arise from the negligence of components of the levers of control framework. Indeed, it is reasonable that all four levers are implemented at the same time in firms, thus neglecting some of them in the models considered may lead to the negligence of the interplay of the different MCS components and therefore distort results (Chenhall, 2007; Davila, et al., 2009).

Most of the studies in table I - 3 consider product development performance as a dependent variable. In firms, this is an area where innovation and change play a major role (Davila, 2000) and is a representative example of innovation that is empirically well manageable (Davila, et al., 2009). Since the levers of control framework is particularly applicable at the top management level (Simons, 1995), a frequent level of analysis is the firm.

Given this research on MCS and innovation, the following two sections outline arising research questions, which are addressed in the second and third papers of this cumulative dissertation. While the second paper (section 2.2.2) addresses how firms in general design the interplay of the levers of control in product development, the third paper (section 2.2.3) identifies clusters of firms that combine the levers of control in different ways, depending on strategy and environment variables.

2.2.2 The interplay of the levers of control in product development

Given the importance of innovation for a firm's competitive advantage (see section 1), product development is one of the possible ways to enhance the innovation performance of a firm. Thus, management has to make sure that product development activities are carried out effectively and efficiently with reference to the organizational goals. To achieve this, one suitable approach is the design of a proper MCS (Anthony & Govindarajan, 1998). However, product development requires MCS that allow and encourage opportunity-seeking, uncertainty, and exploration. The levers of control framework by Simons (1995) offers this opportunity. As described in section 2.2.1, this framework has been used frequently in research on the relationship between MCS and innovation, since it describes clearly the management control efforts of firms operating in uncertain environments. However, table I - 3 shows (1) contradictory results about the effect of the levers on innovation; and (2) the negligence of the beliefs and boundary system in previous investigations. Furthermore, the existing literature is contradictory in its description of how the levers of control operate together in firms (mere coexistence, mutual association, reciprocally conditional levers). Thus, the paper "The interplay of the levers of control in product development" answers the following research questions: (1) How do the different levers of control influence product development performance and organizational performance directly and indirectly?; and (2) What type of interplay of the levers of control best describes the way in which firms operate?

To answer these questions, I collected data from manufacturing firms in German-speaking countries using a structured written questionnaire. The questionnaire items are taken from already validated scales and were adapted slightly to the context of this paper. I obtained a response rate of 34% and used 468 responses from members of the top management for the investigation of these research questions.

Data analysis was carried out by structural equation modeling. This method is appropriate for the available data, since variables such as the emphasis of the interactive or diagnostic control systems are latent constructs that require multiple indicators to be described. Furthermore, measurement and endogenous latent variable residuals are estimated explicitly. Data are fitted to the model by maximum likelihood estimation with bootstrapping. I adopted the alternative model approach by Jöreskog (1993), which allows me tom compare multiple plausible and competing models of the interplay of the levers of control (mere coexistence, mutual association, reciprocally conditional levers). The fit of the data to the model was evaluated

based on chi-square tests and common goodness-of-fit indexes, while I compared the competing models based on chi-square-difference tests and other fit indexes.

Results show that the model that best explains how the interplay of the levers of control in product development works in manufacturing firms is the one of mutual association between the levers. An increase in the emphasis placed to one of the levers leads to an increase in the other levers, and vice versa. Thus, the levers of control seem to operate in a concerted way, i.e., there is an alignment of the different levers. While the beliefs and diagnostic control systems produce the largest positive direct effect on product development performance, the boundary and the interactive control systems have a positive indirect effect on performance that is mediated by the beliefs and diagnostic systems.

This paper contributes to research on MCS since it is the first paper that analyses what happens in the so-called "control package", using a quantitative approach. First, the paper is able to show the superiority of models acknowledging the interplay of the levers against a model neglecting any kind of interplay. Second, there is evidence of the fact that the mutual association of the levers of control better describes the interplay of the levers in firms, rather than does, e.g., a conditional relationship between the levers. Both aspects are of interest for researchers, since they drive their attention on the careful specification of MCS models. At the same time, practitioners can learn how the different control activities are interwoven and thus affect each other. Furthermore, this paper contributes to the discussion on MCS and innovation outlined in section 2.2.1, since it provides a broader insight into the relation between all the four levers and product development on the one hand, and organizational performance on the other hand. While research can gain additional insights into the functioning of Simons' framework, practitioners can profit from the findings by identifying the levers that are best suited to enhance performance.

The conceptual development of the paper, the data collection and the data analysis, as well as the interpretation of results and the formulation of the paper are based on the individual work by Lucia Bellora, the author of this cumulative dissertation. I am grateful for the support of my co-author Thomas W. Günther in providing feedback on the concept and formulation of the paper.

In order to participate to the research discussion on the package of MCS and on the relation between MCS and innovation, earlier versions of this paper were presented at the following conferences: 5th EIASM Workshop on Visualising, Measuring, and Managing Intangi-

bles and Intellectual Capital (Dresden, Germany, October 2009), 1st Empirical Research in Management Accounting & Control Conference (Vienna, Austria, June 2011), 6th Conference on Performance Measurement and Management Control (Nice, France, September 2011). I was invited to present this paper at the *Département Comptabilité et Contrôle* Accounting Research Seminar (Lausanne, Switzerland, October 2011). The paper is currently in the final stage of preparation for the submission to *Accounting, Organisations, and Society*. Results from a descriptive analysis and from multiple regression and moderated regression analysis based on the data for this paper have already been published with the title "*Laissez-faire oder strenge Kontrolle? Produktentwicklung im Spannungsfeld verschiedener Steuerungsmechanismen*" in the working paper collection *Dresdner Beiträge zur Betriebswirtschaftslehre* (together with Thomas W. Günther).

2.2.3 Combinations of the levers of control in product development

The paper presented in the previous section deals with the way in which the levers of control operate together in a product development setting. While it allows a broad impression of all the firms in the sample, it remains unclear how different firms in different environments within this sample combine the levers of control, i.e., how much emphasis they place simultaneously to the different levers. As already addressed in section 2.2.1, while there is agreement among researchers that firms may implement numerous MCS at the same time (e.g., Fisher, 1998; Malmi & Brown, 2008; Otley, 1980), exactly which levers are combined with what emphasis and in which conditions remains unclear (Chenhall, 2007; Malmi & Brown, 2008). The paper "Combinations of the levers of control in product development" addresses this gap by answering the following research questions: (1) Which different levers of control operate in combination in different strategic and environmental backgrounds?; and (2) Are these combinations equifinal in terms of product development and organizational performance?

The contingency tradition (e.g. Donaldson, 2001; Drazin & Van de Ven, 1985) requires the structure of the organization (here the levers of control) to fit the strategy (here the type of strategy formation, i.e., emergent or intended) and the environment (here the innovativeness of the firm, as a proxy for the uncertainty perceived by the firm). Thus, I hypothesize the existence of two different firm clusters that both represent situations of fit. Firms outside these two different firm clusters will not be in fit and will thus experience a lower performance. To answer these research questions, the 468 responses from the survey mentioned in the previous section are used.

I analyzed the data by means of cluster analysis. This is the method of choice when seeking to classify objects (here firms) into groups that are characterized by internal homogeneity and external heterogeneity (Hair, Anderson, Tatham, & Black, 2010; Milligan, 1980). As suggested by Ketchen Jr. & Shook (1996), I used a two-step approach applying Ward's hierarchical clustering method to define the appropriate number of clusters in the data, and, based on this number, I defined the allocation of the firms to clusters based on the non-hierarchical K-means approach.

This procedure leads to the identification of three clusters that are labeled "Values and Norms Control", "Limited Control", and "Performance Measures Control". While the Limited Control cluster is characterized by a mostly low emphasis on the four levers of control, a low degree of innovativeness, and a predominantly emergent strategy, the other two clusters are different in the type of controls that are emphasized. In the Values and Norms Control cluster, control is performed by a particular emphasis on the beliefs and boundary system. This happens in firms where strategies are partially emergent and partially intended, and the degree of innovativeness is high. In turn, the Performance Measures Control cluster focuses on the interactive and diagnostic use of performance measures to implement a predominantly intended strategy and cope with mediocre innovativeness. The Value and Norms Control cluster and the Performance Measures Control cluster are equifinal, i.e., there are no meaningful differences in the product development performance and organizational performance. Both clusters outperform the Limited Control cluster, as predicted.

With these findings, the paper contributes to research on MCS by offering evidence of how the levers of control are combined in certain strategic and environmental conditions. This allows researchers to differentiate between different types of firms when doing further research on the combination of MCS, while practitioners can compare different approaches to control their product development activities. In addition, previous research on the MCS-strategy relation has focused on the use of MCS to implement intended strategies. For an area where merely intended strategies are difficult to find because of the changing nature of tasks, findings show how partially emergent strategies can be controlled successfully. The findings thus encourage researchers to give more attention to how MCS can contribute to the emergence and success of emergent strategies, while practitioners can identify the best combination of levers of control for areas where strategies are not merely intended. Finally, the paper contributes to the research on the relation between MCS and performance by identifying alternative combinations of levers of control that lead to an equally high performance. Thus, firms can identify

which levers of control need to be emphasized, given the status of their environment and strategy.

The conceptual development of the paper, the data collection and the data analysis, as well as the interpretation of results and the formulation of the paper are based on the individual work by Lucia Bellora, the author of this cumulative dissertation.

II Drivers of innovation capital disclosure in intellectual capital statements: Evidence from Europe

Abstract

Innovations are one of the major determinants of competitive success. As a result, there is a demand for information on the innovation efforts of firms among investors, other stakeholders, and the relevant public. Using content analysis, this paper examines the innovation capital disclosure (INCD) characteristics, i.e., disclosure quantity and quality, in intellectual capital statements (ICS) of 51 European for-profit firms. Additionally, the relationship between INCD characteristics and industry, firm size, region of domicile, and disclosure guidelines adopted are analysed. Our content analysis detects an average of 29.16 items on innovation capital (INC) per ICS. These are mainly qualitative, non-financial, and historical-oriented. Furthermore, as expected, industry, firm size, region, and disclosure guideline drive the quantity of disclosure. Prior empirical studies on voluntary disclosure also suggested a relationship between firm size and disclosure quality. Interestingly, our results for INCD in ICS do not support this relationship. This provides tentative evidence of the good applicability of ICS for firms of any size. Furthermore, our findings show mostly homogeneous disclosure patterns across regions in Europe and between disclosure guidelines adopted, suggesting that the multi-national efforts toward fostering INCD made the ICS phenomenon more a European than a local phenomenon.

Keywords: innovation capital, disclosure, content analysis, intellectual capital statements

JEL Classifications: C29, C82, M41, O30

We are indebted to the two anonymous reviewers, to the associate editor and to the editors from *The British Accounting Review*, Mike Jones and Howard Mellett, for their invaluable comments on previous versions of the paper. The authors would also like to acknowledge the useful comments of Jan Mouritsen and of participants in the 2008 Workshop on Visualising, Measuring and Managing Intangibles and Intellectual Capital in Hasselt (Belgium) on a first draft of this paper.

1 Introduction

Innovation capital (INC) describes the generation and use of renewal abilities of a firm and related results in terms of intellectual property rights and other tangible, intangible, and financial assets (Edvinsson & Malone, 1997) and is part of intellectual capital (IC). The transformation of western economies from an industrial to a knowledge-based structure increases the relevance of INC. On a macro-economic level, innovation has become a major driver of economic growth, while the traditional growth enhancers like investments in physical assets are declining in importance (OECD, 2010). On a micro-economic level, innovations are recognized as means of gaining competitive advantage and higher returns (e.g. Griliches, 1981; Hall & Mairesse, 1995).

In the light of this macro- and micro-economic relevance of innovation efforts, related disclosure is of high interest for both individuals and organizations. However, mandatory disclosure according to IFRS or local GAAP is generally restrictive, as usually only data on research and development (R&D) expenses has to be reported (e.g. IAS 38). Thus, voluntary disclosure can provide additional information (e.g. European Commission, 2006). While there are a number of studies dealing with voluntary disclosure of IC in general or human capital disclosure in particular, we did not find studies dealing with voluntary innovation capital disclosure (INCD) (see section 2). In our paper we close this gap by analysing the INCD behaviours of a sample of European firms.

Disclosure behaviour can be explained using a cost-benefit-approach. Potential benefits are described in various theories. According to legitimacy theory (Parsons, 1960 and Weber, 1978), firms voluntarily report information to the relevant public in order to improve their reputation (and thus the necessary inflow of capital, labour, and customers) by demonstrating that socially desirable actions are being taken (Dowling & Pfeffer, 1975; Pfeffer & Salancik, 1978). Innovative actions are considered socially desirable actions as they are expected, on the one hand, to foster growth and employment and, on the other hand, to improve living standards (OECD, 2010). Closely linked, the stakeholder approach (Freeman, 1984) suggests the necessity of providing individuals and organisations affecting, or being affected by, the firm's actions with information (Clarkson, 1995). According to agency theory, voluntary disclosure allows closing the information gap between managers (agents) and investors (principals) (Healy & Palepu, 2001). As a consequence, investors' uncertainty about the expected returns or the cost of capital decrease (e.g. Botosan, 1997). Besides these benefits,

diverse costs arise through INCD. Apart from the direct costs of preparation and dissemination, indirect costs such as opportunity and proprietary costs play a major role in firms' disclosure decisions. Hence, firms will decide to voluntarily disclose information on INC up to the point where the benefits of disclosure equal the costs of disclosure (Depoers, 2000; Leuz & Wysocki, 2008). This cost-benefit-approach explains differences in disclosure levels between firms. Since empirical research cannot directly measure these costs and benefits, it enquires differences in disclosure levels due to different firm characteristics (i.e., drivers), allowing for some tentative inferences on the cost-benefit-relationship within certain firm groups (Depoers, 2000). In our paper, we address industry, size, region of domicile, and the disclosure guidelines adopted as potential drivers.

Costs and benefits from disclosure can vary not only on the basis of *how much* about a topic is disclosed by a firm (i.e., disclosure quantity), but also on the basis of *how* something is disclosed (i.e., disclosure quality) (Beretta & Bozzolan, 2008; Marston & Shrives, 1991). Therefore, in our paper we address both disclosure quantity on the basis of frequency counts, and disclosure quality on the basis of different types of disclosure (financial vs. non-financial, historical vs. forward-looking, etc.).

Among the different disclosure instruments where INCD might be found, we focus on intellectual capital statements (ICS). These are documents issued on a voluntary basis, enabling companies to present their intangible assets – and therewith their innovation efforts – in a narrative, visual, and numeric form (Mouritsen, Larsen, & Bukh, 2001b). There are various reasons for focusing on ICS. (1) ICS are exclusively aimed at presenting firms' intangible assets, including INC (Mouritsen, et al., 2001b). A survey revealed that one of the major motives in working with ICS is to show the firm's innovation efforts (Mouritsen, et al., 2001b). (2) The space and time restrictions of other disclosure instruments such as annual reports or presentations to analysts do generally not allow for a disclosure of innovation efforts conducted and of prospective outcomes, which requires extensive narratives (Striukova, Unerman, & Guthrie, 2008). ICS do not underlie restrictions about the amount of information conveyed and seem thus to be more appropriate when researching voluntary disclosure on INC than other disclosure documents. (3) ICS disclosure are accessible and affordable to firms of any size (e.g., no printing costs since ICS are mostly made available only online; no codification and therefore lower data requirements; etc.) (Mouritsen, et al., 2001b), thus allowing analysis of the disclosure of large as well as small firms.

Based on these considerations, the purpose of our paper is to answer these research questions: (1) What kind, i.e., quantity and quality, of information is provided on INC in ICS?, and (2) Are certain firm characteristics related to the quantity and quality of INCD in ICS?

Informed by these questions, our paper aims to contribute to research in a number of ways. (1) We carry out a quantitative content analysis of ICS. Content analysis is a methodology which codifies text into categories and quantifies the frequency of occurrences within each category (Krippendorff, 2004). As described in the literature review section, research does provide few studies on the themes addressed by ICS from which we can gain a valuable overall picture on what is reported in ICS. Our quantitative content analysis adds evidence to these studies since it enquires the frequency of what is reported and the quality level with which the reporting is provided. Thus, our study contributes to research by allowing for the first time some inferences about what themes are important for firms in the area of INCD. Thus, our paper contributes to the research on ICS by looking at the use of ICS and adds to the existing research that describes the disclosed topics. Furthermore, policy-makers and practice will be able to use our results in order to expand the quality of disclosure. (2) Previous literature on voluntary disclosure mainly focused on IC as a whole. While this allows a broad understanding of IC disclosure, first studies started to claim for a more in-depth approach, thus concentrating their attention on one sub-category of IC, i.e., on human capital (e.g. Abeysekera & Guthrie, 2004a). At the same time, research on other IC category, i.e., disclosure on INC, remains scarce. This stands in contrast to the fact that innovations play a prominent role in the enhancement of firm's value creation (e.g. Lev, 2001). Successful innovations ascertain customer retention, attraction of new customers, increase in firm reputation, and therewith long-term performance increase. Furthermore, innovations play a peculiar role in IC. Following Lev, 2001, "[…] innovation is achieved primarily by investments in intangibles" (Lev, 2001, p. 17). For example, in the network of IC, patents (internal capital) become relevant for firm value if they are used by employees (human capital) for the development of innovative products. Employee training (human capital) is required for the development of successful innovations. The establishment of a network of cooperation and experience exchange with other firms (external capital) is a prerequisite for the achievement of knowledge necessary for development of innovations (e.g. Mouritsen, Bukh, & Bang, 2008). In other words, INC can be considered the result of the emphasis placed on different types of IC. This focal role of INC in IC and thus for value creation supports deeper investigation of disclosure

on INC. This study aims at closing this gap and offers a basis for future research on the role of other forms of IC in the IC network. Our results offers for practitioners the opportunity to gain insights into the possible causes and effects within the IC network, as described and experienced by firms. (3) Our study does not only rely on the quantification of disclosure on INC in ICS, but rather searches for possible explanations of differences between firms concerning disclosure quantity and quality. Thanks to our sample of 51 ICS from different Nordic, German-speaking, and Southern European countries, encompassing ICS from various industries and sizes, and employing diverse disclosure frameworks, we can make inferences about different cost-benefits relationships governing different types of firms. While drivers of IC disclosure have already been considered in several prior studies (e.g. Vergauwen, Bollen, & Oirbans, 2007), our analysis first offers evidence of drivers of INCD in ICS and allows for comparison of results with previous studies. Policy-makers and disclosure guideline setters can use our results to evaluate their efforts in directing INCD toward high quality data and to harmonise the use of ICS across countries.

The remainder of this paper is organised as follows: Comparable studies on voluntary IC disclosure are reviewed in the next section; afterwards, the hypotheses are discussed; while the "Research design" section describes the content analysis carried out; the empirical evidence is then presented in the "Results" section; while the last section in the paper provides results discussion and conclusion.

2 Literature review

This section summarises the characteristics of previous content analyses of IC disclosure by for-profit firms. Campbell & Abdul Rahman (2010) and Striukova, et al. (2008) already deliver useful overviews. As can be drawn from their reviews, a first research stream deals with the disclosure of IC in annual reports, without focusing on a particular IC category, and includes a huge number of studies since 1999. The category system employed is informed by the work by Guthrie, Petty, Ferrier, & Wells (1999). Overall, these studies focus either on a mere quantification of disclosure or additionally identify potential drivers of disclosure. In most cases, the sample encompasses large firms from a single country.

A second stream has favoured addressing in depth the disclosure of one particular type of IC in annual reports. This research focused on human capital in annual reports

(Abeysekera & Guthrie, 2004b; Olsson, 2001; Subbarao & Zeghal, 1997). We did not find evidence of studies addressing other types of IC, such as, for example, INC.

Recent findings demonstrate a strong limitation in the two streams of research mentioned above, since they both focus on annual reports only. Striukova, et al. (2008) show that the disclosure of IC in annual reports is not a good proxy for the overall disclosure of IC in different types of corporate reports (e.g., web pages, interim reports, etc.). This limitation could be partially addressed by a third stream of research, which considers the IC disclosure in ICS instead of in annual reports (table II - 1).

Table II - 1: Previous studies on IC disclosure in ICS (list in chronological order)

Study	n	Country	Type of study	Overall results	INC considered
Mouritsen, Larsen, & Bukh (2001a)	1	Sweden	Qualitative	Description of content and goals of the IC supplements at Skandia	Indicators in the renewal and development focus, such as investment in product development or in process improvement
Mouritsen, et al. (2001b)	17	Denmark	Qualitative	Description of the "story telling" in ICS	Innovation efforts as part of ICS "story telling" as an instrument for achievement of organization goals
Ordóñez de Pablos (2002)	13	Austria, Denmark, India, Israel, Spain, Sweden	Qualitative	Description of the archetypal role of Scandinavian firms for firms worldwide when setting up an ICS	Investment in product and process development, number of new service/products, etc.
Ordóñez de Pablos (2003)	5	Spain	Qualitative	Describes the archetypal role of the Skandia Navigator for ICS in Spain	As in Ordóñez de Pablos (2002)
Ordóñez de Pablos (2005)	3	India	Qualitative	Describes the predominance of the narrative form in Indian ICS and the negligence of indicators	No specific information provided on INC
Mouritsen, et al. (2008)	1	Denmark	Qualitative	Description of content of ICS by Maxon Telecom and the relationship between different knowledge resources and the organizational goal to develop innovation	Innovation is an organizational goal described by a network of knowledge narrative, management challenges, initiatives, and related indicators

Remarkably, this stream includes a limited number of studies analysing the content of ICS (compared with the numerous studies dealing with annual report disclosure), despite the clear focus of ICS on IC disclosure. Furthermore, we do not find evidence of the use of quantitative content analyses and of the investigation of drivers of disclosure in this third stream

of research. Which firms are particularly likely to disclose what type of information? These question remains unanswered in previous research. Instead, the studies focus on in-depth qualitative descriptions of structure and content of ICS. These studies provide first evidence of the use of ICS to disclose about INC, even if they do not perform a quantitative analysis. Our study can enrich the qualitative ICS content analyses of the third stream of IC research in that it uses a systematic approach for both data collection and inferences drawn (Krippendorff, 2004) and can support the second research stream on IC by drawing its attention to a particular type of IC.

3 Development of hypotheses

Our paper aims to answer the questions of (1) the quantity and quality of information provided on INC in ICS, and (2) the relationship between firm characteristics and these disclosure characteristics. For the second research question, we suppose a relationship between disclosure on the one hand and industry, size, region of domicile of the firm, and disclosure guidelines adopted by the firm on the other hand. The rationale for these hypotheses is outlined in the following.

According to legitimacy theory, firms in high R&D intensity industries need to be "licensed" to be a part of this industry from the environment in which they operate (European Commission, 2006), what may drive them to provide more INCD data and of a higher quality than firms that do not need this "license" due to their membership in a low R&D intensity industry (Patten, 1991). This relationship is also supported by the stakeholder approach, which suggests that firms in high R&D intensity industries should communicate their potential by disclosing their innovation efforts in order to attract resources from stakeholders. Furthermore, as the potential of R&D activities of a firms is better known to managers than to investors, the information asymmetry between agents and principals is more pronounced in high R&D intensity firms than in low R&D intensity firms. Therefore, high R&D intensity firms should reduce their industry-inherent information asymmetry by providing detailed disclosure on INC. In summary, we expect that for firms in high R&D intensity industries these benefits from disclosure exceed the costs of disclosure and lead to a higher level of disclosure on INC. Previous IC disclosure research also found an association between disclosure and industry (Boesso & Kumar, 2007; Bozzolan, Favotto, & Ricceri, 2003). This leads to:

H1(a): *The quantity of INCD in ICS is higher for firms in high R&D intensity industries than for firms in low R&D intensity industries.*

H1(b): *The quality of INCD in ICS is higher for firms in high R&D intensity industries than for firms in low R&D intensity industries.*

Moreover, we suggest that firm size is associated with INCD. From legitimacy theory we infer that the actions taken by larger firms have a higher overall impact on the society in which they operate, which leads to a higher legitimisation and therewith higher disclosure pressure on larger firms than on smaller firms. Similarly, it can be claimed that larger firms usually address a larger number of stakeholders and stakeholder groups, which forces larger firms to comply with higher disclosure standards than smaller firms. Agency theory is ambivalent about the association between disclosure and size. On the one hand, statistics (European Commission, 2008a) identify a higher percentage of R&D expenses and innovation output with larger firms – implying higher innovation-related information asymmetry, and therefore higher information expectations from investors. On the other hand, smaller firms might be interested in a higher disclosure level as a means to overcome information asymmetry derived from the fact that they are relatively unknown to investors (Leuz & Wysocki, 2008). Concerning the costs of disclosure, these may be higher with smaller firms as they have to bear fixed disclosure costs without the possibility of profiting from economies of scale available to larger firms (Leuz & Wysocki, 2008). Prior IC disclosure researchers have noted an association between disclosure and firm size (Boesso & Kumar, 2007; Bozzolan, et al., 2003). In the light of this ambiguous theoretical background, two non-directional hypotheses can be formulated:

H2(a): *The quantity of INCD in ICS is related to the size of the firm.*

H2(b): *The quality of INCD in ICS is related to the size of the firm.*

Despite the efforts of several governmental and non-governmental institutions toward increasing the use of ICS for disclosure of INC, the implementation between different European regions remains of a heterogeneous nature (European Commission, 2006). The diverse disclosure practices are influenced by regional cultures (Chaminade & Johanson, 2003). In line with legitimacy theory and stakeholder approach, the relevant public and stakeholders in countries which have a stronger IC tradition, like the Nordic countries, will be more sensitive as to the importance of disclosure on INC and will therefore expect higher levels of disclosure. As such, firms in IC-sensitive regions will be forced to provide higher quantities and quality of disclosure on INC. Following agency theory, countries where IC thinking has deep roots impel a high expectation on INCD amongst investors. Apart from benefits that may have their foundation in regional differences, (perceived) divergent costs of disclosure on INC also seem plausible. For example, Chaminade & Johanson (2003) suggest that Southern

European countries have a stronger fear of competitive disadvantages when disclosing information on IC than Nordic countries. Previous IC disclosure studies support the relationship between disclosure and the region of domicile of a firm (Bozzolan, O`Reagan, & Ricceri, 2006; Guthrie, Petty, & Ricceri, 2006; Vandermaele, Vergauwen, & Smits, 2005; Vergauwen & van Alem, 2005). Therefore, we formulate:

H3(a): *The quantity of INCD in ICS is related to the region of domicile of the firm.*

H3(b): *The quality of INCD in ICS is related to the region of domicile of the firm.*

ICS usually follow the suggestions by disclosure guideline issued by various governmental and non-governmental institutions, as well as by researchers (appendix II - 1 lists common European ICS disclosure guidelines). We assume that the disclosure guideline adopted is related to the quantity and quality of INCD. Given differences in the extent to which each guideline addresses the topic of INC (e.g., by providing examples on adequate key figures), we formulate:

H4(a): *The quantity of INCD in ICS is related to the disclosure guidelines adopted.*

H4(b): *The quality of INCD in ICS is related to the disclosure guidelines adopted.*

4 Research design

4.1 Identification and measurement of INCD

To allow for comparability of this study with previous IC research, the category system employed to allocate the disclosures of the ICS is informed by the system by Guthrie, et al. (1999), which has been adopted by numerous studies, including recent ones by Campbell & Abdul Rahman (2010) and Striukova, et al. (2008). This category systems distinguishes between internal, external, and human capital, and allows therefore to well reflect the previously sketched role of different types of IC in the economic process of innovation generation (Lev, 2001). Conform to the definition of INC, we capture those disclosures that relate to the entire innovation process, including, e.g., disclosure on the involvement of customers in the development of innovations, the training for employees to imparting skills needed to successfully generate and implement new product ideas, the shape of the product development processes, and the results in terms of successful new products developed with cooperation partners, customers, or in the firm. The definitions of the categories were based on those provided by previous studies and adjusted to fit the context of INCD (for similar adjustments see Bozzolan, et al., 2003 or Striukova, et al., 2008). This adjustment resulted from a discursive process between one of the authors and two other experienced content analysts. This proce-

dure is essential to generate consistent coding rules across coders and time (Beattie & Thomson, 2007). We summarise categories and sub-categories, as well as related definitions in appendix II - 2.

