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MANAGEMENT CONTROL SYSTEMS, DECISION-MAKING, AND INNOVATION DEVELOPMENT

THE CDI MODEL

Dawid Szutowski

ROUTLEDGE

Management Control Systems, Decision-Making, and Innovation Development

The systematic approach to innovation development today is one of the world's most prominent scientific fields, and with good reason. When applied correctly, such system produces regular outcomes, which consistently drive lasting competitive advantage. Unfortunately, as much as it is beneficial, the orchestration of an undisturbed flow of multiple complex, dynamic, and flexible innovation development processes is structurally demanding.

In this book, a recognised innovation management specialist sets the record straight, offering a comprehensive approach to the improvement of innovation efficiency with the use of management control system. Unlike other books on the subject, it proposes original representation – the CDI model – of the relationships between management control system, decision-making quality, and innovation system efficiency and explains why management control is fundamental to innovation management. In addition to that, inside the reader will find several original developments. These include: the info-deficiency (I-D) model, depicting the various parameters hindering decision-making in innovation development; the product innovation development (PID) system, offering the original function-based approach to innovation management; and the composite innovation index – specially designed tool intended to evaluate the efficiency of an innovation development system.

It will be of interest to researchers, academics, practitioners, and advanced students in the fields of management, strategy, and innovation.

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Contents

Tables

Figures

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Abbreviations

B	budget
BMP	best-model performance
Ci	citation-based metrics
C	commercialisation
CDI model	control-decision-innovation model
CII	composite innovation index
COOR	coordination
CRED	credibility
CU	customer-related measures
D	development
D Effectiveness	decision effectiveness
DE	directly stated expenditure
DE/E	directly stated expenditure per employee
DM Efficiency	decision-making efficiency
DMDU	decision-making under conditions of deep uncertainty
DO	development output
EO	economic output
ESI	external source of input
FR	financial return
FRI	financial resources input
HRI	human resources input
I	investment
I-D model	info-deficiency model
IG	idea generation
IRE	impact on resource efficiency
IRP	impact on resource productivity
IS	idea selection
M	monitoring
MC	mechanistic control
MCS	management control system
MS	market share
NHR	number of innovation-related employees
NI	number of innovations

NIm	number of improvements
OC	organic control
P-o-I	point of indifference
PA	patent applications
PG	patents granted
PID system	product innovation development system
R	research
R&D	research and development
R&DI	R&D intensity
RE	resource efficiency
RP	resource productivity
RT	recruitment and training
S	sales
SO	scientific output
SP	scientific publications
SPC	specialisation
TR	training
T	testing
TC	trademark count
Ti	time resource
TMS	transactive memory system
TO	technological output
V	value

4 The Control-Decision-Innovation (CDI) Model

4.1. Introductory Remarks

Previous research only produced fragmentary evidence on the interconnections between management control systems, decision-making quality, and innovation systems. While each of these concepts was extensively studied in isolation, or in relation to one of the remaining two, few, if any, attempts were made to link all three within a single consistent framework. The present chapter responds to this research gap and answers the following research question: what are the relationships between the management control system, decision-making quality, and innovation system efficiency? This serves the achievement of the main purpose of this book, which is to create a model representation of relationships between management control systems, decision-making quality, and innovation system efficiency.

The analyses performed in the previous three chapters established the milestones indispensable for an attempt to unify these three components. It was ascertained that, because of the specificity of innovation systems, the foremost challenge to their management and control is the deficiency of information. In response to this challenge, a specific framework devoted to decision-making in an innovation system was created, termed "info-deficiency" (I-D). Within the info-deficiency framework, information deficits in the case of innovation were shown to derive from five factors – broad scope, changing organisational and external conditions, high degree of novelty, and high complexity – all of which may simultaneously impede the decision-making process. Furthermore, it was shown that, in order to bridge the information deficit and facilitate decision-making, managers require support in the form of a management control system. The latter corresponds accurately to the managers' needs as, by definition, it is a system of control mechanisms that supports decision-making by providing information, and thus it enables controlling and steering the behaviour of organisation members so as to align it with the predetermined objectives. Furthermore, a conceptual underpinning was provided for the disaggregation of management control systems into mechanistic

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and organic components, and for the decomposition of decision-making quality into decision effectiveness and decision-making efficiency. At the same time, all of these components are complex in themselves and incorporate numerous individual attributes. Thence, a multi-faceted network of relationships emerges. Moreover, a meticulous analysis of innovation systems resulted in the creation of the product innovation development (PID) system, composed of the functional innovation model depicting the functional areas involved in an innovation development system, and the composite innovation index that arranges and presents the inputs and outputs of the innovation development system.

In this regard, the first objective of the present chapter is to unify the central arguments presented in Chapters 1, 2, and 3. It briefly reiterates the main conclusions presented there and combines them into an exhaustive and consistent framework. Thus, the first section introduces and describes the control-decision-innovation (CDI) model. While this conceptual model has a firm theoretical underpinning, in business practice, the relationships modelled there may be context-specific. Therefore, the present analysis continues with an elaboration on both potential moderators and confounders. This complement to the theoretically justified and established relationships satisfies the second objective set in this chapter, which is to pragmatise the conceptual model with respect to practical applications. Furthermore, in view of the complexity of constructs combined within the CDI framework, the third objective is to conceptualise and operationalise them. To this end, each conceptual construct is disaggregated into its constituent components and reintroduced as a set of discrete items. Consequently, the most important result obtained in this chapter is the comprehensive, conceptually founded and operationalised model representing the relationships between the management control system, decision-making quality, and the composite innovation index. In this form, the CDI model is in a position to be empirically tested in a variety of contexts.

The overview of the chapter is as follows. The first section introduces the CDI model and elaborates on the moderators and potential confounders that may affect it. The second section conceptualises and operationalises the complex constructs used within the CDI framework. The third section provides a rationale for the empirical verification of the model.

4.2. Presentation of the CDI Model

To provide a clear presentation of the control-decision-innovation model, the first section will unify and concisely recapitulate the rationale for relationships between management control systems, decision-making quality, and the composite innovation index. Exhaustive, meticulous, itemised descriptions of these relationships were provided in Chapters 1, 2, and 3, and whenever more information is needed, one may refer to these chapters. Subsequently, considering these conceptual foundations, this section will elaborate on the model and present it in a graphical format. A descriptive part, explaining in detail all items included in the graphical representation, follows.

4.2.1. Aggregate Characteristics of the CDI Model

The control-decision-innovation (CDI) model comprises management control systems (MCS), decision-making quality, and the composite innovation index (CII). The simplest statement of the logic behind it is that mechanistic and organic management control systems have direct and indirect positive effects on decision-making efficiency and decision effectiveness, which, in turn, have a direct positive effect on the composite innovation index. Thus, within all functional areas, the main relationships modelled are as follows:

- a positive effect of mechanistic control systems on decision effectiveness,
- a positive effect of organic control systems on decision effectiveness,
- a positive effect of mechanistic control systems on decision-making efficiency,
- a positive effect of organic control systems on decision-making efficiency,
- a positive effect of decision effectiveness on the composite innovation index, and
- a positive effect of decision-making efficiency on the composite innovation index.

More specifically, the model links management control systems directly to decision-making quality based on control theory, which indicates that the link exists, but it differs from the present approach with regard to the specific tools and control types implemented within the organisation. Furthermore, based on transactive memory theory, the model indirectly links management control systems to decision-making quality via the transactive memory system. At this point, the model specifies that the composite innovation index value results from the sum of the quality of all decisions made within all the functional areas involved in the innovation development system. Lastly, it indicates that all these relationships may be subject to distortion by potential confounders.

The inclusion of moderation and potential confounders in the earlier description necessitates further clarification. While Chapters 1, 2, and 3 focused on MCSs, decision-making quality, and the innovation system (including CII), respectively, they did not explicitly refer to these two issues. This was because their purpose was to examine and establish the main relationships between control, decisions, and innovation. However, the CDI model presented here specifies that the network of dependencies is more complex and extends beyond direct effects. The broader approach, comprising indirect effects and acknowledging potential confounders, corresponds to real-life applications and therefore is conceptually robust. While the core of the model, depicting direct relationships, remains unchanged and derives from previous chapters, in order to complete the model and conform to the requirements of organisational practice, the introduction of moderators and confounders is vital. The moderating effects refer to the human factor and result from the specificity of the innovation development system, the success of which depends on cooperation between highly qualified experts representing distinct knowledge domains. The concept of a transactive memory system is used here, as it focuses precisely on integrating and utilising expert knowledge distributed among group members. Confounders, on the other hand, have to do with company size and sector. The model points to differences in approaches to management control and innovation between relatively small and relatively large companies, representing the service, manufacturing, and agriculture sectors.

Now that the main relationships have been briefly introduced, along with the rationale for the inclusion of moderators and confounders, a detailed description will be provided. It will recapitulate the main conclusions established in Chapters 1–3 and then focus consecutively on the principal issue of information deficiency in innovation development systems, a way of addressing this issue with the use of a management control system, the outcome of applying the MCS in the form of decision-making quality improvement, the organisation of an innovation system encompassing seven functional areas, and the measure of the system's efficiency, i.e., the composite innovation index.

The foundation of the model is derived from the complex, and therefore challenging, nature of innovation system management and control. By its nature, innovation development faces two interconnected issues – information deficiency and high uncertainty. The former is a consequence of scarce comparative or reference data and results from the fact that "innovation is about the unknown, about opportunities and possibilities associated with doing something new" (Gaubinger, Rabl, Swan, & Werani, 2015, p. 8). Moreover, as innovation development is complex and interdisciplinary (Chwastyk, 2015), managers face several kinds of uncertainty, such as technological, market, business, and organisational uncertainty (Afuah, 2003), among others. From the decision-making perspective, the ensemble of issues confronted by decision-makers within an innovation system has been plainly illustrated through info-deficiency. The I-D model indicates that the extent to which the shortage of information impedes high-quality decision-making is a function of: (1) scope (the organisation's involvement in the innovation system, ranging from single task execution to the systematic contribution of all functional areas), (2) organisational conditions (resource and task execution uncertainties), (3) external conditions (dynamic changes in technology, competitors' strategies, and customers' preferences), (4) degree of novelty (the distinction between radical and incremental innovation), and (5) the complexity of the innovation itself (its technical advancement and the team multidisciplinarity required to proceed).

