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Virpi Turkulainen

MANAGING CROSS-FUNCTIONAL INTERDEPENDENCIES

The Contingent Value of Integration

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virpi.turkulainen@tkk.fi
+358 50 577 1699

Helsinki University of Technology
Department of Industrial Engineering and Management
P.O. Box 5500
FIN-02015 TKK, Finland
Tel: +358 9 451 2846
Fax: + 358 9 451 3665
Internet: http://www.tuta.hut.fi/

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ABSTRACT OF DOCTORAL DISSERTATION

HELSINKI UNIVERSITY OF TECHNOLOGY
P.O. BOX 1000, FI-02015 TKK
http://www.tkk.fi

Author **Virpi Turkulainen**

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Opponents	Professor Barbara B. Flynn (Indiana University) and Professor Morgan Swink (Michigan State University)
Supervisor	Professor Eero Eloranta (Helsinki University of Technology)
Instructor	Senior lecturer Mikko Ketokivi (Helsinki University of Technology)

Abstract

This research focuses on designing organizations, especially on the integration of functional units (e.g., manufacturing, R&D, marketing/sales). Cross-functional integration is one of the focal concepts in Operations Management (OM) and it has been approached both in the context of on-going operations as well as in the context of new product development. The existing literature on cross-functional integration focuses primarily on assessing the performance effects of integration and often takes the benefits of integration for granted. Some recent literature, however, suggests that there are costs related to integration. Hence, integration can be considered as an investment, inducing significant financial and managerial costs to the organization. Therefore, it is of fundamental importance to assess when integration is needed and the conditions under which it is essential. In order to understand the value of integration, the antecedents and effects of integration are addressed in this research. The research focuses on cross-functional integration at the manufacturing plant level. A theory-driven empirical research approach is taken.

The theoretical basis of this research is in the contingency theory of organizations, especially the work of the early structural contingency theorists. In this research, integration is approached as an information processing phenomenon. Following the arguments of contingency theorists and information processing scholars, the research makes a distinction between three integration constructs: achieved integration, integration mechanisms, and requisite integration. Furthermore, it is suggested that organizations vary in terms of their needs for integration, and emphasis on complex lateral integration mechanisms is needed only when the requirements for integration are significant.

The first main finding of this research is that the integration dimension of achieved integration has direct consequences in terms of performance; a high level of achieved integration has a positive effect on comparative manufacturing performance. The effect of cross-functional integration on different dimensions of performance is not similar, however; integration provides more value on some dimensions. The second finding is that plants differ in terms of the requirements for integration, and subsequently in terms of the use of integration mechanisms; when the requirements for integration are substantial, more emphasis is needed on lateral integration mechanisms, including cross-functional job rotation and cross-functional teams. Finally, the results indicate that especially a high emphasis on the development of new technology and product customization increase the need for cross-functional integration at manufacturing plant level.

This research contributes to both Operations Management (OM) and Organization Theory (OT), although the main contribution of the research is to OM. To OM literature, this research contributes by (i) providing conceptual clarity to the concept of integration, (ii) conceptualizing and empirically assessing integration as an endogenous variable, and (iii) discussing and assessing the intra-organizational variant of the contingency theory, introduced by Lawrence and Lorsch (1967), in the OM context. Hence, the contribution to OM literature is empirical and theoretical by nature. The contribution to OT literature, on the other hand, is highly empirical by nature. This research contributes to the contingency theory by providing a holistic empirical assessment of the intra-organizational contingency theory argument on integration, including the empirical assessment of the concept of requisite integration.

The research results have implications for practice as well. The concept of requisite integration is highly relevant for managers. Because of variations in the requirements for integration, lateral integration mechanisms are not equally important to all organizations; in certain conditions the integration challenge can well be managed with traditional vertical mechanisms like centralization and standardization. The results also imply that managers' need to pay attention to cross-functional integration depends on which performance dimension is strategically important; integration is more valuable on some dimensions of performance than on others.

Keywords Cross-functional integration, organization design, contingency theory, High Performance Manufacturing

VÄITÖSKIRJAN TIIVISTELMÄ

TEKNILLINEN KORKEAKOULU
PL 1000, 02015 TKK
http://www.tkk.fi

Tekijä **Virpi Turkulainen**

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Tiedekunta	Informaatio- ja luonnontieteiden tiedekunta
Laitos	Tuotantotalouden laitos
Tutkimusala	Teollisuustalous
Vastaväittäjät	Professori Barbara B. Flynn (Indiana University) ja Professori Morgan Swink (Michigan State University)
Työn valvoja	Professori Eero Eloranta (Teknillinen korkeakoulu)
Työn ohjaaja	Dosentti Mikko Ketokivi (Teknillinen korkeakoulu)

Tiivistelmä

Tässä väitöskirjassa tutkitaan organisaatiorakenteita, ennen kaikkea toiminnollisten yksiköiden (esim. tuotanto, T&K, markkinointi) integraatiota. Toiminnollisten yksiköiden välinen integraatio on yksi tuotantotalouden alan keskeisimmistä käsitteistä ja sitä on tutkittu niin nykyisten operaatioiden kuin uusien tuotteidenkin yhteydessä. Alan aikaisempi tutkimus on pääasiassa keskittynyt analysoimaan integraation vaikutuksia ja integraation mukanaan tuomia hyötyjä pidetään usein itsestäänselvyytenä. Viime aikoina on kuitenkin esitetty, että integraatiosta aiheutuu kustannuksia. Täten on tärkeää arvioida, kuinka tarpeellista integraatio on ja kiinnittää huomiota tilanteisiin, joissa integraatio on erityisen merkittävää. Jotta integraation merkitys ymmärrettäisiin, tämä tutkimus arvioi sekä integraation tarpeeseen vaikuttavia tekijöitä, että integraation vaikutuksia. Tutkimus keskittyy toiminnollisten yksiköiden väliseen integraatioon tuotantolaitoksen tasolla. Tutkimusote on empiirinen.

Tutkimuksen teoreettisena viitekehyksenä on kontingenssiteoria, ennen kaikkea sen varhaiset organisaatioiden rakenteisiin pureutuvat muodot. Tässä tutkimuksessa integraatio nähdään informaation prosessoinnin näkökulmasta. Kontingenssiteorian ja informaation prosessionnin argumentteihin pohjautuen, tutkimuksessa tuodaan esiin integraation monimuotoisuus ja erotetaan kolme integraation käsitettä: saavutettu integraatio, integraatiotyökalut ja integraation tarve. Lisäksi tutkimuksessa väitetään, että organisaatiot eroavat integraatiotarpeiltaan ja monimutkaisten horisontaalien integraatiotyökalujen käyttö on tarpeellista vain kun integraatiotarpeet ovat erityisen mittavat.

Tutkimuksen ensimmäinen päähavainto on, että saavutetulla integraatiolla on suora positiivinen vaikutus tuotannon suorituskykyyn. Toiminnollisten yksiköiden välisellä integraatiolla on kuitenkaan erilainen vaikutus tuotannon suorituskyvyn eri osa-alueisiin; integraatio on tärkeämpää tiettyjä suorituskyvyn osa-alueita tavoiteltaessa. Toisena havaintona on, että organisaatiot eroavat integraatiotarpeiltaan ja vastaavasti tavoiltaan saavuttaa integraatiota; kun integraatiotarpeet ovat erityisen korkeat, horisontaalit integraatiotyökalut, kuten johtotason työkierto yksiköiden välillä ja yksiköiden väliset tiimit, ovat tarpeellisia. Tutkimuksen havaintona on myös, että erityisesti panostus uuden teknologian kehittämiseen ja tuotteiden räätälöinti nostavat toiminnollisten yksiköiden välisen integraation tarvetta tehtaissa.

Tämä tutkimus edistää pääasiassa tuotantotalouden alaa, mutta sillä on vaikutuksia myös organisaatio-tutkimukselle. Tutkimus edistää tuotantotalouden alaa (i) selkeyttämällä integraation käsitettä, (ii) tutkimalla käsitteellisesti ja empiirisesti integraatiota endogeenisena muuttujana, ja (iii) käsittelemällä sisäisiin organisaatiorakenteisiin paneutuvaa, Lawrencen ja Lorschin (1967) esittelemää kontingenssiteorian muotoa tuotantotalouden näkökulmasta. Tutkimuksen vaikutukset teollisuustalouteen ovat siten luonteeltaan sekä empiirisiä, että teoreettisia. Tutkimuksen vaikutukset organisaatiokirjallisuuteen taas ovat luonteeltaan vahvasti empiirisiä. Tutkimuksessa tarkastellaan empiirisesti organisaatioiden sisäisiin rakenteisiin pureutuvaa kontingenssiteorian muotoa kokonaisuudessaan mukaan lukien integraatiotarpeen käsitteen empiirinen tarkastelu.

Lisäksi tutkimuksella on suoria vaikutuksia päätöksentekoon organisaatioissa. Erityisesti integraatiotarpeen käsite on tärkeä. Koska organisaatiot eroavat integraatiotarpeiltaan, horisontaalit integraatiotyökalut eivät ole samalla tavoin tärkeitä kaikille; tietyissä tilanteissa integraatiohaaste voidaan hallita perinteisillä vertikaalisilla mekanismeilla kuten päätöksenteon keskittämisellä ja standardoinnilla. Lisäksi tutkimuksen tulokset osoittavat, että päätöksentekijöiden tulee kiinnittää eri tavoin huomiota toiminnollisten yksiköiden väliseen integraatioon riippuen siitä, mikä tuotannon suorituskyvyn alue on strategisesti tärkeä; integraatio on eri tavoin merkittävää eri suorituskyvyn alueille.

Asiasanat Funktioiden välinen integraatio, organisaatiorakenteet, kontingenssiteoria, High Performance Manufacturing

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Meilahti, August 2008

Virpi Turkulainen

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DEFINITIONS OF FOCAL CONCEPTS

Organization	Organizations are composed of people and groups of people in order to achieve some shared purpose through a division of labor, integrated by information-based decision processes continuously through time (Galbraith 1977, p. 3).
Integration	Integration refers to both the state of unity in effort in the actions of various subunits, as well as the process of achieving that unity (Lawrence & Lorsch 1967, [1967] 1986). In this research, the terms coordination and integration are used interchangeably.
Achieved integration	Achieved integration refers to the absence of conflict in the organization, and it can vary on the scale from low to high. A high level of achieved integration among organizational units means that the different units behave as a unified whole without being merged into a single entity (Barki & Pinsonneault 2005; Donaldson 2001).
Integration mechanisms	Mechanisms of integration refer to any managerial tool for achieving integration within an organization, including for example centralization, information systems, and lateral structures (e.g., Lawrence & Lorsch [1967] 1986; Martinez & Jarillo 1989).
Requisite integration	Requisite integration refers to the need for integration, and it can vary on the scale from low to high. A low level of requisite integration means that it is possible for subsystems in an organization to operate independently of each other (Lawrence & Lorsch 1967, [1967] 1986).
Differentiation	Differentiation refers to the state of segmentation of the organizational system into subsystems, each of which tends to develop particular attributes in relation to the requirements posed by its relevant external environment (Lawrence & Lorsch 1967, [1967] 1986).
Uncertainty	Uncertainty refers to the difference between the amount of information required to perform a task and the amount of information already possessed by the organization (Galbraith 1973).

ABBREVIATIONS

AC	Accounting Manager
AMT	Advanced Manufacturing Technique
ATO	Application-to-Order
AUT	Austria
BU	Business Unit
CE	Concurrent Engineering
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CLRM	Classical Linear Regression Model
DF	Degrees of Freedom
DFM	Design-for-Manufacturability
DL	Direct Labor
EFA	Exploratory Factor Analysis
ETO	Engineering-to-Order
FIN	Finland
GER	Germany
GLM	General Linear Model
GLS	Generalized Least Squares
HPM	High Performance Manufacturing
HR	Human Resources Manager
IM	Inventory Manager
IS	Information Systems Manager
ITA	Italy
JPN	Japan
JIT	Just-in-Time
KOR	Korea
MFG	Manufacturing
MKT	Marketing
ML	Maximum Likelihood
MNC	Multinational Corporation
MSA	Measure of Sampling Adequacy
NPD	New Product Development
OLS	Ordinary Least Squares
OM	Operations Management
OT	Organization Theory
PC	Production Control Manager
PCA	Principle Component Analysis
PD	Member of the Product Development Team
PM	Plant Manager
PS	Plant Superintendent
QM	Quality Manager
R&D	Research and Development

RMSEA	Root Mean Square Error of Approximation
ROI	Return-on-Investment
SD	Standard Deviation
SEM	Structural Equation Modeling
SP	Supervisor
SWE	Sweden
TQM	Total Quality Management

CHAPTER 1
INTRODUCTION

The topic of the dissertation is introduced in this chapter. The chapter is divided into six sections. I start by describing the phenomenon of interest and reviewing a case example of Boeing, well-known among organization scholars. I present the main shortcomings of previous Operations Management research on the topic and point out the academic motivation: why is more research needed in the area of cross-functional integration? After that I present the research problem and the objectives of this study followed by a discussion of the perspective to organizations taken in this research, the underlying philosophy of science, as well as the research methods. Finally, I assess the potential contribution of the research and present the structure of the dissertation.

This dissertation is about designing organizations, particularly about integration of organizational units. Integration of organizational units or organizations is a widely adopted and popular concept in the field of management, both in academia and in practice. In Operations Management (OM), integration of organizations or organizational units has been studied under several topics, including cross-functional integration of manufacturing and R&D in the new product development (NPD) process, plant location decisions and the subsequent integration of the global plant network, and integration of a plant with its suppliers and customers (supply chain integration). Integration is often assumed to provide wide benefits. Integration, however, can be considered as an investment inducing significant costs. Therefore, it is of fundamental importance to assess the conditions under which integration is important or essential. This research focuses on cross-functional integration of manufacturing, R&D and marketing/sales to increase the understanding of integration and to gain a holistic understanding of integration of organizational units. A detailed analysis of the concept of integration, as well as an assessment of the antecedents and the consequences of integration are carried out. A theory-driven empirical research approach (Flynn, Sakakibara, Schroeder, Bates & Flynn 1990; Melnyk & Handfield 1998) is adopted. Integration is approached from the perspective of the structural contingency theory (e.g., Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003), conceptualizing it as an information processing phenomenon (Galbraith 1973, 1977).

1.1 DESCRIPTION OF THE PHENOMENON

1.1.1 Designing a Functional Organization

Until fairly recently, organization has seldom been at the top of management interest. Organization design has mainly been perceived as consisting only of necessary but tedious job descriptions. Over the years managers have realized that they need to understand the tools and principles of designing organizations in order to be superior to their competitors (Galbraith 2002; Goold & Campbell 2002). Today, the discussion of organizations often centers on the difficulties in managing work across functional barriers, problems related to the creation of “functional silos”, and the consequent cross-functional integration challenge (e.g., Sherman 2004; Swink, Narasimhan & Wang 2007). As the different functions operate in and adapt to different sub-environments (Lawrence & Lorsch [1967] 1986), there are information processing needs between them to complete the common task of the organization. The following simple illustration (Figure 1-1) shows several information areas that need to be addressed among the major functions of manufacturing, R&D and marketing.

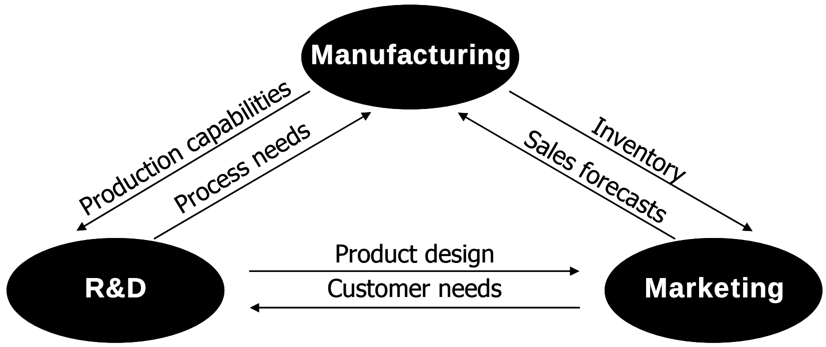

Figure 1-1. Information processing areas between manufacturing, R&D and marketing

In OM, cross-functional integration of manufacturing, R&D, and marketing has been approached especially in the context of NPD but also in the context of on-going operations. This research is essentially about designing organizations. Hence, the research addresses cross-functional integration in the context of various activities that take place within the focal organization.

Majority of the prior research takes the benefits of cross-functional integration as given. Some recent OM literature suggests that there is an increased need for cross-functional integration efforts because of the uncertainty of the competitive environment, due to for example globalization and decreased product life cycles (e.g., Fine 1998; Koufteros, Vonderembse & Jayaram 2005). Others, on the other hand, argue that integration might not be equally important for all organizations, not even within the NPD context (e.g., Swink 1999). Is there an increased need for integration in all organizations? Is it the clockspeed that determines the needs for integration? And even more importantly, which are the most critical factors creating and affecting the needs for integration? The following case example offers a somewhat different angle to integration needs.

1.1.2 Case Example: Integration at Boeing

Major success stories in the aircraft industry include the Boeing aircrafts 747 and 777. The commercial aircraft industry is considered as one of the lowest clockspeed industries because the product life cycles are measured in decades and new products are introduced at the rate of only about two per decade (Fine 1998). For example, the design project of Boeing 777 was launched in 1990, and the aircraft has been in commercial production for over 10 years, receiving new orders still (77 orders in 2006 and 143 in 2007 (Boeing 2008)). Echoing the existing literature on cross-functional integration

(Fine 1998), it is expected that due to the low clockspeed of the aircraft industry, the integration of functions would not be a significant issue at Boeing. Let us take a look at its organization.

Boeing[1] has a basic functional organization structure for the design and manufacturing of aircrafts. Much of the information exchange between the functions is managed by information systems. Advanced information systems, however, are not enough to facilitate the information processing within the organization. In order to manage the significant integration challenge, Boeing has set up additionally altogether 240 cross-functional teams. There are higher-level cross-functional teams in the design, manufacturing, and marketing functions around sections of the aircraft (e.g., engines, wings, cockpit, and avionics). These teams are then further divided into smaller cross-functional teams (e.g., navigation system, flight controls) creating a hierarchy in the structure of the integrating teams. In order to cope with customer requirements, another set of teams has been formed around customer segments. Furthermore, the integrating teams based on sections of the aircraft and customer segments need to be linked to each other. In addition to the cross-functional teams, Boeing has a number of liaison groups and task forces to manage the interdependencies in the organization.

As the case example shows, Boeing has designed a highly complex organization to deal with the integration challenge that it is facing; the organization is multidimensional and includes various inter-unit linkages at different levels across the organization. Hence, even in a very low clockspeed industry such as the aircraft industry (associated by Fine (1998) with sea turtles in contrast to fruit flies of the semiconductor industry) where the decision frame is measured in years or even decades, and thus the resulting uncertainty should be low, the requirements for integration can be extremely intense requiring advanced managerial tools.

The highly complex organization structure of Boeing, including cross-functional teams at multiple levels is well known among organizational scholars. The interesting questions now are: what creates the requirements for integration and the subsequent integration challenge? Why is integration such a fundamental issue and why are highly

[1] The following discussion related to the case example of Boeing is based on the work of Galbraith (1970, 1994).

complex integration mechanisms needed at Boeing? These issues are addressed in the present study.