The ICS have been analysed manually. In this regard, we are consistent with Beattie & Thomson (2007), Krippendorff (2004), and Weber (1990), as we rely on the superior ability of humans to interpret and translate text (we deal with ICS in German and English language), to identify firm-specific terms, and to negotiate synonyms and multiple meanings.

Our hypotheses address the quantity and quality of INCD. The quantity of disclosure was measured in previous content analyses by using as measurement units either the volume of space devoted to an item (in terms of words, sentences, or paragraphs) (e.g. Bozzolan, et al., 2003; Guthrie & Petty, 2000) or the instances of disclosure independent of its length (e.g. Beattie & Thomson, 2007; Striukova, et al., 2008). In the present study the method of counting the instances of disclosure is applied, with each disclosure item on INC counted independently of its length. This means that "sometimes long, complex sentences must be broken down into shorter thematic units or segments" (Weber, 1990, p. 22). There are various rationales behind this decision: (1) we analyse ICS both in German and English language and follow Campbell, Beck, & Shrives (2005), who found that a quantification of disclosure based on the amount of space would lead to invalid inferences due the different etymological structures in the two languages; (2) a disclosure volume consideration is hardly applicable for ICS, whose length vary considerably from report to report and where the marginal cost of additional space is negligible (Striukova, et al., 2008); (3) counting instances of disclosures acknowledges the possibility that multiple INC items are disclosed within one sentence, paragraph, or page (Beattie & Thomson, 2007).

The quantity of disclosure is determined by the number of times an INC item is reported per ICS. Therefore, multiple disclosures and duplicates are explicitly recorded (Beattie & Thomson, 2007). Similar to Botosan (1997), we formulate a quantity index for INCD (INCDQUANT) for a firm *j* over the *i*=1;2;3 categories (internal, external, and human capital) as follows:

$$INCDQUANT_j = \sum_{i=1}^{3} INCDQUANT_{ij}$$

where

$INCDQUANT_{ij}$ = instances of disclosure on INC in category *i* for firm *j*.

Additionally, disclosure researchers have noted the importance of differentiating the types of information provided by an item (e.g. Beretta & Bozzolan, 2008). We use a previously validated index, as constructed by Boesso & Kumar (2007). The quality index for INCD (INCDQUAL) for firm *j* considers type, nature, and time-reference (see also Beretta & Bozzolan, 2008) of the INCD items, as well as the disclosure density (by dividing the weighted number of items per ICS by the number of pages per ICS):

$$INCDQUAL_j = \frac{\sum_{k=1}^{K_j} type_{kj}}{pages_j} + \frac{\sum_{k=1}^{K_j} nature_{kj}}{pages_j} + \frac{\sum_{k=1}^{K_j} outlook_{kj}}{pages_j}$$

where

K_j = number of total text units of the ICS of firm *j*;

$type_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides a qualitative item; 2 if the text unit provides a quantitative item;

$nature_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides a financial item; 2 if the text unit provides a non-financial item;

$outlook_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides an historical item; 2 if the text units provides a forward-looking item;

$pages_j$ = number of pages of the ICS of firm *j*.

Consistent with Boesso & Kumar (2007), INCDQUAL thus assigns a higher weighting to INCD done in a quantitative manner, where firms make efforts to translate narratives into more "accountable" enumerators of INC. Furthermore, non-financial disclosures are awarded a higher score as financial information is already widely available in mandatory reporting. In addition, we assign a higher weighting to forward-looking disclosure, as this kind of information can give insights into the firm's future ability to create value through its INC (AICPA, 1994; IASB, 2007; ICAEW, 2005; Boesso & Kumar, 2007; Hooks, Coy, & Davey, 2002; Mouritsen, et al., 2001a). Finally, INCDQUAL divides these weighted INCD items by the number of pages. This standardisation accounts for the density with which the INC information is disclosed. While INCDQUANT refers to the mere disclosure itself, irre-

spective of the way in which information is conveyed, INCDQUAL focuses on the manner with which INC is described (i.e., with financial or non-financial items, within a succinct number of pages or spread across a long ICS, etc.).

4.2 Reliability and validity

Since each content analysis involves a degree of subjectivity, reliability and validity issues should be considered in depth. We follow the assessment criteria outlined by Krippendorff (2004) and describe in table II - 2 which procedures have been employed in order to safeguard reliability and validity requirements needed to lend credibility to our inferences. The table shows that our content analysis is highly reliable in terms of stability, reproducibility, and accuracy. Furthermore, even if validity per se can be evaluated only tentatively, the table nevertheless provides positive signals for the plausibility of our results and inferences.

4.3 Sample

Following Striukova, et al. (2008), we consider voluntary disclosure in documents besides annual reports, and focus in particular on ICS. Because the main interest in the present paper is the information disclosed to external addressees, the collection of the ICS was based on the criterion of public availability. To fulfil this criterion, two requirements must be satisfied: (1) the guideline on which the ICS is based must provide online a list of participants. Therefore, we survey common IC disclosure guidelines (appendix II - 1) and found lists of participants for the following guidelines: the Austrian Research Centres Model; Danish ICS Guidelines; the framework by the German Federal Ministry of Economics and Technology; the Spanish Modelo Intelect; and the framework "Nordic Harmonised Knowledge Indicators – Putting IC into practice"; (2) the firm mentioned in the participant list must provide the ICS on the firms' web page.[1]

The data collection was carried out between December 2008 and January 2009. According to participant lists, nearly 260 identifiable ICS should be available. Because of the linguistic capacities of the researchers, ICS not in the English or German language were excluded from the sample. After reviewing for public availability and language, the data collection led to the detection of 126 ICS. In the next step, research institutes, universities, or other academic entities, as well as non-profit organizations were excluded.

[1] Additionally, we searched the internet for additional ICS not provided in participant lists to guidelines, but this did not lead to an increase in available ICS.

Table II - 2: Reliability and validity of the content analysis procedure

	Definition	Procedure or measure taken in our study
Reliability		
Stability	the degree to which the analysis is unchanging over time	high intraobserver agreement tested on a sample of items 12 months after first coding (Krippendorff´s alpha=0.971, indicating high stability)
Reproducibility	the degree to which the analysis can be replicated by different analysts working under varying conditions	high intercoder reliability measured on a sample of items taken from 51 ICS by investigator triangulation with 3 experienced content analysts (Krippendorff´s alpha=0.917, indicating high reproducibility)
Accuracy	the degree to which the analysis conforms to a predefined standard	intensive coder training with experienced content analysts
Validity		
Face validity	the correspondence between the definitions of the categories and the constructs intended to be measured	literature review of content analyses employing the category system used; adjustment to the INCD setting in a discursive process by 3 experienced content analysts and formulation of coding rules
Social validity	the addressing of important social issues, the contribution to public debates	innovations are major drivers of economic growth, foster employment, address social challenges; thus INCD is important to a wide range of stakeholders
Empirical validity		
Sampling validity	the degree to which a sample of texts accurately represents the population	an ICS population cannot be identified; our study identifies 51 online available ICS by for-profit firms based on 5 major European disclosure frameworks, thus exceeding the sample size of previous studies on ICS (see table II - 1)
Semantic validity	the degree to which analytical categories accurately describe meanings and uses in the chosen context	development of coding manual on the basis of a training sample of ICS by 3 experienced content analysts; rejection of computer-aided content analysis
Structural validity	the degree to which the analytical construct models the network of relations in the chosen context	INCDQUANT and INCDQUAL are constructs already validated by Botosan (1997)and Boesso & Kumar (2007) as instruments suitable for measuring quantity and quality of disclosure; similar measures lead mostly to qualitatively unchanged results (see discussion section)
Functional validity	the degree to which the analytical categories are useful over time and in many empirical situations	the category system of IC (internal, external, human capital) has been employed since Guthrie, et al. (1999) by numerous studies for different countries, industries, and firm sizes
Correlative validity	the extent to which results correlate with variables that measure the same construct (convergent validity) and the extent to which correlation is absent with variables measuring different phenomena (discriminant validity)	Pearson`s correlation coefficient between INCDQUANT and INCDQUAL ($r=0.534$, $p<0.01$, two-sided test) indicates a significant, but only moderately positive correlation between the indexes, therefore suggesting that the variables are measuring different phenomena
Predictive validity	the degree to which anticipated observations occur in due time	could only be tested with further ICS, that are currently not available; according to Weber (1990) this is why predictive validity is seldom tested by content analysts

Note: The definitions reported in the table are taken from Krippendorff (2004) and Weber (1990).

The reason for this exclusion is twofold: (1) the economic process of innovation of a for-profit firm is hardly comparable with the innovation process of a non-profit firm or of a research institute; (2) universities and other academic entities are often obliged by law to disclose ICS according to a clearly predefined structure and predetermined content (see e.g. Austrian Ministry of Science and Research, 2002), thus not facilitating the analysis of genuinely voluntary disclosure – which comprises the focus of our analysis. This selection procedure leads to a final sample of 51 ICS from 51 different for-profit firms.[2] This sample size can be considered as satisfactory compared with other content analyses of ICS (see table II - 1) and maintaining awareness of the voluntary nature of the ICS use as a disclosure instrument.

Table II - 3: Sample description

Size	Industries						Disclosure guidelines				
	A	B	C	D	E	F	a	b	c	d	e
Large	3	4	4	2	--	3	1	4	7	2	2
Medium-sized	4	8	2	1	2	--	--	1	11	--	5
Small	--	11	3	1	--	--	--	--	6	--	9
Micro	1	1	1	--	--	--	--	--	1	--	2
	8	24	10	4	2	3	1	5	25	2	18

Note: Industries: A=Manufacturing; B=Information and communication; C=Professional, technical, and health service; D=Electricity and construction; E=Financial and insurance activities; F=Wholesale, retail, and other services. Disclosure guidelines: a=Austrian Research Centers; b=Danish ICS Guidelines; c=German Federal Ministry of Economics and Technology; d=Modelo Intelect; e=Nordic Harmonised Knowledge Indicators.

The industry nomenclature is oriented on the NACE Rev. 2 classification (European Commission, 2008b). Manufacturing, information and communication, as well as professional, technical, and health services are considered high R&D intensity industries, based on the results by the Community Innovation Survey (European Commission, 2008a). Firm size is measured based on employees counts (headcounts) following the thresholds proposed by European Commission (2005): large≥250 empl., medium-sized<250 empl., small<50 empl, micro<10 empl. The median of headcounts across all 51 sample firms is 89 employees.

For each firm, we consider the latest ICS published, assuming that because of a learning effect the last published ICS gives the most realistic picture of the information that firms are able and willing to disclose about INC. Furthermore, random sample analyses of ICS by one firm over a number of years suggests that their content and structure remains relatively constant over time, consistent with similar findings for annual reports (Lang &

[2] The data collection led to 52 ICS. The analysis of the INCDQUANT led to the exclusion of an outlier disclosing more than 8,000 INC items. Its inclusion would have distorted our results.

Lundholm, 1993). Eight European countries were included in the sample: Germany (n=24), Denmark (n=10), Iceland (n=5), Sweden (n=4), Finland (n=3), Austria (n=2), Spain (n=2) and Norway (n=1).[3] Only five of the firms in the sample are listed on the stock market, supporting the expectations suggested by legitimacy theory and stakeholder approach, which expect all firms – and not only listed firms – to provide the relevant public with information about their activities and their performance. Sample description is summarised in table II - 3.

5 Results

5.1 Innovation capital disclosure: Descriptive results on quantity and quality of disclosure

Table II - 4 displays the descriptive results of our study. We found a total of 1,487 items dealing with INC in the 51 ICS analysed. On average, each ICS discloses 29.16 items on INC. The highest portion of these items relates to the human capital category, closely followed by internal and external capital.

We find a clear predominance of qualitative, non-financial disclosure, historical-oriented disclosure. Data on the type of disclosure flow into the calculation of INCDQUAL. INCDQUANT and INCDQUAL indexes for our sample are summarised in table II - 5. These data provide first insights into heterogeneous INCD behaviours in ICS. INCDQUANT ranges from a minimum of one to a maximum of 109 INC items per ICS, while INCDQUANT ranges from a minimum of 0.31 to a maximum of 22.50. Potential drivers of differences in INCDQUANT and INCDQUAL are tested in the following section.

5.2 Innovation capital disclosure: Univariate results on potential drivers

In a previous section we developed hypotheses about potential drivers of INCD in ICS. The conjectured relationships are examined using t-tests or ANOVA.[4]

[3] Our sample identification is validated by the RICARDIS report (European Commission, 2006), which found no evidence for the current availability of ICS from Italy, France, The Netherlands, and Eastern European countries (European Commission, 2006). Furthermore, despite the attention drawn by several institutions to intangible assets and their disclosure (ACCA, 2006; ICAEW, 2005), we have found no evidence of the use of ICS disclosure among British firms (see also the findings by Striukova, et al., 2008).

[4] T-Test and ANOVA require a normal distribution of the dependent variables. The one-sample Kolmogorov-Smirnov-test showed that both INCDQUANT and INCDQUAL follow a normal distribution.

Table II - 4: Descriptive results of the content analysis

Total number of pages			1,183	
Average pages per firm				23.20
Total number of disclosed items on INC			1,487	
Average items per firm				29.16
Disclosure by capital category (no. of items and % of total items)			*Average number of INCD by category and sector*	
			High R&D (n=42)	Low R&D (n=9)
Internal (structural)	539	(36.2 %)	11.88	4.44
External (relational)	331	(22.2 %)	7.17	3.33
Human (employee)	617	(41.6 %)	12.57	9.89
Disclosure in terms of type of disclosure (no. of items and % of total items)				
Type				
Quantitative			379	(25.5 %)
Qualitative			1,108	(74.5 %)
Nature				
Financial			38	(2.6 %)
Non-financial			1,449	(97.4 %)
Time-reference				
Historical			1,313	(88.3 %)
Forward-looking			174	(11.7 %)

Notes: Items refer to the instances of disclosure on INC. The distinction between high and low R&D intensity industries is informed by the results of the Community Innovation Survey (European Commission, 2008a).

Table II - 5: Descriptive statistics for INCD indexes

Index	INCDQUANT	INCDQUAL
Mean	29.16	6.69
Median	21.00	5.11
S.D.	24.89	4.99
Kurtosis	2.34	1.41
Skewness	1.47	1.23
Min	1.00	0.31
Max	109.00	22.50

Notes: The table reports on descriptive statistics for innovation disclosure quantity (INCDQUANT) and quality (INCDQUAL). The indexes are computed as follows.

$$INCDQUANT_j = \sum_{i=1}^{3} INCDQUANT_{ij}$$

where

$INCDQUANT_{ij}$ = instances of disclosure on INC in category *i* f

$$INCDQUAL_j = \frac{\sum_{k=1}^{K_j} type_{kj}}{pages_j} + \frac{\sum_{k=1}^{K_j} nature_{kj}}{pages_j} + \frac{\sum_{k=1}^{K_j} outlook_{kj}}{pages_j}$$

where

K_j = number of total text units of the ICS of firm *j*;

$type_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides a qualitative item; 2 if the text unit provides a quantitative item;

$nature_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides a financial item; 2 if the text unit provides a non-financial item;

$outlook_{kj}$ = 0 if the text unit *k* does not provide any item on INC; 1 if the text unit provides an historical item; 2 if the text units provides a forward-looking item;

$pages_j$ = number of pages of the ICS of firm *j*.

For the independent variables we build groups as follows. For the industry variable, we distinguish between firms in high R&D intensity industries and firms in low R&D intensity industries on the basis of the results of the Community Innovation Survey by the European Commission (2008a).[5] For the firm size variable, we distinguish smaller firms from larger ones on the basis of a median split by size in terms of employees headcount in the disclosure year.[6] For the region of domicile of the firm, we follow Chaminade & Johanson (2003) and distinguish between firms from German-speaking countries, Nordic countries, and Southern European countries. Finally, in analysing potential differences in INCD arising from the adoption of different disclosure guidelines, we distinguish between the group of firms adopting the German framework (German Federal Ministry of Economics and Technology, 2008), the group adopting the "Putting IC into Practice" guidelines (Thorleifsdottir & Claessen, 2006) and, for reasons of sufficient group size, the group adopting guidelines other than these.

Univariate results are displayed in table II - 6. Consistent with H1(a) and H1(b), we find that the level of R&D intensity of the industry is significantly related to INCDQUANT and INCDQUAL ($p<0.1$ and $p<0.05$, respectively), meaning that firms in high R&D intensity industries disclose significantly more INC items and on a higher qualitative level than firms in low R&D intensity industries. We find a significant difference ($p<0.1$) in the quantity of disclosure between smaller and larger firms, which is consistent with our conjecture in H2(a). Our sample provides evidence of more disclosure by larger firms than by smaller ones. This cannot be confirmed for the quality of INCD, as we find, in contradiction to our hypothesis H2(b), no significant differences between smaller and larger firms in INCDQUAL. This might indicate that a high level of quality in disclosure of ICS is not exclusive to larger firms, but can equally be achieved by smaller firms with reasonable efforts.

[5] Since firms in our sample have very different underlying reporting standards, e.g., due to different requirements from diverse local GAAP or different requirements for listed and non-listed firms, this hampers accounting data-availability, and firm-specific R&D expenses and thus R&D intensity could not be measured. Therefore, we used the industry-specific R&D intensity as a proxy for firm-specific R&D intensity. The industry-specific R&D-intensity is taken from the Community Innovation Survey 2006 (European Commission, 2008a) and is measured as total innovation expenditures as a percentage of total turnover. Firms in industries with an R&D intensity higher than the average over all industries are considered as having a high R&D intensity, while firms in industries with a lower R&D intensity are considered having a low R&D intensity.

[6] Again, significant differences in reporting standards of the firms in our sample hampers data-availability for alternative measures, such as total assets or total sales. The number of employees headcount was reported in each ICS in the sample.

Table II - 6: Univariate results for INCDQUANT and INCDQUAL

Hyp.	Variable	Groups	N	Mean INCDQUANT	S.D. INCDQUANT	Statistics INCDQUANT		Mean INCDQUAL	S.D. INCDQUAL	Statistics INCDQUAL	
H1	IND	IND_RD	42	31.62	25.83	t-statistic	1.550	7.30	5.10	t-statistic	1.942
		IND_NON_RD	9	17.67	16.09	(0.064)		3.84	3.38	(0.029)	
H2	SIZE	SMALL	26	23.50	16.11	t-statistic	1.688	7.26	5.73	t-statistic	0.833
		LARGE	25	35.04	30.74	(0.098)		6.10	4.12	(0.409)	
H3	REGION	GER_SP	26	31.92	18.24	F-statistic	2.608	6.25	5.47	F-statistic	0.517
		NORDIC	23	23.26	26.04	(0.084)		7.38	4.63	(0.600)	
		SOUTH_EUR	2	61.00	67.88			4.43	0.50		
H4	DISC_GUID	GFMEL	25	31.92	18.62	F_w-statistic	5.416	6.30	5.58	F-statistic	0.178
		PIIP	18	17.22	13.44	(0.016)		6.90	4.64	(0.837)	
		OTHERS	8	47.38	44.87			7.45	4.23		

Notes: The table reports the relationship between independent variables and INCDQUANT as well as INCDQUAL tested using t-test (one-sided for directional hypotheses on IND, two-sided for non-directional hypotheses on SIZE) in case of two groups and ANOVA and F-Test in case of more than two groups (F_w-statistic=Welch's test, employed for non-homogeneous variances across groups according Levene-test); p-values in brackets.

Independent variables are: IND (high R&D intensity vs. low R&D intensity industries), SIZE (number of employees in the disclosure year, SMALL and LARGE based on median split of the sample, median=89), REGION (region of domicile, GER_SP=German-speaking countries, i.e., Germany and Austria; NORDIC= Nordic countries, i.e., Denmark, Finland, Iceland, Norway and Sweden; SOUTH_EUR: Southern European, i.e., Spain), DISC_GUID (disclosure guideline: GFMEL=German Federal Ministry of Economics and Technology; PIIP= Nordic Harmonised Knowledge Indicators: "Putting IC into Practice"; OTHERS: Danish Intellectual Capital Statements pilot Project; Austrian Research Center Model; Club Intelecto Spain).

Interestingly, we find significant (p<0.1) regional differences in the quantity (H3(a)), but not in the quality (H3(b)) of innovation related disclose in ICS. While German-speaking countries and Southern European countries seem to disclosure more innovation-related items, the non-significant difference in INCD quality provides tentative evidence of the fact that the understanding of the type of disclosure conveyed in ICS is virtually homogeneous across European regions. Higher disclosure quantity does not translate into higher disclosure quality.

Finally, we identify a significant relationship (p<0.05) between the disclosure guidelines adopted by a firm and the amount of items disclosed on INC in the ICS. This is consistent with our H4(a) and indicates that disclosure following the Guidelines by the German Federal Ministry of Economics and Technology (2008) as well as "others" disclosure guidelines leads to a higher quantity of INC items displayed in the ICS than the "Putting IC into Practice" project (Thorleifsdottir & Claessen, 2006). Nevertheless, the disclosure guidelines adopted do not seem to be related to a higher or lower quality of the disclosure provided (H4(b)).

6 Discussion of results and limitations

In current literature, INCD is understudied, what stands in contrast to the overall proclaimed micro- and macro-economic importance of innovations and the resulting interest in related firm efforts. Therefore, our paper investigates 51 European ICS, as suitable instruments to disclose about INC, with regard to (1) quantity and quality of INCD, and (2) characteristics likely to drive between-firms differences in this quantity and quality.

Concerning the first question, we can infer from the fact that each ICS encompasses at least one and on average 29.16 items on INC that, overall considered, the benefits of disclosure on INC in ICS seem to exceed the costs of disclosure. ICS seem to respond to the need for more disclosure on innovation raised, for example, by the European Union and the OECD (European Commission, 2006; OECD, 2010). This inference can be detailed by considering the distribution of INCD across the IC categories. Even if human capital is the category with most INCD in ICS, we find a fairly balanced distribution. This empirically supports the proposition that INC is derived by investments in all IC categories (Lev, 2001) and that the different IC categories are highly interwoven with each other and create a network that facilitates innovation and value creation (Mouritsen, et al., 2008).

Furthermore, non-financial, qualitative, historical INCD seems to display the most advantageous cost-benefit relationship. Possibly, financial information is considered a matter for mandatory reporting, but not for voluntary disclosure, i.e., disclosing financial data that may be partially already available to stakeholders is not considered to respond in a sufficient way to the expectations of the public. Furthermore, the fear of proprietary costs may deter firms from quantitative, more verifiable disclosure. At the same time, qualitative texts allow to explain means-ends-chains that, due to space constraints, are not addressable elsewhere in disclosure. One further point deserves attention. In contradiction to the purpose of ICS to be a disclosure instruments that provide insights into the future value creation of firms (e.g. Mouritsen, et al., 2001a), we find a low degree of forward-looking INCD in our ICS sample. The benefits derived from fulfilling the information expectations of stakeholders about the future value of the firm and the related intentions concerning innovations efforts seem not to be sufficient to outperform the proprietary costs of disclosing information about future innovation behaviour. Similar results on the type of disclosure have been found also by other disclosure studies (Boesso & Kumar, 2007; Mouritsen, et al., 2001b; Ordóñez de Pablos, 2005; Striukova, et al., 2008), indicating that from this point of view INCD does not differ from other forms of IC.

Concerning the second question, we find industry, size, country of domicile of the firm, and disclosure guideline adopted to be significantly related to the quantity of INCD in ICS, while only industry makes a difference for the quality.

Thus, we can infer that firms in high R&D intensity industries underlie a higher pressure by public, investors, and other stakeholders to legitimate themselves as part of this industry and to provide value relevant information on innovations than firms in low R&D intensity industries. In other terms, if costs of disclosure are presumed equal, high R&D intensity firms profit more from a high quantity and a higher quality of disclosure on INC than other firms.

Similarly, benefits of INCD disclosure may be higher and costs of INCD disclosure may be lower for larger firms. Larger firms gain more attention from society, investors, and other stakeholders, what leads to uncertainties about the firm outcome. This can be reduced by a higher disclosure quantity than necessary for smaller firms. Additionally, large firms can usually exploit economies of scales in overall disclosure, thus allowing them to add disclosures to decreasing marginal costs. A result that deserves particular attention is that the quali-

ty of disclosure does not differ significantly between small and large firms. From this result, we infer that the benefits and costs of disclosing high quality items are nearly the same for small and large firms. This result is worth mentioning in relation to the efforts undertaken by the European Commission (2006) and described in the RICARDIS report to encourage SMEs to use ICS to disclose their innovation activities. If compared with the findings by Striukova, et al. (2008), who analysed a wide range of firm reports but not ICS, and found an overall higher disclosure quality with larger firms, our results may stress the homogeneous applicability of ICS for both large and small firms. Therefore, our study may highlight a particular potential related to non-codified ICS disclosure when compared with other firm reports.

While the quantity of disclosure differs significantly across regions, we find no significant differences in the quality of disclosure provided. Interestingly, the regions with most INCD are Southern Europe and German-speaking countries, what stands in contrast to the thoughts by Chaminade & Johanson (2003), who argue for higher (perceived) proprietary costs in Southern countries and lower for Nordic countries. The differences in quantity do not translate in higher INCD quality for Southern and German-speaking countries, indicating homogenous disclosure quality across European regions.

Finally, while quantity of INCD disclosure differs across ICS disclosure guidelines adopted, no quality differences are found. This qualitative homogeneity could be attributed either to high levels of similarity in the guidelines concerning the type of disclosures recommended, or to a low impact from the differences in the guidelines on the disclosure practices of firms. For both cases, in the light of the different attempts by multi-national projects to homogenise the use of ICS (e.g. European Commission, 2006), our results provide some evidence of the success of these efforts.