In addition, previous studies have shown that the success of an innovation system is positively and directly related to how knowledgeable and well informed decision-makers are (van Riel, Lemmink, & Ouwersloot, 2004). Accordingly, numerous mistakes throughout the innovation development cycle could have been avoided, if managers disposed of more relevant, reliable, and proven information (Schmeisser, Mohnkopf, Hartmann, & Metze, 2010). Conversely, hasty, ill-informed decisions reduce innovation development system efficiency (McLaughlin & Kennedy, 2016).

Consequently, what drives the efficiency of an innovation system is the quality of decision-making, which in turn depends on how companies address information deficiency. Because the lack of adequate information constitutes the principal challenge in innovation system management and control, its successful provision creates an indispensable foundation for high-quality decision-making. Although organisations seek to address this issue in various manners, the implementation of a management control system corresponds perfectly to the data supply principle. In this vein, the postulate of information provision has been explicitly included in the definition of an MCS as a system which supports decision-making by providing information.

In the light of the earlier discussion, the underlying logic of the control-decision-innovation model is that the introduction of a management control system improves the efficiency of an innovation system by increasing decision-making quality. An MCS improves decision-making quality because it provides adequate and timely information to decision-makers as needed. While this convention applies in a variety of different contexts, it takes on special meaning when innovation development is concerned, since information deficiency is the principal problem in decision-making within an innovation system.

Because both management control systems and decision-making quality were approached from a number of different perspectives in past research, the present model dictates they be illustrated from the angle of an innovation system. Since innovation development requires striking the delicate balance between creativity stimulation and resource restriction, both aspects are distinguished in the model. Accordingly, it builds on the typology of MCSs comprising mechanistic and organic approaches. Mechanistic control systems, while characterised by high centralisation, low complexity, high stratification, and high formalisation (Burns & Stalker, 1961), nonetheless support decision-making within an innovation system by schematising the process of reaching conclusions. Through rules, regulations, and procedures, among other tools, a mechanistic MCS enables managers to maintain control over the innovation system with respect to the available resources (Dickson, Resick, & Hanges, 2006). Moreover, mechanistic control is a valuable approach in a dynamic environment, as it provides the tools and discipline to help manage uncertainty (Ylinen & Gullkvist, 2014). On the other hand, organic MCSs are characterised by low centralisation, formalisation, and stratification (Burns & Stalker, 1961), and are traditionally associated with rapidly changing environments. They stimulate the exploitation of expert knowledge in decision-making, as they are stratified according to expertise possessed by each actor, and assign the tasks to be performed across the organisation to whoever is the most qualified. In this approach, decisions tend to be based on comprehensive, qualitative information. Organic MCSs facilitate certain types of innovations (Kessler, Nixon, & Nord, 2017), innovativeness (Whittinghill, Berkowitz, & Farrington, 2015), and actual change initiatives (Henderson & Neill, 2000). From the operational perspective, due to their complexities, mechanistic and organic control systems are not represented by a single measure within the CDI framework but involve seven specific measures corresponding to their different characteristics. Nevertheless, the interplay between mechanistic and organic control is essential in improving decision-making quality in innovation systems, and therefore has been incorporated into the model.

Furthermore, the CDI model distinguishes decision effectiveness and decision-making efficiency as the two components of decision-making quality. Effectiveness is a target-oriented measure of decision-making quality, determined by the relationship between the decision's output and the pre-established objectives (Anthony & Govindarajan, 2007). Since it measures the degree of achieving the objective(s) of a system, operation, or activity (Daellenbach & Mcnickle, 2005), it remains relative, meaning that the natural measure of output is not the subject of analysis, but it is always presented in relation to some basis of comparison (Hoegl & Parboteeah, 2006). Because of this relative nature of effectiveness, the concept corresponds naturally to control systems, within which performance targets and system performance objectives are established. As explicitly stated, decision effectiveness deals with "the extent to which a decision achieves the objectives established by management at the time it is made" (Dean & Sharfman, 1996, p. 372). At the same time, effective decisions, i.e., ones consistent with the company's strategy and leading to the achievement of its predetermined objectives, are indispensable for increasing the efficiency of an innovation system. By contrast, decision-making efficiency involves the ratio between the input of a system and its output (Hammedi, van Riel, & Sasovova, 2013). Making an informed decision requires rigorous analyses to be performed, which is both resource- and time-consuming. This workload and time expenditure represents the input to the decision-making process. The trade-off here is between changing the amount of time and resources spent and changing the decision quality. Since the innovation milieu is a dynamic one, proceeding with innovation development rapidly (limiting the time outlay) is a source of competitive advantage. Moreover, completing the decision-making process with the use of fewer resources (e.g., cash spent on external consultancy, additional analyses, etc.) allows for redirecting surplus resources to where they are most needed. Consequently, within the CDI approach, the complex character of decision effectiveness and decision-making efficiency entails the need to measure them by means of five specific measures rather than single items. Both time and resources may be optimised based on information accumulated within and provided by a management control system. An MCS supports such optimisation by organising the planning, coordination, communication, and evaluation of information, and assisting in decisions on what, if any, action should be taken (Anthony & Govindarajan, 2007). Accordingly, both decision effectiveness and decision-making efficiency relate to the MCS and contribute to the achievement of the company's innovation-related objectives in an optimum manner.

Since the CDI model has been specifically designed to represent the relationships between management control systems and decision-making quality in the context of innovation, its organisation is based on the specially developed representation of the product innovation development system. In accordance with this dedicated approach, the system consists of seven functional areas: idea generation, idea selection, research, development, testing, commercialisation, and monitoring. Idea generation encompasses exploiting the available internal and external sources of ideas (Bernstein & Singh, 2006). Since it is the most creative functional area (Paasi, Valkokari, Maijala, Luoma, & Toivonen, 2007), it is somewhat chaotic and calls for MCS support in schematisation and organisation. Idea selection is far more analytical. It involves picking the ideas for further processing based on pre-established evaluation criteria (Hansen & Birkinshaw, 2007). Decision-making in this area benefits from the selection objectives and procedures authorised within the MCS. Research and development are usually difficult or virtually impossible to separate because of their numerous operational interrelations. Research is divided into basic – in other words, experimental work undertaken exclusively to acquire new knowledge, and applied – undertaken to acquire knowledge directed towards a specific, practical objective (OECD, 2015). The area is therefore theoretically oriented and poses a challenge to decision-making, as the economic effects of the associated undertakings are difficult to evaluate. Development is focused on the creation of new products or processes, or improvement of existing ones (OECD, 2015). This area is highly information-absorbent, as it comprises not only technical but also managerial tasks. Both areas benefit from MCSs in terms of intense information exchange, reporting, evaluation criteria, and reserve budgets required to provide for serendipity phenomena. The testing area consists of two complementary categories of tests – mandatory and company-internal. In the latter category, tests involving technical and marketing expertise are additionally distinguished. Here, decision-making benefits from a recurrent process of controlling, measurement, correction, and adjustment (Vitezić & Vitezić, 2015). Commercialisation takes place in the form of market introduction or intellectual property trade. The former requires substantial resource commitment, enabling the company to launch the new product or service on the market (Verloop, 2004). It is especially here that decision-makers expect their MCS to provide a broad range of information on technology, potential distribution channels, the production adjustment and marketing adjustment needed, and other topics. Monitoring involves two elements, the first of which is monitoring activity representing the supervision of functions realised in each of the previous functional areas. Its second element is derived from the first one and represents learning – acquisition of knowledge through the analysis of the data gathered (Vitezić & Vitezić, 2015). Because commercialisation constitutes the decisive test for innovation, the experience gathered there is of special importance. The role of an MCS is to collect and distribute this crucial information among decision-makers throughout all the functional areas. Due to the distinctive traits of each functional area, the relationships between mechanistic and organic control systems, on the one hand, and decision effectiveness and decision-making efficiency, on the other, must be modelled separately.

Within the CDI framework, the ultimate effect of any improvement in decision-making quality is an increase of the composite innovation index value. This measure has been specifically developed to evaluate innovation system efficiency, and designed to measure how well the system converts its inputs into the desired outputs. Therefore, it represents the relation between the overall output measure, composed of six elements representing the outputs and impact of the system, and the overall input measure, composed of two elements reflecting the system's inputs. It constitutes a consistent and clear representation of the effects produced by the entirety of operations performed and contributions made within the innovation system. The input measures taken into account here include two types of resources: human (human resources focused on innovation) and financial (expenditures incurred within the system). Intermediate output measures comprise technological (number of patents granted) and scientific outputs (number of scientific publications). Direct output measures include development (number of innovations developed) and economic outputs (sales revenues generated by innovation). Indirect impact measures encompass changes in resource efficiency (minimisation of resources spent in other innovation projects as the result of advancements made in one project) and resource productivity (usage of advancements made in one innovation project to support other projects).

Figure 4.1 illustrates the above-discussed considerations. It constitutes a graphical representation of the CDI model. It is followed by a description of all items included. However, an additional remark is warranted before its presentation. Despite their omission in the earlier description, moderators and confounders are both included in the model. They constitute a necessary complement for the main relationships but have not been described yet due to their supplementary role. Both are described in the next sections.