1.2 ACADEMIC MOTIVATION FOR THE RESEARCH

Cross-functional integration has received significant attention in OM research at different levels, including firm/business unit level (e.g., O'Leary-Kelly & Flores 2002; St. John, Young & Miller 1999), plant level (e.g., Sherman 2004; Swink et al. 2007), and project level (e.g., Gittell 2002; Pinto, Pinto & Prescott 1993; Song & Montoya-Weiss 2001). Despite the vast amount of prior research on the topic, there is still a clear need for further research. The academic motivation for the research is twofold, as presented below.

First, the prior OM research on cross-functional integration has mainly focused on assessing the effects of integration on performance (e.g., Nahm, Vonderembse & Koufteros 2003; Song & Montoya-Weiss 2001; Swink et al. 2007; Swink, Talluri & Pandejpong 2006). As empirical assessment of the practice-performance relationship is in general characteristic to OM research (Ketokivi & Schroeder 2004c), it expectedly dominates also the integration research in the area. However, more theoretical discussion is needed on why and how integration affects performance, especially as the results of prior empirical research on the performance effects of cross-functional integration have been somewhat mixed. Furthermore, it has been suggested that the integration-performance relationship is still elusive (Barki & Pinsonneault 2005)

Second, although some scholars have pointed out a need for addressing the limitations of integration efforts (e.g., Swink 1999; Swink & Song 2007), the antecedents of integration have received very limited attention in prior research. This is somewhat alarming, because a logical premise to explaining the performance effect of a practice is the examination of the antecedents for adopting that practice; an antecedent may become a contingency factor for the practice-performance relationship (Dean & Snell 1996).

The lack of understanding the effects and antecedents of integration has led to non-cumulative research on cross-functional integration (lack of completeness of theory, Mohr 1982, p. 19), which subsequently raises concern: what are the real benefits of integration? Do the benefits of integration always outweigh the potential costs of integration? What are the antecedents of integration and when is integration especially crucial? In order to increase the understanding of integration, the discipline of OM seems to be in need of further theory development as well as subsequent theory-based empirical research. Theory-based empirical research in the field would also set the ground for rigorous future work to achieve cumulative knowledge on integration in various other contexts as well, including the management of a global plant network.

1.3 RESEARCH PROBLEM AND OBJECTIVES

This research focuses on cross-functional integration of manufacturing. At the most general level, the research problem assessed in this dissertation can be stated as follows:

How to effectively integrate manufacturing with other functions?

More specifically, this research addresses such questions as: what are the effects of integration? Why is integration more important to some organizations than for others? Why does integration require more management effort in some organizations than in others? The research takes the information processing perspective to integration (Galbraith 1973, 1977). Effectiveness is perceived as external to the focal organization (Perrow 1967; Pfeffer & Salancik [1978] 2003), and refers to the rational goal approach (Cunningham 1977); an organization is effective when organized in a way to achieve the predetermined goals.

The general aim of this research is to gain a holistic understanding of cross-functional integration of manufacturing. In order to achieve this, research carried out in the fields of OM, organization theory (OT), contingency in particular, and general management is incorporated.[2] The research has three more specific objectives: (i) to clarify the concept of integration, (ii) to increase the understanding of the integration-performance relationship, and (iii) to increase the understanding of the antecedents of integration.

The justification for focusing on cross-functional integration in particular is threefold. First, Lawrence and Lorsch ([1967] 1986) suggest that differentiation in organizations is based on functional variety, which then creates a potential need for integration of the cross-functional type. Second, cross-functional integration has gained significant interest in the academic OM research and is considered to be of utmost importance to the OM audience.[3] Finally, theoretical work on integration has mainly been done in the cross-functional context (e.g., Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003), and hence it seems more apt to discuss these ideas in the OM context first in terms of cross-functional integration, and only after that broaden the discussion to other areas of integration.

Majority of the prior work on cross-functional integration has studied integration in the NPD context (e.g., Griffin & Hauser 1992; Song & Montoya-Weiss 2001; Swink 2000; Tatikonda & Montoya-Weiss 2001). The level of observation in these studies has often been the project. Although understanding integration at project-level is fundamental, Wheelwright and Clark (1995) suggest that success and failure of product development is driven by the functions of the organization, and how the functions work in the organizational level has an important influence on how they work in product development (see also Leonard-Barton, Bowen, Clark, Holloway & Wheelwright 1994). They also point out that "true cross-functional integration" occurs at the organizational level (Wheelwright & Clark 1992, p. 175), calling for an organizational level of analysis to complement the research at project level. In addition, Leonard-Barton et al. (1994) point out that a project's success depends on the organization, suggesting that the organizational context in which the project is conducted should not be ignored. Furthermore, integration mechanisms are mainly implemented at plant, rather than at

[2] This is called *bridging strategy* by Reisman (1988). Several scholars (Amundson 1998; Flynn 2008; Lovejoy 1998; Miles & Snow 2007) have encouraged the use of it in enhancing theoretical discussion in OM.

[3] Top-level academic OM journals, such as Production and Operations Management (Ho & Tang 2006), Management Science (Ho & Tang 2004), and International Journal of Production Economics (Whybark & Wijngaard 1994) have devoted special issues to integration of cross-functional type in particular.

project level. Therefore, this research takes an organization level of analysis to cross-functional integration.

Due to the interest in understanding the integration of manufacturing with other main functions, the unit of observation is a plant. Plants are considered as the proper unit of observation for this research because that is where manufacturing, but also other functional activities, take place: contemporary plants are no longer traditional factories but can be considered as complex technology centers where number of experts from different functional areas work (Ketokivi 2008). Furthermore, the analysis of goal achievement is most observable at plant level; business or corporate level goal achievement is dependent on the achievement of plant level goals, but affected by a number of other often uncontrollable factors. Although the unit of observation is the manufacturing plant, the actual unit of analysis is the dyad from manufacturing to another functional area (e.g., manufacturing - R&D, or manufacturing - marketing, see Figure 1-1).

1.4 APPROACH TO ORGANIZATIONS, EPISTEMOLOGY, AND METHODOLOGY

The phenomenon under investigation in this dissertation is the integration of organizational units, in particular functional units. Organizations are perceived as *rational open systems*. The rational perspective to organizations implies that goal orientation[4] and the formal structure[5] of the organization are emphasized, perceiving structure as a manipulable system to be modified to achieve effectiveness (Baum & Rowley 2002; Gouldner 1959; Lorsch & Lawrence 1972b; Scott 1998). Furthermore, the open system perspective implies that when assessing organizations, the primary attention is on the relationship of the organization with its environment (Baum &

[4] For a detailed analysis of the problem of defining the goals of an organization see Perrow (1961) and Simon (1946a).

[5] As a contradictory perspective, Blau and Scott (1962, pp. 2-8) suggest that it is impossible to understand the nature of a formal organization without also investigating the networks of informal relationships and unofficial norms, because the formally instituted and informally emerging patterns are inextricably intertwined.

Rowley 2002; Scott 1998). An open system is assumed to adapt to its environment, both affecting it as well as being dependent on it (Baum & Rowley 2002; Daft 2004; Joyce, McGee & Slocum 1997; Katz & Kahn [1966] 1978). Another fundamental feature of open systems is that the systems are seen to have subsystems and are themselves subsumed in larger systems, where movement in one part leads to movement in another (Katz & Kahn [1966] 1978; Scott 1998).

The existence of the organization is taken as given (cf. Pfeffer & Salancik [1978] 2003), and organization structure is seen as a fundamental vehicle for achieving rationality (cf. Kaplan & Norton 2001). From a normative perspective, Thompson ([1967] 2003, p. 4) suggests that rationality is more approachable when the organization has control over all the elements involved. Hence, under the assumption of rationality, organizations should try to turn themselves into closed systems which would enable them to pursue predetermined goals with formal structures. In the search for certainty, the *boundedly rational* (March & Simon [1958] 1993)[6] managers use organization design to seal off the subunits from the effects of uncertainty. Some parts of the organization, then, remain more open than others.

Despite the rational open system perspective to organizations taken in this research, another important issue still remains to be addressed: what is the nature of integration and how is it perceived? Is integration something we can observe to exist in organizations or is it a perception of the organizational member? How can we gain information about integration? These questions are related to the paradigmatic assumptions made in the research. A paradigm refers to a general perspective or way of thinking (Kuhn [1962] 1969) reflecting fundamental beliefs and assumptions about the nature of organizations. There are a number of different paradigms in the area of organization research, each of them with their own underlying assumptions.

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[6] *Bounded rationality* means that organizational members have limited capacity to gather and process information or estimate the consequences of different alternatives (March & Simon [1958] 1993). Hence, the purely rational criterion of "maximizing efficiency" is replaced by "satisficing", i.e. looking for a level of performance which is good enough (Cyert & March 1992). Thompson ([1967] 2003) suggests that the assumption of bounded rationality is consistent with the open-system view, but at the same time it also addresses performance and deliberate decisions which are important issues of the rational perspective.

Although some researchers in organization design (Donaldson 2003, 2005) have emphasized a strictly positivist paradigm as in natural sciences, this research follows *scientific realist* philosophy of science (Aronson 1984; McKelvey 1999, 2006; Raatikainen 2004; Van de Ven 2007)[7] and the functionalist paradigm[8] of organizational research (Burrell & Morgan 1979). Hence, the *ontological view*, referring to the very nature or the essence of a phenomenon being investigated and what really exists (Cohen & Manion 1994; Raatikainen 2004; Van de Ven 2007), is objective; organizations, and integration within them, are seen to exist as phenomena of the real world. Using the terminology and classification of Ghoshal and Gratton (2002), integration in this research refers to operational and intellectual integration. The focus is on rather formal ways of enhancing information processing in organizations instead of on emotional or social issues related to integration of organizational members.

Following the realist philosophy of science, the *epistemological standpoint*, referring to the methods for understanding the phenomenon and acquiring knowledge (Burrell & Morgan 1979; Cohen & Manion 1994; Niiniluoto 1980; Van de Ven 2007), of this research is subjective. Even though organizations and integration within them are perceived as real-life phenomena, the attempts to know and understand them are limited (Van de Ven 2007) and imperfect (Lincoln & Guba 2000), and depend at least to a certain extent on the researcher. Because of this, any given theoretical framework is only a partial representation of a complex phenomenon that reflects the perspective of the researcher. Science, then, is considered to progress cumulatively step by step (trial-and-error) to closer approximations of reality (Van de Ven 2007, p. 59).[9]

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[7] Hence, the thesis follows Van de Ven (2007, p. 37), who suggests that it is better to *choose* a philosophy of science than to simply inherit one.

[8] According to the classification of Burrell and Morgan (1979; Morgan 1980), different paradigms can be assessed in two dimensions: assumptions about the nature of social science (subjective-objective) and assumptions about the nature of sociology (regulation-radical change). This research follows scientific realist philosophy of science. Furthermore, this research makes the regulation assumption of the nature of society because of the focus on trying to understand the underlying characteristics of organizations rather than seeking explanations for radical changes in organizations, and hence it can be classified as belonging to the functionalist paradigm.

[9] This is in contrast to for example Kuhn ([1962] 1969) who perceives that the development of scientific knowledge is dependent on the paradigm agreed by the scientific community. Scientific knowledge is then developed in a cycle consisting of phases of normal science, crisis, and revolution (replacement of the old paradigm).

In order to increase the understanding of organizations existing in the real world, this research takes an *empirical approach* (Amundson 1998; Clegg & Hardy 1996; Flynn et al. 1990). It is considered that only with empirical observations can we try to fully understand integration in organizations. Empirical research is approached from the falsification perspective (Popper 1959); merely theories which are falsifiable are considered appropriate. The thesis follows a hypothetico-deductive research logic (e.g., Bacharach 1989; Camerer 1985; Niiniluoto 2000) and makes a distinction between the theoretical domain and empirical domain (Bagozzi 1984; Chimezie & Osigweh 1989; Malhotra & Grover 1998; Nunnally & Bernstein 1994). The process of this research is typical to research in the functionalist paradigm (Gioia & Pitre 1990). A theoretical framework is first constructed of the basis of prior research, and theoretical propositions are drawn from the framework. The propositions are then formulated into empirically testable hypotheses and tested with a large-scale data.

The data used to test the set of hypotheses in this study were collected by the survey research method as part of the third round of the High Performance Manufacturing (HPM) research project (previously World Class Manufacturing Project (for further details, see Schroeder & Flynn 2001)). The data collection took place in 2003-2006. The data are cross-sectional and include information about 236 manufacturing plants in three industries (electronics, machinery, and transportation) in eight countries (Austria, Finland, Germany, Italy, Japan, Korea, Sweden, and the United States). The data are analyzed with statistical methods, mainly with regression analysis.

1.5 INTENDED RESEARCH CONTRIBUTION

This research builds on the existing literature in the fields of OM and OT. The intended contribution of the dissertation is mainly, although not purely, for OM literature. The intended contribution is threefold, as described below.

First, majority of the previous empirical research on cross-functional integration in OM has mainly assumed that the importance of integration is universal, even though the results of empirical research assessing the effects of integration have not fully supported the assumptions. This research intends to provide an explanation for the mixed results by *clarifying the effects of integration efforts*. Multidimensionality of performance is emphasized; integration may be more beneficial for certain dimensions of performance than for others. Furthermore, although increased integration in decision making may mean better decisions (March & Simon [1958] 1993; Nutt 1976), the starting point of this research is that integration is always an investment posing various types of costs to the organization (Barki & Pinsonneault 2005; Ketokivi, Schroeder & Turkulainen 2006; McCann & Galbraith 1981; O'Leary-Kelly & Flores 2002; Porter 1985; Song & Xie 2000; Swink 1999), which are not to be disregarded. It is suggested that there are variations in the requirements for integration, and so, in different organizations the emphasis that is needed for the integration efforts to achieve higher performance varies.

Second, the research intends to *shed light on the antecedents of integration* by assessing variations in the requirements for integration across organizations, as well as by discussing and assessing the roots of integration requirements. Variations in the requirements for integration have rarely been discussed in prior OM research (except conceptually by Ketokivi et al. 2006). Furthermore, even thought the idea of variations in the need for integration arises from OT literature and the work of March and Simon ([1958] 1993), Lawrence and Lorsch ([1967] 1986) and Thompson ([1967] 2003), it has not been further elaborated or empirically assessed in the OT research either (the concept of requisite integration played only a theoretical role in the empirical investigations of Lawrence and Lorsch ([1967] 1986)).

Finally, this research intends to adopt the contingency theory in the OM context in a new way. Even though some scholars (e.g., Meyer, Tsui & Hinings 1993) see that the contingency theory is somewhat outdated, this research shares the view of for example Adler (1995) and Sousa and Voss (2008) in suggesting that it still has a lot to offer. This research applies *the intra-organizational variant of contingency theory* introduced by Lawrence and Lorsch ([1967] 1986) and Thompson ([1967] 2003) to the OM context. These arguments have seldom been applied in OM research. In addition, the theoretical arguments of this contingency theory variant have not been under systematic empirical investigation in general. Hence, the research intends to have some implications to OT as well.

1.6 STRUCTURE OF THE DISSERTATION

The structure of the dissertation follows the diamond model presented by Van de Ven (2007, p. 10) as illustrated in Figure 1-2 below and the basic structure of research in the functionalist paradigm as presented by Gioia and Pitre (1990, p. 593).

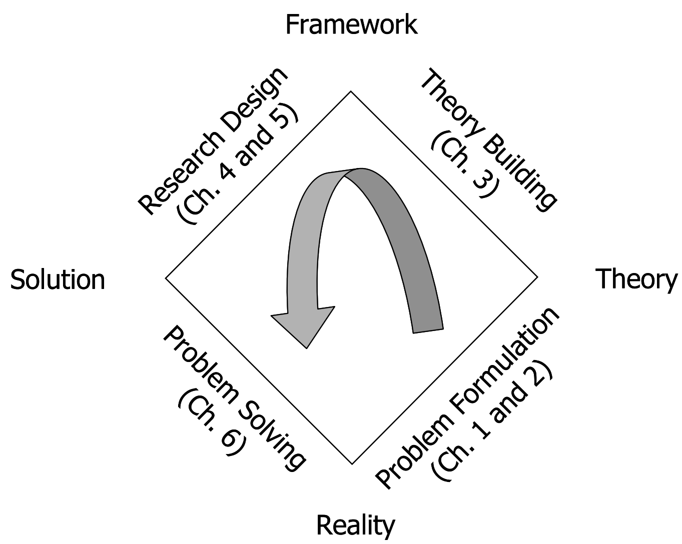

Figure 1-2. Structure of the dissertation

Chapter 2 *Integration Research* focuses on presenting the body of knowledge on cross-functional integration research in OM. The discussion and analysis of prior research point out areas where further research is needed. In addition, four different theoretical perspectives to address the identified research needs on cross-functional integration are presented and assessed, and the chosen perspective is introduced.

Chapter 3 *Theoretical Basis* provides the theoretical foundation of the research. The chapter culminates in the presentation of the theoretical framework to be assessed in the research.

Chapter 4 *Research Design* focuses on discussing issues related to the research methodology. The main focus of the chapter is on explaining the empirical data and measurements, as well as on assessing the issues of reliability and validity.

Chapter 5 *Hypotheses and Statistical Analysis* contains the main empirical part of the research. The theoretical framework (Chapter 3) is formulated into empirically testable hypotheses, which are then tested with empirical data (Chapter 4) using statistical analysis.

Chapter 6 *Discussion* contains an assessment of the present research. The results of the empirical analysis (Chapter 5) are discussed and evaluated in light of the results of prior research. Both theoretical contribution and practical implications are presented and the limitations of the present research are assessed. In addition, an agenda for future research is proposed.

CHAPTER 2
INTEGRATION RESEARCH

This chapter presents a literature review of integration research. The chapter is divided into two main sections. In the first section, I present the body of knowledge related to cross-functional integration in OM. The discussion proceeds step by step from a broader context of integration research to cross-functional integration of manufacturing. I draw together insights from the literature review and present gaps in the existing knowledge. In the second section, I focus on discussing the theoretical roots of integration research. I present different theoretical perspectives and discuss them in light of the identified research needs and the purposes of the present research. Based on the discussion, I suggest that the contingency theory would advance the understanding of integration for the purposes of the present research and provide an overview of its main ideas and focal concepts.

Echoing the perspective of the rational open system view to organizations (Scott 1998) and information processing scholars (Galbraith 1973; 1977), the dissertation adopts Galbraith's (1977, p. 3) definition of organizations:

> *"Organizations are composed of people and groups of people in order to achieve a shared purpose through a division of labor, integrated by information-based decision processes continuously through time."*

After defining the main task of the organization (i.e. the product or service that the firm offers as well as its design, creation, and distribution (Gerwin 1981; Lawrence & Lorsch 1967)), the design of organizations includes two fundamental and opposing decisions, which can be either formally or informally defined (Child 1977, p. 10; Katz & Kahn [1966] 1978, p. 104; Mintzberg 1983, p. 2):

1) division of tasks, and
2) integration or coordination.

The *division of tasks* and the resulting efficiency was introduced by the British economist Adam Smith in 1776[10] when discussing the division of labor in a pin factory (Smith [1776] 2005, Ch. 1). The division of tasks can be based on different dimensions, such as function, process, and knowledge (Mintzberg 1983; Simon 1946b), and at the top level it usually refers to the general form of organizing (e.g., functional, divisional, matrix, and networks (Daft 2004, pp. 99-116; Galbraith & Kazanjian 1986; Miles & Snow 1992)). *Integration or coordination*[11] refers to the management of activities that take place in various units and it is needed to accomplish the organization's overall task (Child 1977, p. 117; Galbraith 1973, p. 9; Mintzberg 1983, p. 2). Integration can be either vertical or horizontal (Galbraith 1973, 1994; Ghoshal & Gratton 2002; Mintzberg 1983; Porter 1985).[12] The division of tasks and the subsequent integration are related in the sense that different ways of dividing the tasks gives rise to different integration challenges (Allen & Gabarro 1972, p. 25). Furthermore, even though increased specialization enhances productivity, at least to a certain extent, it simultaneously increases the challenge of achieving integration. Most importantly, achieving integration is not cost-free but can be considered as an investment requiring significant managerial and financial resources (e.g., Galbraith 1973; Lawrence & Lorsch [1967] 1986). Organization design, then, is about finding a balance between the benefits of specialization and the costs of integration (Galbraith 1970, pp. 118-119; Thompson [1967] 2003, p. 64).