Of course, we must acknowledge a number of limitations inherent to our study. The generalizability of this research is limited to INCD decisions in ICS in European for-profit firms. However, our findings suggest avenues for further exploration by researchers on disclosure in ICS and for other forms of IC. Further limitations relate to the methods employed in this study. First, the indexes used might be criticised based, for example, on the weightings used in INCDQUAL. Nevertheless, we preferred relying on indexes found to be helpful for prior disclosure analyses and which had thus already been validated instead of developing our own, new disclosure index. At the same time, we tested if our results are susceptible to changes if we measure INCDQUAL in a different way. We standardised INCDQUAL with

the number of words per ICS and with the number of characters per ICS (instead of with the number of pages per ICS), and once do not standardise at all. Additionally, we refer to Beattie, McInnes, & Fearnley (2004) and measure INCDQUAL by the Herfindahl concentration index (summed squared proportion of disclosure over the internal, external, and human capital category) and by the number of non-empty disclosure categories (internal, external, human capital) per ICS. All these different measures of INCDQUAL do not change our results, with the only exception of not standardising INCDQUAL, what leads to a significant difference in disclosure quality due to the ICS framework adopted. Secondly, as can be said for practically every content analysis, our results cannot be ultimately claimed to be unshakeably reliable and valid. This issue impels a certain degree of caution in the interpretation and generalization of our results. Nonetheless, we made intensive efforts to maximise the reliability and validity of the content analysis carried out, and provide a detailed schedule of our attempts following the guidelines of Krippendorff (2004) and Weber (1990).

Notwithstanding these limitations, we believe that our paper contributes to research in several ways. (1) We learn that ICS are used to disclose about INC with an average frequency of 29.16 items per ICS. This shows that firms are able to achieve one of the major firm goals when publishing ICS identified by Mouritsen, et al. (2001b), i.e., to show innovation efforts. Similarly to other disclosure instruments analysed in empirical literature, the type of disclosure remains mostly constrained to qualitative and historical data, thus not tapping the full potential of ICS. (2) We find that INCD in ICS is done by fairly using items across the internal, external, and human capital categories. Therewith, we show how INC is interrelated with different types of IC and provide quantitative evidence of the argument that innovations can be generated by accurately mixed investments in IC. (3) We contribute to research on disclosure drivers in that we find that INCD quantity is driven be industry, size, region of domicile, and disclosure guideline adopted, but especially by showing that the quality with which this information is disclosed, i.e., the type of information and the intensity with which this is conveyed, is homogeneous across different firm sizes, regions, and disclosure guidelines. This demonstrates the potential generated by ICS: to be a disclosure instrument which is equally applicable across different types of firms.

Our findings have also implications for policy and practice: (1) small firms especially may identify ICS as adequate instruments toward meeting the demand for INCD; (2) policy-makers may achieve insights into the current disclosure practices on INC and find approaches for further improvements in policy-making. For example, policy-makers in Nordic countries

could recognize in our data the necessity to increase the narratives on INC in their countries to increase the perception of the innovativeness of their economies; (3) guideline-setters may recognize that there is currently no relationship between disclosure framework adopted and the quality of disclosure and may wish to establish common standards to increase the quality of INCD, e.g., by fostering the disclosure of forward-looking information.

Appendix

Appendix II - 1: European IC disclosure guidelines (sorted chronologically)

Guidelines
Skandia Navigator (Edvinsson & Malone, 1997
Intangible Assets Monitor (Sveiby, 1997)
Modelo Intelect (Euroforum, 1998)
Dutch Ministry of Economics (Backhuijs, Holterman, Oudman, Overgoor, & Zijlstra, 1999)
Austrian Research Centers (Austrian Research Centers, 2000)
Meritum project (Meritum, 2000)
Danish Ministry of Science Technology and Innovation (2003)
Nordika (Nordic Industrial Fund, 2001); Frame (Nordic Industrial Fund, 2003); Nordic Harmonized Knowledge Indicators (NHKI); and the follow-up project "Putting IC into Practice" (PIIP) (Thorleifsdottir & Claessen, 2006)
Schmalenbach working group "Accounting and Reporting of Intangible Assets" (Schmalenbach working group "Accounting and Reporting of Intangible Assets", 2005)
German Federal Ministry of Economics and Technology (2008)

Note: While the others guidelines publish their own recommendations, Nordika; Frame; Nordic Harmonized Knowledge Indicators (NHKI) and the follow-up project "Putting IC into Practice" (PIIP) attempt to summarise already existing IC disclosure guidelines. Guidelines listed have been detected on the basis of an extensive literature and internet research for European guidelines aimed at encouraging the delivery of a consolidated numeric and narrative report for external disclosure purposes by profit-oriented firms. Guidelines issued outside Europe (e.g., those by the Japanese Ministry of Economy Trade and Industry (METI), 2005 or by the Australian Society for Knowledge Economics (SKE), 2005) have been excluded as they would not be expected to have an impact on the IC disclosure in European firms. Since the research design is restricted for the sake of better comparability of the disclosure of INC to only for-profit firms, guidelines which address only disclosure by non-profit entities (e.g., those by the Austrian Ministry of Science and Research, 2002) have also been excluded. Approaches aimed at internal reporting, but which are not designed for external disclosure (e.g., the Balanced Scorecard by Kaplan & Norton, 1996) are not considered.

Appendix II - 2: Categories and definitions

Category and subcategory name	Definition / key concepts
Internal (structural) capital category	
1.1 Intellectual property	Legal rights, i.e., majorly patents and copyrights, that protect firm's innovations
1.2 Management philosophy	General beliefs about the role of innovations for the firm, usually formulated into vision or mission statements
1.3 Corporate culture	Set of common behaviors and attitudes adopted by a firm in order to encourage innovation
1.4 Management processes	Functional structure, procedures, and organizational practices used by firm for innovation efforts
1.5 Information and networking system	Network of all communication channels used within a firm to facilitate innovation
1.6 Infrastructure	Resource commitment of the firm for innovation efforts
External (relational) capital category	
2.1 Customers and market	Customer involvement and customer reactions to innovations, innovations developed with customers, as well as financial impact of innovations in term of income, returns, market share, and savings
2.2 Distribution channels	Process involving marketing and distribution of firm's innovations
2.3 Firm reputation	Firm's credit due to innovation efforts
2.4 Business collaborations	Relationship between firm and individuals or organizations that is characterized by mutual cooperation on innovation efforts
Human (employee) capital category	
3.1 Employees	Workforce involved in innovation efforts
3.2 Education	Education level considered important in order to generate successful innovations
3.3 Training	Actions taken to imparting skills considered important for successful innovations
3.4 Work-related knowledge	Competencies, capabilities, and experience considered important for successful innovations
3.5 Innovativeness of employees	Results of the innovation process generated by employees in terms of new ideas, new products, new services, new processes, and related scientific publications

III The interplay of the levers of control in product development

Abstract

This paper contributes to the research on management control systems (MCS) in product development (PD) by exploring the performance effects and the interplay of the levers of control (LOC), i.e., interactive, diagnostic, beliefs, and boundary control systems. We use data from a survey of 468 senior managers from the manufacturing industry and identify the direct and indirect effects of the LOC on PD performance and organizational performance. Therefore, we first scrutinize the possible types of interplay of the levers by comparing by structural equation modeling a base model of unrelated LOC (additive model) with (a) a model of mutual association of LOC (interdependence model), (b) a model of joint use of LOC (interaction model), and (c) a combined model of mutual association and joint use of LOC (combined interdependence/interaction model). The results show that the interdependence model is the most suitable in terms of fit to the data and parsimony, providing evidence of the fact that the LOC move together and influence PD performance and organizational performance both directly and mediated through each other. Interestingly, PD performance is positively affected by both the beliefs system and the diagnostic use of performance measures, as these LOC have a significant direct effect and generate the largest total effects on PD performance. However, the boundary system and the interactive use of performance measures, the last being praised in previous literature for its suitability for PD, have no significant direct effects, show lower total effects than beliefs and diagnostic control systems, but have rather meaningful indirect effects on PD performance. These results hold across different industries and firm sizes. The paper contributes to research and practice by uncovering the interdependence of the LOC in PD, thus clarifying the role of each of the levers for PD performance and organizational and therefore providing suggestions for a more successful design of LOC for PD. Furthermore, it directs the attention of researchers to the consequences of potential misspecifications of LOC models.

Keywords: Management control system, levers of control, product development

JEL Classifications: C39, C83, L60, M40, O32

1 Introduction

Management control systems (MCS) refer to all the actions or activities taken by management in order to direct the behavior of organizational members toward the achievement of organizational goals (Anthony & Govindarajan, 1998; Flamholtz, 1983; Otley, 1994; Simons, 1995). One field in which MCS are used is product development (PD). The need to ensure predictable goal achievement without hindering opportunity-seeking and innovation has made MCS for PD an important area of research (Davila, Foster, & Oyon, 2009). Previous empirical research provides seemingly contradictory results on the effect of formal MCS on PD performance. For example, on the one hand, Abernethy & Brownell (1997) find formal accounting and behavior control systems to be unsuitable for research and development tasks involving a high and frequent number of exceptions. Similarly, interactive control in the form of management intervention is found to be detrimental to PD project performance by Bonner, Ruekert, & Walker Jr. (2002). On the other hand, Bisbe & Otley (2004) find evidence that interactive control enhances PD performance, at least for low-innovating companies, while Henri (2006) identifies a clearly positive relationship between interactive control and innovativeness. It is defensible to argue that at least part of the contradictions stems from (a) the restriction "[…] on a limited set of concepts" (Davila, Foster, & Oyon, 2009, p. 294) used to analyze MCS for PD (e.g., a focus on interactive and/or diagnostic control systems), (b) following on from this, the suppression of non-modeled, but existing relationships between different MCS components (Simons, 1995), and (c) the ambiguity about how these relationships are designed in practice (Davila, Foster, & Oyon, 2009). Our study adds to this area of research as we put our analysis on a broader conceptual basis than previous research, thus allowing a more extended understanding of the phenomenon of control for PD in terms of the relationship between different MCS components. In particular, the paper addresses both the direct and indirect effects of MCS components on PD performance and on organizational performance. In this study, PD performance is defined according to OECD (2005) from an output perspective. Thus, it refers to the results of the PD process in terms of new or significantly improved products and related effects on sales and profit. Organizational performance is understood as financial results of firm activities in terms of profit and return measures.

For decades the impact of different MCS components, like budgets, accounting controls, or the use of performance measures, have been considered separately from each other, as if they act as stand-alone components (in PD as well as in other areas of MCS research) (Malmi & Brown, 2008). However, conceptual developments since the 1980s suggest that

MCS components operate in a combined way as a package (Chenhall, 2003; Fisher, 1998; Malmi & Brown, 2008; Otley, 1980). This means that firms may implement different MCS components with different emphasis simultaneously in a system in which the MCS components all interplay (Malmi & Brown, 2008; Simons, 1995). Recent findings from qualitative studies support the existence of MCS packages (Abernethy & Chua, 1996; Marginson, 2002; Mundy, 2010; Revellino & Mouritsen, 2009; Sandelin, 2008, Tuomela, 2005). Notwithstanding the high level of agreement on the concept of interplay and the "[…] potential for serious model underspecification" (Chenhall, 2003, p. 131) when ignoring it, most quantitative MCS research still relies on the analysis of isolated MCS components (Malmi & Brown, 2008). There is still scarce quantitative evidence of how these components are coupled within the package (Malmi & Brown, 2008; Sandelin, 2008).

Informed by these developments, we use data from a survey of 468 senior managers to learn how different MCS components affect PD performance and organizational performance. To achieve this, we start by comparing competing models that explain how the MCS components are interrelated and use the best-fitting and most parsimonious model (i.e., the model that is most likely to replicate in further samples) to investigate the direct, indirect, and total effects of MCS components on PD performance and organizational performance.

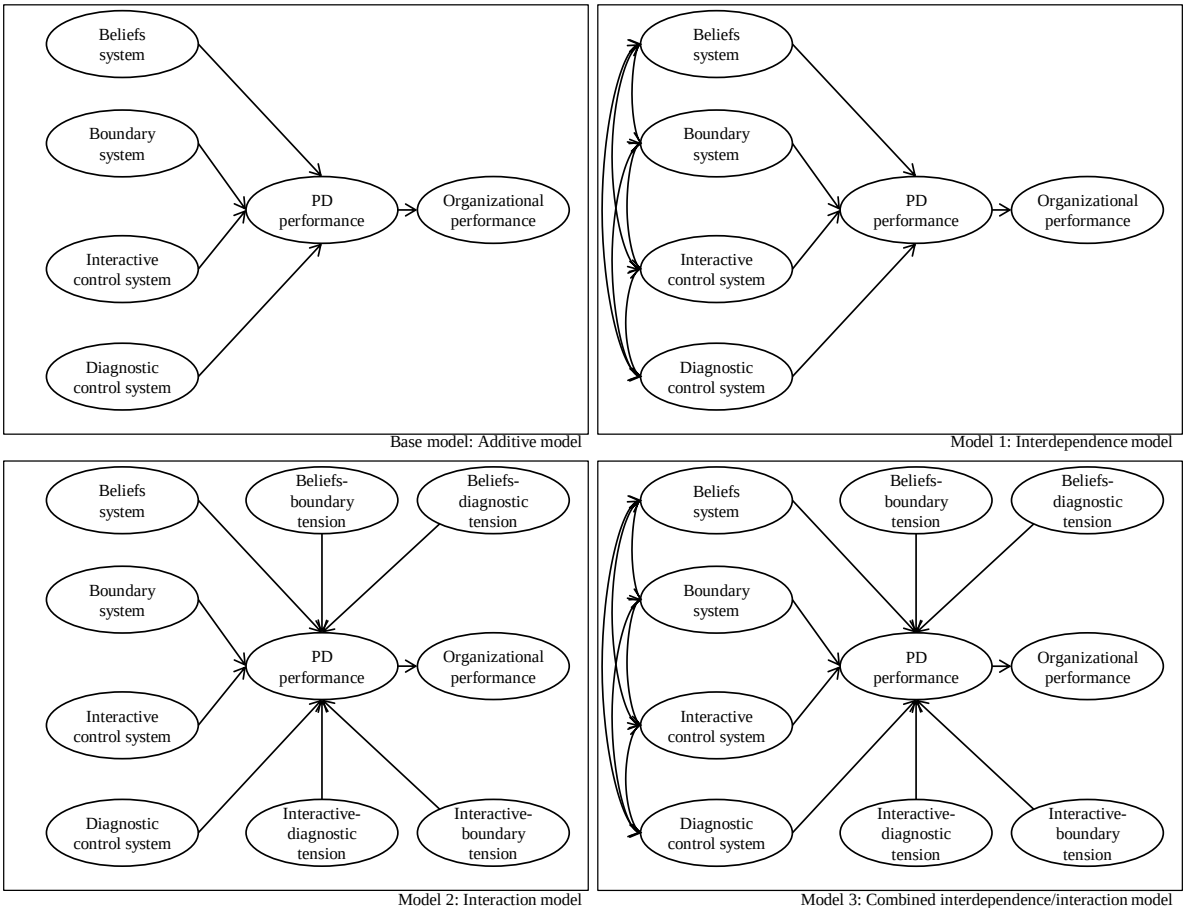
We analyze the interplay within a MCS based on the levers of control (LOC) framework by Simons (1995), who posits that the relation between the interactive use of PD performance measures (e.g., the use of performance measures to sensitize organizational members to strategic uncertainties), the diagnostic use of PD performance measures (e.g., the use of performance measures to monitor results), beliefs (e.g., values and mission statements), and boundaries (e.g., codes of conduct) enhances performance. We prefer the LOC framework to other MCS frameworks like those of Flamholtz, Das, & Tsui (1985), Merchant & Van der Stede (2003), Ouchi (1977), or Ouchi (1979) for several reasons. First, Simons' work incorporates the issue of MCS for PD settings by addressing the need to balance between predictable goal achievement and innovation, which makes his framework a commonly used framework for research on MCS for innovative settings (e.g. Bisbe & Otley, 2004) and allows us to compare the results with previous research in the area. Second, Simons (1995) explicitly addresses the need to combine and balance different levers. This interplay is one of the core aspects of the study. In his own words: "The power of these levers in implementing strategy does not lie in how each is used alone, but rather in how they complement each other when used together" (Simons, 2000, p. 301).

While it clearly stresses the importance of the interplay of the levers, at the same time the LOC framework remains nebulous about the type of interplay. For example, following Simons: "The four control levers are nested – they work simultaneously but for different purposes. Their collective power lies in the tension generated by each of the levers" (Simons, 1995, p. 5). However, what do we learn from this in terms of the type of interplay? Do the LOC simply coexist in firms, without intentional or unintentional reciprocal interferences, since they have different purposes? Alternatively, are they all mutually associated, since they work simultaneously to pursue the same goal of directing employee behavior toward goal achievement? Furthermore, is the performance effect of the levers even conditional on the emphasis placed to the other levers, as they generate "collective power"? Since the LOC framework leaves these questions unanswered, empirical research formulates diversified, not consistent specifications of the interplay of the LOC in empirical studies (e.g., the interactions in Henri, 2006 and the interdependences in Widener, 2007). Conceptual and empirical differences in the specification of the interplay of the LOC, or at least the lack of proper discussion of these differences, lead to results that are hardly comparable and possibly driven by model specification.

To the best of our knowledge, a quantitative analysis of the effect of all four LOC on PD performance and organizational performance is not available and thus we add to the MCS discourse by investigating this relationship. In addition to considering an additive model (i.e., merely coexistent LOC), we look for interdependencies between the LOC (i.e., model 1, with associated LOC), for interactions between them (i.e., model 2, with LOC as mutual conditions for high performance), as well as for both effects simultaneously (i.e., model 3, with both interdependencies and interactions between the levers). Hence, we start our analysis with the simple additive LOC model as a pure base model and compare this with competing models suggesting a different interplay of LOC. The competing models are shown in figure III - 1.

Model 1 suggests mutual interdependencies between LOC in a way that a changed emphasis on one lever is associated with a changed emphasis on each of the other LOC. Model 2 supports the existence of interactions between LOC, meaning that the impact of one lever on performance is dependent on the level of another interacting lever. Model 3 supposes the existence of both interdependencies and interactions. The base model is the model against which these three models are tested. After identifying the best-fitting model, we scrutinize the best-performing model to detect the direct and indirect effects generated from each of the LOC on both PD performance and organizational performance.

Figure III - 1: Base model and competing models



This study contributes to the research in three ways. First, we provide a detailed understanding of the LOC effects in a PD setting. The existing research offers only fragmented evidence of this relationship. For example, Bisbe & Otley (2004) find no generally valid direct effect of the interactive control system on product innovation, while Henri (2006) recognizes a significant positive direct effect and Bonner, et al. (2002) detects a detrimental effect of interactive control systems on PD performance. Following Davila, Foster, & Oyon (2009), one possible reason for these contradictory results is the restriction to a limited concept of control, which omits components of the entire package of controls. Thus, we (a) consider the beliefs, boundary, interactive, and diagnostic control systems simultaneously and (b) discuss the way in which they are related to each other in the context of PD. While we can gain important insights into the isolated effects of interactive and diagnostic control systems from previous studies, we supplement their results and offer a more encompassing picture of the relationship between all the levers and the performance in a PD setting. This provides researchers with a better understanding of the conceptual work by Simons (1995) in an innovative setting, while practitioners can profit from this study by identifying the levers that are

best suited to enhancing the PD performance as well as the overall organizational performance.

Second, there is a strong consensus in the literature on the existence of relationships among different MCS components. This consensus is encouraged by insightful case study research, but nevertheless, it remains unclear whether these findings are generalizable to firms other than those analyzed. We put these analyses on a broader empirical basis by using data from a cross-sectional survey of 468 firms, and show empirically the superiority of models acknowledging the interplay of the LOC. This allows for more generalizable results on the existence of a MCS package that provides support for the underspecification of purely additive MCS models, as conceptually argued by Chenhall (2003). Research can profit from these findings since they provide robust evidence of a phenomenon – the interplay of MCS components in a MCS package – that is widely agreed on, but has lacked solid empirical evidence until now. Practice may be sensitized by this result and thus recognize that changes in the emphasis on one lever will not leave the other levers and/or their performance effects unaffected.

Third, the type of interplay that best describes the MCS package is vague. We add to the discussion on the MCS package by comparing three types of LOC interplay analyzed separately in the literature. For example, Henri (2006) deals with the interplay of different LOC by postulating an interaction between the interactive control system and the diagnostic control system, while Widener (2007) interprets the LOC package as the interdependence between the beliefs, boundary, interactive, and diagnostic control systems. This somehow contradictory modeling leaves researchers doubtful about the soundest model specification. In this vain, we compare an interdependence model that follows Widener's (2007) understanding with an interaction model reflecting Henri's (2006) point of view and with a model combining interdependence and interaction between the levers. Since we use the same construct measurement for these models and cover all four LOC, we are able to compare the models in terms of the best specification. We show in our sample that the interdependence model is superior in terms of fit to the data and parsimony, thus being the specification that is most likely to be replicated in future samples. While we do not claim to formulate the overall and "best" ever model specification, these reflections are intended to prompt MCS researchers to make the specification of the relationship between MCS components a core issue of their research and to the disclose related efforts. Practitioners can learn from the interdependence model how changes in only one lever of control may have a meaningful impact on performance both directly and mediated through the other levers.

The remainder of this paper is organized as follows. The section "Theory development and hypotheses formulation" discusses the relationship between LOC, PD performance, and organizational performance, formulates hypotheses, and proposes competing models on the LOC interplay. The section on "Methods" gives an overview of the data collection process, the variable measurement, and the data analysis procedure. The results are discussed in the related section, while the "Conclusion" section provides the limitations of the study as well as avenues for future research.

2 Theory development and hypotheses formulation

2.1 The levers of control framework

Following Simons (1995), four levers contribute to strategy implementation: the boundary system, diagnostic control system, beliefs system, and interactive control system. While boundary and diagnostic control systems represent constraining forces that impose compliance with rules, beliefs and interactive control systems focus on opportunity-seeking, enabling creativity, and problem-solving (Simons, 1995). Boundary systems "[…] delineate the acceptable domain for opportunity-seeking for organizational participants" (Simons (1995), p. 39). They induce the behavior constraints necessary to prevent employees from engaging in misleading, non-goal-congruent activities. The definition of the off-limits behavior and risks that should be avoided can be formally stated in a code of business conduct or in internal guidelines and should be reinforced by the management (Simons, 1995). In a PD setting, this implicates the definition of markets, product areas, or customers, for which PD is not carried out. An example of such a definition of off-limits behavior for PD can be found with the furniture designer BoConcept: "Principle: We strive to avoid making products that are non-recyclable" (BoConcept, 2011). Similarly focused on rule compliance, the diagnostic control system supports management by exceptions, i.e., budgets, project timelines, milestones, as well as other data from management accounting are used by managers to set standards, monitor organizational outcomes, and correct deviations from preset standard performance, while management intervention only occurs if the results deviate from the standards or goals. The diagnostic use of management accounting information is intended to make goal achievement predictable (Simons (1995), pp. 59). PD has to be tracked in order to monitor the progress of each project according to costs, time, and quality key measures and to compare the achievements with the expectations.

While boundary and diagnostic control systems are constraining forces, beliefs and diagnostic control systems are enabling forces. Beliefs systems are "[…] the explicit set of organizational definitions that senior managers communicate formally and reinforce systematically to provide basic values, purpose, and direction for the organization" (Simons (1995), p. 34). Formal instruments for communicating firm values are, for example, the mission, the vision, and the value statement. Together with the communication of values by the top management during daily activities, mission, vision, and value statements are designed to motivate employees to expand their efforts toward the desired opportunity-seeking (Simons, 1995). In settings where PD is crucial, the mission statement should communicate innovation as a primary value of the firm. Managers should stress the importance of successful PD to foster innovative behavior (Amabile, Conti, Coon, Lazenby, & Herron, 1996). An example of the formulation of innovative behavior as a major value of the firm can be found with the computer manufacturer Microsoft: "Our vision is to create innovative technology that is accessible to everyone and that adapts to each person's needs" (Microsoft, 2012). Interactive control systems are characterized by frequent dialogue between managers and employees and are intended to assure the adaptation capability of the firm in uncertain environments. Management accounting data that are monitored and discussed by the management are used to orient the firm toward key issues and critical success factors, to tie the organization together, and to provide a common vocabulary across departments and hierarchies (Simons, 1995). In terms of PD, an interactive control system requires the use of management accounting data from, for example, project milestones, budgets, or project timelines to align the firm with the critical success factors, like innovation speed. Furthermore, an interactive use of management accounting data generates a common understanding of the issues in PD across different departments, such as the finance, marketing, and PD departments.

Actually, the LOC framework proposes a coherent typology of levers used to control employees' actions by balancing opportunity-seeking and management attention, intended and emergent strategy processes, self-interest, and the desire to contribute (Simons, 1995). This requires the need for interplay of the levers, and this in turn should be considered in the specification of LOC models for research. However, Simons (1995) remains vague about the relation between the levers. He writes about the need to balance the different levers of control ("Implementing strategy effectively requires a balance among the four levers of control" (Simons (1995), p. 10)), about their mutual reinforcement ("These four [levers] are mutually reinforcing" (Simons (1995), p. 161); "These four [levers] are highly interdependent" (Simons (1995), p. 167)), about the dynamic tension they generate ("The interplay of positive and neg-

ative forces generated by these systems creates a dynamic tension between the opportunistic innovation and predictable goal achievement that is necessary for profitable growth" (Simons, 1995, p. 153)).

Facing these vague conceptual definitions, we define competing models. The additive model (i.e., a model that does not display any relationship between the different levers) is our base model, against which we test our LOC interplay models. These are model 1 (i.e., the interdependence model), model 2 (i.e., the interaction model) and model 3 (i.e., the combined interdependence/interaction model) and are introduced hereafter.

2.2 The interdependence model

The interdependence model (model 1) suggests that the LOC are mutually associated, i.e., they somehow move together, so that changes in one of the levers are accompanied by changes in the other levers. This model is supportable by Simons' framework, since he suggests that the levers work together to provide an effective MCS environment (Simons, 1995).