The graphical representation of the CDI model in the figure transparently distinguishes the seven functional areas involved in innovation development, starting with idea generation, and terminating with monitoring. These functional areas are illustrated as the seven rectangles (with dashed borders) situated one above the other. Such an arrangement clearly emphasises that in each functional area, heterogeneous relationships exist between the MCS and decision-making quality. Also, it corresponds directly to the product innovation development (PID) system, which distinguishes seven functional areas and calls for their management and control from both an individual and a system perspective. Now that the illustration of the division among functional areas has been explained, the principal substantial components of the model will be discussed. Within each functional area, the CDI model comprises the management control system, decision-making quality, and moderation, and so these three elements are graphically isolated by three rectangles (with dotted borders) passing through all the areas and spreading from the top of the graph to its bottom. Following these model-wide graphical elements, the items contained within each of the areas must be described. In each functional area are two ovals containing abbreviations MC and OC, standing for mechanistic and organic control. The oval shape is purposeful and bears additional information – namely, it means that these two constructs are complex and may not be directly observed. As part of the CDI model, a well-defined operationalisation consisting of seven items has been specifically developed to measure them. The same interpretation applies to the ovals representing decision-making quality, which contain the abbreviations “DM efficiency” and “D effectiveness”. These, however, are measured using five specifically developed, observed items. The oval-shaped items contrast the one presented as a rectangle (with a solid border) containing the abbreviation TMS. In this case, the rectangular shape indicates that moderators may be directly observed. Four arrows link mechanistic and organic control to decision effectiveness and decision-making efficiency. They designate two kinds of relationships, direct and indirect. First, as they connect the four ovals, they represent direct relationships between them. Then, as the arrows pass through the TMS field, they indicate the indirect effects of MCS on

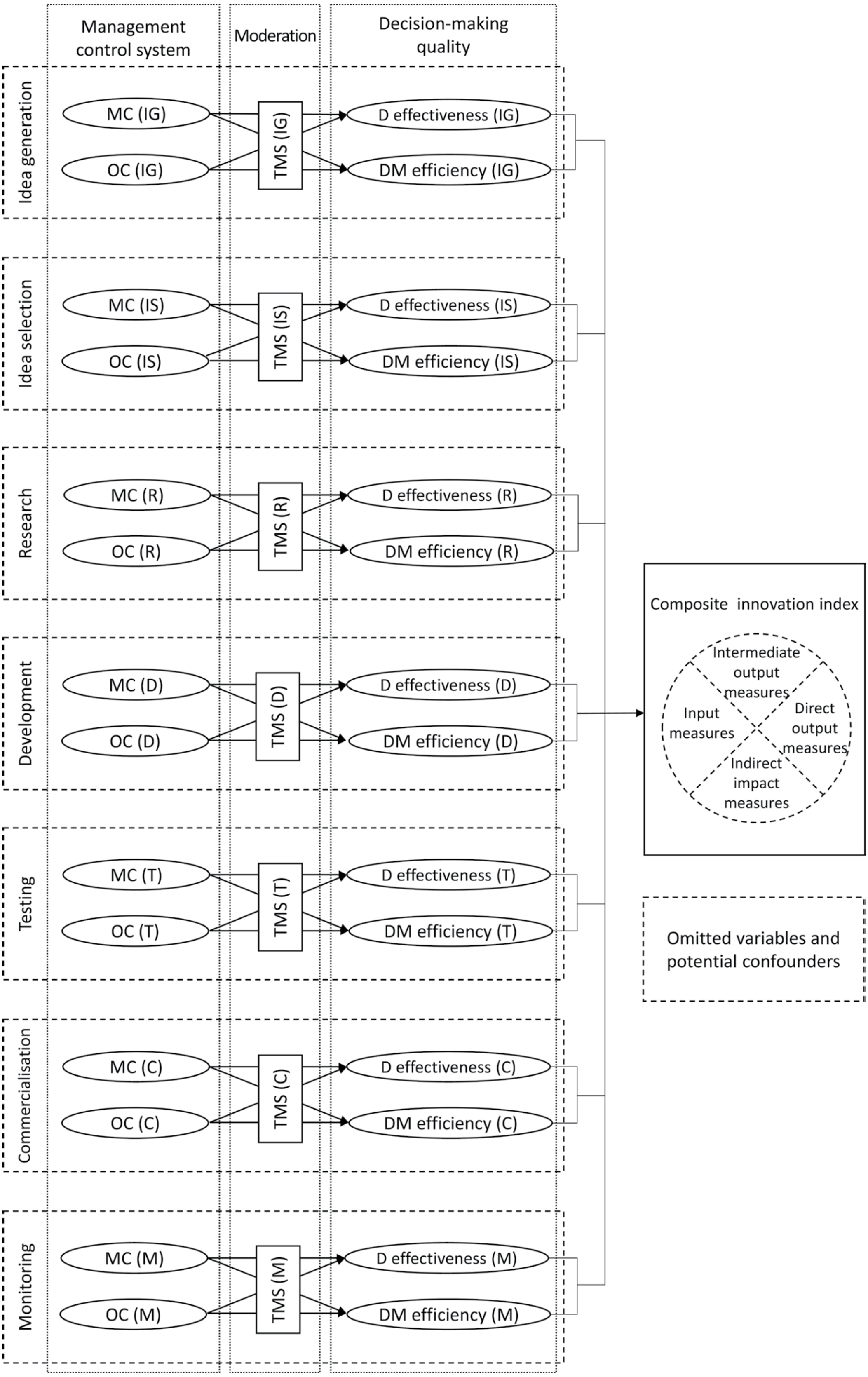

Figure 4.1 The control-decision-innovation (CDI) model

Source: Author's own development.

decision-making quality through the transactive memory system. While the left-hand side of the figure represents the effects of management control systems on decision-making quality, the right-hand side illustrates the composite innovation index. The large rectangle placed there comprises the four components based on which the CII value is calculated. The arrows linking decision effectiveness and decision-making efficiency with the composite innovation index indicate that the efficiency of an innovation system depends on decision-making quality within all the functional areas involved. Furthermore, the graphical representation is complemented by a rectangle (with a dashed border) comprising potential confounders, so as to inform that the relationships modelled here may vary in different contexts.

Now that the model has been clearly introduced, a further elaboration will be provided on the moderation effect, expressed in terms of the transactive memory system, and on potential confounders. The subsequent two sections are explicitly devoted to these two components of the model.

4.2.2. Moderating Effects of the Transactive Memory System

While the earlier restatement of the argumentation presented in Chapters 1–3 explains the direct effects of management control systems on decision-making quality, the relationship will undergo more in-depth analysis here. To adequately express this relationship between the two concepts, in addition to the direct effects, indirect ones are also included in the CDI model. In this regard, the purpose of this section is to establish the role of the transactive memory system as the moderator of the relationship between MCSs and decision-making quality. Accordingly, the elaboration provided in this section pragmatises the conceptual model with respect to practical applications, where direct relationships may be subject to moderation resulting from the inclusion of additional variables. These considerations are important, as in business practice, the modelled relationships may be context-specific.

The rationale here is as follows. An innovation system relies heavily on expert knowledge and therefore calls for the involvement of highly qualified specialists possessing such knowledge. Accordingly, these specialists are indispensable for the achievement of high-quality decisions due to their unique qualifications. Past studies in the field of innovation state explicitly that successful innovation development depends upon the individual and collective expertise of employees (Leonard & Sensiper, 1998). Besides, new product development teams are amongst the ones that are purposefully constructed so as to leverage the specialised expertise of individual group members (Lewis, 2003).

At the same time, the extent to which an organisation benefits from expert knowledge depends on the cognitive interdependence of the staff involved (Brandon & Hollingshead, 2004). One of the primary characteristics of an innovation system is that it requires and processes information pertaining to distinct knowledge domains. Empirical evidence demonstrates that groups tend to divide cognitive labour between their members specialising in different fields (Lewis, 2003). This means that specialists involved in an innovation system rely on one another to be responsible for specific expertise, so that collectively, they dispose of all of the information required for the successful accomplishment of innovation.

Furthermore, the successful management of such cognitive interdependence of specialists involved in each functional area is a remarkably demanding task. This is why the present book advocates for it to be addressed with the use of a management control system. The complementary interplay of mechanistic and organic controls may effectively steer comprehensive and timely exchange of knowledge.

Consequently, the indirect link between management control systems and decision-making quality leads through the cognitive interdependence of specialists disposing of expert knowledge. This path is obligatory, considering that the present investigation targets an innovation system, for which such expert knowledge is nothing less than crucial. It is therefore explicitly placed within the CDI model under the label "Moderation".

In the light of the above-discussed considerations, the concept of the transactive memory system (TMS) has been introduced into the CDI model. The well-established view is that cognitive interdependence motivates and sustains the development of transactive memory (Brandon & Hollingshead, 2004). The TMS conceptualises and schematises the management of expert knowledge among group members. Moreover, it focuses precisely on integrating and utilising distributed expertise, making it specifically suitable for the analysis of decision-making quality. The TMS is usually decomposed into specialisation, credibility-building, and coordination (Peltokorpi & Hood, 2018). The concept of cognitive interdependence was originally referred to as the TMS in the late 1980s (Wegner, 1987), following the observation that group members tend to rely on one another to receive, process, and communicate information from different knowledge domains (Lewis, 2003). The complementarity of knowledge in the TMS is expressed in the statement that others represent locations of external knowledge storage for the individual. In other words, "one person has access to information in another's memory by virtue of knowing that the other person is a location for an item with a certain label. This allows both people to depend on communication with each other for the enhancement or their personal memory stores" (Wegner, 1987, p. 189). Such mutual reliance of group members frees individuals to focus on their distinct areas and develop in-depth expertise, while maintaining access to task-relevant information held by others. The TMS aims to facilitate well-coordinated and rapid access to specialised knowledge, which results in bringing a large amount of task-relevant expertise to bear on group tasks. Ultimately, it is reasonable to assume that the effective exploitation of cognitive interdependence leads to the improvement of decision-making quality. In this vein, addressing the limitation of individual information processing capability, cognition, and expertise lies at the heart of the TMS (Peltokorpi & Hood, 2018), which is indeed crucial considering the fact that all of these factors are fundamental in exploiting the company's potential through high-quality decision-making. This has been further indirectly supported in laboratory research confirming the existence of cooperative memory systems and their positive impact on group performance (Moreland & Myaskovsky, 2000).