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[10] Adam Smith's work is considered fundamental to organization design research because of his realization of the benefits of specialization. In addition to the contribution of the work on organization design, partly due to the publication of Adam Smith's work, the year 1776 is considered to be the start of the industrial revolution (Sprague 2007).

[11] In this research the terms integration and coordination are used interchangeably.

[12] In the classical, universal model of organization design (e.g., works of Weber and Fayol), the division of tasks is highly specialized by nature, and it is expected that subgoals would add up to the overall goal of the organization. When problems occur, hierarchy is used to achieve integration within the organization. (Lorsch & Trooboff 1972).

2.1 REVIEW OF INTEGRATION RESEARCH IN OPERATIONS MANAGEMENT

In this section, I present the body of knowledge on cross-functional integration in OM. In the discussion, I proceed from a more general research on integration towards cross-functional integration from the manufacturing perspective in particular. I start by presenting definitions of integration, then discuss integration research in OM, positioning cross-functional integration in the field, and finally classify and analyze prior research on cross-functional integration from the manufacturing perspective. The section culminates in the explication of gaps in prior research and classification of research needs.

2.1.1 Definitions of Integration

Integration has an essential role in several disciplines in addition to OM, including general strategy (e.g., Miller 1986; Mintzberg 1979, 1983; Porter 1985), organizational theory (e.g., Barnard 1938; Lawrence & Lorsch [1967] 1986; March & Simon [1958] 1993), international business (e.g., Ghoshal & Bartlett 1990; Nohria & Ghoshal 1997; Rugman & Verbeke 2001), and organizational information systems (e.g., Giachetti 2004; Malone & Crowston 1994), each of which have their own perspective on and definition of the concept. Even though integration is central in many management areas, or perhaps because of it, the definitions of integration vary widely in the academic literature, not only across disciplines but also within one discipline. In the following, definitions of integration presented in both OT and OM literature are discussed.

Definitions of integration in the OT literature. In the OT literature, integration and coordination have been used somewhat interchangeably. The definitions vary drastically, in the words of Simon (1991, p. 39) “coordination is a rather slovenly word”. Despite the variations, the definitions of integration and coordination tend to share the idea of achieving the overall goal of the organization, thus avoiding sub-goal pursuit (March & Simon [1958] 1993). Lawrence and Lorsch ([1967] 1986) define integration as the quality of the state of collaboration that exists among departments that are required to achieve unity of effort, and the process of achieving that unity among the various sub-units. Van de Ven et al. (1976) use the term coordination, defining it as “integrating or linking together different parts of an organization to accomplish a collective set of tasks”. Some scholars (e.g., Cray 1984; Gulati, Lawrence & Puranam

2005; Simon 1991), on the other hand, make a clear distinction between integration and coordination. Cray (1984) divides integration into coordination and control, perceiving coordination as a pure lateral integration activity, whereas control refers to vertical integration. Gulati et al. (2005) and Simon (1991), on the other hand, suggest that integration (as defined by Lawrence and Lorsch ([1967] 1986)) can be divided into coordination and cooperation. They point out that even though coordination and cooperation are clearly distinct, the distinction is rarely recognized in the literature. Coordination refers to the alignment of actions, which is needed due to the lack of shared knowledge and understanding of for example decision rules that others are likely to use. Cooperation, on the other hand, refers to the alignment of interests, which is needed because of the self-interest of organizational members.

Using the terminology of Gulati et al. (2005), coordination can be linked to perceiving organizations as information processing systems (e.g., Egelhoff 1982, 1988, 1991; Galbraith 1970, 1972, 1973, 1977; Joyce et al. 1997; Nadler & Tushman 1997; Tushman & Nadler 1978; Walton & Dutton 1969).[13] Information processing refers to gathering, interpreting, and synthesizing information in the context of organizational decision-making (Tushman & Nadler 1978). The information processing perspective considers that conflict and sub-goal pursuit in an organization arises due to lack, error, ambiguity, or asymmetry of information requiring coordination. Cooperation, on the other hand, can be linked to the behavioral perspective to organizations (e.g., Barnard 1938; Lorsch & Morse 1974; Ouchi 1980; Pelled & Adler 1994; Simon 1991), which assumes that organizational members are driven by personal motives or even opportunistic behavior. Rather than the lack or asymmetry of information, the behavioral perspective suggests that differences in members' personal motives are the source of sub-goal pursuit requiring cooperation.

Definitions of integration in the OM literature. In OM, scholars have presented various definitions for integration as well as various labels for the underlying idea of achieving the common purpose of the organization in different contexts. This has also

[13] The information processing perspective has received wide attention across disciplines and research problems, and has been used in different contexts, including manufacturing (Flynn & Flynn 1999), supply chains (Bensaou & Venkatraman 1995; Kaipia 2007), MNCs (Egelhoff 1988; Egelhoff 1993), competitive strategy (Smith, Grimm, Gannon & Chen 1991), and global sourcing (Trautmann, Turkulainen & Hartmann 2007).

led to differences in the operationalization of integration in empirical studies. Majority of the previous OM literature seems to perceive integration as an information processing phenomenon, some including both perspectives (e.g., Leenders & Wierenga 2002), although definitions and operationalizations of integration have not always been presented in prior research (see Appendix A for details).

At a higher level, the definitions of integration in the existing OM literature can be divided into (i) integration as an outcome or a state of the organization and (ii) integration as a process for achieving an outcome, the latter of which seems to be more typical. First, *integration as an outcome* refers to a state of the organizational interface or the extent or magnitude of coordination and has been defined for example as the extent to which separate parties work together in a cooperative manner (O'Leary-Kelly & Flores 2002), the degree of coordination, interaction, communication, and information sharing (Song & Montoya-Weiss 2001), or a state of syncretism (Das, Narasimhan & Talluri 2006).

Second, *integration as a process* has been defined in various ways. For some scholars the integration process refers to developing linkages between organizational units (e.g., Adler 1995; Koufteros et al. 2005; Oliff, Arpan & DuBois 1989), or collaboration and interaction across organizational units (e.g., Pagell 2004). Some authors, on the other hand, explain integration through the concept of information, perceiving integration as the flow or processing of information and knowledge (Koufteros, Vonderembse & Doll 2001; Koufteros, Vonderembse & Doll 2002; Swink et al. 2007). Collaboration differs from information flow in that it forces working together and sharing resources, whereas integration as information flow can be criticized because frequent communication does not guarantee the exchange or processing of useful information. Finally, some scholars use very broad conceptualizations including aspects of coordination, collaboration, cooperation, and information processing (e.g., Kahn & McDonough 1997b; Kahn & Mentzer 1998; Pinto et al. 1993; Swink 1998).

Finally, some define *integration both as a process and as an outcome*. For example, Song et al. (1997) perceive integration as a process of achieving effective unity of efforts as well as the level of cross-functional interaction, communication, information sharing, coordination, and level of joint involvement.

This research follows the definition presented by Lawrence and Lorsch ([1967] 1986). Integration is perceived as both the state of unity in effort in the actions of various subunits, as well as the process of achieving that unity. Integration is approached mainly as an information processing phenomenon. Hence, sub-goal pursuit is perceived to occur due to a lack and asymmetry of information or an inability to process information rather than due to organizational members' personal motives and opportunistic behavior. The multidimensionality of the concept of integration is emphasized, and the varying aspects of it are further discussed in Section 3.1.1. In the following, the discussion proceeds from the definition of integration to how integration of organizations or organizational units has been studied in OM.

2.1.2 Classification of Integration Research

Integration of organizational units or organizations as a topic is highly relevant for OM scholars in several different areas, as the discussion below suggests.[14] In the following, a classification of integration research in OM is presented focusing on the organizational units or organizations to be integrated. The point is to position cross-functional integration in the broad context of integration research in OM. Following the classification of Pagell (2004) and Barki and Pinsonneault (2005), integration studies are divided into external and internal integration.

External integration refers to integration of organizations with formal boundaries. In the OM context it concerns supply chain integration both upstream with suppliers and downstream with customers. The idea of supply chain integration is to incorporate information and inputs from external parties to internal planning (Frohlich & Westbrook 2001). A distinction can be made on the basis of the level and primary intent of integration activities (Swink et al. 2007): (i) operational supply chain integration referring to a set of activities mostly concerned with better coordination of daily or short-term flows, including transactions, material movements, and ordering processes or (ii) strategic supply chain integration referring to a collaborative, long-term joint development activity. The context of the research on external integration is often the

[14] The discussion here focuses on the integration of organizations or organizational units, which within the context of this research is referred to as "organizational integration". In addition to organizational integration, integration has been discussed in OM also for example in the NPD context across development projects (e.g., Verma & Sinha 2002).

NPD process (e.g., Fine 1998; Koufteros et al. 2005; Spina, Verganti & Zotteri 2002) but also general operations (e.g., Bensaou & Venkatraman 1995).

Internal integration refers to the integration of various organizational units within one firm. Four distinct types of internal integration can be identified: (i) strategic integration, (ii) cross-functional integration, (iii) internal supply chain integration, and (iv) integration within a function. *Strategic integration* comprises the alignment of the goals and actions of operations (or functional unit in general) or an operational sub-function, such as purchasing, with the corporate and business unit (Hayes & Wheelwright 1984; Narasimhan & Das 2001; Skinner 1969; Swink et al. 2007).

Significant attention in OM literature has been given to *cross-functional integration*[15, 16] of R&D, manufacturing, marketing, which is considered as a prerequisite for strategic integration (Whybark 1994). Cross-functional integration has been studied at several different levels of analysis in OM varying from the firm/business unit (e.g., O'Leary-Kelly & Flores 2002; St. John et al. 1999) to the plant level (e.g., Sherman 2004; Swink et al. 2007) and further to the project team level (e.g., Gittell 2002; Pinto et al. 1993; Song & Montoya-Weiss 2001), as well as to the context of international operations (Kahn & McDonough 1997b; St. John et al. 1999). In addition to integration of major business functions, also integration of operational sub-functions, such as purchasing, manufacturing, and logistics, referring to *internal supply chain integration*, has been studied (Das et al. 2006; Pagell 2004).

Finally*, integration within one function* encompasses for example integration of geographically dispersed manufacturing units, including the transfer of manufacturing

[15] Some scholars (e.g., Sherman, Souder & Jenssen 2000) perceive that cross-functional integration involves also R&D-supplier integration or strategic alliances. In this research, these types of integration are, however, considered as external integration because their focus is on activities that cross the formal boundaries of firms.

[16] The terminology used in prior research is somewhat confusing. The term cross-functional integration used in this research is not to be considered equivalent to the functional organizational integration of Barki and Pinsonneault (2005), which they define as the integration of administrative and support activities of an organization's process chain, e.g. human resources and accounting. The cross-functional integration within the context of this research refers to Barki and Pinsonneault's (2005) operational integration. However, in OM, operational integration often refers to integration regarding detailed manufacturing information on a daily basis, whereas strategic integration refers to sharing strategically important information and coordination of strategically important issues (e.g., Swink et al. 2007). Hence, in Barki and Pinsonneault's terminology this research focuses on operational integration but in Swink's (2007) terminology it focuses on strategic cross-functional integration.

practices from one plant to another within the international manufacturing plant network of a firm (e.g., Brush, Maritan & Karnani 1999; Cohen & Mallik 1997; Ferdows 1989, 1997; Maritan & Brush 2003; Oliff et al. 1989; Schmenner 1979, 1982). As another example, integration within the manufacturing function also takes place in the context of integrated manufacturing technology (e.g., Dean & Snell 1991, 1996).

Figure 2-1 below illustrates the different types of integration research in OM.

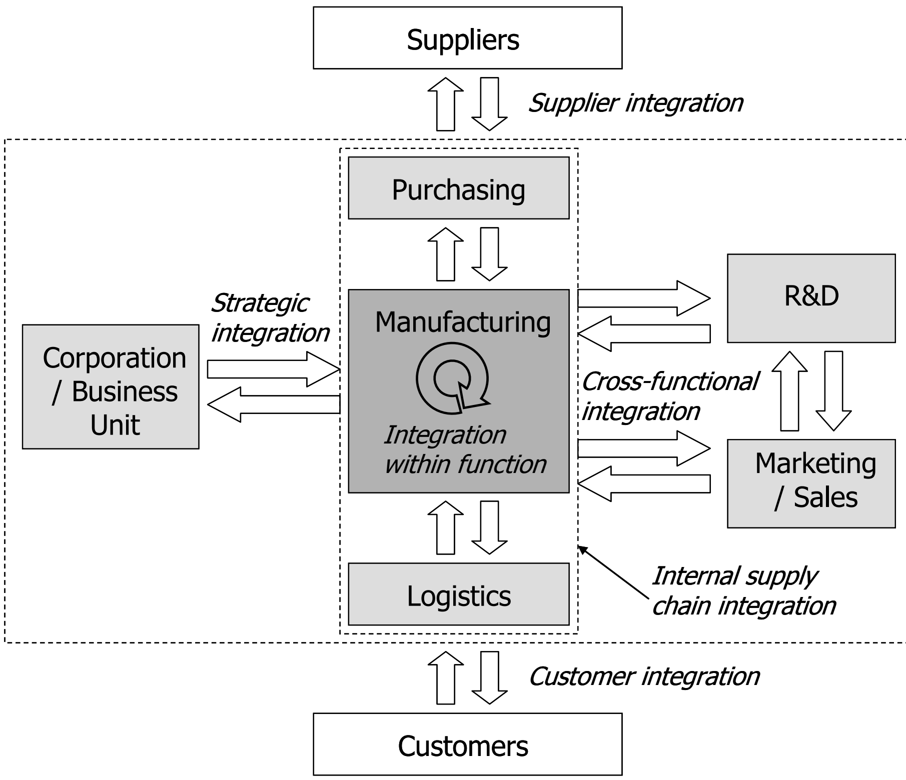

Figure 2-1. Different types of integration studied in the OM context

Table 2-1 presents a classification and summary of different types of integration research in the OM context. Some example references are also included. The classification takes an organization design perspective and hence, the focus of the classification is on the organizations to be integrated.

Table 2-1. Classification of integration research in OM context and example references

Type of Integration	Focus	Example references
External integration		
Supply chain integration	Customer integration	Bagchi & Skjoett-Larsen (2002) Bajaj et al. (2004) Cigolini et al. (2004)* Frohlich & Westbrook (2001)* Hoover et al. (2001)* Narasimhan & Kim (2002)* Swink et al. (2007)* Vachon & Klassen (2008)*
	Supplier integration	Cigolini et al. (2004)* Clark (1989) Cousins & Menguc (2006) Das et al. (2006)* Fine (1998) Frohlich & Westbrook (2001)* Hoover et al. (2001)* Koufteros et al. (2007) Narasimhan & Kim (2002)* Spina et al. (2002) Swink et al. (2007)* Vachon & Klassen (2008)*
	General supply chain integration	Vickery et al. (2003)
Internal integration		
Strategic integration	Manufacturing	Swink et al. (2007)* Skinner (1969; 1996) Hayes & Wheelwright (1984)
	Purchasing	Narasimhan & Das (2001)
Cross-functional integration	Manufacturing-R&D	Adler (1995) Ettlie (1995) Droge et al. (2004)* Nihtila (1999) Swink & Calantone (2004) Vandevelde & Van Dierdonck (2003)
	Manufacturing-marketing	Calantone et al. (2002) Kahn & McDonough (1997b) Kahn & Mentzer (1998) O'Leary-Kelly & Flores (2002) Sawhney & Piper (2002)
	R&D-marketing	Gupta et al. (1986) Maltz et al. (2001) Song & Parry (1992; 1993) Song & Dyer (1995) Souder et al. (1998) Workman (1995)

(Table 2-1 continued)

TYPE OF INTEGRATION	FOCUS	EXAMPLE REFERENCES
Cross-functional integration	General	Koufteros et al. (2001) Koufteros et al. (2005)* Swink (1998)
	Internal supply chain integration	Das et al. (2006)* Pagell (2004) Rosenzweig et al. (2003)
Integration within one function	Geographically dispersed manufacturing units	Brush et al. (1999) Cohen & Mallik (1997) Ferdows (1989; 1997) Oliff et al. (1989) Schmenner (1979; 1982)
	Within operations	Flynn & Flynn (1999)
	Within R&D	Allen et al. (1979) Verma & Sinha (2002)
INTERACTION OF EXTERNAL AND INTERNAL INTEGRATION		
		Droge et al. (2004)* Gimenez & Ventura (2005) Koufteros et al. (2005)*

* The article appears in more than one category.

Although external and internal integration have been studied also simultaneously (e.g., Droge et al. 2004; Koufteros et al. 2005), they are considered conceptually distinct. An exception of this is global sourcing, the concept of which includes simultaneously both international integration of purchasing units located across the world and cross-functional integration of purchasing, manufacturing, and logistics (Monczka & Trent 1991; 2003; Trent & Monczka 2003).

In the following section, the discussion proceeds from organizational integration research in OM to cross-functional integration of manufacturing with other major functions, which is the focus of this research.

2.1.3 Research on Cross-functional Integration of Manufacturing[17]

Background and context. A vast majority of the research on cross-functional integration in OM has focused on manufacturing-R&D (e.g., Adler 1995; Ettlie 1995; Swink & Calantone 2004), manufacturing-marketing (e.g., O'Leary-Kelly & Flores 2002; Sawhney & Piper 2002), and R&D-marketing (e.g., Griffin & Hauser 1996; Gupta et al. 1986; Leenders & Wierenga 2002; Maltz et al. 2001; Song & Dyer 1995; Song, Neeley & Zhao 1996; Song & Parry 1993) interfaces (notable exception is Pagell, Handfield, and Barber (2000) who studied the integration of human resources and manufacturing in the adoption of advanced manufacturing technology (AMT)). Some have studied several dyads simultaneously (e.g., Kahn & Mentzer 1998; Song & Montoya-Weiss 2001) or cross-functional integration in general without specifying the focal interface (e.g., Koufteros et al. 2001; Sherman 2004; Song & Xie 2000; Swink 1999). There is a great body of literature related to the manufacturing-R&D and manufacturing-marketing dyads (cf. O'Leary-Kelly & Flores 2002; Swink & Song 2007), although research on manufacturing-marketing has clearly dominated the research stream until the end of the 1990s.

The *integration of manufacturing and R&D* has mainly, although often implicitly, built on the ideas of Hayes and Wheelwright (1984) and has to great extent focused on integration in the NPD context (e.g., Adler 1995; Ettlie 1995; Koufteros et al. 2002; Nihtila 1999; Swink & Calantone 2004). Hence, the level of analysis has often been the individual NPD project and the research has for example looked at the effects of design-manufacturing integration on new product development performance. Cross-functional integration of manufacturing and R&D has been approached in the existing literature also under the concepts of concurrent engineering (CE)[18], product-process integration, and design-for-manufacturability (DFM).