Firms must ascertain that employees' behavior is beneficial for goal-achievement. To do so, they can rely on the four LOC previously described, which operate in different ways, but follow the same goal of securing and increasing performance. Interactive use of performance measures for PD is implemented to focus the attention of the firm on strategic uncertainties and thus to encourage opportunity-seeking, which is likely to increase in turn PD performance. At the same time, the diagnostic use of performance measures for PD drives the focus of the firm's actions on critical performance variables, which stimulates compliance with the goals in PD without requiring time- and cost-consuming management intervention. Stressing innovativeness as a core value of the firm by a properly designed beliefs system generates the commitment of firm's members toward its business strategy, therefore safeguarding that employees are motivated to operate in terms of an increase in PD performance. Finally, boundary systems delimitate the opportunity-seeking area for firm members by defining the range of actions that is likely to be harmful to PD performance (Simons, 1995). The empirical results partially support the postulates from the LOC framework. Bisbe & Otley (2004) find, at least for low-innovative firms, a significant positive relationship between interactive control systems and product innovation, while Henri (2006) finds an overall significant positive relationship between the interactive use of performance measures and innovativeness. But at the same time he detects a significantly negative association between the diagnostic control system and innovativeness, while Craig (1995) found bureaucracy in terms of formal rules, guidelines, and evaluation systems as a supportive mechanism for PD. Bonner,

et al. (2002) show that the involvement of employees in the development of controls used to monitor PD performance, i.e., an interactive way to deal with control, has a positive impact on PD project performance, while other components of an interactive control system, like management intervention, have no or a detrimental effect on performance. In a field study, Collier (2005) shows the importance of the beliefs and boundary systems for an entrepreneurial organization. Informed by these conceptual and empirical research results, we formulate the following hypotheses:

> H1a: *The emphasis firms place on the interactive use of performance measures, on the diagnostic use of performance measures, on the beliefs system, and on the boundary system for product development is each positively associated with product development performance.*

The mutual association between the LOC is peculiar to the interdependence model. Following Simons (1995), the LOC are "nested" (p. 5) and their use relies on "continual interplay" (p. 30). One defensible statistical specification of this relationship between the LOC is in terms of correlations. This implies that the levers move together, i.e., changes in one lever occur at the same time as changes in other levers. How these interdependencies can be justified is drawn by previous empirical research. Different works argue for an association between a firm's beliefs system, e.g., its mission statement, and other instruments designed to manage and control employees' behavior (Pearce II & David, 1987; Widener, 2007). On the one hand, if the management is not able to communicate what the firm stands for, then it is likely that the other LOC are not being particularly accentuated, since the overall direction and motivation provided by the beliefs system is missing. On the other hand, if the LOC apart from the beliefs system are only emphasized a little and are therefore unable, or able only to a small degree, to define the boundaries of action, to diagnose the level of goal achievement, and to generate a common understanding of the firm's goals, then it is likely that the firm is omitting to emphasize what the overall directions and values of the firm should be. Consistently, Sandelin (2008) finds in her case study about a high-tech entrepreneurial firm that business units' operations "[…] were controlled by mutually reinforcing forms of cultural, personnel, and action control" (Sandelin, 2008, p. 331), while Widener (2007) detects significantly positive correlations between the beliefs system and the interactive, as well as the diagnostic control systems.

In a similar manner, the emphasis on the boundary system might be interwoven with the emphasis on other LOC. The boundary system delineates the area for which opportunity-

seeking is desired and, in turn, for which an evaluation of results based on accounting data is required. Thus, it is likely that a strong emphasis on the boundary system is accompanied by emphasis on both diagnostic and interactive control systems, which are responsible for the evaluation of the compliance with and shaping of organizational goals. Since the boundary system and the diagnostic control system both represent the constraining, negative forces of the LOC framework (Simons, 1995), we suppose that an emphasis on one constraining force coexists with an emphasis on the other constraining LOC (Widener, 2007). At the same time, Mundy (2010) finds in her case study that in the PD process of the financial services firm she investigates an emphasized boundary system is accompanied by an emphasized interactive control system. She finds that changing conditions in PD increase the necessity to debate the new, changing issues and goals of the firm, while the boundary system has to formulate new constraints for operations in PD on that basis. Widener (2007) sees a significant correlation between the boundary system and both the interactive and the diagnostic control systems.

Following the seminal work by Miller & Friesen (1982), the entrepreneurial firm pursues innovation efforts aggressively. The LOC implied by this sort of firm is an interactive control system (Simons, 1995), that supports forward-looking, risk-seeking behavior. Nevertheless, to reduce the risks of excessively aggressive innovative behavior, firms put in place at the same time diagnostic control systems that prevent employees from improper, unstructured innovation, but track the progress of the PD efforts (Bisbe & Otley, 2004; Miller & Friesen, 1982). Tuomela (2005) shows in her case study about the introduction of a new performance measurement system that the interactive discussion about firm goals is accompanied by the diagnostic reporting and review of performance data. This result is supported by Widener's finding that the interactive and the diagnostic control systems are significantly correlated with each other (Widener, 2007).

Besides these arguments for a positive association between the levers, the use of LOC requires management attention, which in turn implicates the consumption of time as one of managers' most limited and thus costly resources. For this reason, it is likely that an increase in emphasis on one lever occurs simultaneously with a reduced emphasis on another lever. Simons (1991) first discusses the issue of the trade-off between the attention paid to different LOC. Mundy (2010) finds that certain LOC are suppressed by managers when their attention is driven toward other LOC. In summary of these considerations, we formulate the following hypothesis:

H1b: *The emphases firms place on the beliefs system, on the boundary system, on the interactive use of performance measures, and on the diagnostic use of performance measures for product development are mutually correlated.*

Since decades, PD performance is expected to lead to a sustained competitive advantage and thus to contribute to organizational performance (e.g. Clark & Fujimoto, 1994; Damanpour, 1991; Drucker, 2001; Schumpeter, 1943). Numerous empirical studies confirm this positive relationship between measures of PD performance and measures of organizational performance (e.g. Capon, Farley, & Hoenig, 1990; Griliches, 1981; Hall & Mairesse, 1995). Thus, we hypothesize:

H1c: *Product development performance is positively associated with organizational performance.*

Consequently, if the LOC are positively linked with PD performance and PD performance is positively linked with organizational performance, than the levers are expected to have a positive impact on organizational performance through the enhancement of PD performance. Thus, we implicitly suggest an indirect effect between the levers designed for PD and organizational performance. In line with previous research (Bisbe & Otley, 2004; Henri, 2006), we do not hypothesize the existence of a direct effect between the levers and organizational performance. From a conceptual perspective, levers which are designed to control PD are not likely to have a direct impact on the performance of the entire organization (Bisbe & Otley, 2004). From an empirical perspective, previous research mostly could not find such a direct relationship (e.g. Abernethy & Brownell, 1999; Bisbe & Otley, 2004; Henri, 2006; Widener, 2007). However, in case the levers used for PD show unpredicted direct effects for the achievement of overall firm goals, we control for the relationship in our statistical analyses.

2.3 The interaction model

The second competing model we present is the interaction model (model 2). Simons (1995) refers to a "[…] collective power [that] lies in the tension generated by each of the levers" (p. 5) and to "dynamic tension" (p. 30) between the levers. Tensions refer to the combination of opposing but interrelated components of the same system (Lewis, 2000). In Simons' understanding, these tensions are referred to as "dynamic" since they do not generate stagnancy, but rather involve reinforcing cycles between the components in tension (Lewis, 2000). The LOC framework proposes constraining and enabling levers which are perceived as opposing (and thus in tension), but are nevertheless all aimed at increasing performance. The generated ten-

sions urge the management and employees to look for solutions (Dent, 1987). These solutions are achieved by communication and debates among firm members on firm goals. These in turn generate a plurality that enhances innovations and that is useful for allowing employees to get involved in the finally agreed goals, which increases organizational performance (Henri, 2006). We follow Henri (2006) and define the dynamic tensions by using interaction terms between the LOC that generate constraining forces and the LOC that generate enabling forces. Thus, the relationship between the LOC described in this model assumes joint use of the levers in tension in a way that the performance impact of one lever is conditional on the emphasis placed to another opposing lever (and vice versa).

These conceptual thoughts find reflection in previous empirical works. Lewis, Welsh, Dehler, & Green (2002) analyze dynamic tensions in a PD setting and find that successful PD requires the ability of managers to cope with tensions between conflicting project management styles, i.e., an emergent, freedom- and innovation-oriented style and a planned, goal implementation-oriented style. They suggest the use of "[…] subtle control: effective managers provide strong leadership to keep teams focused and on schedule, while empowering team members to foster motivation and creativity" (Lewis, et al., 2002, p. 562). In the same vein, Mundy (2010) shows how managers of a financial services firm consciously use opposing LOC jointly, i.e., interactive and diagnostic control systems, beliefs and boundary systems, as well as interactive and boundary control systems with the aim of balancing these opposing forces in order to enhance performance. Henri (2006) tests the effect of the dynamic tension between interactive and diagnostic control systems on innovativeness and finds no significant effect. However, we follow Simons' notion of positive and negative forces in the LOC framework, which subsumes the beliefs system and the interactive control system to the first, and the boundary system as well as the diagnostic control system to the latter. Therefore, we hypothesize:

> H2: *The emphasis firms place on the dynamic tension resulting from a joint use of interactive and diagnostic control systems, of beliefs and boundary systems, of boundary and interactive control systems, and of beliefs and diagnostic control systems is positively associated with product development performance.*

Again and consistent with previous research, we do not see sufficient support for a hypothesis on the direct relation between these dynamic tensions generated in the area of PD and organizational performance. However, we make sure that the direct effect between the dynamic tensions and organizational performance is captured in our statistical model, thus al-

lowing us to differentiate direct effects on organizational performance from effects that are generated through an enhancement of PD performance.

Finally, we incorporate into our interaction model the hypotheses H1a and H1c from the previous model. While we expect that the positive effect of PD performance on organizational performance is still true, we need the H1a relationships in order to separate the main effects of the levers on PD performance from the effects generated by the joint use of different levers.

2.4 The combined interdependence/interaction model

Model 1 and model 2 suppose that the levers are either interdependent (i.e., they move together), or interacting (i.e., the impact of one lever is conditioned by another lever). However, even if these two relationships are considered as competing in previous literature, this does not preclude that the levers are simultaneously interdependent and interacting, i.e., changes in the emphasis placed to one lever changes the emphasis placed to another lever and, at the same time, changes the performance impact of the levers with which the lever considered is interacting. For example, the beliefs system may be stronger emphasized by a strengthening of manager communication on the peculiar role of innovations for the firm. This increased emphasis may require at the same time a clearer specification of the boundaries to the activities in PD to constrain excessive opportunity-seeking. Furthermore, the magnitude of the impact of the boundary system on PD performance may depend on how much emphasis is placed to the beliefs system. Thus, the intensified communication of innovations as a primary focus for the firm may simultaneously lead to an increased impact of the boundary system on PD performance.

Therefore, we propose with model 3 a model of combined interdependence/interaction by both considering our mutual correlation hypothesis from model 1 (i.e., H1b) as well as our interactions hypothesis from model 2 (H2). To distinguish these effects from the main effects we add to model 3 also the main effects between the levers and PD performance (H1a). Finally, we add the relation between PD performance and organizational performance (H1c).

3 Methods

3.1 Data collection

The data were collected through a structured written questionnaire sent by mail to members of the top management of the target firms, i.e., the Chief Financial Officer (CFO), the Chief

Technology Officer (CTO), or the Chief Executive Officer (CEO).[1] We chose them as informants since they are knowledgeable about the LOC and their implementation in PD (Davila, Foster, & Li, 2009; Widener, 2007), which was confirmed by our pilot test. For 85 firms, duplicates, i.e., two questionnaires from two different respondents from one firm, were returned and used to control for interrater reliability potentially affected by different respondents' perceptions (see appendix III - 3). The target population consisted of 8,555 large and medium-sized firms in the manufacturing sector (the C-section in the NACE Revision 2 classification) from German-speaking countries (Germany, Austria, and Switzerland).[2] Firms respecting the following size criteria were sampled: (1) at least 50 employees (full-time equivalents) for the year 2008; (2) at least 10 million euro sales for the year 2008. Since the survey was conducted during the 2008/2009 world economic crisis, we were seeking results that were as far as possible unbiased by this critical event. Thus, we referred our survey questions to the average firm situation over the last three years. In order to be able to check for respondent bias, we sampled those firms that provided financial data in the AMADEUS database for the last three years. Thus, the sample consisted of 2,695 firms, from which we identified 4,961 potential respondents.[3] In order to collect the contact data from this sample, we contacted the firms by phone or e-mail and, wherever possible, prenotified the respondents. This helped us to increase the likelihood that the respondent whom we wanted to answer our questions was indeed the person who received the questionnaire. Each mail-out package included a personally addressed signed cover letter (in which we guaranteed the confidentiality of answers and anonymity in the result reports), the questionnaire, and a prepaid reply envelope. As an incentive to respond, we offered an executive summary of our results and participation in a workshop to discuss the results with researchers and practitioners. The follow-up wave consisted of a second package with a cover letter urging an answer and a replacement questionnaire sent to those who had not answered yet (Dillman, 2007).

From the initial 2,695 potential respondent firms, 87 could not be contacted since the firms had closed, failed, or moved to an unknown address, or they could not provide useful insights since they stated that they did not undertake PD. We received a reply questionnaire

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1 All the potential respondents within one firm received the same questionnaire and had to answer the same questions.

2 The target population is identified through the AMADEUS database. AMADEUS is a database that in October 2009 contained financial information on over 11 million public and private companies in 41 European countries. It combines data from over 30 regional information providers using public mandatory disclosure data.

3 For most of the firms, both the CFO and the CTO could be identified and addressed. For 429 mostly small firms, only the CEO could be identified.

from 962 firms. After correcting for those 68 firms for which the questionnaire came from a respondent who was beyond the scope of our analysis (e.g., a different functional and/or hierarchical level), 894 firms were left. Referring to the 2,695-87=2,608 firms that could be approached with our questionnaire, this equals a response rate of 34.3%. We investigated unit non-response bias by comparing the respondents with the addressed non-respondents and the respondents with the survey population (i.e., all 8,555 manufacturing firms in German-speaking countries with at least 50 employees and 10 million euro sales available in the AMADEUS database for the last available year). The pattern of industry distribution of the respondents following the NACE Rev. 2 divisions compares well with the industry distribution of the addressed non-respondents (chi square(23)=33.079, p=0.08) and of the population. Only division 33 of the NACE classification required corrective actions (reweighting by random deletion of n=61 cases from division 33 "Repair and installation of machinery and equipment"), since there was an overrepresentation of firms in this division compared with the distribution of the population.[4] After this correction, 833 firms remained in our sample and the chi square statistic does not show significant differences in the industry distribution between the respondents and the population (chi square(23)=34.895, p=0.053). In unreported results, we find no statistical differences in the number of employees, sales, EBIT, fixed assets, and intangible assets between the respondents and the addressed non-respondents as well as between the respondents and the survey population.

From the 833 firms considered, 365 declared that they had not any type of performance measure for their PD and could thus not be analyzed in terms of our research question, so we carried out our research based on 468 responses.[5] Table III - 1 shows that there are no statistical differences in the number of employees, sales, EBIT, fixed assets, and intangible assets between the respondents with PD performance measures and the addressed non-respondents as well as between the respondents with PD performance measures and the survey population at $p<0.05$ (with exception for the number of employees for the comparison of the respondents with PD performance measures and the survey population). However, as expected, we find significant differences between the 365 firms without any performance measure for PD and the 468 firms employing performance measures for PD.

[4] When carrying out further analyses including the 61 deleted cases, the results remained mostly unchanged. Nevertheless, in order to safeguard the highest possible level of representativeness of our sample, we omitted these cases from the following analyses.

[5] Additionally, we received 85 duplicates, i.e., questionnaires completed by a second senior manager from a firm that had already responded. We did not include these questionnaires in our basic analyses in order to avoid the bias from considering the same firm twice, but used these duplicates to test for interrater reliability (see the "Results" section).

Table III - 1: Unit non-response analysis for firm characteristics

Variable	Respondents with performance measures for PD (n=468)	Respondents without performance measures for PD (n=365)		Addressed non-respondents (n=1,801)		Survey population (n=8,087)	
Number of employees (in thousands)	2.74	0.38	(t=2.725, p=0.007)	1.22	(t=1.660, p=0.097)	0.78	(t=-2.265, p=0.024)
Net sales (in millions euro)	806.36	89.73	(t=2.511, p=0.012)	354.41	(t=1.523, p=0.128)	247.66	(t=-1.946, p=0.052)
EBIT (in million euro)	40.87	5.32	(t=2.325, p=0.020)	25.79	(t=1.094, p=0.274)	13.62	(t=-1.771, p=0.077)
Fixed assets (in million euro)	386.20	21.61	(t=2.521, p=0.012)	151.61	(t=1.552, p=0.121)	104.16	(t=-1.934, p=0.054)
Intangible assets (in million euro)	96.71	1.22	(t=2.438, p=0.015)	52.91	(t=0.978), p=0.328)	29.47	(t=-1.687, p=0.092)

The table reports variable means as well as t-statistics and related p-values for the comparison of means of variables between the respondents with and without performance measures for PD, between the respondents with performance measures for PD and the addressed non-respondents as well as between the respondents with performance measures for PD and the survey population (two-sided test). The respondents are already corrected for overrepresentation of NACE div. 33.

The 468 questionnaires used led us to a ratio of 9.55 respondents per parameter estimate for the simplest base model and a ratio of 5.38 for the most complex model 3, which indicates an adequate sample size for the estimation of our models (Bentler & Chou, 1987).

To approximate further the unit non-response bias, we compared the responses of early and late respondents (Armstrong & Overton, 1977). We did not find significant differences at the 5% level in construct means, which further supports the representative character of our sample for the manufacturing sector. The results are displayed in table III - 2.

We additionally analyzed item non-response. The descriptive analyses show that a maximum of 6.2% of the responses per question are missed, with most questions ranging between 0.2% and 1.1% of responses missed. There are no indications of patterns of non-random item non-response, as found by Little's MCAR test (chi square(5,002)=5,144.005, p=0.079) (Rubin, 1976). In order to avoid the shortcomings of traditional missing data techniques like mean imputation (i.e., distortion of estimated variances and correlations) (Schafer & Graham, 2002), we used the EM-algorithm to replace the missing values. This algorithm provides consistent and efficient maximum likelihood (ML) estimates for missing completely at random values (Schafer & Graham, 2002, Yuan & Bentler, 2000).

Table III - 2: Comparison of constructs means for early and late respondents

Construct	Early respondents (before the follow-up procedure)	Late respondents (after the follow-up procedure)	t-statistics, p-values (two-sided test)
Diagnostic control system	3.60 (n=290)	3.54 (n=174)	t=-0.839, p=0.402
Interactive control system	2.91 (n=289)	2.93 (n=172)	t=-0.386, p=0.700
Boundary system	2.85 (n=288)	2.78 (n=168)	t=0.525, p=0.420
Beliefs system	3.96 (n=288)	4.04 (n=174)	t=-1.231, p=0.219
Product development performance	2.52 (n=289)	2.48 (n=168)	t=0.567, p=0.571
Organizational performance	2.70 (n=271)	2.70 (n=154)	t=-0.023, p=0.982

The table reports construct means and t-tests on the difference in construct means for early and late respondents. Early respondents are the respondents who returned the questionnaire before the reminder action; late respondents are the respondents who returned the questionnaire after the reminder action. n varies due to missing values.

3.2 Construct measurement

All the measures were borrowed from existing and validated instruments and slightly adapted to the PD setting. We developed the questionnaire in English and then translated it into German for adaption to the sample. Back-translation by an independent party following Brislin (1970) was adopted to verify the equivalence between the translated and the original items. To safeguard the content validity, we additionally talked to experts in the field (both academics and practitioners) to discuss the questionnaire. The three-step test-interview method was used to pilot test the questionnaire with six potential respondents to obtain feedback on the layout of the questionnaire, the clarity of the questions, and the content validity (Hak, van der Veer, & Ommundsen, 2006). This led to slight adjustments to the wording and layout of the questionnaire.

Due to the reflective nature of the constructs (items of one construct were all significantly positively correlated with each other), we could purify our construct measurement by excluding a few items from the original instruments to increase the reliability, without changing the meaning of the factors (Bollen & Lennox, 1991). To make sure that the constructs were still content valid, two experts in MCS research were asked to discuss whether the meaning of the constructs had changed. Appendix III - 1 displays the questionnaire items, descriptive statistics, standardized loadings, and individual item reliability, as well as Cronbach's alpha, average variance extracted, and composite reliability for each construct. The common thresholds for these measures were generally met (standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, individual item reliability>0.4, com-

posite reliability>0.6; see Bagozzi & Yi, 1988; Nunnally & Bernstein, 1994), with slight departures from the thresholds for one item for the boundary system construct and one item for the PD performance construct.[6]

The interactive and diagnostic control systems were measured using an instrument developed by Vandenbosch (1999) and refined by Henri (2006).[7] In this study we investigate the interactive and diagnostic use of performance measures for PD. Performance measures have been chosen due to their diffusion in practice and research (Widener, 2007). The measures of the beliefs and boundary systems was taken from Widener (2007). All these instruments are grounded in Simons (1995) LOC framework and allowed us to use already validated scales that are directly related to the theoretical framework of our analysis. We slightly adapted the questions to the area of PD. The dynamic tensions operationalized in model 2 and 3 are calculated through interaction terms based on the four LOC constructs mentioned above. The interaction constructs can be implemented in SEM with different approaches (Cortina, Chen, & Dunlap, 2001, Marsh, Wen, & Hau, 2004). We followed the interaction approach by Marsh, et al. (2004), who propose using a subset of indicators suggested in the seminal work by Kenny & Judd (1984) and leaving the variance of measurement errors and loadings to be freely estimated. The Marsh, et al. (2004) approach is based on the use of matched-pair products in which the information on each indicator is considered only once (e.g., if factor X has x_1 and x_2 as indicators and factor Y has y_1 and y_2 as indicators, the approach suggests for the latent variable interaction XY two indicators, i.e., x_1*y_1 and x_2*y_2).[8] We favored this approach since it does not require the specification of constraints based upon the assumption of multivariate normality of data (Marsh, et al., 2004). To avoid issues of multicollinearity, the variables were centered before the interaction construct was built (Jöreskog & Yang, 1996).

PD performance was measured with indicators taken from Bisbe & Otley (2004), Capon, Farley, Lehman, & Hulbert (1992) and Griffin (1997) and focused on the share of new products in the product portfolio, the share of profit from new products, and the share of sales from new products. Our construct required the rating of the performance of the firm in com-

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[6] The second item of the boundary system construct (see appendix III - 1) displays a factor loading and individual item reliability below the thresholds. The further results in this paper remain unchanged if we delete this item, while the variance extracted, actually slightly below the cutoff value, increases above the threshold. The first items of the PD performance construct (see appendix III - 1) have individual item reliability slightly below the threshold. Deleting these items does not change the results of the further analyses.

[7] Widener (2007) uses different items to measure interactive control systems. We also collected the items developed in her paper, but found this construct measurement not to be reliable.

[8] For latent variable interaction between constructs with different numbers of items, we chose the items with the highest individual item reliability to build the interaction.

parison with the industry in which the firm operates and therefore followed Govindarajan (1984). Like Bisbe & Otley (2004), we also asked for a rating of the subjective importance of the difference indicators, which allowed us to weight each PD performance criterion with the attached importance. In the same fashion, we referred to the measure of organizational performance by Govindarajan (1984) and asked for a rating about the return and profit growth measures with regard to the industry average.

Since the questions used in our survey relate to the area of PD, we report in appendix III - 2 the results of an exploratory factor analysis across all the questions employed for these analyses to show that the six main factors discriminated as expected.

All our rating scales can be interpreted as interval-scaled, since we respected the condition of at least five scale-points (Bagozzi, 1981) and anchored each of the five points in order to suggest to respondents that the intervals between the points are equal (Westermann, 1985). This allows for the use of methods that require continuous data (Bentler & Chou, 1987).

Table III - 3 reports the correlations between constructs, which are significant but generally moderate and thus suggest discriminant validity.

The confirmatory factor analyses (CFA) for each construct show a good model fit according to the commonly used fit indexes (Henri, 2007, Kline, 2011) for each of the measurement model components. The classical chi square statistic was used to test the exact-fit hypothesis, which can be considered implausible in most empirical research (MacCallum, Browne, & Sugawara, 1996). Therefore, we supplemented the chi square information with more informative approximate fit indexes, i.e., the absolute fit indexes AGFI, RMSEA and SRMR, and the incremental fit index CFI. The thresholds are as follows: p-value of chi square test>0.05, AGFI>0.9 (Bagozzi & Yi, 1988), RMSEA<0.1 (Browne & Cudeck, 1993), CFI>0.95 (Hu & Bentler, 1999), and SRMR<0.08 (Hu & Bentler, 1999).[9] Besides the mentioned CFA, we carried out a number of procedures and tests aimed at providing evidence of construct validity. These are summarized in appendix III - 3. Overall, we find strong evidence of the validity of our constructs.

[9] The majority of these measures lie within the thresholds. The beliefs system construct displays a p-value<0.05 and a RMSEA>0.1. Modification indexes for the beliefs system CFA suggest adding two error term correlations. Further results in this paper are qualitatively unchanged if the beliefs system construct is supplemented by these two error term correlations.

Table III - 3: Correlation matrix

	Diagnostic system	Interactive system	Boundary system	Beliefs system	Dynamic tension diagnostic-interactive	Dynamic tension beliefs-boundary	Dynamic tension beliefs-diagnostic	Dynamic tension boundary-interactive	Product development performance	Organizational performance
Diagnostic control system	1.000									
Interactive control system	0.360***	1.000								
Boundary system	0.355***	0.346***	1.000							
Beliefs system	0.305***	0.396***	0.345***	1.000						
Dynamic tension diagnostic-interactive	-0.137*	0.049	-0.025	-0.042	1.000					
Dynamic tension beliefs-boundary	0.027	-0.003	0.154*	-0.261***	0.294***	1.000				
Dynamic tension beliefs-diagnostic	-0.109	-0.008	0.076	-0.111	0.563***	0.572***	1.000			
Dynamic tension boundary-interactive	-0.060	0.092	0.117	-0.022	0.575***	0.601***	0.194*	1.000		
Product development performance	0.285***	0.239***	0.235***	0.337***	0.050	-0.080	0.006	0.004	1.000	
Organizational performance	0.177**	0.085	0.110	0.307***	-0.062	-0.001	-0.067	-0.014	0.330***	1.000

n=468. This table reports the estimated correlations between constructs in a structural equation model with all the constructs mutually correlated, the correlations to be freely estimated. The latent variable interactions used to measure the dynamic tension constructs are based on Marsh, et al. (2004).
Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

3.3 Data analysis

In order to investigate the relationship between the LOC and the PD performance as well as the organizational performance, we start by comparing the four models presented above following a SEM approach, in order to find the model that best and most parsimoniously fits the data. This model is then analyzed in greater detail in terms of direct, indirect, and total effects.

SEM is chosen since it allows the explicit consideration and estimation of residuals and their variance, and it can incorporate latent, i.e., unobserved, variables. This study follows the alternative model approach proposed by Jöreskog (1993) as an approach that differs from the classical strictly confirmatory approach, which requires the testing of a single model ending with its acceptance or rejection. The alternative approach is suitable for research questions with more than one theoretically justifiable model. This approach is aimed at identifying, based on the same data sample, the model among a number of competing models that best fits the data (Jöreskog, 1993).