As much as organisations may benefit from the TMS in terms of decision-making quality, they may also struggle to effectively manage it due to its intangible and context-specific nature. The issue was originally signalled as follows:

> the transactive memory system in a group involves the operation of the memory systems of the individuals and the processes of communication that occur within the group. Transactive memory is therefore not traceable to any of the individuals alone, nor can it be found somewhere "between" individuals. Rather, it is a property of a group.
>
> (Wegner, 1987, p. 191)

From this perspective, the manner of steering the cognitive interdependence of specialists involved in different functional areas needs to be specially tailored. As the cognitive division of labour comprises internal memory (an individual actor's knowledge) and external memory (knowledge about the information possessed by other actors), a system allowing for the exchange of information, such as an MCS, is required. In this regard, transactive memory systems flourish in a favourable organisational climate (Hammedi et al., 2013) and under transformational leadership (Zhang, Cao, & Tjosvold, 2011), both of which act as antecedents of TMS emergence. At the same time, leadership style and organisational climate expressed in terms of structural forms, process management and control, motivational properties, power arenas, norms, culture and other characteristics (Burns & Stalker, 1961; Courtright, Fairhurst, & Rogers, 1989; Cruz & Camps, 2003; House, 1991; Reigle, 2001; Trott, 2017) constitute the very essence of what the MCS is expected to administer. Yet, transformational leadership consists in transcending the staff's self-interest and reorienting them towards collective goals, promoting commitment, effort, and performance, providing constructive feedback, and coordinating knowledge in decision-making processes (Zhang et al., 2011).

Organisational climate, on the other hand, builds on institutional structures, e.g., social norms, rules, and obligations, and is implicitly expressed in the extent to which co-workers trust one another, the degree to which failure is accepted, the propensity for information sharing, and the range of social norms (Bock, Zmud, Kim, & Lee, 2005). Moreover, it reflects the shared perception of what is important and which behaviours are expected and rewarded. Thus, the subjective scope of these two concepts is largely consistent with the object of interest in management control systems. Consequently, the MCS may be clearly identified as an effective tool for stimulating the emergence of transactive memory within an organisation.

Therefore, the extent to which the management control system exerts an indirect impact on decision-making quality depends on its ability to stimulate the transactive memory system, as its evolution leads to the effective exploitation of the cognitive interdependence of specialists involved in the innovation system. From the operational perspective, operationalising and dealing with the measurement of transactive memory systems, they emerge within an organisation to the extent that three processes – specialisation, credibility-building, and coordination – occur jointly (Lewis, 2003). Table 4.1 succinctly introduces the three concepts.

Against this background, the three next sub-sections delve into the details of specialisation, coordination, and credibility.

Specialisation

The differentiation of knowledge amongst innovation-focused specialists refers to the extent to which they specialise in different knowledge domains (Moreland & Myaskovsky, 2000). Researchers originally reasoned that the TMS only emerges once group members have accepted responsibility for knowledge in different domains (Wegner, 1987). From this perspective, specialisation was defined as “the differentiated structure of member knowledge” (Akgun, Byrne, Keskin, Lynn, & Imamoglu,

Table 4.1 TMS components

Component	*Description*
Specialisation	The extent to which actors within an organisation have specialised knowledge in their respective areas of expertise
Credibility	Actors’ beliefs about the others’ ability to complete a task in a reliable way
Coordination	The ability to divide tasks into sub-tasks and maintain relationships between the staff in charge of the sub-tasks

Source: Author’s own development.

2005, p. 1106), "the level of expertise differentiation within the group" (Peltokorpi & Hood, 2018, p. 3) and "the extent to which team members know who on the team possesses which information" (Hammedi et al., 2013, p. 319). Specialisation may therefore be reasonably speculated to be an antecedent of the TMS. It enables group affiliates to develop non-redundant knowledge (Lewis, 2003) and supports decision-making in a unique and irreplaceable fashion.

On the other hand, reproducing all knowledge already accumulated among associates is unreasonable from the resource administration perspective and is of little bearing on the quality of decision-making. The notion of specialisation links here to that of coordination. While innovation development teams need to share some overlapping knowledge to be able to reach high-quality decisions based on mutual understanding, both too much specialisation and too much overlap hinder the decision-making process. The former creates "islands of expertise" with no mutual interdependence (Lewis, 2003), whereas the latter diminishes the uniqueness of each individual's contribution to innovation development.

Previous research on the TMS demonstrated that knowledge differentiation was especially important in those fields that required the integration of knowledge from various domains (Chen, Li, Clark, & Dietrich, 2013), such as innovation activities. In prior investigations, knowledge-intensive tasks were found to entail specialisation due to the knowledge barriers encountered by the staff involved. In other words, the staff desired specialisation as it freed them from the exigent barrier-overcoming process. Moreover, in a knowledge-intensive context, specialisation was personally rewarding, because individuals could apply knowledge pertaining to their domain at a low cost (Krogh, Spaeth, & Lakhani, 2003). At the same time, the specificity of an innovation system makes it a perfect example of an activity that considerably challenges management control and decision-making. This is due to the dispersion of knowledge which needs to be located, verified, integrated, and successfully utilised to make a high-quality decision. Consequently, because interactions between group members are both indispensable and intense from the point of view of specialisation, their steering, and control, determines the undisturbed flow of the process. Thus, specialisation is especially suited to steering with the use of organic management control systems. An organic MCS builds on the consultative approach, with special regard to interpersonal negotiation, discussion, elaboration, and continual redefinition through interaction (Weick, 1987, cited in: Courtright et al., 1989), as much as team meetings (Manz & Sims, 1984, cited in: Courtright et al., 1989).

Parenthetically, while specialisation is at the origin of different aspects of the TMS, the opposite effect, whereby those aspects impact specialisation, has also been hypothesised. Specifically, the group's progress in terms of credibility and coordination would presumably bring about further specialisation due to the fact that affiliates tend to allocate information considering their colleagues' respective fields of expertise (Hammedi et al., 2013). This reciprocal interaction may be exploited for the organisation's benefit, as it leads to enhanced individual learning within the areas of specialisation. From the operational perspective, this effect is supported by the exchange of information on who can provide credible expertise in which field, which in turn may be stimulated by the tools of organic control systems. The free flow of information and informal communication channels are both essential for coordination and credibility evaluation. In order to effectively use them to optimise specialisation, and to exploit specialisation with a view to improving decision-making, it seems imperative that managers actively encourage open channels of communication and the open sharing of information between staff. Otherwise, the positive effect of the interplay between TMS components on decision-making may be hindered, at least in some measure.

Credibility

Knowledge credibility is the second aspect of the transactive memory system included in the CDI framework. It refers to the extent to which team members trust and have confidence in one another's knowledge (Lewis, 2003). The definitions developed previously described credibility as "cognition-based trust, defined as team members' beliefs about one another's ability to carry out a specific task reliably" (Hammedi et al., 2013, p. 319), "members' beliefs about the accuracy and reliability of other members' knowledge" (Akgun et al., 2005, p. 1106), and "beliefs about the reliability of other group members' knowledge" (Peltokorpi & Hood, 2018, p. 3).

Mutual reliance is a compulsory component of TMS development and a necessary precondition for integrating staffs' knowledge during the processing of complicated tasks, such as those contributing to innovation development. A low level of credibility within a task group indicates that some or even all members do not feel they can trust the expertise of others. Accordingly, if one group member disbelieves that they can trust the others' knowledge, then this member is unlikely to develop specialised knowledge complementary to that possessed by their colleagues. As a result, the amount of specialised expertise contributing to innovation development is reduced (Lewis, 2003). From the decision-making perspective, as the knowledge base diminishes, decision-making quality is undoubtedly impaired. Moreover, incredulity impedes the group's ability to flawlessly coordinate the realisation of particular functions within the innovation development system (Lewis, 2003). While staff may still be redirected from one expert to another, the lack of confidence in the knowledge gained in this manner delays the subsequent interchange of information, as the message recipients seek to verify any advice they have received. This augments the coordination effort. Consequently, since an innovation system comprises different functional areas requiring expertise in different fields, and since the process of verifying clues coming from the different areas is especially lengthy, high intra-group credibility is an antecedent of its efficient flow.

These considerations are reflected in past empirical findings. As previously observed, the staff involved in innovation not only need to know what knowledge others possess; they must also judge this knowledge to be sufficiently credible (Moreland & Myaskovsky, 2000). The perception of others' knowledge as untrustworthy prevents the internalisation of clues formulated by them (Sarker, Sarker, Nicholson, & Joshi, 2005), and thus impedes the decision-making process. On the other hand, high credibility allows group members to perform tasks relying on their specialised knowledge and persuasively advocate for their course of action (Liang, Moreland, & Argote, 1995) without over-criticising the work of others (Moreland & Levine, 1992, cited in: Chen et al., 2013).