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[17] Cross-functional integration has also been approached analytically (e.g., AitSahlia, Johnson & Will 1995; Albino, Pontrandolfo & Scozzi 2002; Loch & Terwiesch 1998). Although the analytical studies provide information about integration, the following literature review focuses on empirical and conceptual papers due to the empirical focus of the present research.

[18] Concurrent engineering is defined in this research as a practice including concurrent work-flows, product development teams, and early involvement of different functional units (Koufteros et al. 2001). Some researchers (e.g., Gerwin & Susman 1996), however, include also external integration with suppliers in the concept of concurrent engineering.

Mainly building on the work of Shapiro (1977), *integration of manufacturing and marketing* has taken both manufacturing (e.g., O'Leary-Kelly & Flores 2002; Sawhney & Piper 2002) and marketing (e.g., Kahn & McDonough 1997b; Kahn & Mentzer 1998) points of view, and has mainly focused on integration in the context of daily operations, such as forecasting and production planning.[19, 20] Manufacturing-marketing integration has often taken a firm or plant level of analysis and studied integration for example in ETO firms (Konijnendijk 1994), ATO firms (Erens & Hegge 1994), JIT firms (Spencer & Cox 1994), and in the international context (Kahn & McDonough 1997b; St. John et al. 1999).

Finally, *cross-functional integration in general* (referring to integration of functional units without specifying the focal interface under investigation) has mainly been studied in the NPD context taking a project-level of analysis. Several researchers have approached it within the concept of concurrent engineering (Koufteros et al. 2001; Swink 1998).

In the following, prior research on cross-functional integration from the manufacturing point of view is analyzed and classified. Rather than focusing on the specific functional dyads under analysis like above, the focus of the classification is on the treatment of the integration construct. This is considered important in terms of the major aim of the research to create a holistic understanding of integration.

Classification and evaluation of prior research. The prior OM research on cross-functional integration can be divided into three categories based on the *focus of the research*; whether integration is treated as an exogenous or endogenous variable. Studies treating integration as an exogenous variable focus on discussing and assessing the effects of cross-functional integration (Type 1). Studies treating integration as an endogenous variable, on the other hand, focus on discussing and assessing the antecedents of integration, including drivers for cross-functional integration and conditions under which it is emphasized to a greater extent or under which it is more

[19] A special issue was dedicated to the manufacturing-marketing integration from the operations perspective in the International Journal of Production Economics in 1994 (Whybark & Wijngaard 1994), as well as in Management Science in 2004 (Ho & Tang 2004).

[20] For a thorough literature review on the research on integration of manufacturing and marketing, see Parente (1998).

critical (Type 2). The third category (labeled as "other", Type 3) refers to studies discussing cross-functional integration but not directly assessing the effects or the antecedents of it.

In Table 2-2 below, the prior research is classified according to the dimensions presented above supporting the general aim of the research to form a holistic understanding of integration in the cross-functional context. In addition to the general focus of the prior research, different studies make different assumptions regarding integration. This is a crucial distinction especially for studies focusing on the effects of integration. The underlying assumptions can be divided into a universalist perspective or a contingency perspective. The studies representing the universalist perspective somehow consider the benefits and the subsequent importance of integration universal; integration is perceived to have purely positive effects. The contingency perspective, on the other hand, builds on the idea that integration requires resources; there might be situations and conditions where the costs outweigh the benefits, or at least situations in which integration is more beneficial. Hence, the contingency theory perspective suggests that it cannot be assumed that integration always leads to equal positive effects, but it can be more important and relevant under certain conditions. It is important to note that assessment of the antecedents of integration (Type 2) necessarily leads to a contingency perspective.

Comparison of studies of Type 1 and Type 2 shows that a majority of the prior research has focused on assessing the effects of integration. Type 3 studies, on the other hand, have mainly focused on discussing integration in general and have not directly addressed either the effect of integration on performance or the antecedents of integration. Studies of Type 3 are included in the table because they are related to the research problem at hand, although not of further interest.

Table 2-2. Previous research on cross-functional integration of manufacturing

FOCUS OF RESEARCH	
The effects of integration (Type 1)	
Universalist perspective	
Bergen & McLaughlin (1988)	Parente et al. (2002)
Droge et al. (2004)	Pinto et al. (1993)
Eisenhardt & Tabrizi (1995)	Rho et al. (1994)
Ettlie (1995; 1997)	Rusinko (1999)
Ettlie & Reza (1992)	Sawhney & Piper (2002)
Griffin & Hauser (1992)	Sherman et al. (2000)
Haddad (1996)	Song & Parry (1997)
Hausman et al. (2002)	St. John & Rue (1991)
Hull et al. (1996)	Swink (1999; 2002)
Kahn & McDonough (1997a; 1997b)	Swink & Nair (2006)
Kahn & Mentzer (1998)	Swink et al. (2005; 2007; 2006)
Moffat (1998)	Swink & Song (2007)
Nahm et al. (2003)	Takeuchi & Nonaka (1986)
Narasimhan et al. (2005)	Tan & Vonderembse (2006)
Pagell (2004)	Vandevelde & Van Dierdonck (2003)
Contingency perspective	
Ketokivi & Schroeder (2004a)	O'Leary-Kelly & Flores (2002)
Koufteros & Marcoulides (2006)	Song & Montoya-Weiss (2001)
Koufteros et al. (2005)	Song & Xie (2000)
Krohmer et al. (2002)	Swink (2000)
Liker et al. (1999)	Tatikonda & Montoya-Weiss (2001)
Antecedents of integration (Type 2)	
Contingency perspective	
Adler (1995)	Rondeau et al. (2000)
Barki & Pinsonneault (2005)	Sherman (2004)
Ketokivi et al. (2006)	Song et al. (1997; 1998)
Konijnendijk (1994)	St. John et al. (1999)
Koufteros et al. (2001; 2002)	Swink & Calantone (2004)
Olson et al. (2001)	
Other integration research (Type 3)	
Universalist perspective	
Calantone et al. (2002)	Hahn et al. (1994)
Erens & Hegge (1994)	Nihtila (1999)
Ettlie & Reifeis (1987)	Nemetz & Fry (1988)
Ettlie & Trygg (1995)	Shapiro (1977)
Gerwin (1993)	Swink (1998)
Contingency perspective	
Spencer & Cox (1994)	Whybark (1994)
Wheelwright & Clark (1992)	

A more detailed summary of previous research on cross-functional integration is presented in Appendix A. Table in Appendix A also includes details about the focal context of the prior research. In the following, some examples of prior research are discussed, offering more insight into the studies presented in Table 2-2 above. The discussion follows the distinction made between research focusing on the effects of integration (Type 1) and research focusing on the antecedents of integration (Type 2).

Studies on the effects of integration. Droge, Jayaram, and Vickery (2004) represent a typical type of study in the field taking a universalist perspective to integration. Droge et al. (2004) assess the effect of operational manufacturing-R&D integration (in addition to supplier integration) on time-based performance measures of time-to-market, time-to-product, responsiveness, and firm performance. The data were collected in 57 first-tier suppliers of the Big Three automotive firms in the USA at SBU level. The results suggest that integration has a positive direct effect on the financial performance, as well as an indirect effect through time-based performance. Linking internal integration to financial performance of the firm, however, is somewhat questionable due to the number of other factors affecting it. In addition, the results need to be interpreted with caution because of the potential specific characteristics related to the single industry in focus.

Other typical studies of Type 1 taking a universalist perspective to integration include Kahn and McDonough (1997b) and Kahn and Mentzer (1998). They investigate the effect of manufacturing-marketing integration (in addition to marketing-R&D integration) on an overall performance measure (which includes for example department and product development performance). Integration is defined and subsequently operationalized in two ways: as information flow (interaction) or as collaboration and coordination. The underlying assumption in the research is that integration has a universal positive effect on performance. The data were collected from managers in electronics firms headquartered in the USA, Europe and Far East. Both studies report a strong positive effect of collaboration and coordination on performance, whereas interaction was not found to have any significant effect on performance. This can indicate that too much interaction is detrimental, pointing to the direction that greater emphasis on integration efforts is not always better due to its costs, but the authors do not investigate this further. The results also point out that the way how integration is defined and operationalized has a significant effect on the empirical results.

Taking a contingency perspective to integration, O'Leary-Kelly and Flores (2002) assess the moderating effect of business strategy and demand uncertainty on the relationship between manufacturing-marketing integration and performance (perceptual profitability). The data were collected in 121 firms in the central USA in primary metal, fabricated metal, industrial machinery and equipment, and transportation industries. The results suggest that both business strategy and demand uncertainty have a moderating effect on the relation between integration and performance, implying that under certain conditions integration is more important in terms of performance. In a similar vein, St.John, Young, and Miller (1999) discuss the effect of international strategy on the interdependence and conflict between manufacturing and marketing. Their data were collected by a survey from manufacturing and marketing managers in 48 firms in a number of industries. Contrary to the results of O'Leary-Kelly and Flores (2002), St.John et al. (1999) do not report international strategy to affect the relationship between marketing and manufacturing. Even though both papers are important as they propose that the relationship between integration and performance is not direct but affected by some contingency variables, the theoretical argument for using business or international strategy as a contingency for the relationship is missing.

Studies on the antecedents of integration. Adler (1995) discusses the integration mechanisms between manufacturing and R&D in the NPD context at project level, proposing a taxonomy of mechanisms and developing a set of hypotheses as to which mechanism is the most efficient one for dealing with the different types of integration challenges. The data represent 13 organizations in the industries of printed circuit boards for electronics components and hydraulic tubing for aircrafts. The paper is very interesting especially theoretically, as the author suggests that the degree and type of interdependence between departments, the intensity of their interaction, as well as the integration mechanisms change over time and the life cycle of the project, which was ignored by earlier researchers. Adler (1995), however, does not discuss when integration is needed, although his theorizing about when to use different integration mechanisms is a significant contribution to the field.

Song et al. (1998) assess the integration of manufacturing, R&D, and marketing and suggest that beneficial integration efforts vary in terms of the particular interface and stage of the NPD process. The authors pose very important questions such as do all functions need to be simultaneously involved in every NPD stage? For a given pair of functions, is their joint involvement equally important across all NPD stages? The data were collected from 236 managers working in the R&D, manufacturing, and marketing departments of 16 Fortune 500 firms. The findings suggest that new product success may be more likely when a firm employs function-specific and stage-specific patterns of cross-functional integration than it is when the firm attempts to integrate all functions during all NPD stages. Further on, the authors found that at some stages of the NPD process, cross-functional integration can have counterproductive performance effects. Interestingly, the authors present a theoretical explanation for their mixed findings and suggest that there are differences in the nature of the task and in the type and the level of interdependence but they do not investigate these further.

In another theoretically interesting paper, Sherman (2004) investigates the level of manufacturing-R&D integration, hypothesizing that a fit between integration requirements and the institution of optimal modes and levels of integration will result in optimal patterns of information processing. The data were collected at three time intervals from engineers and scientists working in 24 Department of Defense project offices and laboratories. Even though the optimum level of integration that Sherman (2004) claims to address would be theoretically highly interesting and a significant contribution, the author does not actually study it. In the paper, optimal integration is measured as the overall use of integration mechanisms, and thus greater use of integration mechanisms is considered more optimal. This paper further indicates that the varying level in the need for integration has not been understood before.

Finally, Koufteros et al. (2001) assess the use of concurrent engineering practices (cross-functional integration, early involvement and simultaneous work) in different environments and its consequences in terms of product innovation, quality and premium pricing in the NPD context. They suggest that firms face uncertainty and equivocality and they have to adopt organization design that is efficient in both acquiring and processing additional information, as well as in processing rich information. The data were collected with a mail survey from 244 respondents in firms in various industries.

The results suggest that CE practices have a significant positive effect on product innovation but not on quality or premium pricing. The results further indicate that firms in high change environments adopt higher levels of CE practices. Later on, Koufteros et al. (2002) have assessed the effect of concurrent engineering and use of computers in NPD process on product innovation and quality, and further on premium pricing and profitability with the same data. Integration was not found to have an effect on computer use or product innovation but on quality. Firms in high uncertainty and equivocality environments were found to adopt higher levels of integration although highly integrated firms even in low uncertainty and equivocality environments enjoyed higher levels of performance, thus questioning the role of uncertainty as a contingency variable to the integration-performance relationship.

Conclusion. As is evident in Table 2-2 above, prior OM research on cross-functional integration is dominated by empirical studies focusing on assessing the effects of integration on performance (Type 1). A majority of these studies adopt a universalist perspective to integration, taking the benefits of integration for granted. Recently, some scholars have emphasized the contingency perspective to integration. These studies suggest that the integration-performance relationship is affected by for example the level of uncertainty (Koufteros et al. 2005; Song & Montoya-Weiss 2001), product innovativeness (Song & Xie 2000), and strategy (O'Leary-Kelly & Flores 2002), indicating that integration is more valuable in terms of performance under certain conditions. The underlying assumption in the contingency studies is that there are costs in achieving integration; more emphasis on integration does not necessary always lead to higher performance. In addition, some scholars (e.g., Swink et al. 2007; Swink & Song 2007) have pointed out the limitation of prior research addressing the effects of integration. Interestingly, they have suggested that there are costs related to integration and possible trade-offs, but still take a universalist perspective to integration in their empirical analyses. These ideas are considered very important especially as the results of the empirical assessments of integration-performance relationships are somewhat mixed; some scholars have found that integration has a positive effect on performance while others have found no effect at all and some have found a negative effect. For example, Song et al. (1998) found that the effect of manufacturing-R&D-marketing integration in the NPD context has both positive and negative effects on NPD effectiveness and efficiency and Swink and Song (2007) report that manufacturing-marketing integration in NPD context leads to longer project lead time (for further details, see Appendix A). Very few studies have directly assessed the antecedents of integration (Type 2): when is integration of functions needed or more important and why?

2.1.4 Insights from Prior Research and Research Needs

The purpose of this section is to draw together the insights on cross-functional integration gained from prior research.

First, it seems that the concept of integration is not well defined; there seems to be no consistency in what the nature of integration really is. Subsequently, scholars have used various operationalizations of integration in empirical research, operationalizing integration either as an outcome or as a process leading to highly diverse empirical assessments of the concept.

Second, the prior research on the effects of integration is somewhat diverse; the research can be characterized by empirically examining the effect of cross-functional integration on various dimensions of performance. In the investigations, scholars have used numerous performance dimensions, such as financial measures (Kahn & McDonough 1997b; O'Leary-Kelly & Flores 2002), competitive advantage (Swink & Song 2007), customer satisfaction (Parente et al. 2002), time-based performance measures (Droge et al. 2004; Ettlie 1995; Swink et al. 2007), and manufacturability in the NPD context (Swink 1999) depending somewhat on the level of observation. Scholars have in a somewhat oversimplified way assumed that if cross-functional integration is to affect performance positively, it has a positive effect on *all* dimensions of performance at different levels of analysis (i.e. project level, plant level, and at company level). However, linking for example cross-functional integration at project level to financial performance, especially at corporate level, is not warranted because the link is not direct, and corporate level performance is affected by a number of other factors.

Finally, despite the focus of prior research on assessing the performance effects of integration, the prior research has paid little attention to the potential costs of integration. The benefits of integration have mainly been taken for granted, as Pagell's (2004, p. 459) statement "the importance of integration is not in doubt". Wheelwright and Clark (1992, p. 175) are some of the few authors to argue that even in the NPD project, the OM context most emphasized for the benefits of cross-functional integration, "deep cross-functional integration" is not always needed. In addition, also Swink (1999; 2000) points out that cross-functional integration might not be always needed in the NPD project. In the research at hand it is argued that integration is an investment, and the costs of achieving integration might outweigh the benefits or at least significantly reduce the value of integration. And thus, much like specialization, integration can be pushed too far (Katz & Kahn [1966] 1978). Ignoring the costs of integration is dangerous, especially when the requirements for integration are not significant. Although it is likely that an integrated organization outperforms a non-integrated one, it is not appropriate to overlook the costs that the integrated firm has faced in the integration efforts. Integration must always be viewed as an investment and commitment of resources that could be allocated to other productive use as well.

Based on the discussion above, more research is clearly needed on the following areas:

- There is a need to clarify *the concept of integration* due to the lack of consistency in defining it and, subsequently, lack of consistency in operationalizing integration in empirical studies.

- There is a need to clarify *the relationship between integration and performance* in order to understand the theoretical explanation for the relationship between integration and performance.

- There is a need to clarify *when and why firms should emphasize cross-functional integration efforts,* due to the lack of research on the antecedents of integration, especially as it is argued that the costs of achieving integration are significant and cannot be overlooked.

Thus, there remains a clear need for more theory-based empirical research on cross-functional integration in OM. In the following section, different theoretical perspectives underlying the integration research are presented. Even though the different perspectives address the same phenomenon, they clearly make very different assumptions. The theoretical perspectives are discussed in light of the research problem of the present research and the identified research gaps.

2.2 TRACING THE THEORETICAL ROOTS OF INTEGRATION RESEARCH

This dissertation calls for a theory-based empirical research on cross-functional integration. In the previous section I discussed how integration has been studied in OM. In this section, the focus turns to the theoretical roots of the prior research. I present different theoretical perspectives that could be taken in integration research and discuss them in light of the research problem and identified research needs. Based on the discussion, I conclude that in particular contingency theoretical arguments would increase the understanding of cross-functional integration in terms of the purposes of the present research. I also introduce the focal issues of contingency theory. It is important to note that I do not argue that one of the perspectives is somehow better or superior to the others; I argue that the perspectives are different and subsequently differ in terms of how informative they are for different purposes.

2.2.1 Theoretical Perspectives in Prior Research on Cross-functional Integration

Like the perspectives to organization design in general vary, so do the theoretical roots of integration research. Especially interesting for the purposes of this research are theoretical perspectives that address the issues of *when* and *why* organizations engage in cross-functional integration efforts and how integration is related to operational performance. There are at least four theoretical perspectives to the topic: (i) economic efficiency, (ii) institutional efficiency, (iii) institutional legitimacy, and (iv) contingency theory.[21] These are discussed briefly in the following in terms of the underlying assumptions and central arguments, as well as in terms of how they would advance the understanding related to the research problem at hand.

Building on the economic rationality argument, the *economic efficiency* perspective perceives integration efforts as a way of achieving economic efficiency. The economic efficiency perspective assumes that there are both costs and benefits related to integration efforts, and managers are perfectly aware of them. According to the economic efficiency perspective, organizations should engage in integration efforts simply when the benefits are greater than the costs (e.g., Pagell 2004).

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[21] For a thorough explanation of different theoretical arguments and their assumptions, see Ketokivi et al. (2007).

The *institutional efficiency argument*, on the other hand, builds on the bounded rationality argument (March & Simon [1958] 1993); managers are not perfectly aware of the benefits or costs of integration efforts. Because of bounded rationality, the institutional efficiency argument assumes that integration brings economic benefits even in the absence of direct empirical evidence (Ketokivi & Schroeder 2004c). For example, lean manufacturing practices were partly adopted for institutional efficiency reasons; following the success of Toyota, many firms implemented lean manufacturing practices before their link to economic benefits was established (Ketokivi & Schroeder 2004c). The institutional efficiency argument takes the benefits of integration for granted, suggesting that organizations should always engage in integration efforts.