We use the AMOS 18 software program with the maximum likelihood (ML) estimation approach. ML requires multivariate normally distributed data. Mardia's test for multivariate kurtosis (Mardia, 1970) gives an indication of multivariate non-normality of the data, but the univariate kurtosis and skewness are far lower than the thresholds for the identification of non-normality (the highest absolute value for skewness in sample=1.443<3.00 threshold; the highest absolute value for kurtosis in sample=2.043<10.00 threshold) (Kline, 2011). Furthermore, the normal probability plots do not provide any evidence of deviations from univariate normal distribution (D'Agostino, Belanger, & D'Agostino Jr., 1990). Therefore, the employment of ML estimation seems reasonable. To make sure that the slight departure from multivariate normality does not affect the estimates in a meaningful way, we take 2,000 bootstrap samples with replacement for each model estimated and inspect for all the estimates the bias between the mean estimate from all the bootstrap samples and the estimate from the original model. According to Nevitt & Hancock (2001), our sample size (since $n \geq 200$) is sufficient to obtain accurate bootstrapping results. For all the models tested and presented in the following section, we can find no meaningful bias in the estimates.

The four proposed models are evaluated based on two major types of goodness-of-fit indexes. First, we analyze the model fit to the data by using the exact-fit chi square test, AGFI, CFI, RMSEA, and SRMR. Second, we compare the four models. This is accomplished for nested models (i.e., the base model and model 1, as well as model 2 and model 3, respectively) with a chi square difference test. Additionally, for nested as well as non-nested models we

employ the three criteria proposed by Jöreskog (1993): the Akaike's information criterion (AIC), the consistent Akaike's information criterion (CAIC), and the expected cross-validation index (ECVI). AIC (Akaike, 1974) is a predictive fit index that measures model fit based on the ability of the model to replicate in future samples. The AIC is adjusted for parsimony by considering the degrees of freedom of the model. In a similar manner, the CAIC (Bozdogan, 1987) extends the AIC by providing a penalty for complex models by additionally considering the sample size. Finally, the ECVI (Browne & Cudeck, 1989) analyzes the difference between the estimated variance-covariance matrix and the expected variance-covariance matrix that would be obtained from a sample with the same size taken from the population. To strengthen our inferences, we scrutinize the 90% confidence interval for the ECVI. The lower the values, the better fitting and more parsimonious the model is (Jöreskog, 1993; Kline, 2011).

4 Results

4.1 Model testing

The results of the model comparison are displayed in table III - 4. We find a significant positive relationship between the beliefs system and PD performance ($p<0.001$) as well as between the diagnostic control system and PD performance ($p<0.001$). Furthermore, we identify the expected significant positive relationship between the PD performance and organizational performance ($p<0.001$). We controlled for a non-hypothesized direct relationship between the levers and organizational performance and did found only one meaningful relationship between the beliefs system and organizational performance. All other tested relations are non-significant. The poor fit of the base model (e.g., AGFI=0.863 and SRMR=0.137) suggests that this model is not likely to describe adequately the functioning of the LOC in a PD context.

Model 1 postulates interrelated LOC. All the correlations between the LOC are shown to be significant at $p<0.001$ and positive, ranging from a minimum of 0.305 for the correlation between the emphasis on the beliefs system and the emphasis on the boundary system to a maximum of 0.396 for the correlation between the emphasis on the beliefs system and the emphasis on the interactive control system. The significant main effects identified in the base model are still valid in model 1. The fit of the model to the data is fairly good (e.g., AGFI=0.919 and SRMR<0.044). It seems that within the package, the LOC move together in the same direction. Comparing this model with the base model, we find a clear superiority of the interdependence model over the additive model, as can be recognized by the significant chi

square difference test (chi square(6)=187.413, p<0.001). Additionally, all three indexes for the comparison of models (AIC, CAIC, ECVI with its confidence interval) show that model 1 performs better than the base model, which supports a better-fitting and more parsimonious description of the functioning of the LOC in a PD environment with the interdependence approach.

Model 2 proposed to understand the relationship between LOC within the package as dominated by the dynamic tension between those LOC that represent opposing forces in Simons' (1995) understanding. We included the four dynamic tension constructs as latent interaction constructs. Against our expectation, we cannot find significant effects arising from the interaction terms for PD performance. This is consistent with the findings of Henri (2006), who is also unable to find a significant effect of the dynamic tension between the interactive and the diagnostic control systems on innovativeness.

Against all the expectations from theory, the joint use of LOC seems not to be so complex and seems not to require one lever to be put into place and emphasized in order to allow another lever to produce a stronger impact on PD performance. Nevertheless, we find an unexpected significant positive effect (p<0.001) of the dynamic tension between the beliefs and the boundary systems on organizational performance. This means that the positive effect of the beliefs system on organizational performance is higher when the beliefs system is emphasized jointly with the boundary system. In other words, the boundary system serves as a condition for a stronger impact of the beliefs system on organizational performance. Thus, the beliefs system is especially effective when the boundary system makes sure that the opportunity-seeking postulated through the beliefs system is not exacerbated in a manner that goes beyond the borders of what is considered to be positive for firm development (et vice versa). The significant positive effects between the beliefs system as well as the diagnostic control system and PD performance, between the PD performance and organizational performance, and between the beliefs system and organizational performance detected in the base model replicate in this model. However, these effects do not pay off in terms of an increased model fit when compared with the two previous rival models. Instead, there is an overall poor model fit (e.g., AGFI=0.828 and SRMR=0.109).

Table III - 4: Results of SEM estimation of the four competing models

Dependent variable	Independent variable	Base model Additive model	Model 1 Interdependence model		Model 2 Interaction model		Model 3 Combined interdependence/interaction model	
		Stand. estimate	Hypothesis (expected sign)	Stand. estimate	Hypothesis (expected sign)	Stand. estimate	Hypothesis (expected sign)	Stand. estimate
PD performance	Interactive control system	0.084	H1a (+)	0.060	H1a (+)	0.080	H1a (+)	0.055
	Diagnostic control system	**0.181*** **	H1a (+)	**0.166*** **	H1a (+)	**0.190*** **	H1a (+)	**0.176*** **
	Beliefs system	**0.252*** **	H1a (+)	**0.239*** **	H1a (+)	**0.250*** **	H1a (+)	**0.236*** **
	Boundary system	0.088	H1a (+)	0.072	H1a (+)	0.088	H1a (+)	0.073
	Dynamic tension interactive-diagnostic	--	--	--	H2 (+)	0.064	H2 (+)	0.063
	Dynamic tension beliefs-boundary	--	--	--	H2 (+)	-0.029	H2 (+)	-0.029
	Dynamic tension interactive-boundary	--	--	--	H2 (+)	-0.008	H2 (+)	-0.008
	Dynamic tension beliefs-diagnostic	--	--	--	H2 (+)	0.024	H2 (+)	0.024
Organizational performance	Interactive control system	-0.069	--	-0.088	--	-0.065	--	-0.082
	Diagnostic control system	0.066	--	0.071	--	0.046	--	0.049
	Beliefs system	**0.232*** **	--	**0.243*** **	--	**0.245*** **	--	**0.258*** **
	Boundary system	-0.017	--	-0.028	--	-0.024	--	-0.035
	PD performance	**0.249*** **	H1c (+)	**0.255*** **	H1c (+)	**0.255*** **	H1c (+)	**0.262*** **
	Dynamic tension interactive-diagnostic	--	--	--	--	-0.037	--	-0.036
	Dynamic tension beliefs-boundary	--	--	--	--	**0.133***	--	**0.132***
	Dynamic tension interactive-boundary	--	--	--	--	-0.051	--	-0.051
	Dynamic tension beliefs-diagnostic	--	--	--	--	-0.059	--	-0.059
Beliefs system	Boundary system[a]	--	H1b (+/-)	**0.345*** **	--	--	H1b (+/-)	**0.345*** **
	Interactive control system[a]	--	H1b (+/-)	**0.396*** **	--	--	H1b (+/-)	**0.396*** **
	Diagnostic control system[a]	--	H1b (+/-)	**0.305*** **	--	--	H1b (+/-)	**0.305*** **
Boundary system	Diagnostic control system[a]	--	H1b (+/-)	**0.353*** **	--	--	H1b (+/-)	**0.353*** **
	Interactive control system[a]	--	H1b (+/-)	**0.345*** **	--	--	H1b (+/-)	**0.345*** **
Interactive control system	Diagnostic control system[a]	--	H1b (+/-)	**0.359*** **	--	--	H1b (+/-)	**0.359*** **
Chi square		496.621	309.208		1,250.254		1,062.859	
df		161	155		447		441	
p-value		0.000	0.000		0.000		0.000	
AGFI		0.863	0.919		0.828		0.854	
CFI		0.922	0.964		0.850		0.884	
RMSEA[90% confidence interval]		0.067 [0.060-0.074]	0.046 [0.039-0.054]		0.062 [0.058-0.066]		0.055 [0.051-0.059]	
SRMR		0.137	0.044		0.109		0.072	
Chi square difference test			**187.413 (6)*** **				**187.295 (6)*** **	
AIC		549.621	**419.208**		1,412.254		1,236.859	
CAIC		846.896	**702.374**		1,829.280		1,684.776	
ECVI [90% confidence interval]		1.273 [1.138-1.425]	**0.898** [0.799-1.013]		3.024 [2.806-3.258]		2.649 [2.452-2.861]	

This table presents the results of the four structural equation models. The chi square, df, p-value, AGFI, CFI, RMSEA, and SRMR allow for the evaluation of the fit between the model in the analysis and the data. The AIC, CAIC, and ECVI allow the comparison of non-nested models according to their ability to fit the data (parsimoniously). Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, and SRMR<0.08. Note that the model chi square used to test the exact-fit hypothesis is commonly viewed as too restrictive for SEM, leading to a more in-depth analysis of the approximate fit measures, like RMSEA; see Steiger (2007). Nested models can be compared by chi square difference test. The chi square difference statistic tests the equal-fit hypothesis. When adding paths to the model, a significant chi square difference test indicates that the competing model fits the data statistically better than the base model. The best-fitting and most parsimonious model displays the lowest AIC, CAIC, and ECVI values.

[a] The reported relationship is not a dependent-independent variable relationship, but represents the correlation between the variables and the significance level of these correlations.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level. The significance levels are derived from a one-sided test for a one-sided hypothesis and a two-sided test for a two-sided hypothesis.

Additionally, the model comparison based on the AIC, CAIC, and ECVI ranks this model as the one that is least able to fit the data if compared with the base model and to model 1. Since the base model and model 2 are non-nested due to the addition of the dynamic tension variables to model 1, we cannot employ a chi square difference test to compare these models. The AIC, CAIC, and ECVI are of course not comparable with statistical tests. Nevertheless, the 90% confidence interval computed for the ECVI shows us with an error probability of 10% that the ECVI value for model 2 is clearly larger than both the value for the base model and the value for model 1 (since the three confidence intervals are non-overlapping).

Finally, model 3 suggests a combination of the interrelation and the interaction between the levers. The model confirms the significant (all $p<0.001$) effects found in model 1 and model 2. This leads to a nearly acceptable overall model fit (e.g., AGFI=0.854 and SRMR=0.072) and to a model that is significantly better able to describe the data in the sample than model 2 (chi square(6)=187.413, $p<0.001$). The AIC, CAIC, and ECVI further support a better performance of model 3 over model 2.

Comparing the AIC, CAIC, and ECVI shows that the model out of the four that best and most parsimoniously describes the interplay of the levers and their effect on PD and organizational performance is the interdependence model. Indeed, the AIC, CAIC, and ECVI values are the smallest with this model. Furthermore, the ECVI 90% confidence interval is non-overlapping with the ECVI 90% confidence interval of the other models. Thus, we inspect model 1 more in detail.

We find a significant positive association between the beliefs system designed for PD and the PD performance as well as organizational performance. This indicates that communicating innovativeness as a core value of the firm through mission statements or by management communication influences employees' behavior and encourages a fruitful idea-generating and idea-implementing attitude. The beliefs system represents the most powerful lever in a PD setting, as can be seen from the coefficient size (λ=0.239 in model 1). This result, which is consistent with the LOC framework, clearly stresses what decades of creativity and innovation management researchers have preached: the importance of the generation of a common understanding of the importance of innovativeness in the firm and of a culture that formally and informally reinforces the great relevance of PD to corporate activities (Amabile, 1998). Moreover, the beneficial effect of the beliefs system does affect not only the PD performance and organizational performance through PD performance, but also shows a positive direct effect on organizational performance (λ=0.243 in model 1). This finding may be ex-

plained by the fact that the encouragement of innovativeness primarily affects the area of PD, but is also able to support opportunity-seeking in other firm areas (e.g., marketing), what in turn may directly impact organizational performance.

Also interesting, in the same vein, is that the diagnostic control system of control does not only show a significant association with PD performance, but this association bears a positive sign in all four models (λ=0.166 in model 1). It seems that the Miller & Friesen's (1982) and the Adler & Borys' (1996) arguments about the importance of formal controls aimed at constraining excessive innovation efforts shows up in our data and are still valid. A diagnostic control system helps the firm to avoid preventable resource wasting due to excessive, uncontrolled opportunity-seeking, which detracts attention from the firm goals. These results seemingly stands in contrast to the finding of Henri (2006), who identifies a significantly negative association between the diagnostic control system and innovativeness. This difference might arise from the fact that Henri (2006) concentrates on innovativeness in terms of a competency, while we focus on PD performance in terms of outputs achieved by PD. It is likely that the two results can be reconciled: while the search for innovation may be constrained by the diagnostic system, the results of the process in terms of, for example, sales with the new products, may increase with an increase in the emphasis of the diagnostic control system, since it allows concentration on the most promising PD projects. Against the expectations from theory and empirical research, the interactive control system and the boundary system are not associated significantly with PD performance and organizational performance, in either a positive, or a negative way. The benefits from the implementing interactive and boundary systems may – at least for the direct effects – be outweighed by the costs of implementation, e.g., management involvement is required (Widener, 2007). This result is consistent with the work by Bisbe & Otley (2004), who do not find a significant direct relationship between interactive control systems and PD performance.

Finally, as expected, PD performance is positively associated with organizational performance (λ=0.255 in model 1). It is still true that firms that perform well in PD generate a competitive advantage that helps them to create outstanding organizational performance.

Table III - 5: Decomposition of the effects of the LOC on PD performance and organizational performance

	PD performance		Organizational performance	
	Base model (0.111)	Model 1 (0.159)	Base model (0.156)	Model 1 (0.161)
Beliefs system				
Direct effect	0.252	0.239	0.232	0.243
Indirect effects	0.000	0.053	0.063	0.080
Total effects	0.252	0.292	0.295	0.323
Boundary system				
Direct effect	0.088	0.072	-0.017	-0.028
Indirect effects	0.000	0.104	0.022	0.094
Total effects	0.088	0.176	0.005	0.066
Interactive control system				
Direct effect	0.084	0.060	-0.069	-0.088
Indirect effects	0.000	0.105	0.021	0.103
Total effects	0.084	0.165	-0.048	0.015
Diagnostic control system				
Direct effect	0.181	0.166	0.066	0.071
Indirect effects	0.000	0.063	0.045	0.080
Total effects	0.181	0.229	0.111	0.151

The table reports the standardized direct, indirect, and total effects of the LOC on the two performance constructs for both the base model and model 1. In this scope, the correlations between the LOC are turned into reciprocal direct relations and pairwise constrained to be equal (Kline (2011)). Squared multiple correlations for the endogenous variables are displayed in parentheses.
Note: Significance levels are not displayed since there are no tests of statistical significance for indirect effects through two or more mediators (Kline, 2011).

A more detailed insight into the functioning of the LOC-performance relationship in PD is achieved through an inspection of the indirect and total effects (see table III - 5). As for the direct effects, the highest total effects on PD performance are derived from the beliefs system, followed by the diagnostic control system. However, the total effects of the boundary system and of the interactive control system are also remarkable. This is due to their relatively high indirect effects (relative to negligible direct effects). This means that in the LOC package the beliefs and the diagnostic control systems are useful mediators of the effects of the other levers. An increase in emphasis in the boundary and the interactive control systems is accompanied by an increase in emphasis on the other levers, which in turn have a large impact on PD performance. For organizational performance, the highest direct effect can again be found

with the beliefs system. For the remaining levers, the indirect effects, mediated, for example, by the beliefs system itself, are larger than the direct effects and thus do not serve as direct triggers of enhanced organizational performance, but are rather legitimized to complete the LOC package by leading to an increase in emphasis on the other levers, the direct impact of which on performance is higher.

The difference in modeling the interplay between the LOC as additive or interdependent and thus the risk of misspecification are supported by this scrutiny of the total effects. We show that modeling disregarding the fact that the LOC move together (i.e., without correlations between the LOC) leads to the suppression of a considerable amount of total effects by artificially constraining the correlation between the LOC to zero.

4.2 Robustness of results

In order to lend credibility to our results, several procedures were carried out. We already presented the procedures related to construct validity in appendix III - 3 and found indications for the validity of the measurements carried out. Now we supplement this discussion by providing evidence of the robustness of our results regarding the issues of internal and external validity. The related procedures are summarized in appendix III - 4. For example, we cope with the issue of correlated omitted variables by modeling possible drivers of the LOC (environmental unpredictability, innovativeness of the firm, and PD strategy) and see that the results are qualitatively unchanged (see appendix III - 5). Furthermore, we inspect the effect of firm size and industry and found that these variables do not moderate the results (see appendix III - 6). Even if neither internal nor external validity can be definitively proved or rejected, we find evidence of the fact that the design of our study has an acceptable level of validity and we are confident that the findings are likely to be replicated in future studies.

5 Conclusion

Our study uncovers the interplay between the four LOC in PD. We find that the beliefs system generates the largest direct effects on PD performance, followed by the diagnostic control system, while the boundary and interactive control systems transmit their effect mainly through other levers, as they all move together in the same direction. The beliefs and diagnostic control systems have the highest impact on PD performance in terms of the total effects. However, while the diagnostic control system loses some of its power in terms of its effects on organizational performance, the beliefs system again plays the most important role between the levers in the enhancement of organizational performance.

Of course, some limitations must be noted. Our study concentrates on the PD setting of the manufacturing industry in German-speaking countries. We put a great deal of effort into safeguarding the representativeness of our study. However, even if the representativeness of our sample holds, the sample is only representative of a narrow population, i.e., our findings cannot per se be generalized outside our setting. Further research will be required to test our hypotheses for other industries, other regions, and other business areas. Furthermore, our study equals a snapshot of a certain moment in time. We tried to achieve a certain degree of stability of answers by referring our questions to the situation that was experienced on average in the last three years. Nevertheless, our results may be affected by external events that we could not control for. Therefore, it would be helpful to see other studies dealing with our research questions at different moments in time. However it should be remarked that the aim of our paper is not to claim without any restriction that the interdependence model is the best, but to prompt future research to reflect the implications of the different model specifications.

Furthermore, our study follows a cross-sectional, survey-based approach. Thus, we could not demonstrate causality between our variables empirically, which would, for example, require a time lag between the dependent and the independent variables. Future studies could employ a longitudinal approach to overcome this limitation. Nevertheless, the analyses of interrater agreement and convergent validity offer reasons to be optimistic that our inferences hold in other studies. Additionally, careful theoretical reasoning may allow implying a direction in the relation between the variables in the model.

Our model specification also needs to be critically reviewed. We tested models that were carefully derived from theory and empirical research. Of course, these are not the only models that could be plausible. Therefore, further research should attempt to propose additional rival models in order to validate our results. Furthermore, we cannot compare model 2 and model 3 with the base model and with model 1 by means of a statistical test, since the base model and model 1 are not nested models of model 2 and model 3. Nevertheless, the AIC, the CAIC, and especially the ECVI confidence intervals seem to clearly suggest that model 2 and model 3 perform worse that the other two models.

Our findings contribute to the research in several ways. First, we join the discussion raised by Malmi & Brown (2008), among others, about the existence of a package of MCS, i.e., a number of MCS components that operate in a combined way when influencing employees behavior. Therefore, we analyze a non-package model (our base model, the additive model) to see whether the package notion itself holds based on cross-section data from the manu-

facturing industry for a PD setting. We find that the additive model is not able to reflect the data in an adequate manner and can therefore confirm that a package model may better describe what firms experience when implementing LOC in PD.

Second, we propose and test three models of interplay between LOC in order to shed some light on the nebulous concept of MCS packages. We compare the interdependence model with the interaction model and with the combined interrelation/interaction model and find that the interdependence model is the one that best represents the data. This means that the notion that emphasizing one lever is a condition for a higher impact of another lever on performance does generally not describe the real world situation in an accurate and parsimonious manner.

Finally, we refine the previous findings on the effect of single LOC on PD performance. Especially, we add to the work of Bisbe & Otley (2004), who did not find an overall significant effect of interactive control systems on PD performance, and could confirm this finding. Furthermore, we can add to Bisbe & Otley's (2004) work by stating that, against what was expected according to the LOC framework, the diagnostic control system has a significant positive impact on PD performance. Similarly to Henri (2006) we cannot identify a significant relationship between the tension among interactive and diagnostic control systems and the PD performance. A significant and positive effect is generated from the beliefs system, which stresses the importance of the PD efforts in the firm. Scrutiny of the total effects demonstrates how powerful the beliefs and diagnostic control systems are in a PD setting. These findings are relevant to practitioners dealing with the issue to design a MCS able to enhance the PD performance. Based on our results, firms should particularly care about the emphasis placed to the beliefs and diagnostic control systems. Thus, on the one hand, it seems advisable to formulate the importance attached to innovativeness both in the mission statement and in the regular communication of the management with the employees. On the other hand, the management should make sure that clear goals are developed for the PD and that the achievement of these goals is regularly monitored in a way that that allows immediate intervention and corrective actions in case of deviations.

Appendix

Appendix III - 1: Questionnaire items, descriptive statistics, confirmatory factor analysis, and reliability measures

Organizational performance

In comparison with the industry average, please rate the performance of your firm and the importance of the following indicators for your firm over the last three years:

Scale for performance: 1=well below average; 5=well above average

Scale for importance: 1=not important at all; 5=absolutely important

An index for product development performance was obtained by weighting the performance rating with the importance rating.

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
Return on investment	1-5	2.640	0.882	0.834***	0.900	0.75	0.696	0.92
Return on sales	1-5	2.697	0.902	0.917***			0.843	
Profit growth	1-5	2.733	0.918	0.848***			0.718	

n=468, chi square(1)=0.056, p=0.812; AGFI=1.000; CFI=1.000; RMSEA=0.000; SRMR=0.001.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, and composite reliability>0.6.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

Product development performance

In comparison with the industry average, please rate the performance of your product development and the importance of the following indicators for your firm over the last three years:

Scale for performance: 1=well below average; 5=well above average

Scale for importance: 1=not important at all; 5=absolutely important

An index for product development performance was obtained by weighting the performance rating with the importance rating.

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
The percentage of new products in our product portfolio	1-5	2.34	0.838	0.632***	0.813	0.62	0.398	0.89
Sales with new products	1-5	2.49	0.943	0.940***			0.883	
Profit with new products	1-5	2.43	0.927	0.810***			0.657	

n=468, chi square(1)=3.293, p=0.070; AGFI=0.972; CFI=0.996; RMSEA=0.070; SRMR=0.027.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, and composite reliability>0.6.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

Diagnostic control system

Please rate the extent to which your top management team used product development performance measures in the last three years to:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
Track progress toward goals	1-5	3.55	0.890	0.707***	0.807	0.59	0.500	0.85
Monitor results	1-5	3.64	0.852	0.848***			0.719	
Compare outcomes with expectations	1-5	3.54	0.859	0.762***			0.581	

n=468, chi square(1)=0.405, p=0.524; AGFI=0.997; CFI=1.000; RMSEA=0.000; SRMR=0.009.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, composite reliability>0.6.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

Interactive control system

Please rate the extent to which your top management team used product development performance measures in the last three years to:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
Provide a common view of the organization	1-5	3.05	0.971	0.698***	0.850	0.59	0.486	0.85
Tie the organization together	1-5	2.73	0.981	0.781***			0.611	
Enable the organization to focus on common issues	1-5	2.92	1.003	0.790***			0.624	
Develop a common vocabulary in the organization	1-5	2.98	0.992	0.795***			0.633	

n=468, chi square(2)=1.564, p=0.458; AGFI=0.992; CFI=1.000; RMSEA=0.000; SRMR=0.008.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, and composite reliability>0.6.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

Boundary system

Please rate the extent to which the following statements describe your firm in the last three years:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
Our code of business conduct informs our workforce about behaviors that are off-limits in product development.	1-5	2.71	1.177	0.686***	0.726	0.48	0.417	0.69
Our firm has a system that communicates to our workforce risks that should be avoided in product development.	1-5	3.00	1.061	0.565***			0.316	
Our workforce is aware of the firm's code of business conduct for product development.	1-5	2.78	1.098	0.813***			0.670	

n=468, chi square(2)=1.206, p=0.272; AGFI=0.990; CFI=0.999; RMSEA=0.021; SRMR=0.010.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, and composite reliability>0.6.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level (two-tailed).

Beliefs system

Please rate the extent to which the following statements describe your firm in the last three years:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Standardized loading (CFA)	Cronbach's alpha	Variance extracted	Individual item reliability	Composite reliability
Our mission statement clearly communicates innovativeness as a firm's core value to our workforce.	1-5	4.20	0.885	0.762***	0.876	0.62	0.581	0.89
Top managers communicate innovativeness as a firm's core value to our workforce.	1-5	4.15	0.816	0.802***			0.644	
Our workforce is aware of innovativeness as a firm's core value.	1-5	4.02	0.869	0.797***			0.638	
Our mission statement inspires our workforce.	1-5	3.58	0.930	0.792***			0.627	

n=468, chi square(2)=40.402, p=0.000; AGFI=0.790; CFI=0.958; RMSEA=0.203; SRMR=0.035.

Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, SRMR<0.08, standardized loading>0.6 and significantly different from zero, Cronbach's alpha>0.7, variance extracted>0.5, individual item reliability>0.4, composite reliability>0.6.

Note: * Significant at the 0.05 level; ** Significant at the 0.01 level; *** Significant at the 0.001 level (two-tailed).

Appendix III - 2: Exploratory factor analysis

	Factor 1 (organizational performance)	Factor 2 (PD performance)	Factor 3 (diagnostic control system)	Factor 4 (interactive control system)	Factor 5 (boundary system)	Factor 6 (beliefs system)
Return on investment	0.842					
Return on sales	0.911					
Profit growth	0.842					
Percentage of new products in our product portfolio		0.579				
Sales with new products		0.986				
Profit with new products		0.751				
Track progress toward goals			0.680			
Monitor results			0.887			
Compare outcomes with expectations			0.737			
Provide a common view of the organization				0.661		
Tie the organization together				0.791		
Enable the organization to focus on common issues				0.826		
Develop a common vocabulary in the organization				0.785		
Our code of business conduct informs our workforce about behaviors that are off-limits in product development.					0.748	
Our firm has a system that communicates to our workforce risks that should be avoided in product development.					0.497	
Our workforce is aware of the firm's code of business conduct for product development.					0.816	
Our mission statement clearly communicates innovativeness as a firm's core value to our workforce.						0.826
Top managers communicate innovativeness as a firm's core value to our workforce.						0.807
Our workforce is aware of innovativeness as a firm's core value.						0.765
Our mission statement inspires our workforce.						0.735

This table reports the results of an exploratory factor analysis across the questions of our questionnaire. We use principal factor analysis with promax rotation to extract factors with eigenvalues >1. Loadings <0.3 are omitted.