Now that the idea behind credibility has been introduced, the next crucial issue to address is how to effectively exploit it to improve decision-making quality. Mechanistic control should not be neglected here, even though it is organic control that seems essential for improving intra-group credibility. The latter attaches a great deal of importance to qualitative, broad-spectrum information needed for specific innovation-related tasks. It relies heavily on high-quality expertise and, as the innovation development process progresses, provides a considerable amount of information as a basis for forming one's opinion on its quality. In this context, empirical evidence suggests that knowledge credibility is indeed efficiently evaluated by each worker's task performance (Davenport & Prusak, 1998, cited in: Chen et al., 2013). With an organic MCS in place, untrustworthy contributions are therefore rapidly detected and may be corrected accordingly. From this perspective, a mechanistic MCS complements the organic one as it requires that the actions taken to correct any deviations be reported to managers (Chenhall & Morris, 1995). As such, it organises and supports supervision over the process of rectifying unreliable contributions, which in turn indirectly supports decision-making.

Coordination

The third principal dimension of the transactive memory system included in the CDI model is coordination, which enables the effective exploitation of the previous two. Coordination was previously defined as "the ability of the team to develop a shared representation of how the task can be divided and the relationships between subtasks and team members" (Hammedi et al., 2013, p. 319), and "effective and orchestrated knowledge processing" (Akgun et al., 2005, p. 1106).

Without effective coordination, group members would need to individually process all innovation-related information, which carries the risk of cognitive overload (Hammedi et al., 2013) and impedes decision-making. As explained in the construct of bounded rationality, individuals root their decisions in subjectively derived cognitive models, which diverge among them and seldom converge due to the incompleteness of available information (Heugens, 2004). Consequently, group members are likely to underuse or even ignore information that is unrelated to their own field of expertise. A number of dissimilar interpretations can emerge, which subsequently lead to divergent rationales for making a particular decision. In the case of ineffective coordination, the formulation of a commonly accepted decision may encounter two main obstacles: focusing on shared general information to find common ground between decision-makers or focusing on scattered individual preferences (Hammedi et al., 2013). The former situation entails the risk of a superficial assessment of individual contributions while overlooking pertinent information. The latter increases the likelihood of power-based, political, and subjective decisions emerging. In either case, an optimal choice is unlikely.

As the vital role of coordination has been established earlier, the issue of steering it will now be addressed. Because coordination focuses on how tasks can be divided and distributed amongst group members, and how the relationships between the sub-tasks and the individuals responsible for their completion should be organised, both mechanistic and organic control systems may be presumed to contribute here. To wit, employing formal rules, regulations, and procedures, and explicit reporting requirements is at the heart of the mechanistic approach to coordination. This is complemented by the organic component, involving discussions and informal ways of resolving issues, with the use of open communication channels and the free flow of information. An optimal interplay of mechanistic and organic approaches is therefore presumed to bring out the full potential of the decision-making process.

Other Dimensions

Although the operationalisation of the TMS as comprising specialisation, credibility, and coordination is widely recognised, it is not the only one. One other example is knowledge stock, proposed as a complementary dimension of the TMS (Austin, 2003). This category captures the individual knowledge element of the transactive memory construct. However, because it was not recognised in later studies and no field measure has ever been developed, it will not be considered in the present investigation. Similarly, the categories of “consensus” (the extent to which group members agree about who has what knowledge) and “accuracy” (the extent to which individuals identified by others in the group as possessing particular knowledge actually possess that knowledge) (Austin, 2003) are largely covered by coordination, and therefore will not be explicitly isolated here. Furthermore, previous studies complemented knowledge differentiation, knowledge location, and knowledge credibility with the usage of mailing lists (Chen et al., 2013). On the one hand, the last category is distinctive from the previous three, but on the other, it reflects a tool-level perspective and was introduced explicitly for the open-source software development context. Hence, it is of little bearing for the present investigation and is not included here as a dimension of the TMS.

4.2.3. Omitted Variables and Potential Confounders

In addition to the direct and indirect effects of management control systems on decision-making quality, the CDI model includes potential confounders to account for the context-specific character of the relationships modelled there. Their omission in the model would result in the attribution of their effect to the variables actually included in it, which could potentially cause a significant bias in the estimation of the parameters. Thus, the selection and inclusion of potential confounders is a well-founded requirement. Owing to their inclusion, the model is in a position to be empirically validated in a variety of business environments. Potential confounders include company size and the sector in which it operates.

Because the different extent to which companies exploit management control systems depends on their size, the inclusion of this variable as a potential confounder is imperative. According to previous studies, the percentage of companies adopting different product development systems is a function of company age and size (Davila, Foster, & Li, 2009). This means that as companies grow, the range of MCS sub-systems in use increases from none to the whole set of "project milestones, reports comparing actual progress to plan, budget for development projects, project selection process, product portfolio roadmap, product concept testing process, project team composition guidelines" (Davila et al., 2009, p. 333). Furthermore, as companies expand, the MCS components in use tend to differ. According to previous evidence, project milestones represented the first component to be adopted in most companies. The size at which this component was implemented differed significantly from other sub-systems, except for "product concept testing", where the difference was not significant. Companies that adopted product concept testing did so early in their development. Furthermore, the project selection component tended to be added significantly later than all other subsystems except for product portfolio roadmaps. Roadmaps were also implemented later than any other sub-system except for product concept testing. These components were likely to complement the range of MCS sub-systems in relatively large companies, because they required that various products be considered in the development plan once the initial product had been developed and released to the market (Davila et al., 2009). In addition to these considerations, further empirical evidence related to innovation demonstrated that the adoption rate of specific MCS tools, such as balanced scorecard, was particularly low in small companies. On the other hand, most medium and large companies monitored the performance of their innovation activities by using specific financial and non-financial measures (Zizlavsky, 2015). Furthermore, research showed that only a small number of companies – especially large-sized ones – created consistent systems acknowledging the cause-and-effect relationship between metrics. In smaller entities, such an approach tended to be a rarity (Zizlavsky, 2015).

Now that the size variable has been introduced, the focus will shift to the sector in which a company operates. This variable generally differentiates service from manufacturing companies (Son, Lee, Lee, & Chang, 2011). From the point of view of the present study, a number of differences between manufacturing and services may impact the design of the MCS that is in place. Such characteristics as the intangibility of services, impossibility of storage, inseparability of the service provider, lower potential of standardisation, varying quality standards, impossibility of repairs, rarity of replacement, instantaneous consumption, high intensity of contacts with consumers, and participation of consumers in conversion (Chary, 2009), among others, all determine the organisation of the MCS. Moreover, as shown in previous studies, service companies are characterised by flatter organisational structures than manufacturing ones; the role of high-level management tends to be supportive, while in manufacturing companies it is mainly "demanding"'; communication in service companies is often crosswise, instead of vertical; and the desired design is organic, while in manufacturing companies, it is often "rational" (Chary, 2009). In direct relation to the MCS, the issue was described as follows: "manufacturing companies may design their MCSs differently than non-manufacturing industries. Thus, moving from one industry sector to another may cause problems in terms of comparability among measures of MCS" (Dropulic, 2013, p. 376). However, in the study reported in this book, the focus is set on a wider range of companies, which operate not only in services and manufacturing but also in agriculture. Therefore, the division into manufacturing and service companies seemed insufficient, and consequently, agricultural companies were also distinguished. As a result, the CDI model accounts for differences in approaches to management control and innovation between relatively small and relatively large companies representing the service, manufacturing, and agriculture sectors.

4.3. Operationalisation of Constructs Used in the CDI Model

The previous section presented the entirety of relationships modelled within the CDI framework. However, the model is more specific, and the detailed presentation of each single construct included in it constitutes its integral part. Therefore, the purpose of the present section is to operationalise these constructs, which means that each of them will be disaggregated into constituent components and reintroduced as a set of explicitly defined items.

For each construct, the operationalisations presented here will build on the descriptions of attributes introduced in Chapters 1–3 (whenever a theoretical reference is needed, one may refer there). As evident from the conclusions presented there, each construct is complex on its own, though this holds especially true for mechanistic and organic control systems, and decision effectiveness and decision-making efficiency, which are all characterised by several attributes. Since the previous chapters have already provided a sound theoretical basis for these attributes, the analysis here will focus on operationalisations used in previous investigations. Deductive and inductive reasoning, with the brief introduction of selected literature, will lead the process. The analysis is intended to overcome any quantifiability issues – otherwise, operational problems could impede the validation of even best-justified concepts.

Since the CDI model illustrates the relationships between management control systems, decision-making quality, and the composite innovation index, which are complemented by the inclusion of moderating variables and potential confounders, the operationalisations developed here will follow this order. Thus, the operationalisation of variables representing mechanistic and organic management control systems will be provided first; specifically formulated items measuring decision effectiveness and decision-making efficiency will follow; and next, a succinct discussion on the operationalisation of the composite innovation index will be presented, as the indicators of its particular components have already been extensively elaborated on in Chapter 3. After operationalising the principal variables embodying the main relationships modelled, further quantifiable items representing transactive memory systems will be introduced. The section will terminate with a concise discussion on the measurement of potential confounders.

4.3.1. Operationalisation of Organic and Mechanistic MCSs

The theoretical analyses reported here have resulted in the isolation of four attributes characterising a mechanistic MCS, namely: regulation level, scope of control, information used, and reporting requirement. Table 4.2 provides example operationalisations of these attributes, used in previous studies, along with items developed specifically for use in the CDI model testing study. The table is followed by a description of the strengths and weaknesses of particular formulations used.

The regulation level is mainly represented by conformity to established rules, regulations, and procedures in the company's operations.