According to the *institutional legitimacy perspective*, integration efforts are important especially for legitimacy and social reasons (e.g., gaining access to resources or gaining order-qualifier status (Hill 2000)) rather than economic or efficiency reasons (DiMaggio & Powell 1991). For example, the adoption and form of TQM practices have been found to be related to the search for legitimacy, especially in case of late adopters (Westphal, Gulati & Shortell 1997). Although related to the institutional efficiency argument, institutional legitimacy is clearly distinct from it. The institutional legitimacy argument is based on the rationality argument, although not on economic rationality; organizational behavior is rational as there is a clear goal-orientation, such as gaining access to resources or new customers, but the goal is not economic efficiency. This type of rationality has been labeled as normative, and defined as rationality in terms of choices induced by historical precedent and social justification (Oliver 1997). Although the main purpose for engaging in integration efforts are not economic benefits, engaging in integration efforts can still be also economically beneficial.

Finally, building on the bounded rationality argument (March & Simon [1958] 1993), the *contingency theory* argues that integration efforts are not always required for the success of the organization (Lawrence & Lorsch [1967] 1986). Furthermore, it is considered that just like specialization, integration efforts can be pushed too far (Katz & Kahn [1966] 1978). The contingency theory acknowledges that organizations vary in terms of the requirements for integration; integration is crucial and leads to higher effectiveness only when the requirements for integration are high. The contingency theory, thus suggests that integration provides benefits in terms of performance, but the benefits of are not universal.

Table 2-3 below is a summary of different theoretical perspectives to integration.

Table 2-3. Assumptions and main arguments of different theoretical perspectives to integration

THEORETICAL PERSPECTIVE	ASSUMPTIONS AND MAIN ARGUMENTS	EXAMPLE REFERENCES
Economic efficiency	Building on the perfect rationality assumption, the main idea is that integration efforts enhance economic efficiency. It is assumed that there are significant costs related to integration efforts and managers are perfectly aware of both the costs and the benefits of integration efforts. Hence, it is suggested that firms should engage in integration efforts whenever the benefits outweigh the costs related to them.	Pagell (2004)
Institutional efficiency	Building on the bounded rationality argument, the main idea is that integration efforts enhance economic efficiency; there is not necessarily any theoretical or empirical support for this assumption but it has become perceived as a known fact. Hence, it is suggested that firms should always engage in integration efforts in order to achieve economic benefits.	Droge et al. (2004), Ketokivi & Schroeder (2004c)
Institutional legitimacy	Building on the normative rationality assumption, the main idea is that firms engage in integration for legitimacy and social reasons; the economic benefits of it are not relevant and are outside consideration. Hence, it is perceived that firms should engage in integration efforts whenever there are social benefits related to them.	Meyer & Rowan (1977; 1991), Westphal et al. (1997)
Contingency theory	Building on the bounded rationality assumption, the main idea is that organizations differ in terms of how integration efforts enhance organizational integration; integration can be pushed too far, and so, more emphasis on integration can also be detrimental. Furthermore, it is assumed that there are differences in the requirements for integration efforts. Hence, it is suggested that organizations should engage in integration efforts depending on the requirements for integration.	Gupta et al. (1986), Lawrence & Lorsch ([1967] 1986), Song et al. (1997)

The different theoretical perspectives clearly address when and why to integrate and the link to performance with different underlying assumptions emphasizing different issues. The prior empirical OM research has mainly taken the institutional efficiency perspective on integration; the benefits of integration have been taken as given while the costs of integration have mainly been ignored (e.g., Droge et al. 2004; Ettlie 1995;

Griffin & Hauser 1992; Kahn & Mentzer 1998). Building on contingency theory, several authors (e.g., Koufteros et al. 2005; O'Leary-Kelly & Flores 2002) have assumed that the relationship between integration and performance is affected by some contingency factors. The economic efficiency perspective, assuming perfect knowledge of the costs and benefits of integration efforts, and the institutional legitimacy perspective emphasizing the importance of integration for legitimacy reasons, have not received significant attention in the empirical OM literature. Even though the four perspectives make different assumptions, they all provide information in terms of when and why firms should engage in cross-functional integration.

2.2.2 Assessment of the Different Theoretical Perspectives in Light of the Purposes of the Present Research

The interesting question then is, which of the perspectives is most informative for the purposes of the present research when the overall emphasis is on explaining variations in the performance of manufacturing plants. For example, which of the perspectives is most informative when the goal is to explain the relationship between cross-functional integration and performance of a manufacturing plant and when the goal is to explain simultaneously when plants are more likely to engage in integration efforts taking into account the costs of integration? In the following, the different theoretical perspectives are discussed in the context of the present research. It cannot be stressed too much that none of the perspectives is considered to outweigh the others in general; all of them address the same phenomenon with different underlying assumptions, and hence, the perspectives complement each other. The point below is to discuss which of them is most appropriate and informative for the purposes of the present research.

The economic efficiency perspective is very appealing because it emphasizes the costs of integration efforts. The economic perspective addresses interesting questions like: what are the costs of integration? Are the benefits of integration greater than the costs? The economic efficiency perspective is somewhat challenging, however. It makes an assumption about perfect rationality; according to the perfect rationality assumption managers (or researchers) can calculate the exact costs and benefits of integration efforts. In practice this is rather difficult, although some estimations can be made.

The institutional efficiency argument, on the other hand, builds on the idea that more emphasis on integration always leads to higher performance. The institutional efficiency perspective is highly relevant for integration research and it characterizes a majority of the prior research. However, the institutional efficiency argument does not assess the question of why and how integration is related to performance; the benefits of integration are taken as given because they are not considered relevant. Rather than economic performance, the organizations are considered to be driven by survival and, subsequently, the institutional efficiency perspective does not see the costs of integration as important because other more critical issues are considered to drive integration.

The institutional legitimacy argument assesses the importance of integration in terms of gaining legitimacy, addressing questions such as: how can integration be used for increasing legitimacy among customers or suppliers? Can cross-functional integration be used for gaining legitimacy among the network of plants of the focal firm? Like the institutional efficiency argument, also the institutional legitimacy argument does not see the effects of integration on performance as important; integration is needed for social and legitimacy reasons, not in order to increase the economic performance of the organization.

The contingency theoretical arguments, on the other hand, suggest that although integration does provide performance benefits, there are costs related to integration efforts. Moreover, firms are suggested to differ in terms of the needs for integration. Especially the contingency theory variant treating the organizational structure as a dependent variable (Mohr 1971), and the idea of variations in the requirements for integration (Lawrence & Lorsch [1967] 1986), address the issue of when and why firms need to integrate. Furthermore, the assumption of the costs of integration efforts and the notion of potential over-investments in integration are highly important and interesting.

Clearly all the four theoretical perspectives are interesting and relevant for advancing the integration research in OM, as they provide information about integration with different underlying assumptions. Hence, the perspectives complement each other. For the purposes of the present research, the contingency theoretical perspective is chosen. It is perceived as fruitful in advancing the understanding of integration related to the objectives of the present research; both the antecedents and the performance effects of integration. Contingency theorists have paid significant attention to integration in organizations, and the theory has also served as a stimulation for both conceptual and empirical work on integration in various other disciplines, such as marketing (e.g., Gupta et al. 1986; Krohmer et al. 2002; Song et al. 1996), international business (e.g., Ghoshal & Nohria 1989; Kim, Park & Prescott 2003; Nohria & Ghoshal 1997), operations management (e.g., Song & Dyer 1995; Swink 2000), purchasing (e.g., Narasimhan & Das 2001), and general management (e.g., Gerwin 2004). Contingency theorists have provided a great amount of research, especially on integration efforts in organizations, as well as on contingencies explaining effective integration efforts and on the effect of integration on performance. The contingency theory perspective could then be complemented with other theoretical arguments as well to provide more holistic understanding of integration (this, however, is outside the scope of the present research). Discussing the different theoretical perspectives also nicely positions the present research in terms of the underlying assumptions driving integration research. Before discussing the potential contributions of the contingency theory to the study of cross-functional integration in OM and presenting the theoretical framework assessed in the research at hand, the basic ideas of the contingency theory are discussed in the next sub-sections.

2.2.3 Explaining the Theoretical Perspective of the Present Research – Intellectual Roots, Main Ideas, and Focal Concepts of the Contingency Theory

Intellectual roots and principle arguments of the contingency theory. Until the late 1950s, academic writings about organizational structures were dominated by the classical management schools[22] with universalistic theories, suggesting that maximum performance comes from maximum level of one structural variable (Donaldson 2001, pp. 3-4). This perspective treated organizations prescriptively. The study of organizational structure, however, witnessed a significant change in the 1960s when the classical management school was overthrown by the new paradigm of the contingency theory (Donaldson 1996, p. 58). The contingency theory can be classified as a *sociological* (using the terminology of Swedberg (2003)) and a *system-structural view* (using the terminology of Astley and Van de Ven (1983)) to organizations due to its

[22] Examples of theories of the classical management school include Principles of Scientific Management by Taylor (2005, originally Bulletin of the Taylor Society, December 1916) and Theory of Bureaucracy by Weber (2005, originally Gerth, H.H. & C.W. Mills (1964). From Max Weber: Essays in Sociology, Oxford University Press, New York, NY).

focus on deterministic individual organizations rather than populations of organizations. The conceptual antecedents of many contingency theorists are in socio-technical[23] and cognitive models[24] and it follows the rational open systems view to organizations taken in this dissertation (Section 1.4). The contingency theory is considered as one of the most influential organization theories (Scott 2003, p. xxi) and a major lens to view organizations (Donaldson 2001).

At a very general level, the contingency theory states that the effect of one variable on another depends upon some third variable; the effect of variable X on variable Y differs depending on third variable Z (Donaldson 2001, p. 5). There are a number of different contingency theories depending on the focus of the research (Donaldson 2001, p. 6). The contingency theory in the context of this research refers to the *structural contingency theory*, the main focus of which is on organizational structures. The overarching hypothesis of the structural contingency theory is that organizational effectiveness results from fitting the characteristics of the organization to contingencies that reflect the context of the organization (e.g., Burns & Stalker [1961] 1968; Child 1975; Drazin & Van de Ven 1985; Lawrence & Lorsch 1967, [1967] 1986; Scott 1998). Thus, differences in organizational structures are not random, but structural factors in effective organizations vary along the differences in the contexts of the organizations. The theoretical roots of the contingency theory are in the work of March and Simon ([1958] 1993) and Burns and Stalker ([1961] 1968), although Lawrence and Lorsch ([1967] 1986) and Thompson ([1967] 2003) have probably had the greatest impact. In the pioneering literature, the environment (Burns & Stalker [1961] 1968; Katz & Kahn [1966] 1978; Lawrence & Lorsch [1967] 1986) and technology (Mohr 1971; Woodward [1965] 1994), or both (Thompson [1967] 2003) are the main contingencies affecting organizational design. Others have emphasized strategy (Chandler [1962] 1990; Child 1972b; Fouraker & Stopford 1968; Galbraith 1973, 1977, 1994) or size (Child 1972b, 1973a, 1973b, 1975; Miller & Dröge 1986; Pugh, Hickson & Hinings 1969a) at

[23] The sociotechnical model perceives the organization as a system interacting with its environment. In the system, the behavior is influenced by multiple issues including human, technological, sociological, and organizational inputs. A formal organization is perceived as separate from an informal one. (Allen & Gabarro 1972, pp. 17-18).

[24] The cognitive model focuses on the decision making processes in organizations (Allen & Gabarro 1972, p. 22) and refers to the works of the Carnegie School (e.g., Cyert & March 1992; March & Simon [1958] 1993).

different levels of analysis and in different contexts. It is important to note that the implications of many of these factors are restricted only to some specific areas of the organization (Lenz 1981).

Different streams of structural contingency theory research on integration. The structural contingency theoretical discussion on integration can be divided into two different streams:[25] comparative analysis arising from the work of the Aston group (Child 1972b, 1973a, 1973b, 1975; Pugh et al. 1963; Pugh, Hickson, Hinings & Turner 1968), Woodward ([1965] 1994), and Burns and Stalker ([1961] 1968) and the intra-organizational analysis arising from the work of Lawrence and Lorsch ([1967] 1986).

Comparative analysis treats the organization as a more or less determinate entity than as a system to be designed by management. The organization is mainly perceived as a response to the focal environmental conditions of uncertainty, complexity or size (Blau & Scott 1962; Burns & Stalker [1961] 1968; Child 1973a). Scholars have treated the organization as a whole, describing it in terms of the overall structure, and a bundle or a pattern of organization design elements (e.g., mechanistic organization, which refers to a high degree of specialization, centralization of decision-making, and formalization (Burns & Stalker [1961] 1968)). The unit of analysis is mainly at macro-organizational level, although some scholars have also assessed different integration efforts individually. The distinctive characteristic of the research stream is the emphasis on *inter*-organizational assessments. Subsequently, the empirical research in the stream has focused on comparisons of effective organizations (including the aspects of integration) under different contingencies with large survey samples.

Intra-organizational analysis, on the other hand, argues for the importance to look at specific components of organizations and their interrelations and calls for a micro-level of analysis; according to the intra-organizational argument, organizations (and integration within them) cannot be understood without the analysis of the internal components and their interrelations, emphasizing both internal and external fit

[25] There are probably a number of different ways to classify the structural contingency research, but the classification made here is considered most advantageous in terms of the focus of the research on integration. Donaldson (2001) makes a difference between organic and bureaucratic theories and Gerwin (1981) between comparative analysis and systems design. The classification used here, however, closely resembles the distinction made by Scott (2003) into theories focusing on variations between organizations and variations within organizations.

(Lawrence & Lorsch [1967] 1986). Although this perspective to the contingency theory is somewhat more elaborate, empirical attempts to address it have been less rigorous (Gerwin 1981) and has mainly been carried out with case studies (e.g., Lawrence & Lorsch [1967] 1986). Intra-organizational analysis has not received much attention in OM research, even though it is considered highly relevant (Ketokivi et al. 2006).

Although the contingency theory in general has been open to some critique (e.g., Schoonhoven 1981; Sinha & Van de Ven 2005), it is considered that especially the approach of Lawrence and Lorsch ([1967] 1986) is fruitful for the research on cross-functional integration in OM and overcomes some of that critique. For example, Sinha and Van de Ven (2005) suggest that a majority of the work on the contingency theory has taken a somewhat simplistic perspective and focused on examining the external fit between the context and one design variable at a time (e.g., Donaldson 1996). In this research, the intention is to bring back some of the richness that was inherent in the early work of the contingency theorists by looking at differentiation and integration holistically within organizations. The intra-organizational argument is particularly attractive in the sense that it enables simultaneously both a detailed and an encompassing analysis of the internal structures of organizations, including varying integration efforts. In the following, the main contributions of intra-organizational contingency theory research are briefly presented.

Intra-organizational research. The main contributors for the intra-organizational stream are Lawrence and Lorsch ([1967] 1986) and later on the information processing scholars (e.g., Daft & Lengel 1986; Galbraith 1973, 1977; Tushman & Nadler 1978). Lawrence and Lorsch ([1967] 1986) have developed the classical problem of organization design, concluding that the division of tasks and coordination are more complex than usually assumed. They perceive organizations in terms of differentiation and integration and as open systems facing multiple environments. The underlying argument of Lawrence and Lorsch ([1967] 1986) is that effective organizational subunits (e.g., functions) adapt to their particular environment introducing differentiation and then the organization is integrated into a common whole.

The work of Lawrence and Lorsch ([1967] 1986) is explorative by nature. They report the results of a comparative study in 10 organizations in plastics, container, and packaged food industries, looking at differentiation and integration across functional interfaces within organizations. The main contingency factor affecting organization design in the work of Lawrence and Lorsch ([1967] 1986) is environmental uncertainty, which is suggested to affect both the level of differentiation and the required integration. The results imply that depending on the environmental conditions, a different level of integration is required in different functional interfaces in organizations; companies in the plastics and food industries are characterized with high uncertainty and require integration of R&D and manufacturing as well as R&D and sales, whereas the container industry is characterized with more certainty and requires integration between manufacturing and R&D as well as manufacturing and sales. The authors further report that high-performing organization use a different set of integrative devices in different industries: plastics firms focus on an integrative department, food firms on integrators, and container firms on direct managerial contact. Lawrence and Lorsch ([1967] 1986) conclude that in high-performing organizations integration efforts are consistent with both differentiation and the requirements of the environment.

Lawrence and Lorsch ([1967] 1986) leave the explanation for why effectiveness results from the fit between environment and organizational structure rather open. This fit-performance relationship has been further addressed by the information processing perspective introduced by Galbraith (1973, 1977). At the macro organizational level[26] the main thesis of the information processing perspective is that in effective organizations there is a match between the information processing requirements and the information processing capacity of the organization. The requirements for information processing are perceived to arise from uncertainty; the more uncertain the task is, the more information needs to be processed for successful completion of the task. The capacity of the organization to process information, on the other hand, depends on integration; the more effort is put on integration, the better is the information processing capacity of the organization.

The underlying factor affecting organizational design in the work of contingency theorists is uncertainty, which can be linked to both environment and technology (and the subsequent interdependence). Pennings (1975) points out that environment and

[26] Integration as an information-processing phenomenon has also been studied at team level (e.g., Van de Ven et al. 1976), focusing on the integration in individuals within a group rather than integration of organizational units.

technology are often confused because of uncertainty; both contingencies are often described in terms of the uncertainty they pose to the focal organization. However, also uncertainty seems to lack clarity in the contingency theory work (cf. Donaldson 1996, p. 63 who suggests that contingency theorists have presented precise definitions of focal concepts). In the following, the focal contingencies of environment and technology are briefly defined and discussed.

Environment. The environment is an important contingency because the interdependence of the organization with its task environment infers with the goal attainment of the rational organization, introducing uncertainty in the organization in completing its task (Thompson [1967] 2003, p. 13). Two different environmental concepts can be identified in contingency theory literature: the task environment and total environment, the latter of which basically refers to everything outside the task environment. In his seminal work, Dill (1958) defines the task environment as a source of information and a body of accessible information relevant or potentially relevant to the organization's goal setting and goal attainment. The task environment thus includes for example customers, suppliers, competitors, and regulatory groups outside the legal boundaries of the focal organization. The same definition is followed also by Duncan (1972), Pennings (1975), and Galbraith (1973, 1977). Lawrence and Lorsch ([1967] 1986), on the other hand, perceive the task environment as the environment *within* the focal organization (e.g., design and production), leading them to analyze what they call the external environment. In the present research, the conceptualization of Dill (1958) is used. According to contingency theorists, the task environment affects the internal contingencies, which then affect the appropriate structural characteristics (Donaldson 2001). Hence, the effect of the environment on organizational structure is suggested to be indirect.

Technology. Whereas the environment is a source of inputs and the target of outputs for organizations, technology is the means for transforming inputs into outputs. Technology leads to uncertainty in the organization due to the interdependence that it induces (Thompson [1967] 2003); the actions of units depend on the actions and decisions made by other units, making the completion of tasks more uncertain.

Numerous authors have discussed technology and its effect on organizational structure (for an excellent review, see Gerwin 1981). The first author to link technology and structure was Woodward ([1965] 1994), who empirically assessed the relationship between technology and structure in manufacturing plants. Focusing on the manufacturing context (within the manufacturing function), Woodward ([1965] 1994) defines technology as the production process (batch, mass production, process). Building on Woodward ([1965] 1994), Perrow (1967) and Thompson ([1967] 2003) broaden the discussion of technology to all kinds of organizations, including multi-functional organizations. Perrow (1967) defines technology as the cognitive process involved in completing the task: work done on raw materials (raw materials can be humans or other inanimate objects for which some actions are taken with or without the aid of tools or mechanical devices). Thompson ([1967] 2003) presents a rather similar definition, defining technology as the specific arrangements to transform inputs into outputs.