Appendix III - 1: Construct validity

Content validity	• Use of existing and validated scales; translation into German; back-translation into English to verify equivalence (Brislin, 1970)	• No substantial differences detected by back-translation
	• Talk to experts (practitioners and academics)	• Slight adjustments to the wording and layout of the questionnaire
	• Pilot test with six potential respondents (three-steps test interview following Hak, et al., 2006)	• Slight adjustments to the wording and layout of the questionnaire
	• Cautious choice of respondents	• Respondents had served on average for 6.3 years in their current position and for 13.1 years in their current firm, thus imparting confidence in their ability to evaluate the issues in the questionnaire objectively
Reliability: Internal consistency	• Cronbach's alpha	• Values above the 0.7 threshold for all constructs (see appendix III - 1)
Reliability: Interrater reliability	• Calculation of interclass correlation coefficient (ICC(1)) for agreement between raters in the 85 duplicate firms[1]	• Acceptable level of agreement throughout the questionnaire items. However, the boundary system construct should be considered with some caution, since the ICC(1) of all its items fall below the 0.1 threshold, as does also the ICC (1) of the item about the perceived importance of profit growth and of the item about the perceived importance of the percentage of new products in the firm's product portfolio. All the other items show ICC(1) values lying between 0.154 and 0.542.
	• Multiple group comparisons (i.e., a series of chi square difference tests when stepwise adding an additional constraint across models) performed for model 1 to compare the estimates across responses from CFOs, CTOs, or CEOs for the entire sample[2]	• We find measurement and structural invariance across CFO and CTO • The model comparison between CFO and CEO displays measurement invariance, but a significant difference in the structural model due to the boundary system–PD performance path, which is significantly positive for the CEO group of respondents and non-significant for the CFO group • Comparing the measurement model of the CTO with that of the CEO displays measurement non-invariance due to three item loadings. To control for this issue, we drop the related items and reestimate the models. We find that these items do not drive our results, since the estimates are qualitatively unchanged.

Appendix III - 3: Construct validity (continued)

Convergent validity	• Inspection of CFA for each construct	• CFA for each construct shows a good model fit; composite reliabilities >0.6 and consistently high standardized factor loadings for each construct
	• For the organizational performance construct: examination of the correlation between the scores from the respondents and the objective data collected from the AMADEUS database	• Measures are modestly, but significantly positively correlated (r=0.199 ($p<0.001$) for profit growth, 0.195 ($p<0.001$) for return on sales, and 0.245 ($p<0.001$) for return on investment); the magnitude of correlations is in line with previous research (Venkatraman & Ramanujam, 1987)
	• For the dynamic tension constructs: examination of robustness of results due to different approaches for building the latent variable interactions by comparing the Marsh, et al.(2004) approach with the Ping Jr. (1995) approach, which is a single indicator approach that constrains error variances and interaction loadings and multiplies the sums of the indicators of the basic constructs (i.e., the sum of the indicators of each lever) to build the indicator for the latent interaction construct	• While the significant effect of the dynamic tension between beliefs and boundary controls on organizational performance does not hold with the Ping Jr. (1995) approach, the ranking of model 2 and model 3 in the model comparison and all the other inferences from model 2 and model 3 remain unchanged.
Discriminant validity	• Correlation between constructs	• Correlations between constructs are moderate (see table III - 3)
	• Fornell & Larcker's (1981) criterion	• For each construct, the variance extracted is larger than the squared correlation between the construct considered and the other constructs
	• A series of chi square difference tests to compare a model with two constructs that can freely correlate with a model constrained to a correlation of 1	• For all the pairs of constructs there is a significant difference between the constrained and the unconstrained model
	• Exploratory factor analysis with all the items employed (Harman's single-factor test)	• Exploratory factor analysis does not generate one factor (thus common method bias does not seem likely to have occurred), but rather the six factors conjectured (see appendix III - 2) • Lack of cross-loadings >0.3

[1] Following Shrout & Fleiss (1979), ICC(1) is calculated as follows: ICC(1)=(BMS-WMS)/(MSB+(K-1)*WMS) , where BMS=between-targets mean square, WMS=within-targets mean square, and K=number of judges. In our analysis, the targets are the different firms while the judges are the different respondents (see Shrout & Fleiss, 1979, p. 423). In general, the ICC(1) lies between -1 and +1 for the two respondents case, values above 0.1 are considered indicative of individual responses that approximate the perception of other firm members well (Bliese, 1998; Shrout & Fleiss, 1979).

[2] Model 1 turns out to be the best-performing model and is thus chosen for this test.

Appendix III - 2: Internal and external validity

Criterion	Procedure or test	Results
Internal validity	• Test for significance of the relationships between independent and dependent variables	• See table III - 4
	• The questionnaire design takes into account that variation in the independent variables should be contemporaneous with, or precede, variation in the dependent variable	• The survey questions for the dependent and independent variable refer to the same time period • The questionnaire starts with dependent variable questions, than independent variables follow to avoid bias due to respondents' implicit theories
	• We exclude plausible alternative explanations for the significant correlations between the LOC and the control in model 1, in line with Davila (2000), for environmental unpredictability,[1] innovativeness of the firm,[2] and PD strategy[3] as potential drivers of the LOC	• Overall, we find that model 1 remains unchanged the best-performing model in terms of fit and parsimony (see appendix III - 5) • Including LOC drivers, of course a decrease in magnitude of the correlations between the levers is shown, but the correlations remain, with the exception of the beliefs-diagnostic correlation, positively significantly different from zero. • Overall, the drivers account only for a part of the correlation between the LOC
External validity	• Analyses of the effect of moderating variables, i.e., firm size and industry, by multiple group comparison (median split for firm size in terms of sales and allocation of industry to R&D-intensive vs. non-R&D-intensive industries based on the results of the Community Innovation Survey (European Commission, 2008)	• Neither firm size nor industry moderates the paths and correlations in model 1 as a whole (see appendix III - 6)
	• Analysis of sales as a control variable directly added to model 1	• The variable does not have any significant effect either on PD, or on organizational performance
	• Test for stability of the results across two random sub-samples	• The ranking of the models is the same in the full sample and in both subsamples

[1] The higher the uncertainty, the larger the gap between the desired and the available information, thus the greater the need to use the LOC in order to reduce this gap. We proxy uncertainty by measuring the perceived unpredictability of the environment. Environmental unpredictability is measured based on items taken from Gordon & Narayanan (1984) about how the predictability of competitors and the tastes and preferences of customers have developed over the last three years. The higher the score, the less predictable the environment has become.

[2] As the LOC are designed to reconcile innovation with predictable goal achievement, it is likely that the degree of innovativeness is positively associated with the emphasis on the LOC. The measure of innovativeness is borrowed from Miller & Friesen (1982) and addresses the emphasis of the firm on R&D, technological leadership, and innovation, the number of new lines of products marketed in the last three years with respect to the competitors, and the degree of change in product lines over the last three years. The higher the score, the more innovative the firm.

[3] Simons (1995) argues that the LOC are necessary to balance the different types of strategy. We ask for PD strategy using a one-item instrument based on Mintzberg & Waters (1985) and anchored on the one hand with "Our PD strategy is completely defined and controlled based on the firm's intensions" and on the other hand with "Our PD strategy is completely imposed by the environment". The higher the score, the more emergent and the less deliberate the strategy is.

Appendix III - 3: Results of SEM of the four competing models including drivers of LOC (robustness check for environmental predictability, innovativeness of the firm, and PD strategy)

Dependent variable	Independent variable (expected sign)	Base model Additive model Stand. estimate	Model 1 Interdependence model Stand. estimate	Model 2 Interaction model Stand. estimate	Model 3 Combined interdependence/interaction model Stand. estimate
PD performance	Interactive control system (+)	0.076	0.059	0.071	0.054
	Diagnostic control system (+)	**0.172****	**0.169****	**0.181*****	**0.179****
	Beliefs system (+)	**0.248*****	**0.259*****	**0.246*****	**0.258*****
	Boundary system (+)	0.093	0.066	0.093	0.065
	Dynamic tension interactive-diagnostic (+)	--	--	0.060	0.061
	Dynamic tension beliefs-boundary (+)	--	--	-0.025	-0.023
	Dynamic tension interactive-boundary (+)	--	--	-0.007	-0.007
	Dynamic tension beliefs-diagnostic (+)	--	--	0.025	0.026
Organizational performance	Interactive control system (+)	-0.076	-0.080	-0.071	-0.075
	Diagnostic control system (+)	0.063	0.070	0.042	0.048
	Beliefs system (+)	**0.234*****	**0.238*****	**0.250*****	**0.253*****
	Boundary system (+)	-0.026	-0.027	-0.033	-0.035
	PD performance (+)	**0.250*****	**0.250*****	**0.256*****	**0.255*****
	Dynamic tension interactive-diagnostic (+)	--	--	-0.038	-0.038
	Dynamic tension beliefs-boundary (+)	--	--	**0.133***	**0.133***
	Dynamic tension interactive-boundary (+)	--	--	-0.051	-0.051
	Dynamic tension beliefs-diagnostic (+)	--	--	-0.059	-0.059
Beliefs system	Environmental unpredictability (+)	-0.010	0.018	-0.010	0.018
	Innovativeness (+)	**0.627*****	**0.405*****	**0.627*****	**0.405*****
	PD strategy (-)	**-0.210*****	**-0.171*****	**-0.211*****	**-0.171*****
	Boundary system (+/-)[a]	--	**0.118****	--	**0.118****
	Interactive control system (+/-)[a]	--	**0.134*****	--	**0.134*****
	Diagnostic control system (+/-)[a]	--	0.039	--	0.039
Boundary system	Environmental unpredictability (+)	-0.019	-0.003	-0.018	-0.003
	Innovativeness (+)	**0.424*****	**0.128***	**0.424*****	**0.128***
	PD strategy (-)	-0.118*	-0.081	**-0.118***	-0.081
	Diagnostic control system (+/-)[a]	--	**0.147*****	--	**0.147*****
	Interactive control system (+/-)[a]	--	**0.122*****	--	**0.122*****
Interactive control system	Environmental unpredictability (+)	**-0.180****	**-0.195***	**-0.180***	**-0.195***
	Innovativeness (+)	**0.445*****	**0.133***	**0.445*****	**0.132***
	PD strategy (-)	**-0.186*****	**-0.146****	**-0.186*****	**-0.146****
	Diagnostic control system (+/-)[a]	--	**0.127*****	--	**0.127*****
Diagnostic control system	Environmental unpredictability (+)	0.009	0.038	0.010	0.039
	Innovativeness (+)	**0.407*****	**0.157***	**0.407*****	**0.158***
	PD strategy (-)	**-0.188*****	**-0.150****	**-0.188*****	**-0.150****

Appendix III - 4: Results of SEM of the four competing models including drivers of LOC (robustness check for environmental predictability, innovativeness of the firm, and PD strategy) (continued)

	Base model Additive model	Model 1 Interdependence model	Model 2 Interaction model	Model 3 Combined interdependence/interaction model
Chi square	697.800	631.345	1,548.100	1,481.643
df	279	273	637	631
p-value	0.000	0.000	0.000	0.000
AGFI	0.869	0.884	0.828	0.837
CFI	0.913	0.925	0.846	0.856
RMSEA [90% confidence interval]	0.057 [0.051-0.062]	0.053 [0.048-0.058]	0.055 [0.052-0.059]	0.054 [0.050-0.057]
SRMR	0.069	0.062	0.075	0.072
Chi square difference test		**66,455 (6)*** **		**66,457 (6)*** **
AIC	841.800	**787.345**	1,756.100	1,701.643
CAIC	1,212.489	**1,188.925**	2,291.541	2,267.974
ECVI [90% confidence interval]	1.803 [1.644-1.977]	**1.686** [1.537-1.851]	3.760 [3.522-4.016]	3.644 [3.411-3.893]

This table presents the results of the four structural equation models. The chi square, df, p-value, AGFI, CFI, RMSEA, and SRMR allow for the evaluation of the fit between the model in the analysis and the data. The AIC, CAIC, and ECVI allow the comparison of non-nested models according to their ability to fit the data (parsimoniously). Common threshold values are applied: chi square test p-value>0.05, AGFI>0.9, CFI>0.95, RMSEA<0.1, and SRMR<0.08. Note that the model chi square used to test the exact-fit hypothesis is commonly viewed as too restrictive for SEM, leading to a more in-depth analysis of the approximate fit measures, like RMSEA; see Steiger (2007). Nested models can be compared by chi square difference test. The chi square difference statistic tests the equal-fit hypothesis. When adding paths to the model, a significant chi square difference test indicates that the competing model fits the data statistically better than the base model. The best-fitting and most parsimonious model displays the lowest AIC, CAIC, and ECVI values.

[a] The reported relationship is not a dependent-independent variable relationship, but represents the correlation between the variables and the significance level of these correlations. To allow the LOC to correlate in the AMOS model despite being dependent from the modeled drivers, we use reciprocal direct relations, pairwise constrained to be equal. The partial correlations are constrained to be equal. The unstandardized estimates are equal, while the displayed standardized estimates can slightly diverge based on the direction of the partial correlation. Only one partial correlation per relation is displayed, since the differences are negligible and do not change the interpretation of the results.
Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level. The significance levels for the parameter estimates are derived from a one-sided test for one-sided hypotheses and a two-sided test for two-sided hypotheses. For drivers, where hypotheses are not provided, significance levels refer to one-sided tests.

Appendix III - 5: Analysis of the moderating effect of firm size and industry

		Firm size		Industry	
Dependent variable	Independent variable	Small (n=234)	Large (n=234)	Low R&D intensity (n=196)	High R&D intensity (n=272)
PD performance	Interactive control system	0.071	0.049	0.058	0.077
	Diagnostic control system	**0.163***	**0.190***	**0.196***	**0.160***
	Beliefs system	**0.261****	**0.182***	**0.217****	**0.222****
	Boundary system	0.125	0.041	0.137	0.025
Organizational performance	Interactive control system	-0.118	-0.071	**-0.141***	-0.046
	Diagnostic control system	**0.219****	-0.044	0.080	0.050
	Beliefs system	**0.261***	**0.299*****	**0.455*****	0.117
	Boundary system	-0.051	0.030	**-0.157***	0.060
	PD performance	**0.192***	**0.288*****	**0.180***	**0.300*****
Beliefs system	Boundary system[a]	**0.423*****	**0.277*****	**0.375*****	**0.320*****
	Interactive control system[a]	**0.364*****	**0.454*****	**0.307*****	**0.406*****
	Diagnostic control system[a]	**0.238****	**0.391*****	**0.366*****	**0.300*****
Boundary system	Diagnostic control system[a]	**0.289****	**0.400*****	**0.345*****	**0.349*****
	Interactive control system[a]	**0.401*****	**0.300*****	**0.252****	**0.400*****
Interactive control system	Diagnostic control system[a]	**0.421*****	**0.311*****	**0.199***	**0.457*****
Chi square constrained measurement model, unconstrained structural model (df)		525.548 (324)		521.090 (324)	
Chi square constrained measurement model, constrained structural model (df)		545.887 (339)		541.802 (339)	
Chi square difference test		20.338 (15), p=0.159		20.712 (15), p=0.146	

This table presents the results of the structural equation model estimation of model 1 for different firm sizes and industries. For firm size, the two groups are built by median split of sales, while we classify firms based on industry by the average R&D intensity (R&D expenditures by total turnover) reported by the Community Innovation Survey for each NACE Rev. 2 industry (European Commission, 2008) (i.e., we take the median R&D intensity across manufacturing firms and allocate the industries with R&D intensity below the median to the low R&D intensity industry and the industries with R&D intensity above the median to the high R&D intensity industry). The standardized coefficients are taken from a model with the measurement model constrained to be equal across groups and the structural model (i.e., paths and correlations) left free to vary. The measurement model is constrained to be equal after making sure that measurement invariance is granted.

Note: * Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level.

IV Combinations of the levers of control in product development

Abstract

This paper contributes to the recent literature on the relationship between management control systems (MCS) and innovation (e.g. Bisbe & Otley, 2004; Bisbe & Malagueno, 2009) by considering how the four levers of control (LOC), i.e. interactive and diagnostic control systems, as well as beliefs and boundary systems, are combined in product development (PD). In a survey of 468 manufacturing firms, I employ cluster analysis to determine how the LOC are combined, depending on the type of strategy formation (i.e., intended or emergent) and the degree of innovativeness of the firm. I identify three clusters and label them "Values and Norms Control", "Performance Measures Control", and "Limited Control". While the first two clusters are consistent overall with my hypotheses, thus representing a situation of fit between strategy, LOC, and environment, and are equifinal in terms of PD performance and organizational performance, the third cluster has a significantly lower performance. The results contribute to research in that (1) they respond to the call for analysis of "packages" of control instead of isolated MCS components; (2) they provide first quantitative evidence of the relationship between strategy formation and LOC and thus build on previous qualitative results; and (3) they enrich the MCS-innovation literature by addressing the combinations of LOC that are capable of generating the highest performance. Practice can profit from my results by identifying the best combination of LOC, which depends on the manifestation of strategy and environment variables.

Keywords: management control systems, levers of control, product development, cluster analysis

JEL Classifications: C38, C83, L60, M40, O32

1 Introduction

Understanding the appropriateness of different control mechanisms in different environments has been recognized as an important line of research in management accounting and control research in the last decades (Chenhall, 2007; Fisher, 1995). In this vein, a considerable number of researchers has dealt with the appropriateness of management accounting and control systems in innovative settings (Davila, Foster, & Oyon, 2009). While the traditional view considered formal management control systems (MCS) unconditionally as a deterrent to innovation (e.g. Amabile, Conti, Coon, Lazenby, & Herron, 1996; Ouchi, 1979), several empirical studies found that some MCS components foster innovation (e.g. Abernethy & Brownell, 1997; Bisbe & Otley, 2004; Bonner, Ruekert, & Walker Jr., 2002; Davila, 2000). However, there has only been little research on which different MCS components operate in combination in different strategic and environmental backgrounds in these innovative settings (Bisbe & Malagueno, 2009). Which different MCS components complement each other? Which substitute each other? How is this complementary or substitutive relationship conditional on the innovative environment of the firm or on its strategy formation? Are these combinations equifinal? To answer these questions, I cluster firms based on the different MCS components they employ for product development (PD). I focus on PD rather than on additional innovation efforts such as the development of new processes or new marketing methods since I found when talking with practitioners that PD for the manufacturing sector I am surveying is the most common form of innovation. I analyze MCS components based on the well-accepted levers of control (LOC) framework by Simons (1995) and thus distinguish between beliefs and boundary systems, interactive and diagnostic use of performance measures. I focus on the use of performance measures for PD (instead of, e.g., budgets) since (1) performance measures are commonly used in product development, as revealed both by my talks with experts and previous literature (Davila, 2000); (2) these are commonly used in empirical research in order to investigate the use of LOC (e.g. Henri, 2006; Widener, 2007); and (3) performance measures allow the monitoring of issues critical to firm performance beyond mere accounting data and thus are suitable for the PD area (Kaplan & Norton, 1992). The environment is considered by using the degree of innovativeness as a proxy for the environmental uncertainty experienced by the firm (Salomo, Weise, & Gemünden, 2007). I further investigate how strategies are formed in the firms by distinguishing between intended (i.e. a priori planned) and emergent (i.e. derived from impulses from the environment) strategies (Mintzberg, 1978). To investigate if different LOC combinations are equifinal, I scrutinize PD

performance and organizational performance of the firm categories identified. I follow the OECD (2005) in defining PD performance from an output perspective. Thus, PD performance refers to the results of the PD process in terms of new or significantly improved products, their time to market, and related effects on sales and profit. Organizational performance is understood as financial results of firm activities in terms of sales, profit, and return measures.

As regards my setting, Bisbe & Malagueno (2009) analyzed the combination of the management accounting system used interactively with the organizational and managerial processes employed to manage innovations, and found the two aspects to be related. Thus, Bisbe & Malagueno (2009) draw the attention of researchers toward the existence of different configurations of approaches to control product innovation activities in firms. Henri (2006) considered the joint effect of interactive and diagnostic use of performance measurement systems, but did not find a significant effect of this interaction on innovativeness. To the best of my knowledge, there are no studies that allow drawing conclusions on the combinations of the four different levers in PD.

This stands in contrast to prior conceptual (e.g. Chenhall, 2003; Fisher, 1998; Malmi & Brown, 2008; Otley, 1980) and empirical research (Abernethy & Chua, 1996; Mundy, 2010; Revellino & Mouritsen, 2009; Sandelin, 2008; Tuomela, 2005) that already established the importance of the simultaneous consideration of multiple MCS components. Furthermore, the literature acknowledges that different MCS components do not only complement, but also substitute each other (Fisher, 1995; Gerdin, 2005; Widener, Shackell, & Demers, 2008). The simultaneous need for predictable goal achievement and creative innovation can be accomplished by different MCS designs, which may be equifinal in terms of PD performance and organizational performance. For example, the demand for predictable goal achievement and creative innovation may be met either satisfied by formal cultural controls, e.g., by using a constraining boundary system together with an enabling beliefs system, or by the interactive use of performance measures.

This substitutive relation may hold under certain conditions, while under other conditions the LOC may be complementary (Gerdin, 2005). The contingency tradition calls for the consideration of environmental and strategic variables to draw conclusions on the best combination of structural variables (Donaldson, 2001). In this respect, it is likely that the combination of the LOC is related to the overall degree of innovativeness of the firm (Bisbe & Otley, 2004). For example, a culture-related control may be more appropriate for firms with a high degree of innovativeness (Tushman & O'Reilly, 1997). Additionally, the combination of the

LOC may be related to the type of strategy that is dominating the area of PD (Simons, 1991). The use of a diagnostic control system may be particularly related to an intended strategy which clearly defines the goal achievements that have to be monitored. Hence, I consider degree of innovativeness and type of strategy formation as variables related to the combination of the LOC. Finally, I test if certain clusters outperform other clusters or whether, alternatively, the clusters are equifinal.

The method for data analysis is cluster analysis (Aldenderfer & Blashfield, 1995). Cluster analyses are the superior methods when researching typologies of firm, since they allow for a consideration of a "[…] wider variety of dimension of context and MCS" (Chenhall, 2003, p. 156) than other statistical approaches.

Based on previous research, I argue for the existence of at least two clusters. I hypothesize that highly innovative firms operate in a rapidly changing environment that requires strategies to emerge from employees, who perceive changes in the environment and design potential reactions to these changes. These firms will particularly emphasize the beliefs, boundary, and interactive control systems. Allowing strategies to emerge requires the definition of values (beliefs system) and norms (boundary system) that give an overall direction (arising, for example, from the mission statement or from the code of conduct) to these emerging strategies. Furthermore, interactive control systems will encourage new strategies by to the continual challenge and debate of assumption and plans. Firms that are less innovative will focus more on intended strategies and rely on diagnostic systems to control the achievement of these intended strategies. I argue that these two combinations of LOC, degree of innovativeness, and type of strategy formation will be equifinal, i.e., they will not lead to significant differences in performance.

My results show three clusters, with two that are pretty similar to those hypothesized above, while a third encompasses firms that place low emphasis to all the four LOC. I label my clusters "Values and Norms Control" (cluster 1), "Limited Control" (cluster 2), and "Performance Measures Control" (cluster 3). Clusters 1 and 3 do not display significant performance differences and can thus be defined as equifinal alternatives.

This study contributes both to research and practice in multiple ways. First, my paper adds to the emerging body of literature arguing for a simultaneous consideration of different LOC implemented at the same time in firms, instead of focusing on just one. By covering all the four LOC, I allow for the identification of typologies of firms that combine the levers in different ways; thus, researchers are able to learn more about the "package" of LOC used in

firms (e.g., do the different LOC complement each other?) (Gerdin, 2005). This is in response to the original issue raised by, for example, Bisbe & Malagueno (2009) as well as Chenhall (2007) for the use of a broader taxonomy of control. I also supplement the qualitative results on the interplay of the LOC (e.g. Mundy, 2010 and Tuomela, 2005) with my quantitative findings.

Second, I search for associations between intended and emergent strategies with the emphasis on the four LOC. This extends the work of Simons (1991) on the association between interactive control systems and emergent strategy and, therefore, enriches the body of literature on LOC and strategy formation (e.g. Davila, 2005; Marginson, 2002). That is, I fill in the research gap identified by Langfield-Smith (2007): "[…] in empirical research the importance of the distinction between intended and realized strategy is rarely acknowledged […]" (Langfield-Smith, 2007, p. 756).

Third, I contribute to the research on LOC and innovation. While previous literature focused on the overall relation between one or two LOC and innovation performance (e.g. Bisbe & Otley, 2004; Bonner, et al., 2002; Henri, 2006), this paper identifies for the first time categories of firms based on the combination of the four LOC for PD. Related results show performance effects of different possible combinations, thus widening perception from the individual relation between one lever of control and innovation performance to the relation between a package of LOC and innovation performance. I relate my results to the degree of innovativeness and to the type of strategy formation, in order to provide a clearer picture of the different PD control categories. In the words of Gerdin (2005): "[…] the use of categories, rather than single one-dimensional variables, may give a clearer picture of the appropriateness of different control mechanisms in different environments" (Gerdin, 2005, p. 119).

My analysis also addresses performance differences across clusters. This makes the findings of interest not only to researchers, but also practitioners, who will be able, based on the identification of the degree of innovativeness and on the firm's typical strategy formation, to identify the most favorable emphasis on all the four LOC for PD.

The paper is organized as follows: the description of the LOC framework, the degree of innovativeness, the types of strategy formation, as well as the expected performance effects are accomplished within the next section. The data collection, the measurement of the variables, and the cluster analysis carried out are detailed in the "Methods" section. The resulting clusters are investigated in the "Results" section, which also sketches the robustness of re-

sults. Finally, the "Conclusion" section discusses and summarizes the findings and limitations, and suggests future research.