Table 4.2 Operationalisation of mechanistic management control systems

Attribute	*Example previous operationalisations*	*Items developed for the CDI model*
Regulation level	– "The organisation has a strong central controller function which develops and implements financial control systems and monitors their use" (Chenhall & Morris, 1995, p. 495). – "The organisation does very detailed and precise strategic planning, and is reluctant to modify any actions contained in it; There are clearly established procedures for decision making, which must be followed strictly" (Cruz & Camps, 2003, p. 122).	The system is organised based on formal rules, regulations, and procedures.
Scope of control	– "I am required to submit control reports that explain in detail budget variances on a line-by-line basis; My corporate superiors are interested not only in how well I achieve my overall budget, they also evaluate how well I am on target on each of the budget line items; From the comments made by my corporate superiors, I know that they investigate my budget in every detail" (Van Der Stede, 2001, p. 127). – "I judge my project team performance with performance measures that explain in detail project performance variances on a line-by-line basis; I am not only interested in how well my project team achieves the overall project performance targets, but I also evaluate the extent to which my project team is on target in each of the project performance line-items" (Ylinen & Gullkvist, 2014, p. 108).	The interest is placed not only on overall performance targets, but also specific, individual tasks.
Information used	– "Budget targets are strong commitments and cannot be changed during the year; My corporate superiors attach a great deal of importance to interim budget deviations" (Van Der Stede, 2001, p. 127). – "I attach a great deal of importance to interim project performance target deviations from budgeted performance and project milestones" (Ylinen & Gullkvist, 2014, p. 108). – "Tight formal control of most operations by means of sophisticated financial control and information systems" (Chenhall & Morris, 1995, p. 495).	A great deal of importance is attached to predetermined, quantitative information.

Attribute	*Example previous operationalisations*	*Items developed for the CDI model*
Reporting requirement	– "Reports to top management; Reports on codified problems; Reports on established schedule" (House, 1991, p. 28). – "Periodic reports on financial performance are reviewed carefully by senior management" (Chenhall & Morris, 1995, p. 495). – "I require my project team subordinates to report the actions taken to correct causes of deviation from the interim project performance target" (Ylinen & Gullkvist, 2014, p. 108).	The actions taken to correct deviations from performance targets must be reported to managers.

Source: Author's own development.

A notable operationalisation of a mechanistic management accounting system included five items (Chenhall & Morris, 1995), the most suitable of which is contained in Table 4.2. It links the formulation and execution of financial control explicitly to the person of controller. Since these functions may be performed by different actors, irrespectively of the establishment of a remote controlling unit, the operationalisation developed within the CDI model will disregard this emphasis on a central controller. Furthermore, in a large study on the validation of a measurement scale for mechanistic and organic organisations, planning and control systems were identified as one of the eight crucial elements (Cruz & Camps, 2003). Two of the items used there are cited in Table 4.2. While this approach evaluates compliance with established plans, it also emphasises reluctance to modify them. Because such rigidity may lead to ineffective solutions of a ceremonial nature (Christensen, Rikhardsson, Rohde, & Batt, 2018), its inclusion in the operationalisation would be questionable and thus will not be followed here. Consequently, focus will be placed entirely on the principal idea behind bureaucratic control, i.e., system organisation with the use of rules and regulations developed within the company.

As to the scope of control attribute, it mainly corresponds to the distinction between overall performance targets and specific, individual tasks. In this vein, an extensive conceptual basis was developed in the research devoted to tight budgetary control (Van Der Stede, 2001). While a number of specific items defined there contribute to the operationalisation developed here, three of them represent good examples of control scope. Furthermore, a direct operationalisation of the mechanistic form of control was developed in the study on the effects of MCS on exploratory and exploitative innovation (Ylinen & Gullkvist, 2014). It included two specific items defined in the context of project management, which are essential to control scope. All these operationalisations are listed in Table 4.2. Because the cited operationalisations are largely consistent, the item developed here unifies them by explicitly emphasising the itemised control executed within mechanistic systems. At the same time, it proposes a generally oriented focus, detached from the detailed characteristics of any particular situation.

The concept of information used refers to the extent to which predetermined, quantitative information constitutes the basis for decision-making. It is derived from the operational perspective on the mechanistic MCS, which relies extensively on established targets and budgetary deviation monitoring. Both budgets and key performance targets, which are predominantly quantitative, are determined in advance and controlled throughout the period for which they have been set. While numerous operationalisations include these notions, most do it when asking about other attributes. Examples of such operationalisations are provided in Table 4.2. One important similarity amongst them is the reference to (quantitative) target deviations. In the present study, the essence of the "information used" attribute will therefore be brought down to the quantitative and predetermined nature of the information used.

In reference to reporting requirement, whenever mechanistic control is introduced, a bidirectional flow of information is essential, with a top-down stream that includes instructions, and a bottom-up one providing feedback for managerial decision-making. Here, the operationalisation emphasises the latter, and so it involves reporting to management. Since this attribute constitutes one of the foundations of mechanistic systems, it has been soundly operationalised in previous studies. Two examples of items referring to the nature of reporting and the importance of formal reporting in mechanistic systems are contained in Table 4.2. While certainly informative, these approaches ignore the contents of reports, which is a crucial consideration from the decision-making and control perspectives. The issue is addressed by the third item cited earlier. Consequently, the item developed within the CDI framework stresses the obligatory character of reporting, as much as the substance of the reports provided.

Now that the mechanistic MCS has been operationalised, a similar discussion regarding the organic type will follow. In line with the theoretical foundation established earlier, the location of decision-making, informal communication, and free flow of information are the three principal attributes of organic systems. Table 4.3 provides both the example operationalisations of these attributes developed in past investigations and items developed for use in the CDI model.

The very essence of the first attribute boils down to the involvement of staff in decision-making, instead of restricting decisive power to

Table 4.3 Operationalisation of organic management control systems

Attribute	*Example previous operationalisations*	*Items developed for the CDI model*
Location of decision-making	– "An emphasis on consensus-seeking, participative decision making; managers share information with colleagues" (Chenhall & Morris, 1995, pp. 494–495). – "Participation and group consensus used frequently" (Trott, 2017, p. 136). – "The blue-collar workers in this organisation have the freedom to take decisions; in the organisation, the decision-making capacity tends to be located at the lowest possible level of the hierarchical scale; in this organisation, the managers of the operating units have freedom both to set their strategies and to implement them" (Cruz & Camps, 2003, pp. 122–123).	Managers decide on actions taken to correct system performance deviations together with the staff involved.
Informal communication	– "My own project team subordinates and I often discuss and resolve project performance issues together informally" (Ylinen & Gullkvist, 2014, p. 108). – "Culture encourages informal signalling of potential problems; easy informal access to senior managers" (Chenhall & Morris, 1995, p. 495).	Staff involved often informally discuss and resolve system performance issues together.
Free flow of information	– "I place considerable emphasis on open channels of communication and the free flow of information between myself and my subordinates" (Ylinen & Gullkvist, 2014, p. 108). – "The organisation tends to eliminate physical barriers that prevent direct contact among the workers of the same centre; the organisation tries to facilitate as much as possible the communication by technical means between workers in the same or different centres: telephone, e-mail, post, and so forth; the organisation not only does not restrict, but positively encourages, free and open debate in which the workers can express their opinions" (Cruz & Camps, 2003, p. 123).	The manager in charge encourages open channels of communication and the free flow of information between staff.

Source: Author's own development.

managers. Among the numerous operationalisations of organic management control systems, a notable one was developed in the study on entrepreneurial and conservative organisations (Chenhall & Morris, 1995). It is especially informative here, as it emphasises organic decision-making and communication processes. Two of the items developed there are contained in Table 4.3. While the first statement introduces the involvement of staff, the second seems somewhat repetitive. After all, participative decision-making necessarily requires information exchange. In other publications, the concept was operationalised in relation to decision-making in organic structures (Trott, 2017), and to the dispersion of decisive power (under the label "Centralisation") (Cruz & Camps, 2003). Because all of the listed items essentially deal with delegating decisions to the lowest hierarchical levels possible, they cover analogous areas. This is why the operationalisation developed here builds on them but does not follow the approach in which the concept is broken down into several items. Thus, a single item has been developed to cover staff involvement and the scope of decisive power redirected to them.

Another characteristic attribute of organic control systems is their reliance on informal communication. The idea behind this concept is that staff develop solutions while omitting formally established communication channels. In previous studies on the effects of organic and mechanistic control in exploratory and exploitative innovations, the issue was operationalised with a single item (Ylinen & Gullkvist, 2014). This approach is especially informative here, as it combines the idea of communication based on informal channels with the content of such communication, which concerns problem-solving. After all, companies do not benefit from informal communication per se, but from solutions developed thereby. Further operationalisations followed a similar path. Therefore, the item developed here builds on these operationalisations and combines both the exploitation of informal communication channels and the problem-solving orientation of this communication.

The free flow of information is the third attribute of organic control systems isolated based on the present theoretical considerations. It involves the stimulation of a free flow of information between staff by the executives. While informal information exchange between staff is often a bottom-up initiative intended to bypass formal structures, and thus initiated in the lower hierarchical levels, top-down managerial proposals supporting the free flow of information are a necessary precondition. In this respect, one item developed in previous studies (Ylinen & Gullkvist, 2014) corresponded to the decision-maker's position. Such an expression of the managerial perspective is consistent with the understanding of free information flow inducement followed within the CDI framework. Furthermore, past research offered more technical operationalisations (Cruz & Camps, 2003). On the one hand, such a formulation explicitly mentions initiatives conceivably undertaken by the management, and on the other, it restrains the creativity of managers to some extent, by suggesting certain solutions while ignoring others. Due to the perspective confinement, this approach seems too narrow to be followed here, and consequently, the item developed for the purpose of this study covers the totality of managerial initiatives encouraging the free flow of information.

4.3.2. Operationalisation of Decision Effectiveness and Decision-Making Efficiency

Decision effectiveness focuses on the output of the decision-making process. It refers precisely to the degree of achieving the objective(s) of a system, operation, or activity (Daellenbach & Mcnickle, 2005). Therefore, as might have been expected, operationalisations used in previous studies disregard the inputs necessary to make a decision. Conforming to these conceptual underpinnings, this measure is derived from consistency with company strategy, achievement of objectives, and improvement of overall company performance. Table 4.4 presents example operationalisations and the items developed for the CDI model.