In this research, the definition of Thompson ([1967] 2003) is adopted. He discusses variations in technology, identifying three different types as follows: *mediating technology* requires operating in standardized ways, *long-linked technology* requires one task to be performed successfully before starting to perform another, and *intensive technology* is a custom technology, the successful employment of which rests on the availability of all capacities potentially needed, but also on appropriate custom combination of selected capacities as required by the individual case or project.

Thompson ([1967] 2003, pp. 54-56) continues by presenting a typology of interdependence arising from different types of technology. He focuses on the type of linkage between different units, suggesting that there are three types of interdependence:[27]

[27] The discussion of interdependence is somewhat problematic in prior research. First, the definition of interdependence often remains only implicit. This is also the case in the writings of early system theorists (e.g., Katz & Kahn [1966] 1978), even though interdependence is one of the most central concepts for them. Second, in the prior literature, interdependence has to some extent been used interchangeably with integration (e.g., Allen 1970; Ettlie & Reza 1992). In this research, however, they are considered conceptually different although closely related. Third, interdependence can be subsumed under the broader contingency of uncertainty (Donaldson 2001, pp. 56-58; Lawrence 1981), which might cause misinterpretations in trying to understand the effect of different contingency factors on the design of organizations. Finally, interdependence is often used as a descriptive variable despite a call for development of the interdependence construct (Victor & Blackburn 1987).

- *Pooled interdependence* arising from mediating technology means that organizational units are interdependent in a sense that each unit makes a discrete contribution to the whole organization, and unless each unit performs adequately the whole organization is jeopardized.

- *Sequential interdependence* arising from long-linked technology refers to interdependence of serial form. In addition to the pooled aspect of interdependence, the order of interdependence is specified.[28]

- *Reciprocal interdependence* arising from intensive technology refers to a situation in which the output of each unit becomes the input for another. In addition to pooled and sequential aspects of interdependence, there is also reciprocity of the interdependence.

According to Thompson ([1967] 2003, p. 55), all organizations have pooled interdependence among their sub-units, but more complex ones have both sequential and pooled, and the most complex ones reciprocal, sequential and pooled interdependence. Furthermore, interdependence is partly asymmetric: if organizational unit A is sequentially interdependent on organization unit B, unit B is not necessary sequentially interdependent on unit A. Van de Ven et al. (1976) suggest an additional dimension to Thompson's ([1967] 2003) typology of interdependence called *team arrangement*. It refers to situations where the task completion needs to be undertaken jointly by organizational units. Rather than the output of a unit being an input for another and vice versa, as in the case of reciprocal interdependence, joint problem solving and task completion among the units is needed. Hence, there is no temporal lapse in the flow of work between units; the task is completed simultaneously by members of different units. Team interdependence involves pooled, sequential, and reciprocal aspects of interdependence. The different types of interdependence according to Thompson ([1967] 2003) and Van de Ven et al. (1976) are illustrated in Figure 2-2

[28] Recently Giachetti (2006) has presented a further development of Thompson's ([1967] 2003, pp. 54-56) typology. He distinguishes two different types of sequential interdependence: sequential interdependence due to the control flow of activities and sequential interdependence due to the flow of information. He argues that these dimensions are clearly distinct. Sequential interdependence of control is assumed to be more difficult to manage because in a control flow the succeeding task cannot start until the previous task is completed, but in information-sequential interdependence the succeeding task has alternative courses of action frequently if the information is delayed or otherwise interfered with.

below. Due to the two-way interaction in reciprocal and team interdependence and its implications to integration in the context of this research, a major distinction is made on the interdependence continuum between reciprocal and sequential types of interdependence. Hence, interdependence in plants is characterized being either reciprocal or not. When interdependence is reciprocal, it involves at least reciprocity of the units but may also involve team interdependence. And when interdependence is not reciprocal, it involves either pooled or sequential interdependence.

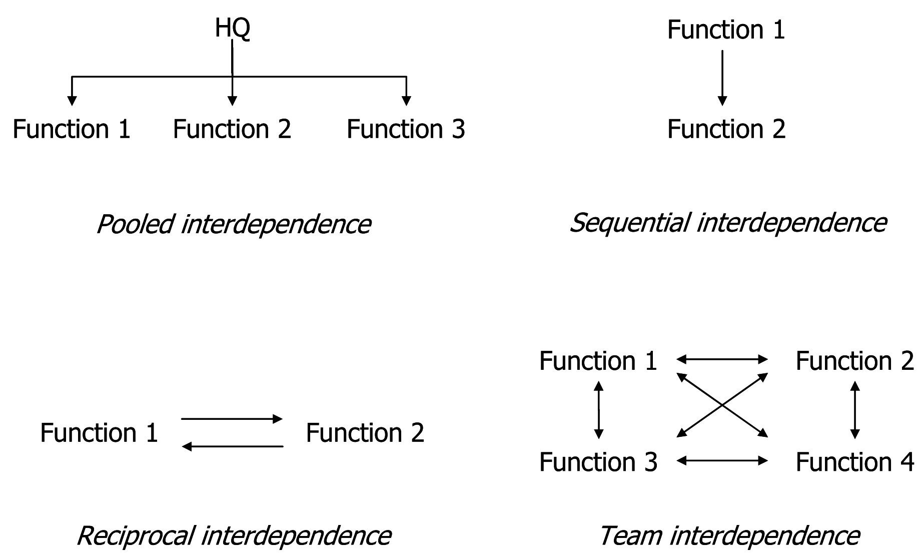

Figure 2-2. Illustration of different types of interdependence

There exist also other conceptualizations of interdependence. McCann and Ferry (1979) conceptualize interdependence as the amount of transaction or exchange (i.e. as an additive function) where the object of transaction includes for example funds, products, support services, as well as information essential for the unit's performance. McCann and Ferry (1979) present a formal definition for interdependence as follows: "[i]nterdependence exists when actions taken by one referent system affects the actions or outcomes of another referent system". McCann and Galbraith (1981) criticize the earlier conceptualizations of interdependence of Thompson ([1967] 2003) and McCann and Ferry (1979) and argue that neither one of these is able to empirically assess the differing amounts of interdependence. As a response, McCann and Galbraith (1981) assume that the relationship between two units can be described in terms of three requirements for action: requirements for one's own actions, requirements for the actions of others, and requirements for the joint action as dictated by technological, environmental, organizational and interpersonal determinants of work flow specified by the division of labor. Whether this conceptualization of interdependence is significantly easier to empirically asses is questionable, and thus in line with the conceptualization of technology, the typology of Thompson ([1967] 2003) is used in this research.

Let us briefly discuss the different types of cross-functional interdependence in the OM context. In the classical organizational model, still used in many firms, a complete product design is developed first and then handed on to manufacturing for production (Adler 1995; Wheelwright & Clark 1992, p. 176). This represents a sequential (serial) form of interdependence between design and manufacturing. When there is sequential interdependence of the functions, the typical Stage-Gate approach to new product introduction, in which the development activities are grouped into stages which are autonomous and must be completed before transferring the task to the next one, is appropriate (Hayes, Pisano, Upton & Wheelwright 2005, pp. 224-227). In some development projects the Stage-Gate model is inappropriate, however. This is when the development activities cannot be divided into autonomous sequential steps but require either mutual adjustment or even parallel processing, for example due to time pressures (Hayes et al. 2005, pp. 225-226). In such a case the functions are characterized by reciprocal or team interdependence. Reciprocal interdependence requires for example timely information sharing, whereas team interdependence requires joint problem solving and direct observation. As an example of reciprocal interdependence, design engineers take into account the preliminary process designs in order to make products easier and less costly to manufacture, and likewise process engineers develop their capabilities to go with the demands of the product designs (Wheelwright & Clark 1992). As an example of team interdependence, members of design and manufacturing functions work *jointly* as a team to develop a product.

2.3 CONCLUSION

In this chapter I focused on two issues. First, I presented prior OM research and existing knowledge on cross-functional integration from the manufacturing perspective. Based on the literature review, I pointed out areas where further research is needed in order to enhance the understanding of cross-functional integration in OM. In the second section, I focused on presenting different theoretical explanations underlying the prior, primarily empirical research on integration. Based on the discussion of the different theoretical perspectives in light of the purposes of the present research, I suggested that the contingency theory is highly informative and would advance the OM research on cross-functional integration. Finally, I presented the main ideas of the contingency theory.

Although addressing also the underlying theoretical perspectives and arguments, the focus of this chapter was on reviewing prior research. In the next chapter, the focus of the discussion shifts from reviewing previous literature to discussing and presenting theoretical arguments for the purposes of the present research, laying out the ground for subsequent empirical work. Hence, the focus of the next chapter is in building theoretical arguments rather than reviewing prior research. A theoretical framework addressing the research gaps identified in this chapter is developed on the basis of early structural contingency arguments and the information processing perspective.

CHAPTER 3
THEORETICAL BASIS

This chapter presents the theoretical framework examined in this research. The chapter is divided into three sections. First, building on the contingency theory, I formulate theoretical arguments related to the identified research needs on cross-functional integration in OM. In the second section I present two conceptual frameworks found in the existing literature, related to the research problem of the thesis. In the third section I present the theoretical framework examined in this research, as well as some insights from previous empirical research related to the framework.

Based on the literature review (see Section 2.1.4), I concluded that further clarification is needed in the following areas:

- The concept of integration;
- The relationship between integration and performance; and
- The antecedents of integration.

In the previous chapter (Section 2.2) I argued that in order to increase the understanding of cross-functional integration, OM scholars could go back to the early work on contingency theorists. Especially early structural contingency theorists have addressed the issues that were identified as areas where further research is needed. Rather than reviewing literature as in Chapter 2, the focus of this chapter is on theoretical discussion and building theoretical arguments. Hence, this is not an all-encompassing literature review of contingency theory. In the following, ideas and arguments of structural contingency theorists that are perceived advantageous and informative in terms of advancing OM research on cross-functional integration in the three areas of research needs are presented.

3.1 CONTINGENCY THEORY ARGUMENTS FOR INTEGRATION

3.1.1 Concept of Integration

Rather than treating integration as a single unidimensional concept, the level of which varies in one dimension only, structural contingency theorists (e.g., Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003) make a (partly implicit) distinction between three dimensions of integration: (i) achieved integration, (ii) integration mechanisms, and (iii) requisite integration. In the following, the different integration dimensions are defined and discussed in detail in terms of the present research by taking the information processing perspective (Galbraith 1973, 1977).

Achieved integration. The level of achieved integration refers to an outcome, a state of affairs between different functions. The notion of achieved integration arises from the idea of organizational conflict. Due to the division of tasks and multiple sub-environments, each organizational unit adapts to its specific sub-environment and has information from its specific sub-environment only (Lawrence & Lorsch [1967] 1986) leading to a potential sub-goal pursuit (March & Simon [1958] 1993). As a consequence, the organization as a whole might be in conflict, i.e. the goals and the subsequent decisions of the various organizational units might not be in line with the overall goal of the organization due to for example information asymmetry (March & Simon [1958] 1993).

More specifically, achieved integration is related to the absence of conflict in the organization. It can vary on a continuum from low to high; a high level of achieved integration refers to a state where everything works well between different functions, reflecting the fact that different units of the organization behave as a unified whole without being merged into a single entity (Barki & Pinsonneault 2005; Donaldson 2001). From the information processing perspective, a high level of achieved integration refers to a state in which the various organizational units have both relevant and accurate information regarding other units and are able to interpret and synthesize the information when making decisions. Hence, they are able to take more consistent action for the benefit of the whole organization. In the context of this research, a high level of achieved integration means that the manufacturing, R&D and marketing/sales work in a coordinated manner towards the goal of the plant.

Integration mechanism. Mechanisms of integration[29] refer to any managerial tool for achieving integration within an organization (Galbraith 1973; Lawrence & Lorsch [1967] 1986; March & Simon [1958] 1993; Thompson [1967] 2003). Integration mechanisms resemble closely the conceptualization of integration as a process and are the most typical way of conceptualizing integration in OM (see Section 2.1.1). From the information-processing perspective, integration mechanisms are used to increase the information processing capacity, because organizations are often too large to allow face-to-face communication to be the main way of processing information (Galbraith 1973).[30] Integration mechanisms affect the information processing capacity in two separate ways: they increase the amount of information processed in the organization, as well as the richness of that information (Daft & Lengel 1986; Galbraith 1973). Integration mechanisms vary both in their capacity to facilitate information processing and the richness of the information they facilitate, as well as in their complexity and costs (Galbraith 1973, 1977). The costs of integration mechanisms do not include just the time and resources needed for the implementation of the mechanisms, but for example training programs, side effects or dysfunctions resulting from change or misuse, and increased inter-group communication (McCann & Galbraith 1981).

Several authors have provided overviews of integration mechanisms. Leenders and Wierenga (2002) focus on cross-functional integration in the operations-marketing interface, Martinez and Jarillo (1989) on integration in MNCs, and Grandori (1997) on

[29] In the literature, integration mechanisms are also called mechanism of coordination (Galbraith 1973; Martinez & Jarillo 1989) and integration or coordination devices (Lawrence & Lorsch 1967, [1967] 1986; Porter 1985).

[30] From the behavioral perspective, integration mechanisms have a different purpose; integration mechanisms are ways of overcoming the organizational members' limitations regarding perceptions and understanding in the ability to achieve the common goal of the organization (e.g., Barnard 1938; Lorsch & Morse 1974; Ouchi 1977, 1980; Pelled & Adler 1994).

inter-firm integration. A majority of integration mechanisms are the same despite the context, although not all mechanisms are relevant or even applicable everywhere (for example, even though co-location (Ketokivi 2006) and strategic alliances (Gerwin 2004) can be used for achieving cross-functional integration, they are applicable in the MNC context rather than at manufacturing plant level). Also other classifications exist, although at a somewhat higher level. Burns and Stalker ([1961] 1968, pp. 119-121) make a distinction between mechanistic and organic organizations involving aspects of centralization and formalization. March and Simon ([1958] 1993) classify integration mechanisms as either mechanisms relying on programming and control or mechanisms relying on mutual adjustment and feedback. Van de Ven et al. (1976) develop this classification further and make a distinction between impersonal, personal and group coordination, which they call *modes of coordination*. The impersonal mode refers to March and Simon's ([1958] 1993) programming and it includes standardization, formalization and plans. Personal and group modes of coordination, on the other hand, refer to mutual adjustment, depending on how they are applied, and include both vertical and horizontal mechanisms.[31]

Integration mechanisms can be divided into vertical and horizontal ones. In Table 3-1, a summary of vertical and horizontal integration mechanisms in the cross-functional context is presented.[32] The mechanisms are further divided into different categories, depending on their characteristics and resembling closely the categorization of Martinez and Jarillo (1989). Hence, for example the creation of lateral relations includes a number of different individual integration mechanisms (e.g., promoting informal

[31] Related to the mechanisms of integration, sometimes the concept of integration or coordination strategy is used (e.g., Dietrich 2007; Grandori 1997; McCann & Galbraith 1981). Integration or coordination strategy refers to a logic through which different integration mechanisms are being used, including both which mechanisms are used and their relative importance. As an example, McCann and Galbraith (1981) discuss different strategies and suggest that they can be analyzed on dimensions of formality, level of cooperation, and centralization. Grandori and Soda (1997), on the other hand, discuss integration strategies in the inter-firm context.

[32] Galbraith (1973) and subsequently Tushman and Nadler (1978) perceive centralization and standardization as static by nature (they use the term structure) rather than being under management control and to be modified to affect the information processing capacity of the organization. In this research a somewhat different perspective is taken, and centralization, standardization, and rules are perceived as characteristics of organizations that can be modified to affect the information processing capacity. Furthermore, Galbraith (1973) perceives information systems as a mechanism for vertical information processing but depending on their span and focus, this research assumes that they can be either vertical or horizontal.

communication across functions with different practices like managerial meetings, training, and cross-functional job rotation or more formal lateral structures like task forces, integrator roles, and cross-functional teams), which share the same idea of creating informal and formal lateral relationships.

The categories below are organized in the order of increasing information processing capacity and richness of the information that they facilitate (Daft & Lengel 1986; Galbraith 1973). Even more importantly, considering the purposes of the present research, the categories are also organized in terms of increasing costs of implementation and use (Galbraith 1973). For example, although lateral mechanisms increase the information processing capacity of the organization more than centralization and formation, the financial and managerial investments required by the implementation and use of centralization and formalization are less than the investments required by the creation of lateral relations. The costs of centralization and standardization are related to overloading the decision makers and limiting organizational creativity (this can of course be significant, depending on the goals of the organization) (Galbraith 1970; McCann & Galbraith 1981). Lateral mechanisms, like cross-functional teams, on the other hand, require more time and effort to design and implement, time to adjust to work as a team, resources to maintain, and can lead to overloading the team members and distorting them from functional issues (Galbraith 1973, 1994). The pros and cons of different mechanisms analyzed in this research are discussed in more detail when formulating specific hypotheses regarding them (Section 5.2.2).

Table 3-1. Summary of vertical and horizontal integration mechanisms from the information processing perspective

CATEGORY	DEFINITION AND IMPLICATIONS	EXAMPLE REFERENCES
Centralization of decision making	Refers to the level where the locus of the decision making authority is: whether the focal unit has autonomy in decisions or not. Simplifies information processing as the decision maker gathers, controls, and processes information.	Burns & Stalker ([1961] 1968) Child (1972a, 1973a, 1973b) Edström & Galbraith (1977) Galbraith (1973) Hage et al. (1971) Khandwalla (1974) Lawrence & Lorsch ([1967] 1986) McCann & Galbraith (1981) Mintzberg (1979, 1983) Nemetz & Fry (1988) Pierce & Delbecq (1977) Pugh et al. (1969a, 1968) Van de Ven et al. (1976)
Formalization and standardization	Includes written policies, rules, job descriptions, standard procedures achieved with manuals, charts and the like regarding for example information processing practices. Eliminates the need for further communication as there are clear standards for processing of information.	Burns & Stalker ([1961] 1968) Child (1972a, 1973a, 1975) Daft & Lengel (1986) Edström & Galbraith (1977) Galbraith (1973) Ghoshal & Gratton (2002) Hage et al. (1971) March & Simon ([1958] 1993) McCann & Galbraith (1981) Mintzberg (1979) Nemetz & Fry (1988) Pierce & Delbecq (1977) Pugh et al. (1969a, 1968) Thompson ([1967] 2003) Van de Ven et al. (1976)
Planning and control	Includes strategic planning, functional plans and scheduling, financial performance control, technical reports, and control of sales and marketing data. Provides a formal platform for information processing.	Galbraith (1973) March & Simon ([1958] 1993) Mintzberg (1979, 1983) Thompson ([1967] 2003) Van de Ven et al. (1976)
Information systems	Includes for example increasing the scope of the data base and degree of formalization of information flows. Enhances the capacity of the organization to process information, enables rapid information exchange without overloading the hierarchy.	Daft & Lengel (1986) Galbraith (1973, 1977, 1994) Ghoshal & Gratton (2002)

(Table 3-1 continued)

CATEGORY	DEFINITION AND IMPLICATIONS	EXAMPLE REFERENCES
Creation of lateral relations	Includes temporary or permanent liaison roles, task forces and teams, integrative departments or integrators, informal communication, which can be enhanced by management trips, meetings, conferences, and transfer of managers. Increases the capacity to process information and reduces equivocality without overloading the vertical organization, creates potential for more creative ideas.	Daft & Lengel (1986) Galbraith (1973, 1977, 1994) Hage et al. (1971) Lawrence & Lorsch ([1967] 1986) McCann & Galbraith (1981) Mintzberg (1979) Nemetz & Fry (1988) Thompson ([1967] 2003) Van de Ven et al. (1976)
Incentives and social mechanisms	Includes reward and incentive structure and building an organization culture of known and shared strategic objectives and values. Influences the decision making, judgments, and sharing of information.	Edström & Galbraith (1977) Ghoshal & Gratton (2002) McCann & Galbraith (1981)

The classical contingency theory literature discusses the conditions under which to implement different integration mechanisms (e.g., Child 1972b, 1973a; Pugh, Hickson, Hinings & Turner 1969b). However, research focusing on the use of different combinations of integrating mechanisms in terms of how they reinforce or attenuate the effect of one another is less developed.