2 Theoretical background and hypotheses formulation

2.1 Levers of control

The LOC framework proposes a coherent typology of levers used to control employees' actions by balancing opportunity-seeking and management attention, intended and emergent strategy formation, self-interest and desire to contribute (Simons, 1995). Following Simons (1995), four LOC contribute to strategy implementation: boundary system, diagnostic control system, beliefs system, and interactive control system. While boundary and diagnostic control systems represent constraining forces that impose compliance with rules, beliefs and interactive control systems focus on opportunity-seeking, enabling creativity, and problem-solving (Simons, 1995). Boundary systems "[…] delineate the acceptable domain for opportunity-seeking for organizational participants" (Simons (1995), p. 39). They induce behavior constraints necessary to prevent employees from engaging in misleading, goal-incongruent experimentation. The definition of the off-limits behavior and risks that should be avoided can be formally stated in a code of business conduct or in internal guidelines and should be reinforced by management. Boundary systems allow the emergence of new strategies since they provide transparency about the area for which emerging strategies are desired (Davila, 2005; Simons, 1995). In a PD setting, this implicates the definition of markets, product areas, or customers, for which PD is not carried out. Similarly focused on rule compliance, the diagnostic control system supports management by exceptions, i.e., budgets, project timelines, and milestones, as well as other data from management accounting used by managers to set standards, monitor organizational outcomes, and correct deviations from preset standard performance. Management attention is limited because intervention is only required if results deviate from goals. The diagnostic use of management accounting information is intended to make goal achievement predictable, thus it is appropriate for the implementation of intended strategies (Simons (1995). PD has to be tracked in order to monitor the progress of each project according to costs, time, and quality key measures, and to compare the achievements with the expectations.

While boundary and diagnostic control systems tend to be constraining LOC forces, beliefs and diagnostic control systems are more enabling forces. Beliefs systems are "[…] the explicit set of organizational definitions that senior managers communicate formally and rein-

force systematically to provide basic values, purpose, and direction for the organization" (Simons (1995), p. 34). Formal instruments to communicate firm values are, for example, the mission, the vision, and the values statement. Together with the communication of values by top management during daily activities, the mission, vision, and value statements are designed to motivate employees to increase efforts toward desired opportunity-seeking and thus toward the emergence of new strategies (Davila, 2005; Simons, 1995). In PD settings, the mission statement as well as managers daily actions should communicate innovation to be a primary value of the firm. Interactive control systems are characterized by a frequent dialogue between managers and employees and are intended to ensure the adaptation capability of the firm, e.g., by the emergence of new strategies in unstable environments (Davila, 2005; Simons, 1995). Management accounting data that is monitored and discussed by management are used to orient the firm toward key issues and critical success factors, to tie the organization together, and to provide a common vocabulary across departments and hierarchies (Simons, 1995). In terms of PD, an interactive control system requires the use of management accounting data from, for instance, project milestones, budgets, or project timelines to align the firm to the critical success factors, and to challenge regularly and debate the assumptions behind the existing strategy. In Simons' (1995) framework, the interactive control system is considered particularly well-suited for innovative environments, since it is focused on the analysis of strategic uncertainties – which may be the basis for renewal and change.

2.2 Strategy formation

MCS are designed to direct employees' behavior toward the implementation of strategies (Anthony & Govindarajan, 1998; Flamholtz, 1983; Otley, 1994; Simons, 1995). But while traditional MCS approaches have been mostly understood as management-by-exception or command-and-control tools to implement intended strategies (Andrews, 1971), the LOC framework proposes the interactive use of management accounting techniques as an instrument allowing new strategies to emerge (Simons, 1990; Simons, 1991). The distinction between intended and emergent strategies goes back to Mintzberg (1978) and refers to strategies that are purposeful and formally planned by the firm (intended strategies) and strategies that come up in absence of an a priori intention, but arise from day-to-day activities and the interaction with a firm's environment (emergent strategies) (Mintzberg, 1978). Between these two types of strategy formation there is a continuum of hybrid strategies that are more or less intended or emergent (Davila, 2005; Mintzberg & Waters, 1985). Thus, in line with Simons (1995) argument that the type of strategy formation plays a central role in the LOC frame-

work, this study investigates the combination of the LOC with these different types, i.e., intended and emergent strategies. This distinction has been considered crucial by previous literature, since it overcomes the common understanding of strategies as conscious plans formulated prior to actions (Dent, 1990; Langfield-Smith, 2007).

The relationship between the LOC and the type of strategy formation was previously considered by Marginson (2002), who found in his case study of a telecommunication firm that beliefs and boundary systems are helpful in allowing and directing the emergence of new strategies, while notably the interactive use of key performance indicators did not provide strategic impetus. In contrast, Henri (2006) found the interactive use of performance measurement systems to be positively related to capabilities required for strategic change. In this paper, I examine the combination of all four LOC and the degree to which strategies are emergent or intended.

2.3 Degree of innovativeness

The degree of innovativeness of the firm is defined as the degree of change the firm experiences in terms of new product lines and in terms of the importance attributed to this change. The degree of innovativeness may influence the combination of LOC which is best applicable (Salomo, et al., 2007). The contingency approach suggests that uncertainty is a major contingency variable that should match the organizational variables (Donaldson, 2001; Duncan, 1972; Lawrence & Lorsch, 1976). Since the degree of innovativeness is a proxy for the uncertainty which is experienced by the firm (Salomo, et al., 2007), it is in line with the contingency tradition to expect a relationship between strategy and LOC on the one hand, and innovativeness on the other hand. Salomo, et al. (2007) found that innovativeness does not moderate the positive relationship between PD project planning and innovation success, while it does moderate negatively the relationship between process formality and innovation success. According to Droge, Calantone, & Harmancioglu (2008), the organicity of the organizational structure is positively related to the degree of innovativeness of the firm. This result is rooted in the conceptual work by Miller & Friesen (1982), who distinguish between organic and mechanistic systems, whereby the former are appropriate for changing and uncertain conditions, while the latter are better suited for stable, certainty conditions. Organic systems are often related to interactive control systems (Chenhall & Morris, 1995; Henri, 2006; Widener, 2007) and are considered to be more adequate for high-innovative settings than for low-innovative settings. In these organic systems, where there is a day-to-day interaction between management and subordinates about the premises and goals of the firm, the emergence of new

strategies is more likely to occur than in mechanistic systems (Davila, 2005; Miller & Friesen, 1982).

2.4 Combinations of levers of control, strategy formation, and degree of innovativeness

There is theoretical and empirical evidence of the relationship between the LOC, the strategy formation, and the degree of innovativeness of the firm.

I expect that firms with a high degree of innovativeness operate in uncertain environments and thus their performance is dependent on the ability to allow the emergence of proper new strategies (Davila, 2005). This becomes feasible through the interactive use of performance measures, since this lever of control requires the continual challenge and debate of the assumptions resting on the performance measures used and their implicit relation to strategy, thus stimulating organizational learning and focusing the attention on strategic uncertainties (Henri, 2006; Simons, 1995). Furthermore, emerging strategies have to be directed according to the norms and values the firm is based on. This requires a particular emphasis on the boundary system, which has to define, for example, for which product lines, market, and customer PD will not be carried out and thus will not be part of emerging strategies. Furthermore, emerging strategies require an emphasized beliefs system that formulates the importance of product innovations for the firm and thus the areas where opportunity-seeking is desired (Marginson, 2002). I summarize this category into the following hypothesis:

> H1: *Firms with a high degree of innovativeness have emergent strategies and emphasize beliefs, boundary, and interactive control systems.*

In contrast to this first category, I expect that firms with a low degree of innovativeness experience a stable environment, which allows them to rely on intended strategies. Stable environments are more predictable and thus performance is dependent on the degree in which plans are intentionally formulated and consequently pursued. Consequent pursuing of strategies is most appropriately carried out with a command-and-control approach inherent to the diagnostic use of some critical performance variables. Management attention is required only on exception basis, if deviation analyses indicate upcoming problems (Simons, 1995). I summarize this category into the following hypothesis:

> H2: *Firms with a low degree of innovativeness have intended strategies and emphasize diagnostic control systems.*

In line with the contingent tradition, the above categories describe the fit between strategy, context, and structure variables (Drazin & Van de Ven, 1985; (Gerdin & Greve, 2004). Adapted to the LOC context, the categories describe the firms that are in fit. Therefore, both should ascertain a high level of performance and be equifinal alternatives. That is, I expect firms allocated to one of the two categories to be in fit concerning their strategy, LOC, and innovativeness, and to outperform the PD performance and organizational performance of the firms that fall outside the two hypothesized clusters. Formally stated:

> H3: *Firms that have a LOC combination that fits to the type of strategy formation and to the degree of innovativeness outperform firms that are not in fit.*

3 Methods

3.1 Data collection

I investigate the combination between LOC, strategy formation, and degree of a firm's innovativeness. I refer the LOC and strategy formation to the area of PD because both LOC and strategy formation processes are likely to differ across the firm. I select the PD area since in my discussions with experts they stressed the importance of this area as critical to performance, confirming previous research findings (e.g. Capon, Farley, & Hoenig, 1990).

The data were collected through a structured written questionnaire sent by mail to members of the top management of the target firms, i.e., the Chief Financial Officer (CFO), the Chief Technology Officer (CTO), or the Chief Executive Officer (CEO).[1] I chose them as informants since they are knowledgeable about the LOC and their implementation in PD (Davila, Foster, & Li, 2009; Widener, 2007), which was confirmed by our pilot test. For 85 firms, duplicates, i.e., two questionnaires from two different respondents from one firm were returned and used to control for interrater reliability potentially affected by different respondents' perceptions. The target population consisted of 8,555 large and medium-sized firms in the manufacturing sector (the C-section in the NACE Revision 2 classification) from German-speaking countries (Germany, Austria, and Switzerland).[2] Firms respecting the following size criteria were sampled: (1) at least 50 employees (full-time equivalents) for the year 2008; (2)

[1] All the potential respondents within one firm received the same questionnaire and had to answer the same questions.

[2] The target population is identified through the AMADEUS database. AMADEUS is a database that in October 2009 contained financial information on over 11 million public and private companies in 41 European countries. It combines data from over 30 regional information providers using public mandatory disclosure data.

at least 10 million euro sales for the year 2008. Since the survey was conducted during the 2008/2009 world economic crisis, I was seeking results that were as far as possible unbiased by this critical event. Thus, I referred my survey questions to the average firm situation over the last three years. In order to be able to check for respondent bias, I sampled those firms that provided financial data in the AMADEUS database for the last three years. Thus, the sample consisted of 2,695 firms, from which I identified 4,961 potential respondents.[3] In order to collect the contact data from this sample, I contacted the firms by phone or e-mail and, wherever possible, prenotified the respondents. This helped me to increase the likelihood that the respondent whom I wanted to answer my questions was indeed the person who received the questionnaire. Each mail-out package included a personally addressed signed cover letter (in which I guaranteed the confidentiality of answers and anonymity in the result reports), the questionnaire, and a prepaid reply envelope. As an incentive to respond, I offered an executive summary of my results and participation in a workshop to discuss the results with researchers and practitioners. The follow-up wave consisted of a second package with a cover letter urging an answer and a replacement questionnaire sent to those who had not answered yet (Dillman, 2007).

From the initial 2,695 potential respondent firms, 87 could not be contacted since the firms had closed, failed, or moved to an unknown address, or they could not provide useful insights since they stated that they did not undertake PD. I received a reply questionnaire from 962 firms. After correcting for those 68 firms for which the questionnaire came from a respondent who was beyond the scope of our analysis (e.g., a different functional and/or hierarchical level), 894 firms were left. Referring to the 2,695-87=2,608 firms that could be approached with my questionnaire, this equals a response rate of 34.3%.

[3] For most of the firms, both the CFO and the CTO could be identified and addressed. For 429 mostly small firms, only the CEO could be identified.

Table IV - 1: Unit non-response analysis for firm characteristics

Variable	Respondents with performance measures for PD (n=468)	Respondents without performance measures for PD (n=365)		Addressed non-respondents (n=1,801)		Survey population (n=8,087)	
Number of employees (in thousands)	2.74	0.38	(t=2.725, p=0.007)	1.22	(t=1.660, p=0.097)	0.78	(t=-2.265, p=0.024)
Net sales (in millions euro)	806.36	89.73	(t=2.511, p=0.012)	354.41	(t=1.523, p=0.128)	247.66	(t=-1.946, p=0.052)
EBIT (in million euro)	40.87	5.32	(t=2.325, p=0.020)	25.79	(t=1.094, p=0.274)	13.62	(t=-1.771, p=0.077)
Fixed assets (in million euro)	386.20	21.61	(t=2.521, p=0.012)	151.61	(t=1.552, p=0.121)	104.16	(t=-1.934, p=0.054)
Intangible assets (in million euro)	96.71	1.22	(t=2.438, p=0.015)	52.91	(t=0.978), p=0.328)	29.47	(t=-1.687, p=0.092)

The table reports variable means as well as t-statistics and related p-values for the comparison of means of variables between the respondents with and without performance measures for PD, between the respondents with performance measures for PD and the addressed non-respondents as well as between the respondents with performance measures for PD and the survey population (two-sided test). The respondents are already corrected for overrepresentation of NACE div. 33.

I investigated unit non-response bias by comparing the respondents with the addressed non-respondents and the respondents with the survey population (i.e., all 8,555 manufacturing firms in German-speaking countries with at least 50 employees and 10 million euro sales available in the AMADEUS database for the last available year). The pattern of industry distribution of the respondents following the NACE Rev. 2 divisions compares well with the industry distribution of the addressed non-respondents (chi square(23)=33.079, p=0.08) and of the population. Only division 33 of the NACE classification required corrective actions (reweighting by random deletion of n=61 cases from division 33 “Repair and installation of machinery and equipment”), since there was an overrepresentation of firms in this division compared with the distribution of the population. After this correction, 833 firms remained in my sample and the chi square statistic does not show significant differences in the industry distribution between the respondents and the population (chi square(23)=34.895, p=0.053). In unreported results, I find no statistical differences in the number of employees, sales, EBIT, fixed assets, and intangible assets between the respondents and the addressed non-respondents as well as between the respondents and the survey population.

From the 833 firms considered, 365 declared that they had not any type of performance measure for their PD and could thus not be analyzed in terms of our research question, so I carried out my research based on 468 responses. Table IV - 1 shows that there are no statistical differences in the number of employees, sales, EBIT, fixed assets, and intangible assets between the respondents with PD performance measures and the addressed non-respondents as well as between the respondents with PD performance measures and the survey population at $p<0.05$ (with exception for the number of employees for the comparison of the respondents with PD performance measures and the survey population). However, as expected, I find significant differences between the 365 firms without any performance measure for PD and the 468 firms employing performance measures for PD.

To approximate further the unit non-response bias, I compared the responses of early and late respondents (Armstrong & Overton, 1977). I did not find significant differences at the 5% level in construct means, which further supports the representative character of my sample for the manufacturing sector. The results are displayed in table IV - 2. Thus, I am confident to use for the categorization of firms data that are representative of the population of manufacturing firms in German-speaking countries. This representativeness is a prerequisite of cluster analysis, the method used to classify my cases (Hair, Anderson, Tatham, & Black, 2010).

I additionally analyzed item non-response. The descriptive analyses show that a maximum of 6.2% of the responses per question are missed, with most questions ranging between 0.2% and 1.1% of responses missed. There are no indications of patterns of non-random item non-response, as found by Little's MCAR test (chi square(5,002)=5,144.005, p=0.079) (Rubin, 1976). In order to avoid the shortcomings of traditional missing data techniques like mean imputation (i.e., distortion of estimated variances and correlations) (Schafer & Graham, 2002), I used the EM-algorithm to replace the missing values. This algorithm provides consistent and efficient maximum likelihood (ML) estimates for missing completely at random values (Schafer & Graham, 2002, Yuan & Bentler, 2000).

Table IV - 2: Comparison of constructs means for early and late respondents

Construct	Early respondents (before the follow-up procedure)	Late respondents (after the follow-up procedure)	t-statistics, p-values (two-sided test)
Diagnostic control system	3.64 (n=290)	3.59 (n=173)	t=-0.720, p=0.472
Interactive control system	3.13 (n=288)	3.14 (n=172)	t=-0.238, p=0.812
Boundary system	3.05 (n=288)	2.98 (n=168)	t=0.938, p=0.349
Beliefs system	3.96 (n=288)	4.04 (n=174)	t=-1.231, p=0.219
Degree of innovativeness	3.25 (n=287)	3.27 (n=169)	t=-0.255, p=0.799
Product development strategy formation	2.41 (n=291)	2.46 (n=177)	t=-0.430, p=0.668
Product development performance	2.57 (n=289)	2.55 (n=166)	t=0.282, p=0.778
Organizational performance	2.69 (n=271)	2.66 (n=152)	t=0.412, p=0.680

The table reports construct means and t-tests on the difference in construct means for early and late respondents. Early respondents are the respondents who returned the questionnaire before the reminder action; late respondents are the respondents who returned the questionnaire after the reminder action. n varies due to missing values.

3.2 Measurement of variables

All measures used in the questionnaire are borrowed from existing and validated instruments and slightly adapted for the PD setting. I developed the questionnaire in English and then translated it into German for adaption to the sample. Back-translation by an independent party following Brislin (1970) was adopted to verify equivalence between translated and original items. To safeguard content validity, I also discussed the questionnaire with experts in the field (both academics and practitioners). The three-steps test-interview method was used to pilot test the questionnaire with six potential respondents to obtain feedback on the layout of the questionnaire, clarity of the questions, and content validity (Hak, van der Veer, & Ommundsen, 2006). This led to slight adjustments in wording and layout of the questionnaire.

Appendix IV - 1 shows the questionnaire items and descriptive statistics, as well as Cronbach's Alpha and variance extracted for each factor. Cronbach's alpha values lie all above the 0.7 threshold, with the exception of the degree of innovativeness construct that amounts to a value larger than 0.5, which is still acceptable for exploratory research (Nunnally & Bernstein, 1994). Additionally, I use principal component analysis for each construct separately and display the variance extracted by each of these procedures, which is above the 0.5 threshold for all constructs considered.

The LOC are measured using instruments by Vandenbosch (1999) and refined by Henri (2006) for interactive and diagnostic control systems as well as instruments by Widener

(2007) for beliefs and boundary systems.[4] The items for the degree of innovativeness are taken from Miller & Friesen (1982). The question for strategy formation is developed based on the description by Mintzberg & Waters (1985). PD performance is measured with indicators taken from Bisbe & Otley (2004), Capon, Farley, Lehman, & Hulbert (1992) and Griffin (1997), while the organizational performance measure is grounded in Govindarajan (1984). The wording of the original items has been slightly adapted to the area of PD, where necessary. While the strategy formation and the degree of innovativeness questions are based on 5 point differential scales, the remaining questions are 5 point Likert scales. All scales are fully anchored.

3.3 Data analysis

Wolf (1926) and Kemeny (1959) suggest that classification should be both the first and the last effort used in a research area. Cluster analysis provides such a powerful instrument to classify objects into groups (i.e., clusters) that display internal cohesion and external isolation. This, therefore, is the method of choice for my analysis (Milligan, 1980). Cluster analysis allows both identification of natural groups of firms and detection of the relation between the variables considered (Hair, et al., 2010).

Cluster analysis is typically used when investigating the fit between multiple design, strategy, and contextual variables (Drazin & Van de Ven, 1985; Gerdin & Greve, 2008) and is a well-accepted instrument in management accounting and control research (Bisbe & Malagueno, 2009; Chenhall & Langfield-Smith, 1998; Gerdin, 2005). While Chenhall (2003) points out that cluster analysis suffers from some limitations, like the numerous research decisions required to carry out this method and the complexity of the relationships described, he, nevertheless, acknowledges its importance for a broader understanding of contingency relationships. Or, in the words of Ketchen Jr. & Shook (1996): "[…] cluster analysis can provide very rich descriptions of configurations without overspecifying the model" (Ketchen Jr. & Shook, 1996, p. 442). In my study, I search for clusters of firms that are similar in terms of their use of the LOC in PD, their strategy formation, and their degree of innovativeness.

Following Milligan (1980), the best-performing clustering method is a combination of a hierarchical and a non-hierarchical clustering method. I use the K-means non-hierarchical

[4] I differ from Henri (2006) in that I do not use the item "Enable continual challenge and debate underlying data, assumptions and action plans" for the interactive use of performance measures, since I collected this item, but found that it had a very low correlation with the other items of the interactive control system which it was intended to measure. On account of the item's unclear nature, I preferred to delete it form further analyses, as the cluster analysis I employed may have reacted sensibly to the inclusion of a noisy item (e.g. Hair, et al., 2010).

method to allocate the cases to cluster. The algorithm involves an optimization procedure that minimizes the distance between the cases in each cluster and maximizes the distance between clusters by an iterative assignment of cases until a convergence criterion is met. This criterion addresses the change in cluster means by each step and is set equal zero. The K-means clustering method is superior to hierarchical methods since it involves an optimization procedure (instead of stopping after the first pass through the data), and is less susceptible to changes to the distance measure used, to the inclusion of random noise variables, and to the existence of outliers in the data (Hair, et al., 2010; Ketchen Jr. & Shook, 1996; Milligan, 1980; Punj & Stewart, 1983).

The K-means non-hierarchical method allocates cases to clusters, but requires a priori knowledge of the number of clusters in the data. Thus, I follow the suggestion by Milligan (1980) and Punj & Stewart (1983) to use a hierarchical method in order to predetermine the number of clusters in the data as basis for the K-means non-hierarchical method. I choose one of the most frequently used cluster methods in social sciences (Everitt, 1993), i.e., Ward's hierarchical method, an agglomerative technique that minimizes the variance within each cluster. Punj & Stewart (1983) reviewed a number of studies analyzing the performance of different clustering methods and found Ward's method to outperform the rest in most of the cluster method efficacy studies they reviewed.

The goal of Ward's method is to determine the number of clusters that best represent the categories in the population and that are the basis for the allocation of cases by the K-means non-hierarchical method. Determining the proper number of clusters is the most critical issue in cluster analysis, since it is often the step of the analysis that relies most on researchers' discretion. In order to avoid this drawback, I employ, beside the inspection of the dendrogram and the graph of the development of the amalgamation coefficient throughout the possible cluster solutions, the Calinski-Harabasz stopping rule (Calinski & Harabasz, 1974). This stopping rule suggests choosing the number of clusters where the relation of the between-cluster sum of squares and the within-cluster sum of squares is maximized. Milligan & Cooper (1985) found that the Calinski-Harabasz stopping rule is the best-performing stopping rule among the 30 they tested.

While the cluster method defines the way in which the cases are assigned to clusters, no matter how the distance between the cases or clusters is calculated, the distance measures allow for calculation of how (dis-)similar the cases are in terms of all their variables and, fi-

nally, to apply the cluster method. The distance measure most suitable for the cluster method I employ is the squared Euclidian distance (Hair, et al., 2010).[5]

Multicollinearity can create serious problems in cluster analysis by overweighting one or more variables in the data (Hair, et al., 2010). Indeed, my items have been used in previous literature to measure constructs. Thus, items used to measure the same construct are likely to correlate, as can be confirmed by untabulated results. For this reason, I follow Punj & Stewart (1983) by using a principal component analysis with orthogonal varimax rotation, and employ the resulting – uncorrelated – factor scores for my cluster analysis. The results of the factor analysis of all LOC and degree of innovativeness are displayed in appendix IV - 2.[6] Appendix IV - 3 shows the results of a principal component analysis for the PD performance and organizational performance items.

The factor scores generated are already standardized, i.e., they have a zero mean and a standard deviation of 1. Standardization is considered useful in cluster analysis to avoid some variables being weighted higher than others due to differences in standard deviation or in range of the scale (Hair, et al., 2010).

Employing Ward's algorithm to define properly the number of clusters in the data requires data that are free of severe outliers (Milligan, 1980). I ensured that the highest possible degree of representativeness was reached for the population of manufacturing firms in German-speaking countries with my data collection. Therefore, and after careful analysis of descriptive data, I do not have reasons to suspect the existence of outliers (Hair, et al., 2010).

As with every empirical analysis method, cluster analysis suffers from some weaknesses. I address the potential drawbacks of the method by providing several tests for the robustness of my results. I address the stability of the results with changes in the methodological choices (stopping rule, cluster method, other plausible cluster solutions), the type of variables employed (data without factorization, data allowed to correlate freely and without standardization), and the sample (outlier detection).

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[5] Squared Euclidean distance $=\sum_{i=1}^{v}(x_i - y_i)^2$, where i=number of considered variables in the cluster analysis and x and y are the values of a variable for case x and y, respectively.

[6] The item for strategy formation is not included in the factor analysis, since this is a single item variable and not a multiple item variable that requires factorization. Thus, only the strategy formation factor remains correlated with the other factors, whereby related correlations are negligible in magnitude.

4 Results

4.1 Description of clusters and hypotheses tests

I use Ward's hierarchical cluster method based on the squared Euclidian distance measure in order to identify the number of clusters in my data. The dendrogram (i.e., the graphical depiction of the distance between clusters), which is presented in figure IV - 1, displays where each cluster is formed and offers first insights into the number of clusters in the data.

The dendrogram suggests the existence of three clusters, while the unreported graph displaying the development of the amalgamation coefficient throughout the possible cluster solutions does not show a clear flattening by a certain cluster solution. Thus, I supplement the visual identification of the number of clusters with the use of the Calinski-Harabasz stopping rule (Calinski & Harabasz, 1974). This rule supports that the most proper cluster solution, i.e., the number of clusters that maximizes the relation among the between-cluster sum of squares and the within-cluster sum of squares, is the three clusters solution.

The three clusters solution is used as information for the allocation of the firms to clusters by the K-means non-hierarchical cluster method. Based on this allocation, I display the mean scores of variables for each of the three clusters in table IV - 3.

I label cluster 1 as "Values and Norms Control", cluster 2 as "Limited Control", and cluster 3 as "Performance Measures Control". 31% (n=144) of the firms belong to the Values and Norms Control cluster. These firms are characterized by particular emphasis on the beliefs and boundary systems of the LOC framework. They rely on more culture-oriented controls than firms in the other clusters. Their approach to direct employees' behavior toward the development of new successful products is to define clearly that innovativeness is one of the core values of the firm in which they operate. To allow employees to generate safely new ideas, these firms define the boundaries of acceptable behavior in PD, e.g., by emphasizing in the code of conduct for PD the markets, the customers, or the products for which PD should not be carried out. Interestingly and against my expectation, they combine the strong use of beliefs and boundary systems with a moderate use of their diagnostic control system.