One characteristic attribute of an effective decision is that it corresponds to the company's strategy. The operationalisation explicitly introduced in previous investigations on screening decisions consisted of a single item proposing a comprehensive view (Hammedi et al., 2013). This approach contrasts with previous works (Pike, 1988), which introduced a more detailed perspective. It seems, however, that referencing the overall company strategy favours a more comprehensive view of effectiveness, and therefore this approach is followed in the item developed here.

The essence of the second attribute concerns the extent to which the objectives established before a particular decision are met. The perspective of the achievement of pre-established objectives was explicitly covered in previous studies on entry-mode decisions (Ji & Dimitratos, 2013) and screening decisions (Hammedi et al., 2013). The operationalisations developed there are largely consistent, and therefore the item developed for the CDI model corresponds to them. One additional clarification is required: this attribute differs from the previous one in that it addresses operational level objectives, and therefore is single-project-oriented. The strategy-related attribute, on the other hand, emphasises the company-wide perspective.

The last of these, conceptually underpinned, attributes refers to the improvement of overall company performance. Numerous operationalisations were proposed here. The similarity among them was that they all approached company performance from the large-scale, comprehensive perspective. The difference is that while the first operationalisation proposed a direct reference to "overall company performance", the others introduced a number of specific measures. The first approach will be

Table 4.4 Operationalisation of effective decisions

Attribute	*Example previous operationalisations*	*Items developed for the CDI model*
Consistency with strategy	– "This screening decision was consistent with the company's current strategy" (Hammedi et al., 2013, p. 325). – "The extent to which [the managers] were currently meeting capital investment plans (e.g., achieving the required return) compared with the situation five years ago" (Pike, 1988, p. 348).	The decisions are consistent with company strategy.
Achievement of the established objectives	– "The overall objectives of the entry mode decision" (Ji & Dimitratos, 2013, p. 1004). – "This screening decision met the screening committee objectives" (Hammedi et al., 2013, p. 325).	The decisions lead to the achievement of the established objectives.
Improvement of overall performance	– "This screening decision contributed to overall company performance" (Hammedi et al., 2013, p. 325). – "The extent to which the decision generated the expected results in terms of 1) revenue increase, 2) expected profitability, 3) expected increase in market share, and 4) increased efficiency or productivity" (Garbuio, Lovallo, & Sibony, 2015, p. 370). – Short-term success (e.g., revenue), long-term success (e.g., sustainable competitive advantage, success of the brand, loyalty or customers satisfaction) and indirect success (e.g., new knowledge) (van Riel, Semeijn, Hammedi, & Henseler, 2011). – "Linkages achieved with local partners, enhancement of the firm's competitive position, success in learning critical skills or capabilities, overall decision-making effectiveness" (Ji & Dimitratos, 2013, p. 1004).	The effects of the decisions contribute to overall company performance.

Source: Author's own development.

followed here, as it is more exhaustive and automatically incorporates all the specific measures.

Although some aspects related to decision-making efficiency have already been indirectly introduced in previous paragraphs, the discussion on the operationalisation of the measures representing this parameter will now follow. In line with the conceptual approach, decision-making efficiency may be seen from the resource- and time-efficiency viewpoints. Previous studies proposed some operationalisations of the measures covering both perspectives – Table 4.5.

To begin with, resource efficiency (excluding time) was operationalised in terms of a variety of tangible and intangible outlays needed to reach a decision. Here, in line with the understanding of efficiency followed in this book, using either too much or too little resources signifies non-optimality. The measures of efficiency were expressed in terms of the costs incurred during the decision-making process or compliance with budget (Kaufmann et al., 2012), or earnings, profitability, growth, and

Table 4.5 Operationalisation of an efficient decision-making process

Attribute	*Example previous operationalisations*	*Items developed for the CDI model*
Resource efficiency	– "Total cost relative to expectation . . ." (Kaufmann, Carter, & Buhrmann, 2012, p. 422). – "The project having come in on budget" (Lechler & Dvir, 2010, p. 208). – The relation between the inputs and outputs (earnings, profitability, growth and financial independence) of the activities under consideration (Neuert & Hoeckel, 2013). – "The committee made optimal use of all available information and knowledge" (Hammedi et al., 2013, p. 325); "the team thoroughly considered and evaluated all the relevant information to make the decisions" (Passos & Caetano, 2005, p. 237).	The resources used to make a decision are optimal (not too much and not too little resources used).
Time efficiency	– "The project having come in on schedule" (Lechler & Dvir, 2010, p. 208). – "The screening committee came rapidly to a conclusion" (Hammedi et al., 2013, p. 325). – "The team made good use of time to make the decisions" (Passos & Caetano, 2005, p. 237).	The time used to make a decision is optimal (not too much and not too little time taken).

Source: Author's own development.

financial independence (Neuert & Hoeckel, 2013). Further items (Hammedi et al., 2013; Passos & Caetano, 2005) demonstrated the potentially intangible character of resources, in the form of information and knowledge, needed to make a decision. Importantly, different decision-making processes require different sets of resources. While routine decisions are unlikely to necessitate substantial spending, more unconventional ones may entail considerable costs (e.g., external analyses, consultancy etc.) and call for the gathering of highly-specialised information. Consequently, the general reference to "resources" in the CDI item seems more appropriate than the isolation of their specific components.

As concerns the time efficiency attribute, it covers the optimality of time used in the decision-making process. Previous studies evaluated efficiency based on adherence to schedules (Lechler & Dvir, 2010). This operationalisation is of value here, as it refers to a predetermined agenda and approaches decision-making time efficiency from the angle of the effects of complying with a fixed timetable. While this relates to the present research, since goal-setting is part of the responsibilities of an MCS, it has a certain limitation – namely, it establishes the schedule as the sole reference point and ignores the fact that the schedule itself may not be optimal. Furthermore, the rapidity of making a decision was emphasised (Hammedi et al., 2013). While this corresponds partially to the understanding of efficiency elaborated in this book, this formulation is unidirectional, meaning that it invariably favours quick decisions. Thereby, it disregards the possibility of going too far and devoting insufficient time to the process, and consequently making hasty, poor decisions. The third operationalisation discussed here addressed this issue (Passos & Caetano, 2005) by passing over the amount of time used, and focusing on the quality of its use instead. Certainly, the exact amount of time notwithstanding, its optimal use is of central value for the process of seeking a conclusion. In the light of the previous discussion, the CDI item developed here intends to combine the amount and the optimality of time use.

4.3.3. Operationalisation of the Composite Innovation Index

While in the case of the MCS and decision-making, theoretical foundations were established in previous chapters and followed with the operationalisation developed here, in the case of the composite innovation index, the presentation will be slightly different. As the CII was designed, developed, and described in Chapter 3, the discussion on its components, including specific indicators, has already been provided there. Consequently, the items presented in Table 4.6 are followed only by a succinct description.

Since the innovation system brings together experts from different functional areas, operationalising human resource input as the total number of people involved is preferred over the sum of R&D employees (Cavdar & Aydin, 2015). In the same vein, financial resource input is

Table 4.6 Operationalisation of the composite innovation index

Group	*Cluster of measures*	*Items developed for the CDI model*
Input measures	Human resources input	On average, how many people in total are involved in the innovation system within all functional areas?
	Financial resources input	What is the average total annual innovation cost incurred for the innovation system within all functional areas?
Intermediate output measures	Technological output	How many patents were granted to your company within the last 5 years?
	Scientific output	How many scientific publications were published by your company's staff within the last 5 years?
Direct output measures	Development output	How many breakthrough new products were developed within the last 5 years as the result of the innovation system in your company?
	Economic output	On average, does commercialising a single new product increase the sales volume of your company (during the first 3 years after commercialisation)?
Indirect impact measures	Impact on resource efficiency	On average, are advancements made in one innovation project used to support other innovation projects in your company?
	Impact on resource productivity	On average, are advancements made in one innovation project used to minimise the resources spent in other innovation projects in your company?

Source: Author's own development.

represented by an item covering total innovation cost incurred, instead of isolated R&D spending (Belitz et al., 2011). Furthermore, technological output refers to patents granted instead of patent applications (Makkonen & Have, 2012), as the former represent the successful finalisation of the process. Scientific output has been operationalised as the number of scientific publications, due to the practical issue with collecting data on citations. Development output expressed in terms of breakthrough new products is derived from the essence of an innovation system, and this has been firmly established in previous studies as well (Avermaete et al., 2004). The item covering economic output refers to sales volume increase, as this measure is the most commonly calculated when evaluating innovation in practice. Impacts on resource efficiency and productivity expressed in terms of the minimisation of resources spent and the usage of advancements made in other projects link directly to previous conceptual work (Arundel & Kemp, 2009).

4.3.4. Operationalisation of the Transactive Memory System and Potential Confounders

Now that the constructs involved in direct relationships modelled in the CDI framework have been operationalised, the specific items for moderators will be formulated. As explained in the previous section, the transactive memory system emerges to the extent that three processes occur jointly: specialisation, credibility building, and coordination (Lewis, 2003). Table 4.7 presents previously used operationalisations and ones developed for use within the CDI framework.

Table 4.7 Operationalisation of the transactive memory system

TMS component	*Example previous operationalisations*	*Items developed for the CDI model*
Specialisation	– “Each team member has specialised knowledge of some aspect of our project; I have knowledge about an aspect of the project that no other team member has; different team members are responsible for expertise in different areas; the specialised knowledge of several different team members was needed to complete the project deliverables; I know which team members have expertise in specific areas” (Lewis, 2003, p. 604). – “Each screening committee member has specialised knowledge of specific aspects of new service proposals; different screening committee members are responsible for expertise in different areas; the specialised knowledge of several different screening committee members was needed to evaluate innovation proposals” (Hammedi et al., 2013, p. 325).	Different workers involved are responsible for expertise in separate areas. Each worker involved has specialised knowledge on a specific aspect of innovation.