In practice, the trend has been on moving towards emphasizing complex lateral integration mechanisms, whereas traditional vertical mechanisms of centralization and standardization are often considered outdated. Despite the appeal of the lateral mechanisms and the recent trends, vertical mechanisms are not to be forgotten. Vertical mechanisms are less complex and less costly to use than lateral mechanisms and might increase the information processing capacity as needed, being most appropriate in certain situations. As an example, Hyundai has been successful in using centralization for integrating operations and marketing (Hahn et al. 1994). Furthermore, new mechanisms have emerged over the recent years due to the advancement of technologies, such as the World Wide Web and other IT systems.

Requisite integration.[33] The third dimension of integration is requisite integration. It represents the core of the theoretical arguments for the purposes of the present research. March and Simon ([1958] 1993, p. 141) were probably the first researchers to introduce the idea of "felt need for joint decision making", pointing out that it may vary across situations. The idea has been developed further to the concept of requisite integration by Lawrence and Lorsch who define it as "whether task characteristics make it possible for a subsystem in an organization to operate independently of each other or require continual collaboration in making decisions before a given subsystem may act" (Lawrence & Lorsch 1967, p. 10).[34]

The idea of requisite integration can be understood as follows. Due to the benefits of specialization and the costs of integration, rational organizations search for organizational designs that require less integration (Galbraith 1970, pp. 118-119; Thompson [1967] 2003, p. 64).[35] In other words, rational organizations try to find structures that require less emphasis on integration and when needed, select integration mechanisms that are appropriate but least costly. Due to the complexity of the organizational tasks in reality, no division of tasks ensures the achievement of coordination of activities, and there are always some activities that fall between organizational units (McCann & Galbraith 1981, p. 60). The level of requisite integration refers to the requirements for integration efforts in an organization to achieve its goals *after* the division of tasks; when the level of requisite integration is high, lateral integration mechanisms are needed to a greater extent (either increasing the

[33] Grounding on cybernetics, Ashby (1956) discusses the concept of requisite variety, which is sometimes (although according to my understanding mistakenly) considered equivalent to the concept of requisite integration. According to Ashby (1956, Ch. 11), the variety in a unit should be as high as the variety of other units in the system to control for variety in the outcomes (Law of requisite variety: "Only variety can destroy variety"). Translated to the organizational context this means that the variety of the organizational unit should match the variety of the focal environment. Thus, requisite variety is related to the work of Lawrence and Lorsch ([1967] 1986), but instead of being the same as requisite integration, it is equivalent to their concept of differentiation, which means that as a consequence of trying to adapt to its environment the organizational units vary in terms of structure and orientation.

[34] Later on, when comparing their original work (Lawrence & Lorsch [1967] 1986) with the work of Thompson ([1967] 2003), Lorsch and Lawrence (1972a) use the term "required interdependence" which is considered equivalent to the concept of requisite integration.

[35] A contrasting perspective is presented by Rivkin & Siggelkow (2003) and empirically addressed by Ketokivi (2008). They suggest that rather than dividing tasks to achieve minimum interdependence, firms might achieve higher performance by "incomplete" division of tasks because it creates additional searches when making decisions, which might be advantageous when for example high innovation is desired. This perspective represents different underlying assumptions regarding organization design and is suggested as a potential stream for future research.

use of the current mechanisms or using additional mechanisms). From the information processing perspective, the level of requisite integration is closely related to the requirements for information processing.

Discussion. Prior empirical OM research on cross-functional integration has not made a clear distinction between the different dimensions of integration presented above, and has mainly operationalized integration as the use of various integration mechanisms. In this research, it is argued that the distinction between three integration dimensions is essential in order to advance the understanding of integration in OM. The distinction into three integration dimensions needs also be taken into account in the future empirical OM research, both when formulating hypotheses (which specific integration dimension the hypothesis is addressing) as well as when operationalizing integration in order to build solid theoretical arguments and to avoid misspecifications of theoretical models.

In addition to the multidimensionality of integration recognized by the contingency theorists, this research suggests that the concept of requisite integration is highly relevant for OM scholars in order to increase the understanding of integration. There are two reasons for this. First, requisite integration questions the notion that integration is highly and equally important and valuable for all organizations acknowledging the potential costs of integration (O'Leary-Kelly & Flores 2002; Swink 1999). This way the idea of requisite integration provides a potential theoretical explanation for why empirical research has not found fully consistent evidence for the positive effect of the use of integration mechanisms on different dimensions of performance. Second, requisite integration addresses the issue of when and where to integrate. By tracing the roots of requisite integration, it is possible to address the issue of when and where integration is more important.

After presenting the distinct dimensions of integration, the next relevant question is how the dimensions are related to each other. According to the information processing perspective, in effective rational organizations there is a fit between the information processing requirements and the capacity to process information (Galbraith 1973). The theoretical argument for the fit between information processing requirements and capacity leading to effectiveness can be found in bounded rationality (March & Simon [1958] 1993, p. 173) and the related satisficing principle (Cyert & March 1992).

Building on the bounded rationality argument, the attention-based theory (March & Simon [1958] 1993, p. 173; Ocasio 1997) suggests that the information processing taking place in organizations depends on what issues the selective members focus their attention on while ignoring others. Hence, due to their cognitive limits, organizational members focus their attention on their immediate sub-unit rather than the organization as a whole (March & Simon [1958] 1993, p. 152), which limits the capacity of the organization to process information. However, decisions that are made under uncertainty (i.e. lack or inaccuracy of information or inability to efficiently process information) are not rational. In the search for certainty and subsequent effectiveness, rational organizations try so seal off their technical core from uncertainty (Thompson [1967] 2003)[36] by increasing the capacity to process information. Furthermore, the more desired the rationality is, the more effort is placed on the search for certainty (Thompson [1967] 2003). At the same time increasing the information processing capacity excessively is not rational, because the satisficing principle of the behavioral theory (Cyert & March 1992) holds that information is costly. Hence, rational organizations try to find a balance (fit) between the requirements for information processing in decision making and the capacity of the organization to process information.

Using the dimensions of integration, these arguments can be understood as follows. In order to function well as a unified whole, an organization needs to first assess the level of requisite integration and only then design the implementation of integration mechanisms. Integration mechanisms are implemented according to the requirements; when the level of requisite integration is low, the organization needs to put less emphasis on implementing integration mechanisms, and simpler (and hence, less costly) mechanisms such as centralization and formalization can be used. Whereas, when there are significant requirements for integration, lateral mechanisms are needed. In addition to requisite integration, also differentiation is related to the use of integration mechanisms. Differentiation is inversely related to the effectiveness of integration mechanisms (Lawrence & Lorsch 1967); when the level of differentiation is high, more emphasis is needed on integration mechanisms (keeping the level of requisite

[36] According to Thompson ([1967] 2003), uncertainty in the technical core can be traced for example to inputs, outputs, and distribution of outputs.

integration constant). In line with the open system perspective to organizations, organizations are assumed to be equifinal in terms of integration (Donaldson 2001; Gresov & Drazin 1997).[37] First, a given level of achieved integration can be reached despite the level of requisite integration, and second, a given level of achieved integration can be reached with different combinations of integration mechanisms. A direct implication of the equifinality assumption is that managers are assumed to have some strategic choice (Child 1972b) when designing the organization to achieve integration (this type of equifinality is referred to as tradeoff equifinality by Gresov and Drazin (1997)).

3.1.2 Relationship between Integration and Performance

Even though structural contingency theorists address the issue of how organization design affects performance, they are not very specific about what they mean by performance. Subsequently, the operationalizations of performance vary from study to study (e.g., profits and sales (Lawrence & Lorsch [1967] 1986), efficiency (Van de Ven 1976), and employee satisfaction (Dewar & Werbel 1979)). Donaldson (2000; 2001, p. 6) presents an overall definition of performance, relating it to effectiveness, suggesting that performance in the arguments of contingency theorists can be linked to the extent to which the organization attains the goals it is trying to achieve. Building on the rational perspective to organizations, contingency theorists take the goals of the organization as given and do not investigate them. High performance then results when the goal of the organization (whatever it is) is achieved.[38]

From the information processing perspective, the primary benefits of integration are related to information (Galbraith 1973; Takeuchi & Nonaka 1986). The division of

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[37] Equifinality was introduced by von Bertalanffy (1950), who perceives it as a general property of an open system and suggests that as far as the system attains a steady state, this state can be reached from different initial conditions and in different ways, hence being equifinal. Katz and Kahn ([1966] 1978, p. 30) take the idea of von Bertalanffy to the organizational context and suggest that a system (i.e. organization) is equifinal when it can reach the same final state from different initial conditions and with different means.

[38] Instead of effectiveness, Thompson ([1967] 2003, pp. 14-15) uses the term technical rationality, which can be evaluated with two criteria: instrumental and economic. Instrumental rationality refers to whether the specified actions taken in the organization do in fact produce desired outcomes. Economic rationality, on the other hand, refers to whether the targeted outcome is obtained with least expenditures in resources. Thompson ([1967] 2003) further points out that even though instrumental rationality is more important, economic rationality has been given more attention in the literature. Rationality as perceived in this research refers to Thompson's ([1967] 2003, pp. 14-15) instrumental rationality.

organizations into sub-units and sub-organizations operating in different environments, mainly having information from the particular sub-environment only can lead to a state of conflict at the organizational level. Whereas the requirements for integration and the subsequent need for implementing integration mechanisms vary among organizations, the contingency theorist suggest that a high level of achieved integration is always needed for the organization to operate effectively; when the units have relevant and accurate information in making decisions in a timely manner, more consistent action is possible, making the organization into a unified whole and enabling it to perform better. In contrast, if there are problems in terms of information among the organizational units (e.g., lack, ambiguity, or error of information), less optimal actions might be taken, leading to lower performance.

Thus, in examining cross-functional integration (or integration in general), the contingency theory does not argue that a greater emphasis on the use of integration mechanisms would lead to higher performance, an assumption made by conventional empirical OM research (e.g., Ettlie 1995; Kahn & McDonough 1997b). The reasoning underlying this argument is that there are significant costs related to the use of integration mechanisms, as well as variations in the requirements for integration; increasing the capacity to process information excessively leads to redundancy and additional costs.

3.1.3 Roots of Integration Requirements

The most important contributors in theorizing about requisite integration and its roots are March and Simon ([1958] 1993) and Thompson ([1967] 2003). March and Simon ([1958] 1993, p. 142) introduce the idea of requisite integration and suggest that "the felt need for joint decision making" in an organization can arise from a number of reasons, two of which are particularly critical: resource allocation and scheduling. They argue that the greater the mutual dependence on limited resources and the interdependence related to the timing of the activities, the greater is the felt need for joint decision making.

Building on the arguments of March and Simon ([1958] 1993), Thompson ([1967] 2003, pp. 54-56) further develops the interdependence argument and suggests that there are variations in the type of interdependence, and each type can be managed with different integration mechanisms. *Pooled interdependence* is less difficult to deal with and it can be managed with standardization requiring a relatively high stability of the environment, whereas *sequential interdependence* can be managed with planning and scheduling. *Reciprocal interdependence* is the most difficult type of interdependence to deal with. The management of reciprocal interdependence requires mutual adjustment, involving transmission of new information during the process and communication across hierarchical lines. Hence, whereas pooled and sequential interdependence can be managed with vertical mechanisms such as centralization, standardization and planning, reciprocal interdependence requires the use of lateral integration mechanisms.[39]

Even though Lawrence and Lorsch (1967, 1967 [1986]) introduce the concept of requisite integration, they do not assess its roots more deeply due to the limits of their data (all organizations were found to have high requisite integration (Lawrence & Lorsch 1967, p. 10)), but suggest that the integration efforts must be consistent with the "requirements of the environment", emphasizing the uncertainty of the environment and the level of differentiation. Later, inspired by Thompson's ([1967] 2003) work, Lorsch and Lawrence (1970; 1972a) reanalyzed their data and report that Thompson's typology of interdependence (Thompson [1967] 2003, pp. 54-56) can be utilized to understand the required and actual integration, as well as the entire pattern of differentiation and integration between organizational units. They conclude that the type of interdependence together with the level of differentiation affects the use of integration mechanisms in organizations: reciprocal interdependence gives rise to higher integration needs, but increasing differentiation simultaneously requires the use of more elaborated mechanisms.

On the basis of the discussion above, it is possible to trace the roots of integration requirements to interdependence of the organizational units, especially reciprocal and team interdependence; a higher level of requisite integration is an implication of higher reciprocal and team interdependence. In all plants, the functions are sequentially interdependent, and at some plants there is also reciprocal and team interdependence. From the information processing perspective, the relationship between interdependence and requisite integration can be explained as follows. Interdependence is related to one

[39] Later also Giachetti (2006) follows Thompson ([1967] 2003) in suggesting that interdependence affects integration and in the case of a more difficult type of interdependence, more time and effort is needed, as well as more elaborate integrating mechanisms.

of the fundamental features of open systems: the systems are seen to have subsystems and are themselves subsumed in larger systems where the movement in one part leads to a movement in another (Katz & Kahn [1966] 1978, p. 3; Scott 1998, pp. 88-89). This creates uncertainty in the organization; the organizational units are not independent in completing their tasks but are dependent on the actions and decisions made by other units. In order to complete their tasks successfully, rational organizations try to reduce uncertainty, and subsequently face information processing requirements leading to integration requirements.

3.1.4 Summary of Contingency Theory Arguments

Based on the discussion above, it is argued that building research on the early structural contingency theoretical arguments and explanations would increase the understanding of integration in OM in terms of the identified research needs as follows:

1) Integration is not a unidimensional concept. A distinction between different integration dimensions of achieved integration, integration mechanisms, and requisite integration can be made. These dimensions need to be understood also in OM and take into account in empirical work, both when defining and operationalizing constructs as well as when formulating hypotheses.

2) There are significant costs related to integration. Due to the costs associated with the use of integration mechanisms, a more extensive use of them is not always desired in terms of higher performance, a hypothesis made in majority of the prior empirical OM research. Moreover, firms differ in their needs for integration mechanisms. When and where integration mechanisms are needed and to which extent, depends on the requisite integration, and thus, assessing requisite integration before the design of the integration mechanism is necessary.

3) The requirements for integration, requisite integration, are mainly determined by the interdependence of the organizational units. More specifically, whereas pooled and sequential interdependence can be managed with vertical mechanisms, reciprocal and team interdependence give rise to requirements for lateral integration. The question of why we observe reciprocal interdependence across functions in some manufacturing organizations and not in others is still

left open. This will be discussed in Chapter 5 when explicit hypotheses are formulated for subsequent empirical testing.

After discussing the theoretical arguments for the clarification of the concept of integration, the integration-performance relationship, and the roots of integration requirements, two conceptual frameworks found in the existing literature addressing the research issues of this dissertation are presented in the following chapter.

3.2 THEORETICAL FRAMEWORKS IN THE EXISTING LITERATURE

The prior contingency theory literature includes to the best of my knowledge two frameworks that address both the antecedents and the effects of integration: the framework of Donaldson (2001), summarizing the work of early structural contingency theorists, and the framework of Tushman and Nadler (1978), summarizing the work of information processing scholars. In the following, I present these frameworks and discuss how they would help in understanding the research problem at hand.

3.2.1 Contingency Theory Framework

Donaldson (2001) discusses the ideas of earlier structural contingency theorists and presents a concluding framework of the work mainly done by Lawrence and Lorsch (1967, [1967] 1986; Lorsch & Lawrence 1972a) and Thompson ([1967] 2003). The framework of Donaldson is presented in Figure 3-1 below.

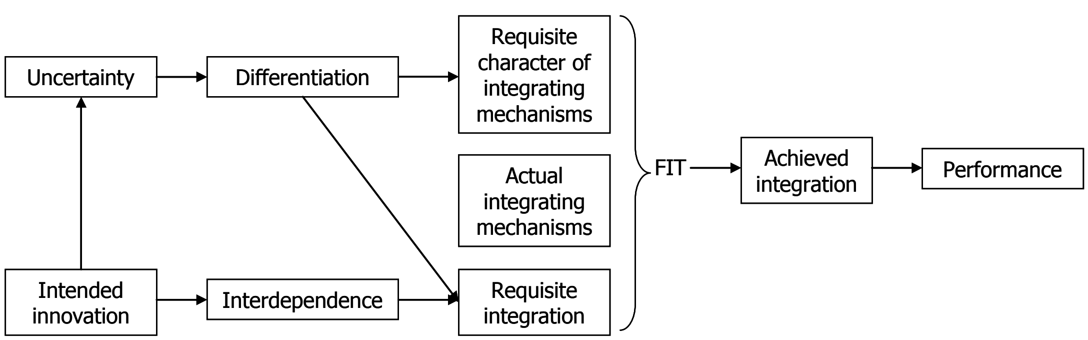

Figure 3-1. Donaldson's concluding framework (modified from Donaldson 2001, p. 45)

Following the structural contingency theorists, Donaldson (2001, p. 45) makes a distinction between achieved integration, integration mechanisms, and requisite integration. He also makes a further distinction between the intensity of requisite integration and the requisite characteristics of integration mechanisms (i.e. appropriate integration mechanisms). Based on prior literature, Donaldson concludes that requisite integration is a result of both differentiation and interdependence. Furthermore, both differentiation and interdependence are the results of the level of intended innovation, although the relation to differentiation is mediated by uncertainty; innovative environments are more uncertain and characterized by higher interdependence. Finally, achieved integration results from the fit between the requisite character of the integration mechanisms, the actual integration mechanisms and requisite integration and is directly associated with performance.

The conceptual framework of Donaldson (2001, p. 45) seems to capture the main ideas of earlier contingency theorists considered important in this research, including the multidimensionality of the integration construct and the idea of requisite integration. However, it is considered that the framework needs some modifications because some points of the early contingency theorists can be interpreted differently. These issues are discussed in the following.

First, Donaldson (2001, p. 45) suggests that more elaborate mechanisms are needed to achieve integration when the level of differentiation is high, thus arguing that the requisite character of integration mechanisms is determined by differentiation. However, both Thompson ([1967] 2003) and Lorsch and Lawrence (1970; 1972a) suggest that the type of interdependence is related to requisite integration in terms of the required character of the integration mechanisms: pooled or sequential interdependence can be managed with less demanding mechanisms such as standardization, whereas the management of a more complex type of interdependence requires more elaborate integration mechanisms, such as integrators and integrating teams. Further on, although Lawrence and Lorsch ([1967] 1986) suggest that differentiation has an effect on the required character of integration mechanisms, they do not perceive that differentiation itself induces the requirements on the integration mechanisms (Lawrence & Lorsch [1967] 1986). Rather, interdependence between the units is needed for the requirements to arise. Only in case the units are interdependent, are there requirements for the implementation of integration mechanisms.