Figure IV - 1: Dendrogram

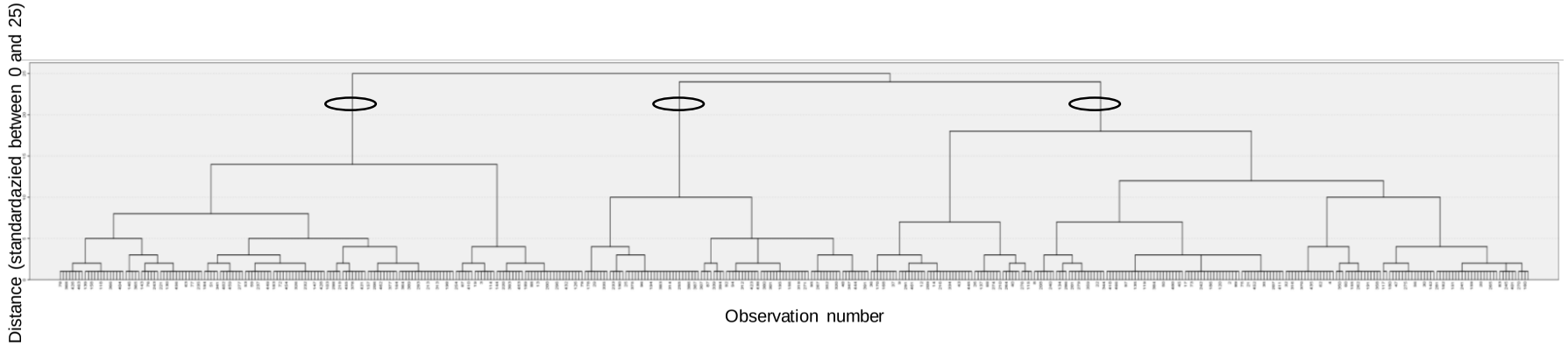

Table IV - 3: Mean scores of variables for each cluster, ANOVA, and pairwise t-tests

	Clusters					
Numbers of firms per cluster	C1 144	C2 134	C3 190	F-statistic (p-value)	Rank (1)> Rank (2) t-statistic (p-value)[b]	Rank (2)> Rank (3) t-statistic (p-value)[b]
Beliefs system	0.35 (1)	-0.67 (3)	0.19 (2)	50.563 (0.000)	1.676 (0.047)	8.035 (0.000)
Boundary system	0.59 (1)	-0.37 (3)	-0.18 (2)	52.657[a] (0.000)	7.457 (0.000)	1.858 (0.032)
Interactive control system	-0.82 (3)	-0.06 (2)	0.66 (1)	165.238[a] (0.000)	7.801 (0.000)	8.033 (0.000)
Diagnostic control system	0.00 (2)	-0.48 (3)	0.34 (1)	29.639 (0.000)	3.313 (0.000)	4.086 (0.000)
Product development strategy formation	0.00 (2)	0.95 (1)	-0.66 (3)	216.636[a] (0.000)	9.829 (0.000)	7.763 (0.000)
Degree of innovativeness	0.27 (1)	-0.36 (3)	0.05 (2)	14.813 (0.000)	2.082 (0.019)	3.621 (0.000)
Product development performance	0.07 (2)	-0.33 (3)	0.18 (1)	11.569 (0.000)	1.022 (0.153)	3.498 (0.001)
Organizational performance	0.08 (2)	-0.32 (3)	0.16 (1)	10.142 (0.000)	0.727 (0.234)	3.601 (0.000)

The table reports the mean scores per variable across the three clusters and related ANOVA F-test results. T-tests are used to compare the mean score of the variable between the cluster ranked first for that variable and the cluster ranked second, and between the cluster ranked second and the cluster ranked third. The ranking of the cluster for a certain variable is displayed in brackets after the mean score of each cluster.

[a] Because the Levene test rejects equal variances across clusters, the Welch-test is used as a robust test procedure. The related statistic is asymptotically F-distributed. [b] One-sided test.

Consistently with this combination, the strategy formation is allocated in an average position between a strong intended and a strong emergent focus. That is, the strategy formation process relies both on a purposeful internal planning process and on reactions to changes in the environment. Therefore, the part of the strategy that is intended by the firm can be controlled by performance measures that are used diagnostically, while the part of the strategy that emerges from the environment is controlled by values and norms.

Such a strategy-control combination appears in firms with a high degree of innovativeness, that is, the innovativeness stressed by the beliefs system is reflected in the employees' behavior and results. This cluster is consistent with the findings by Marginson (2002), that beliefs and boundary systems are combined to achieve organizational change and build the basis for innovation. Against the original assumption based on Simons (1995), high innovativeness is not associated with a high emphasis on the interactive use of performance measures in PD. This strengthens the previous finding by Bisbe & Otley (2004), who asserted that interactive control systems are not beneficial in highly innovative firms, since dangerous experimentation can turn into dysfunctional innovation results.

Firms in cluster 3, the Performance Measures Control cluster (40% of firms, n=190), place an average emphasis on their beliefs and boundary systems in PD, but focus highly on performance measures for their PD. I find both a high emphasis on an interactive use and on a diagnostic use. Thus, I identify, consistently with Tuomela (2005) and Widener (2007), that some performance measures are used strongly diagnostically, while others are, at the same time, used strongly interactively. Bisbe & Malagueno (2009) recognize this decision for which control instruments to be used interactively as dependent on the "[…] organisational and managerial processes by which innovation arises […]" (Bisbe & Malagueno, 2009, p. 373). This cluster is related to the findings by Marginson (2002), who qualitatively identifies a cluster of firms focusing on performance measures and asserts that the use of performance measures may create tensions. Furthermore, Henri (2006) notes that the tensions originated by the joint use of performance measures in an interactive and diagnostic way may generate positive performance effects. In contrast to the Values and Norms Control cluster, where guidance for goal-achievement is provided by delineating the areas where opportunity-seeking is expected and where it is not, the focus in this cluster is on guiding employees' behavior by providing accountability through the use of performance measures (Tuomela, 2005). Values and norms are present, but they do not make up the major control momentum. While a part of the measures related to PD are generated by continuous communication between managers

and subordinates, the remaining part is based on measures that are used in the traditional management-by-exceptions basis. Chenhall & Langfield-Smith (1998) already provided indication of the complementary relationship between different management accounting and control practices and techniques.

The firms display a mediocre degree of innovativeness, while the strategy is strongly intended. Hence, the intended strategy is best controlled by the use of performance measures, while, additionally, the moderately emphasized values and norms help to delineate roughly the area for which opportunity-seeking is desired.

Besides these two clusters that are similar to the clusters expected and described in the hypotheses section, I find a third cluster (cluster 2) encompassing 134 firms and thus 29% of the sample firms labeled the Limited Control cluster. This cluster is characterized by an overall low reliance on the LOC. The diagnostic control, the beliefs, and the boundary systems are underdeveloped, while there is an average interactive use of performance measures. This combination is related to a clearly emergent strategy and, at the same time, a low degree of innovativeness. It seems that the interactive control system contributes to the emergence of new strategies, for example, by integrating the information provided by the interaction with customers (Davila, 2005), but the low emphasis on the other LOC deters the firms from translating the early reception of changes in the environment into changes in the firm's product lines.

Table IV - 3 displays the ANOVA F-values for each variable and confirms that overall the clusters are substantially different from each other. Additionally, I compare the mean scores for each variable between the cluster ranked first and the cluster ranked second, as well as between the second and the third cluster by t-tests. Again, I see significant differences across the clusters.

On the basis of these findings, I review my predictions formulated in the hypotheses. Hypothesis 1 expected that firms with a high degree of innovativeness have emergent strategies and emphasize beliefs, boundary, and interactive control systems. I find that cluster 1, Values and Norms Control, is the cluster with the highest degree of innovativeness. It is characterized by an average strategy formation, i.e., strategies are partially emergent and partially intended, but there is still a significant difference in the "degree of emergence" when compared with cluster 2, the Limited Control cluster. Another finding is that the beliefs and boundary systems are indeed emphasized higher in this cluster than in all other clusters.

Against my expectation, the emphasis on the interactive use of performance measures is significantly lower than in the other two clusters. Thus, I can partially support hypothesis 1.

In hypothesis 2, I formulate the expectation that firms with a low degree of innovativeness have intended strategies and emphasize diagnostic control systems. Cluster 3, Performance Measures Control, emphasizes the diagnostic use of performance measures significantly more than in the other two clusters. This is related to a clear predominance of intended formation of strategies. The degree of innovativeness is significantly lower than for cluster 1. However, in contrast to my theoretical arguments, I find that firms in this cluster also strongly emphasize the interactive control system. In summary, I can also partially support hypothesis 2.

On account of this (partial) support of hypotheses 1 and 2, I am now able to investigate if firms that are in fit – i.e., firms where the type of strategy formation and the degree of innovativeness are accompanied by the combination of the LOC, of strategy, and innovativeness as predicted – outperform firms that are not in fit (hypothesis 3). The combination of LOC, degree of innovativeness, and type of strategy formation found in cluster 2 (Limited Control), does not display a combination according to theory. None of the LOC is strongly emphasized, meaning that no direction is provided for the strategy formation that is highly emergent. Even if the strategy is derived from the changing environment and could, therefore, be accompanied by organizational changes and a high degree of innovativeness, the opposite is the case. Hence, I expect that the PD performance and the organizational performance of firms in this cluster are significantly lower than the performance of firms in one of the two other clusters. Results from the t-tests show that firms whose LOC, strategy formation, and degree of innovativeness are in fit have a significantly higher performance than the firms in the Limited Control cluster. Thus, I find support for hypothesis 3.

Moreover, the fact that there is no significant performance difference between the Values and Norms Control cluster and the Performance Measures Control cluster deserves particular attention. These LOC-strategy-innovativeness combinations are substitutes, i.e., both are equally capable of generating high performance. The equifinality of these alternatives allows identifying the LOC that best complement each other, given the characteristics of the strategy and the environment of a firm.

4.2 Robustness of results

As previously mentioned, the major drawback of cluster analysis is the high dependence of the results on the subjective judgment of the researchers. For this reason, I carried out intensive efforts to validate the results by making transparent how changes to the decisions taken above affect results (Punj & Stewart, 1983). The use of different methods, different type of variables, or different data could change results.

From a methodological point of view, I define the number of clusters in the data based on the inspection of the dendrogram and on the consistent result from the Calinski-Harabasz-index. However, these instruments are not able to reflect the theoretical background of the analysis (Hair, et al., 2010). Therefore, I consider how the results of my analysis change if I choose a two clusters solution, as theoretically predicted. Of course, the cluster method chosen (Ward's method) influences the cluster solution found. Consequently, I validate results by using the complete linkage method, which measures the similarity of clusters based on the maximum distance of cases in each cluster, and the centroid method, which measures the similarity of clusters based on the distance between the means of the variables used for clustering (Hair, et al., 2010). Milligan (1980) has shown that complete linkage and centroid methods perform differently from Ward's procedure depending on the types of possible error perturbation (i.e., outliers, random noise variables, etc.). Using these cluster methods allows controlling for biases of the cluster methods in some direction. While the centroid method suggests a two clusters solution, the complete linkage method finds a four clusters solution to deliver the best categorization. The two clusters solution is already reviewed for theoretical reasons. I review also the four clusters solution. Furthermore, I employ the Je(2)/Je(1) stopping rule by Duda & Hart (1973), which is, after the Calinski-Harabasz-index, the second best-performing stopping rule according to Milligan & Cooper (1985). I find that this stopping rule, applied to the results from Ward's method, suggests that the five clusters solution performance is best (if forced to choose a cluster solution smaller or equal to five for the sake of interpretation). Therefore, I review also the five clusters solution.

The two clusters solution replicates the existence of a Limited Control cluster that does not emphasize any of the levers and which is characterized simultaneously by low innovativeness and predominantly by emergent strategies for PD. This cluster performs significantly worse than the other cluster that seems to merge the Values and Norms Control cluster with the Performance Measures cluster of my basic solution. In this cluster, the strategy is dominantly intended and is implemented by a strong emphasis given to all LOC, which in

turn creates the environment required to keep the degree of innovativeness of the firm high. In this respect, the two clusters solution does not comply with the expectations I formulated in my hypotheses, since a high emphasis on all LOC is found in one cluster that outperforms the Limited Control cluster that I did not predict. This result is particularly interesting because it shows that a simultaneous emphasis on different components of formal MCS is compatible with high innovativeness (under the premise of prevailing intended strategies), which stands in contrast to the dominant previous understanding of MCS. Typically, the diagnostic control system was considered as impacting negatively the innovativeness of a firm (e.g. Henri, 2006), but it seems that this effect is mitigated and compensated by the combined intensive use of the other three levers.

The four clusters solution finds a cluster similar to the Limited Control cluster (low emphasis on the LOC, purely emergent strategy, low innovativeness) and one similar to the Performance Measures Control cluster (high emphasis on the interactive and diagnostic use of the performance measures, average innovativeness, and predominantly intended strategy), but splits the Values and Norms Control cluster into one cluster that strongly emphasizes the beliefs, but neglects the boundary system, and one cluster that strongly emphasizes the boundary system and has an average focus on the beliefs systems. For both these two latter clusters the strategy tends to be partially emergent and partially intended, but the beliefs control cluster displays a very low degree of innovativeness, while the boundary control cluster is the most innovative cluster. Only the Performance Measures Control cluster is equifinal with the boundary control cluster by both PD performance and organizational performance.

Finally, the five clusters solutions identifies a cluster resembling the Performance Measures Control cluster (high emphasis on diagnostic and interactive control, average innovativeness, and clearly emergent strategy) as well as one cluster resembling the Values and Norms Control cluster (high emphasis on the beliefs and boundary control, a strategy that is partially emergent and partially intended, but an average degree of innovativeness, and also a strong emphasis on the diagnostic control system). The remaining three clusters are different manifestations of the Limited Control cluster of my basic analysis. The Performance Measures Control cluster in this solution is equifinal to the Values and Norms Control cluster in this solution, which strengthens my basic findings. These clusters, that represent a fit between LOC, strategy, and environment, outperform all the other clusters in terms of organizational performance and, in all but one case, all the other clusters in terms of PD performance.

Overall, these robustness tests show that changes in the number of clusters change the manifestation of the clusters to a certain degree, but most importantly the main findings remain the same. I consistently detect a distinction between a Limited Control cluster and cluster(s) that encompass different LOC. The Limited Control cluster relies on low emphasis on the LOC and is accompanied by strategies that are mostly emergent. With the exception of one of the clusters which has a limited emphasis on the LOC in the five clusters solutions, all the Limited Control clusters are characterized by a mediocre to low level of innovativeness. These clusters perform generally worse than the clusters that emphasize one or more LOC both in terms of PD performance and organizational performance. The Values and Norms Control cluster(s) as well as the Performance Measures cluster are overall equifinal (with the exception of the PD performance in the four clusters solution, where the performance of the Performance Measures Control cluster is significantly higher than that of the boundary system dominated cluster, and this, in turn, higher than the beliefs system dominated cluster). In the basic three, in the four, and in the five clusters solution I always detect a Performance Measures Control cluster. Thus, the combination of interactive and diagnostic control seems to be complementary, i.e., the performance measures that are developed interactively should be grounded in a number of performance measures adopted diagnostically.

The results of the cluster analysis are also susceptible to the handling of the variables used. The data in this study were standardized before cluster analysis, which has the advantage of allowing each variable to contribute equally to the cluster solution. Nevertheless, this choice has a drawback, since the standardization may eliminate meaningful distances among elements (Edelbrock, 1979). I follow the advice by Ketchen Jr. & Shook (1996) and compare my cluster analysis solution based on standardized factor values with the solution generated by non-standardized factor values and find a two clusters solution. This solution leads to a Limited Control category (low emphasis on all LOC, emergent strategy, low innovativeness) and to a category where both values and norms and performance measures are emphasized (high emphasis on all LOC, intended strategy, high innovativeness), where the latter outperforms the first. This result is equivalent to the two clusters solution proposed above.

Furthermore, I carry out a cluster analysis with all items used in the questionnaire in order to control for the stability of results due to factorization (Ketchen Jr. & Shook, 1996) and obtain the same two clusters solution as above.

Overall, changes in the handling of the data do not majorly affect the results, since I still find the distinction between firms with either a high, or a low emphasis on the LOC (and related strategy as well as innovativeness), even if the Performance Measures Control cluster and the Values and Norms Control cluster merged together.

Finally, the data structure used for clustering may cause unstable solutions. As a result, I detect outliers in my sample and repeat the clustering procedure to identify changes in the results. The single linkage cluster method allows the identification of outliers in the data. With single linkage, the distance between clusters is determined based on the shortest distance between cases. Thus, the cases that are aggregated in the last steps of the single linkage procedure can be considered as outliers. The inspection of the single linkage dendrogram and of the related distance measures for each clustering step show that the clustering of the last two cases is accompanied by a sudden increase in the distance between clusters. Thus, I delete these two cases, use Ward's method to define the number of proper clusters, and then employ the K-means non-hierarchical method to allocate cases to clusters. I obtain a two clusters solution whose interpretation is entirely consistent with the two clusters solution presented above.

In summary, while obviously changes in the method used, in the type of variables employed, and in the shape of the data change the numbers of clusters detected, the interpretation of the clusters remains qualitatively unchanged.

5 Conclusion

This paper contributes to the literature on the relationship between LOC and innovation. I analyzed the survey data and identified combinations of the LOC, which are, depending on the strategy and the environmental conditions, the combinations that assure the best performance. There were three clusters: Values and Norms Control, Performance Measures Control, and Limited Control.

Of course, the study suffers from some limitations. First, the cross-sectional nature of the survey data does not allow describing the development of the clusters over time. There is need, therefore, for future research analyzing the dynamics of the variables in consideration over time. Second, the sample used is restricted to firms from the manufacturing sector of German-speaking countries that are engaged in PD. Even if I carefully considered the representativeness of the sample for this population, I am not able to make inferences for additional industries, sectors, or other business areas where the LOC are employed. An avenue for future

research is the investigation of various types of innovations in different industries in multiple countries. Third, the primary drawback of the method of cluster analysis is the reliance on the subjective judgment of the researcher for numerous decisions. This criticism can never be completely addressed, but the "Robustness of results" section should lend sufficient confidence to my findings.

Notwithstanding these limitations, the results contribute to research in several ways. First, evidence is offered of the combination of LOC that is best given certain strategy and environmental variables. Chenhall (2007), Fisher (1995), Malmi & Brown (2008), and Otley (1980), among others, have raised the call for more emphasis on the consideration of MCS in terms of packages, of components that operate together, jointly, simultaneously. In response, the cluster analysis of this present study demonstrates that, given the manifestation of the strategy formation and the degree of innovativeness variable, the beliefs and boundary control, together with an average emphasis on the diagnostic use of performance measures (Norms and Values Control cluster), are substitutes for the interactive and diagnostic control systems, together with an average use of beliefs and boundary control (Performance Measures Control cluster). In comparison, previous literature mostly concentrated on only a few of the LOC or did not address the issue of how the LOC are combined.

Second, while previous literature was proliferous about the relationship between intended strategies and MCS, the distinction between intended and emergent strategies and the relationship to different MCS components has been neglected for a long time (Langfield-Smith, 2007). Marginson (2002) was the first to provide a longitudinal case study of the relation between the LOC and the type of strategy formation. My results provide a quantitative basis for his findings. Indeed, I can confirm the finding that beliefs and boundary systems are related to high innovativeness of the firm and thus to organizational change and to partially emerging strategies. Furthermore, I detected the simultaneous interactive and diagnostic use of different performance measures. It is possible, therefore, to support the finding that the use of key performance indicators may generate tension in innovative settings. In addition to the confirmative role of my results, I am able to describe the existence of categories on the basis of quantitative data. These categories encompass a cluster that deviates from those theoretically formulated in this paper, as it represents a combination of low reliance across all the four LOC that is associated with emergent strategies and low innovativeness. It seems that firms whose strategy formation process is driven mostly by the pressure of the environment

are not able to translate these strategies into innovativeness and change, perhaps due to their overall low reliance on the LOC.

Third, I contribute to the MCS-innovation stream of research by providing evidence of the combinations of the LOC that deliver the highest PD performance and the highest organizational performance. Previous literature examined the performance effects of single levers, while I show how a package of different control systems and their joint use affects performance. Furthermore, I take into consideration both a strategy and an environmental variable. Thus, practitioners are able to choose between the combinations of LOC the one that is best suited for their specific background. For example, firms with a high degree of innovativeness should generate intended as well as emergent strategies and particularly emphasize the beliefs and boundary systems in order to get the strategy implemented. In contrast, firms whose innovativeness is well below the average should try to move to a cluster with at least average innovativeness in order to achieve the highest possible performance.

Appendix

Appendix IV - 1: Questionnaire items, descriptive statistics, Cronbach's alpha, and variance extracted

Organizational performance

In comparison with the industry average, please rate the performance of your firm and the importance of the following indicators for your firm over the last three years:

Scale for performance: 1=well below average; 5=well above average

Scale for importance: 1=not important at all; 5=absolutely important

An index for product development performance was obtained by weighting the performance rating with the importance rating.

Item	Theoretical range	Mean	Standard deviation	Cronbach´s alpha	Variance extracted
Sales growth	0.2-5	2.62	0.827	0.840	0.68
Return on investment	0.2-5	2.64	0.883		
Return on sales	0.2-5	2.70	0.903		
Profit growth	0.2-5	2.73	0.917		

n=468.

Product development performance

In comparison with the industry average, please rate the performance of your product development and the importance of the following indicators for your company over the last three years:

Scale for performance: 1=well below average; 5=well above average

Scale for importance: 1=not important at all; 5=absolutely important

An index for product development performance was obtained by weighting the performance rating with the importance rating.

Item	Theoretical range	Mean	Standard deviation	Cronbach´s alpha	Variance extracted
Number of new products	0.2-5	2.74	0.911	0.837	0.61
Time to market	0.2-5	2.53	0.931		
Percentage of new products in our product portfolio	0.2-5	2.34	0.837		
Sales with new products	0.2-5	2.50	0.943		
Profit with new products	0.2-5	2.42	0.923		

n=468.

Diagnostic control system

Please rate the extent to which your top management team used product development performance measures to in the last three years:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
Track progress toward goals	1-5	3.55	0.890	0.817	0.65
Monitor results	1-5	3.64	0.852		
Compare outcomes with expectations	1-5	3.54	0.861		
Review key measures	1-5	3.76	0.484		

n=468.

Interactive control system

Please rate the extent to which your top management team used product development performance measures to in the last three years:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
Enable discussion in meetings of superiors, sub-ordinates, and peers	1-5	3.06	0.959	0.862	0.59
Provide a common view of the organization	1-5	3.05	0.971		
Tie the organization together	1-5	2.73	0.981		
Enable the organization to focus on common issues	1-5	2.92	1.003		
Enable the organization to focus on critical success factors	1-5	3.34	0.938		
Develop a common vocabulary in the organization	1-5	2.98	0.992		

n=468.

Boundary system

Please rate the extent to which the following statements described your firm in the last three years:

Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
Our firm relies on a code of business conduct to define appropriate behavior for product development for our workforce.	1-5	3.62	0.995	0.728	0.55
Our code of business conduct informs our workforce about behaviors that are off-limits in product development.	1-5	2.70	1.177		
Our firm has a system that communicates to our workforce risks that should be avoided in product development.	1-5	3.00	1.060		
Our workforce is aware of the firm's code of business conduct for product development.	1-5	2.78	1.098		

n=468.

Beliefs system
Please rate the extent to which the following statements describe your firm in the last three years:
Scale: 1=not at all; 5=to a great extent

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
Our mission statement clearly communicates innovativeness as a firm's core value to our workforce.	1-5	4.20	0.885	0.867	0.72
Top managers communicate innovativeness as a firm's core value to our workforce.	1-5	4.15	0.815		
Our workforce is aware of innovativeness as a firm's core value.	1-5	4.02	0.869		
Our mission statement inspires our workforce.	1-5	3.58	0.929		

n=468.

Degree of innovativeness
Please rate the extent to which the following statements describe your firm:
Scale: 1 to 5

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
In general, the top managers favor: A strong emphasis on the market of tried products ...vs. ...A strong emphasis on R&D, technological leadership, and innovation.	1-5	3.25	0.752	0.576	0.54
How many new product lines has your firm marketed in the past three years in comparison with the industry average? Considerably less … vs. … considerably more	1-5	3.39	0.780		
Changes in product lines have been usually of minor nature … vs. … Changes in product lines have usually been dramatic.	1-5	3.13	0.745		

n=468.

Strategy formation
Please rate the extent to which the following statements describe your firm:
Scale: 1 to 5

Item	Theoretical range	Mean	Standard deviation	Cronbach's alpha	Variance extracted
The strategy for product development…is internally, consciously and formally planned … vs. … is imposed by the external environment.	1-5	2.40	1.039	n.a.	n.a.

n=468.

Appendix IV - 2: Principal component analysis of LOC and degree of innovativeness items

	Factor 1 (interactive control system)	Factor 2 (beliefs system)	Factor 3 (diagnostic control system)	Factor 4 (boundary system)	Factor 5 (degree of innovativeness)
Enable the organization to focus on common issues	**0.817**	0.124	0.046	0.070	0.033
Develop a common vocabulary in the organization	**0.804**	0.097	0.070	0.115	0.113
Tie the organization together	**0.791**	0.038	0.098	0.135	0.082
Provide a common view of the organization	**0.767**	0.168	0.101	0.092	0.056
Enable the organization to focus on critical success factors	**0.674**	0.143	0.293	0.083	0.036
Enable discussion in meetings of superiors, sub-ordinates, and peers	**0.577**	0.111	0.222	0.053	-0.044
Our mission statement clearly communicates innovativeness as a firm's core value to our workforce.	0.069	**0.840**	0.043	0.034	0.090
Top managers communicate innovativeness as a firm's core value to our workforce.	0.155	**0.808**	0.127	0.141	0.138
Our workforce is aware of innovativeness as a firm's core value.	0.173	**0.787**	0.093	0.104	0.182
Our mission statement inspires our workforce.	0.227	**0.774**	0.091	0.196	0.101
Monitor results	0.139	0.073	**0.825**	0.124	0.094
Compare outcomes with expectations	0.161	0.090	**0.804**	0.157	0.034
Track progress toward goals	0.161	0.078	**0.748**	0.069	0.078
Review key measures	0.148	0.073	**0.706**	0.118	-0.023
Our code of business conduct informs our workforce about behaviors that are off-limits in product development.	0.083	0.006	0.032	**0.843**	0.071
Our workforce is aware of the firm's code of business conduct for product development.	0.140	0.097	0.076	**0.787**	0.055
Our firm has a system that communicates to our workforce risks that should be avoided in product development.	0.137	0.115	0.208	**0.664**	-0.004
Our firm relies on a code of business conduct to define appropriate behavior for product development for our workforce.	0.075	0.295	0.203	**0.511**	0.020
Changes in product lines have been usually of minor nature … vs. … Changes in product lines have usually been dramatic.	0.135	-0.004	0.063	0.048	**0.821**
How many new product lines has your firm marketed in the past three years in comparison with the industry average? Considerably less … vs. … considerably more	-0.003	0.166	0.088	0.098	**0.719**
In general, the top managers favor: A strong emphasis on the market of tried products ...vs. ...A strong emphasis on R&D technological leadership and innovation.	0.048	0.302	-0.012	-0.028	**0.583**

The table displays factor loadings from principal component analysis with varimax orthogonal rotation, factor extraction based on eigenvalues >1.0. Loadings in bold are >0.5.

Appendix IV - 3: Principal component analysis of PD performance and organizational performance items

	Factor 1 (PD performance)	Factor 2 (organizational performance)
Percentage of new products in our product portfolio	**0.836**	-0.005
Sales with new products	**0.812**	0.203
Number of new products	**0.790**	0.043
Time to market	**0.704**	0.030
Profit with new products	**0.700**	0.357
Return on sales	0.115	**0.902**
Profit growth	0.087	**0.894**
Return on investment	0.045	**0.885**
Sales growth	0.116	**0.539**

The table displays factor loadings from principal component analysis with varimax orthogonal rotation, factor extraction based on eigenvalues >1.0. Loadings in bold are >0.5.

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