TMS component	*Example previous operationalisations*	*Items developed for the CDI model*
Credibility building	– "I was comfortable accepting procedural suggestions from other team members; I trusted that other members' knowledge about the project was credible; I was confident relying on the information that other team members brought to the discussion; When other members gave information, I wanted to double-check it for myself, I did not have much faith in other members' 'expertise' " (Lewis, 2003, p. 604). – "To what extent do you trust the following individuals/entities; how would you rate the performance of the following individuals/ entities up to this point" (Sarker et al., 2005, p. 209).	Staff involved are comfortable accepting suggestions from other staff. Staff involved trust their co-workers' knowledge to be credible.
Coordination	– "Our team worked together in a well-coordinated fashion; our team had very few misunderstandings about what to do; our team needed to backtrack and start over a lot; we accomplished the task smoothly and efficiently; there was much confusion about how we would accomplish the task" (Lewis, 2003, p. 604). – "Our screening committee worked together in a well-coordinated fashion; our screening committee had very few misunderstandings about what to do; we accomplished the screening task smoothly and efficiently" (Hammedi et al., 2013, p. 325).	Staff involved work together in a well-coordinated fashion. Staff involved perceive and interpret any new information similarly.

Source: Author's own development.

Specialisation stands for the differentiated structure of organisation members' knowledge and the degree to which they have specialised knowledge in their respective areas of expertise. In a previous study on scale validation, specialisation was operationalised in terms of five items (Lewis, 2003). While items 1, 2, 3, and 5 correspond to the conceptualisation of specialisation followed here, item 4 introduces a project-specific perspective. It is inconsistent with the others in the sense that the response is driven by the specificity of the innovation project, irrespectively of the specialisation level within the organisation. Moreover, even though item 2 addresses overlapping knowledge possessed by different actors, it partially repeats item 1. These issues were addressed in a study on screening decisions, in which specialisation was expressed in terms of three items (Hammedi et al., 2013). However, the last item again introduced a project-specific perspective. Consequently, the operationalisation formulated here is based solely on the first two items.

Credibility represents organisation members' beliefs about the reliability of other members' knowledge and, consequently, their willingness to rely on it. In a past study, it was operationalised with the use of five items (Lewis, 2003, p. 604). While informative, the last two items are largely repetitive and reversely code the information already included in the previous three. Their elimination was thus a common practice in later studies (Akgun et al., 2005). Furthermore, though items one and three differ in that they distinguish procedural suggestions and other information, the issue of being comfortable in accepting the opinions of one's co-workers is repeated. An alternative operationalisation, addressing this issue, was therefore formulated thereafter (Sarker et al., 2005). The items developed here follow the two main themes of previous operationalisations, namely those of trust and being comfortable.

As to coordination, it is understood as effective, orchestrated knowledge processing, including well-coordinated workflows and a similar perception and interpretation of any new information by all staff involved. Its early operationalisation relied on five items (Lewis, 2003), though Items 3 and 5 rehashed the remaining three, reversely coding the responses. The problem was reproduced in some later studies (Akgun et al., 2005) and successfully addressed in others (Hammedi et al., 2013). Nevertheless, it seems that working in a well-coordinated fashion would necessarily entail few misunderstandings and smooth and efficient progress. This is why the operationalisation formulated here focuses on the extent to which the coordination is well organised. In addition to that, and in relation to the MCS, the role of which is to provide information, the second item formulated here concerns a similar perception of information by all parties involved in the coordinated system. This is derived from previous studies on organisational innovation (Lam, 2006).

On a side note, from the operational perspective, scales for specialisation, credibility building, and coordination within the CDI framework are calculated by averaging the appropriate items. For example, when responses given to the two items representing specialisation are averaged, the result represents the extent to which a respondent believes the organisation has developed specialisation. In the particular case of TMS, research practice has demonstrated, based on the item-total correlations for all scales and the alpha reliabilities for the specialisation, credibility, and coordination scales, that averaging of subscale items is a robust approach (Lewis, 2003).

The last component of the CDI framework contains omitted variables and potential confounders, which essentially include company size and sector. These two variables are operationalised here in line with the discussion reported in the previous section. Company size is represented by company capitalisation at the time of the study. This is because the measure relatively adequately incorporates all the information, at a given moment in time, that is significant from the company-value perspective (Fama & French, 2007). Sector is operationalised as a three-category variable, and the categories are: manufacturing, services, and agriculture.

4.4. Rationale for Empirical Verification

Although the CDI model demonstrably has sound conceptual grounding, it shall undergo the procedure of empirical validation. In this regard, following the scrupulous descriptions of the main relationships within the model with a meticulous explanation of indirect effects and potential confounders, as well as the operationalisations of all constructs used, is of particular importance, as this lays the foundation for the empirical verification. As explained previously, the relationships modelled here may vary depending on the environment in which they are studied. Bearing this in mind, the empirical validation of the model in different contexts will enable the testing of 42 hypotheses representing the relationships postulated within the CDI framework. This number results from modelling six relationships in each of the seven functional areas involved in the product innovation development system. Six hypotheses to be tested in each functional area are as follows:

H. 1–7. A mechanistic control system positively affects decision effectiveness.

H. 8–14. An organic control system positively affects decision effectiveness.

H. 15–21. A mechanistic control system positively affects decision-making efficiency.

H. 22–28. An organic control system positively affects decision-making efficiency.

H. 29–35. Decision effectiveness positively affects the composite innovation index.

H. 36–42. Decision-making efficiency positively affects the composite innovation index.

Due to the fact that the hypotheses to be tested within all functional areas should be formulated in the same manner, they will not be repeated here. Instead, the abbreviated, tabular format will be provided. Table 4.8

Table 4.8 Hypotheses to be tested within the CDI framework

Functional areas \ *Hypotheses*	*H. 1–7*	*H. 8–14*	*H. 15–21*	*H. 22–28*	*H. 29–35*	*H. 36–42*
Idea generation	H.1	H.8	H.15	H.22	H.29	H.36
Idea selection	H.2	H.9	H.16	H.23	H.30	H.37
Research	H.3	H.10	H.17	H.24	H.31	H.38
Development	H.4	H.11	H.18	H.25	H.32	H.39
Testing	H.5	H.12	H.19	H.26	H.33	H.40
Commercialisation	H.6	H.13	H.20	H.27	H.34	H.41
Monitoring	H.7	H.14	H.21	H.28	H.35	H.42

Source: Author's own development.

connects the six hypotheses listed with the seven functional areas isolated. For example, the intersection H. 15–21 and idea selection, marked H. 16, represents the following hypothesis: "A mechanistic control system positively affects decision-making efficiency in the idea selection functional area".

Chapter Summary

The control-decision-innovation (CDI) model depicts the network of relationships between management control systems (MCS), decision-making quality, and the composite innovation index (CII). It indicates that mechanistic and organic MCSs exert direct and indirect positive effects on decision-making efficiency and decision effectiveness, which in turn have a direct positive effect on the composite innovation index. Therefore, the main relationships are modelled as follows:

- a positive effect of mechanistic control systems on decision effectiveness,
- a positive effect of organic control systems on decision effectiveness,
- a positive effect of mechanistic control systems on decision-making efficiency,
- a positive effect of organic control systems on decision-making efficiency,
- a positive effect of decision effectiveness on the composite innovation index, and
- a positive effect of decision-making efficiency on the composite innovation index.

Because the control-decision-innovation model represents the aforementioned relationships within the product innovation development (PID) system, it is internally divided in accordance with its representation introduced in Chapter 3. This means that, within the CDI framework, each of the following functional areas – idea generation, idea selection, research, development, testing, commercialisation, and monitoring – is depicted separately. Consequently, the composite innovation index results from the sum of the quality of all decisions made within all functional areas involved in the innovation system.

In addition, because of the role that knowledge assets play in the improvement of decision-making quality, a complementary, indirect path linking MCS and decision-making quality has been included in the model to explain how organisations leverage these assets. This moderating effect builds on the crucial importance of knowledge workers to innovation systems, where their experience and expertise are indispensable in creating innovative products. In this vein, the conceptual construct selected to represent the indirect effect is that of the transactive memory system (TMS). Furthermore, potential confounders, including company size and sector, have been introduced into the model. Both of these complements pragmatise the model with respect to practical applications, in which the relationships modelled are context-specific and may be subject to distortions.

Since the model is in a position to be empirically validated in a variety of business environments, in addition to modelling the relationships between constructs, the detailed presentation of each single construct included constitutes its integral part as well. This means that each of these constructs has been disaggregated into constituent components and reintroduced as a set of explicitly defined items. Mechanistic control systems have been operationalised in terms of four items, reflecting the following attributes: regulation level, scope of control, information used, and reporting requirement. Three items represent organic MCS, capturing the following attributes: location of decision-making, informal communication, and free flow of information. Decision effectiveness has been approached with the use of three items, addressing consistency with strategy, achievement of the established objectives, and improvement of overall performance. In addition, two items have been used to describe an efficient decision-making process with respect to its resource and time efficiency. Furthermore, eight items, covering human resources input, financial resources input, technological output, scientific output, scientific output, development output, economic output, impact on resource efficiency, and impact on resource productivity have been introduced to operationalise the composite innovation index. Besides, specific items have also been formulated for moderators and potential confounders.

Consequently, the principal, original result of this chapter is the comprehensive, conceptually underpinned and operationalised control-decision-innovation (CDI) model. This means that the objectives of unifying the main argumentation presented in Chapters 1, 2, and 3, pragmatising the conceptual model with respect to practical applications, and operationalising the constructs used, have all been achieved. Consequently, the main research objective of creating a model representation of the relationships between management control systems, decision-making quality, and innovation system efficiency has also been reached. Because the model is only conceptual at this stage, in the next chapters, the methods and results of its empirical verification will be reported.

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