Second, citing Lawrence and Lorsch ([1967] 1986), Donaldson (2001) suggests that the intended innovation determines both the environmental uncertainty and interdependence. Lawrence and Lorsch ([1967] 1986, pp. 88-99), however, do not talk about interdependence only in relation to innovation. In contrast, they argue that the dominant competitive issue in general is related to uncertainty. Although uncertainty is considered higher when the dominant competitive issue is innovation, organizations emphasizing competition based on delivery or quality are not necessary similar in terms of uncertainty. Thompson ([1967] 2003, pp. 54-55), on the other hand, argues that technology determines the interdependence of the units: mediating technology being related to pooled interdependence, long-linked technology to sequential interdependence, and intensive technologies to reciprocal interdependence.

3.2.2 Information Processing Framework

The information processing framework presented by Tushman and Nadler (1978) attempts to draw together the seminal work of Galbraith (1970, 1973) on information processing in organizations. The framework addresses the issue of why the fit between the organization design and context leads to higher effectiveness in more detail than the work of early structural contingency theorists (e.g., Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003). The framework has been applied also to the OM context, both in supply chain (Bensaou & Venkatraman 1995) and manufacturing contexts (Flynn & Flynn 1999). Also this framework addresses integration within the organization, acknowledging that there are different needs for integration mechanisms in different organizations, but takes a somewhat different perspective than Donaldson (2001, p. 45). The framework is presented in Figure 3-2 below.

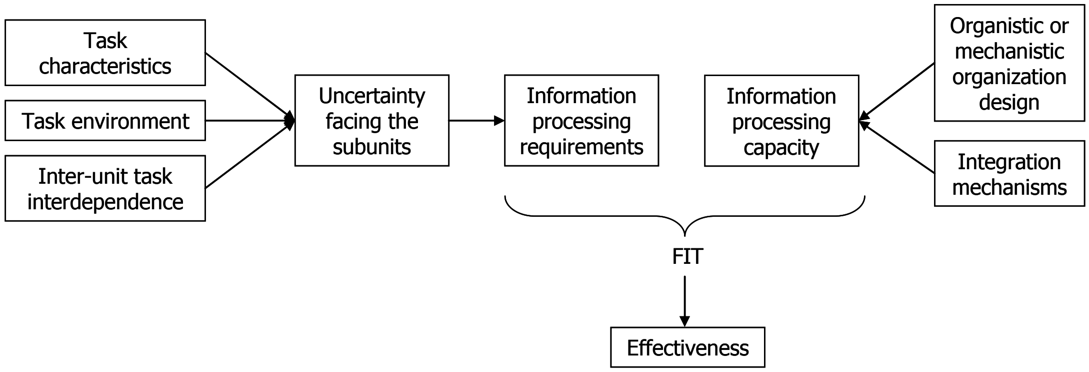

Figure 3-2. Information processing framework (modified from Tushman & Nadler 1978)

Tushman and Nadler (1978) suggest that different organizations face different requirements for information processing, depending on the task, task environment and inter-unit task interdependence. In effective organizations, there is a fit between the information processing requirements and information processing capacity. Capacity to process information in an organization depends on the overall structure (centralization, standardization) as well as on the use of (lateral) integration mechanisms. The framework incorporates the idea that the integration mechanisms are not equally important for all organizations but rather differ in terms of the information processing requirements. Effectiveness then is a result of a fit between the requirements to process information and the capacity to process it, hence addressing also the integration-performance relationship.

There are, however, two important issues why some modifications to the framework are needed for the context of the research at hand. First, the framework addresses how the contingencies affect the information processing requirements *within* an organizational subunit (e.g., within the manufacturing function) rather than the design of a multiunit organization, which includes the issue of subunit relationships (i.e. integration of functions). Hence, it is not correct to conclude on the basis of the framework that the three contingencies of task characteristics, task environment, and inter-unit task interdependence all directly affect the information processing requirements. Rather, also Tushman and Nadler (1978) point out that only inter-unit interdependence directly affects information processing requirements *across* subunits.

Second, although tempting, relating information processing requirements only to the concept of requisite integration is not warranted. Even though requisite integration implies information needs, requisite integration is not the sole factor affecting information processing needs, because, building on the work of Lawrence and Lorsch ([1967] 1986) and Thompson ([1967] 2003), it is possible to link the notion of information processing requirements to both requisite integration and differentiation. Information processing scholars, however, do not make a distinction between differentiation and integration, and hence, tracing the antecedents of integration (even within a subunit such as function) is somewhat problematic; some of the contingencies affecting information processing needs can be linked to requisite integration and some to differentiation.

Based on the discussion above it is clear that although the two frameworks take a somewhat different perspective and focus on different issues, both of them tackle the problems addressed in this research. Because the frameworks take a somewhat different perspective to the same problem, drawing them together is considered beneficial. For the purposes of this research, I build on the two frameworks and the underlying theoretical ideas of early structural contingency theorists (e.g., Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003) and information processing scholars (e.g., Galbraith 1973; Tushman & Nadler 1978). In the following section, I present the modified concluding framework used in this research.

3.3 THEORETICAL FRAMEWORK EXAMINED IN THE PRESENT RESEARCH

The theoretical framework of this research is presented in Figure 3-3.[40] The framework builds on the concluding frameworks of Donaldson (2001, p. 45) and Tushman and Nadler (1978) and the underlying ideas of structural contingency theorists (Lawrence & Lorsch [1967] 1986; Lorsch & Lawrence 1972a; Thompson [1967] 2003), as well as the

[40] The theoretical framework assessed in this research can be classified as a variance model (Langley 1999; Van de Ven 2007, Ch. 6). Van de Ven (2007, p. 158) suggests that variance models are more suitable in organization studies focusing on questions regarding the antecedents and consequences of something, as is the case in the present research.

information processing scholars (Galbraith 1970, 1973; Tushman & Nadler 1978). The framework draws together the theoretical concepts and arguments which address each of the three objectives of this research (see Section 3.1): to clarify the integration concept, to increase understanding of the integration-performance relationship, and to clarify the antecedents of integration (requisite integration). In addition to the theoretical framework, Figure 3-3 also includes references to relevant empirical research related to different parts of the framework.[41]

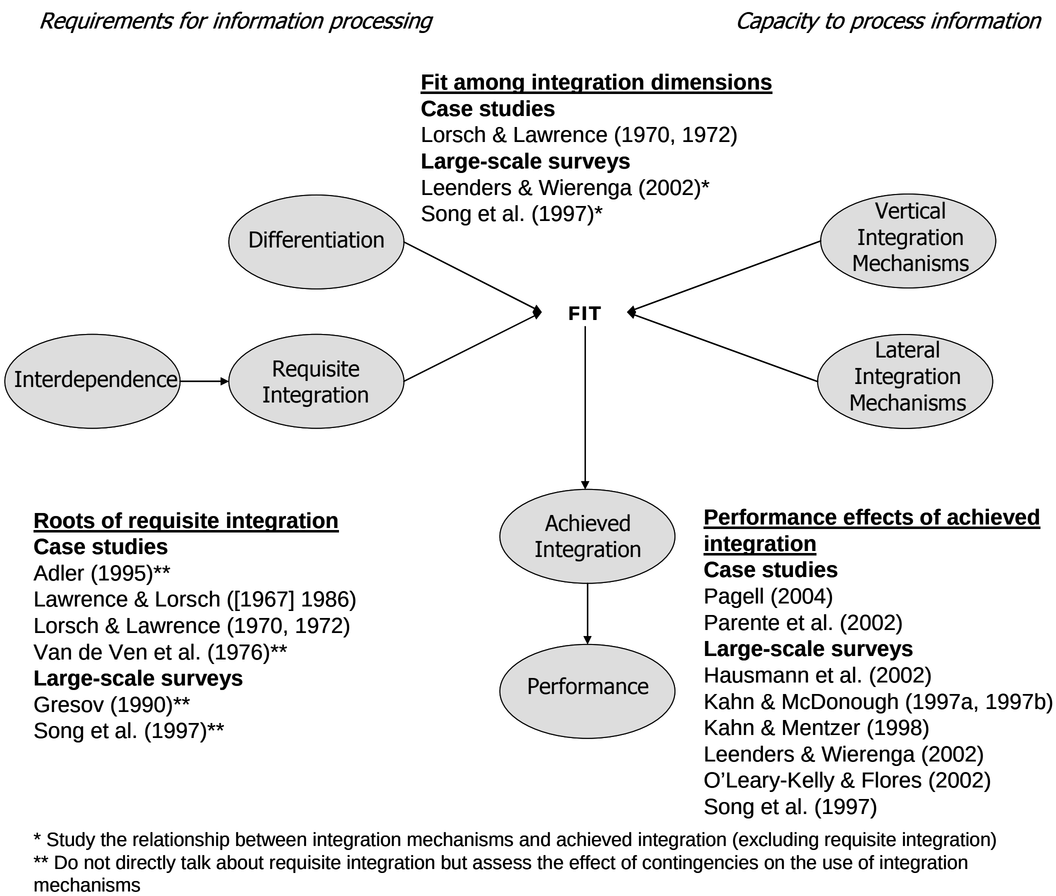

Figure 3-3. Theoretical framework examined in the present research and related empirical studies

[41] It is important to note that I do not claim that the framework of the dissertation is somehow better than the ones in the existing literature. A modified framework is needed because it is more suitable for the purposes of the present research and because I have interpreted some of the ideas of the contingency theorists differently than Donaldson (2001). This is in line with the somewhat subjectivist epistemology taken in this research; theoretical frameworks are always seen only as a partial representation of a complex phenomenon that reflects the perspective of the researcher and the purposes of the research.

On the left-hand side of the figure are factors affecting the requirements for information processing; requisite integration and differentiation. On the right-hand side are factors related to the information processing capacity of the organization; vertical and lateral integration mechanisms. Following the information processing scholars, a fit between information processing requirements and capacity to process information is suggested to lead to effectiveness (Galbraith 1973; Tushman & Nadler 1978). *Clarifying the concept of integration*, taking the level of differentiation as given, the framework posits that a fit between requisite integration and vertical and lateral integration mechanisms is associated with a higher level of achieved integration. In terms of addressing the *integration-performance relationship*, the framework suggests that the achieved integration is related to performance. Finally, in terms of the *antecedents of integration*, the framework follows the arguments of Thompson ([1967] 2003) and Lorsch and Lawrence (1970, 1972a); the requirements for integration are determined by inter-unit interdependence. More specifically, requisite integration is an indicator of reciprocal or team interdependence.

The framework can also be linked to the classical approach to work design (e.g., Sinha & Van de Ven 2005)[42]. Work design consists of decisions regarding differentiation, centralization, formalization, and integration (referring to the use of lateral integration mechanisms). The framework of this research extends it by incorporating the concept of requisite integration as an integral part of work design. The framework of this research takes a holistic perspective to organization design, which has been called for (Sinha & Van de Ven 2005), including issues of inputs (contingencies), design, and outputs (performance). The framework also emphasizes the internal fit argument (configuration hypothesis of Mintzberg (1979, p. 219)) at the organizational level, arguing for the importance of internal consistency among the design parameters of differentiation, requisite integration, and vertical and lateral integration mechanisms in order to design an effective organization.

Issues included in the framework have rarely been addressed empirically or theoretically in OM. Moreover, even though the issues have been discussed

[42] For empirical work assessing the traditional work design problem in OM, see Rondeau et al. (2000), who address the design of a manufacturing organization.

theoretically in OT, empirical research in that field is very limited. First, research addressing interrelations of different integration dimensions is scarce. Few scholars have identified two integration dimensions (achieved integration and integration mechanisms) (Leenders & Wierenga 2002; Song et al. 1997), and research addressing all three dimensions is hardly found (except for Lorsch & Lawrence 1970, 1972a). As prior OM research has not made a distinction between different integration dimensions, it has not empirically addressed the interrelationships of these dimensions, either. Likewise in OT, the empirical work on assessing the interrelations of requisite integration, integration mechanisms, and achieved integration is very scarce. Second, there is limited research directly assessing the effect of achieved integration on performance. When analyzing the operationalizations of integration in OM, it is possible to identify some research addressing that specific relationship (Leenders & Wierenga 2002; O'Leary-Kelly & Flores 2002; Song et al. 1997). Third, there is very limited amount of research on the concept of requisite integration and its roots. Requisite integration has not been studied empirically in OM and it has also received very limited attention in OT since the seminal work of Lawrence and Lorsch ([1967] 1986; Lorsch & Lawrence 1970, 1972a). Some scholars do address how contingencies, such as task interdependence affect the use of integration mechanisms, acknowledging the idea of requisite integration without directly addressing it, although the context varies widely (e.g., cross-functional integration at interdepartmental level (Adler 1995) or at team level (Van de Ven et al. 1976), or integration in the context of strategic alliances (Gerwin 2004)). Finally, the few empirical investigations on the framework are mainly case-based; less emphasis has been given to addressing the framework with large-scale data.

Comparison of the framework above (Figure 3-3) with the framework of Donaldson (Figure 3-1) points out two fundamental differences, both of which are related to the critique presented in this research on Donaldson's (2001) framework. First, a fundamental difference is that Donaldson (2001) makes a distinction between the requisite level of integration and requisite character of integration mechanisms. In the framework examined in the present research, the concept of requisite integration captures ideas of both the requisite level of integration and requisite character of integration mechanisms; it is assumed that when the requirements for information processing are more demanding, more elaborated integration mechanisms and/or more extensive use of current mechanisms are needed. The second difference is related to the roots of requisite integration. Whereas Donaldson (2001) considers that requisite integration is determined solely by intended innovation and the subsequent interdependence, the framework of the dissertation leaves the determinants of interdependence for further analysis; in the cross-functional context it seems that interdependence can also be a result of some factors related to current products rather than just new innovation (Scott 1998, p. 233) (e.g., the technology of Thompson ([1967] 2003); this issue is further discussed in the context of this research when formulating explicit hypotheses for testing in Section 5.3). Comparison of the framework with the information processing framework of Tushman and Nadler (Figure 3-2) also points two fundamental differences. First, the framework assessed in the present research makes a clear distinction between information processing needs induced by differentiation and information processing needs induced by integration (i.e. requisite integration); information processing needs are not directly equal to requisite integration. Second, the level of observation in the framework examined in the present research is in particular in the cross-functional context rather than at the work-unit level.

In this chapter, I have built the theoretical basis of the present research. I have explained and drawn together the theoretical ideas and arguments of the early structural contingency theory that I perceive important and relevant for advancing the research on cross-functional integration in OM, and discussed them in terms of the purposes of the present research. The theoretical discussion presented in this chapter has targeted the research gaps identified on the basis of the review of prior research on cross-functional integration in OM. The chapter culminates in the presentation of a theoretical framework building on the ideas of early structural contingency theorists and information processing scholars. In order to further advance the research stream, empirical assessment of the theoretical framework is needed. The following chapter focuses on the empirical assessment; issues related to the research approach as well as data and measurements, including operationalizations of the constructs are discussed.

CHAPTER 4
RESEARCH DESIGN

Issues related to the empirical part of this research are discussed in this chapter. The chapter is divided into five sections. In the first section, I briefly present the research strategy taken in this research: the hypothetico-deductive empirical research approach. In the second section, I discuss the empirical data and the data collection, followed by an overview of the methods of data analysis in the third section. In the fourth section, I present the operationalizations of the constructs, and finally, in the fifth section I discuss and assess the topics of validity and reliability.

The discussion about research design often focuses on the qualitative-quantitative debate. The strategy for gaining new knowledge about organizations, however, depends rather on the underlying assumptions and ways of thinking; the paradigmatic assumptions underlying the research play an integral part in the selection of research design and data (Burrell & Morgan 1979; Daft 1983; Gioia & Pitre 1990; Morgan & Smircich 1980). This research follows the scientific realist philosophy of science (see Chapter 1), which emphasizes objective ontological and subjective epistemological perspectives and can be classified as belonging to the functionalist paradigm in the classification of Burrell and Morgan (1979; Morgan 1980). It is, however, important to note that the functionalist paradigm characterizes the meta-theoretical assumptions of the research; within the functionalist paradigm, different scholars emphasize different issues and take different standpoints. In light of this, the functionalist paradigm can be considered as the global paradigm of this research. At a more detailed level, then, this research follows the contingency theoretical paradigm.

The assumptions regarding ontology and epistemology have implications for the appropriate research methodology (Burrell & Morgan 1979; Cohen & Manion 1994; Niiniluoto 1980, p. 28). Following the scientific realist philosophy of science, this research takes the objective (nomothetic) approach, which emphasizes the importance of a systematic protocol and technique and the use of such methods as surveys, questionnaires, and other standardized research instruments (Burrell & Morgan 1979). The objective methodology (like subjective) can then be employed in either a deductive or inductive sense. The following discussion about the research methodology closely follows the systematic approach presented by Flynn et al. (1990). The approach, which they build on the work done in social sciences, consists of the following parts: discussion of the role of theory, data collection strategy and method, implementation (sample selection, instrument development etc.), and methods of data analysis.

4.1 RESEARCH STRATEGY

Research strategy refers to the logic of approaching the research questions and deals with the relationship between data and theory. The research strategy chosen for the purposes of this research is hypothetico-deductive theory-driven empirical research design, with data collected by survey research method. The selected research strategy, as well as the justification for it is discussed in the following. First, the perspective to theory is discussed.

4.1.1 Definition of Theory

Within the context of this research, theory is defined as a statement of relationships between units (Bacharach 1989; Daft 1985). Theory is seen as a noun (cf. Glaser & Strauss [1967] 1999). The building blocks of theory are (Bacharach 1989; Bagozzi 1984; Schmenner & Swink 1998; Wacker 1998; Whetten 1989): (i) definitions and explanations of factors part of the phenomenon (what), (ii) relationships of how the factors are related (how), (iii) explanation of the underlying aspects that justify the selection of factors and proposed relationships (why), and (iv) temporal and contextual limitations of the theory (when).

In this research, a clear distinction is made between the theoretical and empirical domain (e.g., Bacharach 1989; Bagozzi 1984; Chimezie & Osigweh 1989; Malhotra & Grover 1998; Nunnally & Bernstein 1994). *Constructs* are located in the theoretical domain (Malhotra & Grover 1998) and explicated in the language of theory (Bagozzi 1984). Constructs are defined as empirical approximations which by their very nature cannot be observed directly but are in fact "constructed" by the researcher. Examples of constructs include the level of achieved integration and the level of centralization. *Variables*, on the other hand, are defined as entities observed in the empirical world (or what Malhotra & Grover (1998) call the operational domain). Examples of variables include the number of organizational levels in the hierarchy and the number of employees in the organization. The relationship between construct and variable, then, is called operationalization.

4.1.2 Hypothetico-Deductive Theory-Based Empirical Research Design

The discussion about the relationship between data and theory is related to the question of whether data precede theory or theory precedes data (Raatikainen 2004, p. 37). The relationship between data and theory, as well as the approach to theory are different in different research paradigms (Gioia & Pitre 1990). This research, like typical research in the functionalist paradigm, emphasizes the hypothetico-deductive research design (e.g., Bacharach 1989; Camerer 1985; Melnyk & Handfield 1998; Niiniluoto 2000)[43]; hypotheses are formulated on the basis of contingency theoretical arguments to address the research gaps identified in the prior research and then tested. The hypothetico-deductive research design is considered appropriate also due to the technical knowledge interest of the research (Niiniluoto 1980, p. 72); the interest of gaining knowledge in this research is perceived as explaining potential causal relationships inherent in the real world, including both the effects and the antecedents of cross-functional integration in manufacturing plants rather than emancipating or understanding.

In order to increase the understanding of organizations and integration within them, the research takes an *empirical approach* (Amundson 1998; Clegg & Hardy 1996; Flynn et

[43] Deductive here is related to the research design rather than to the way of reasoning. There is a clear difference between research design and scientific reasoning, even though same terminology is used and they are often considered as pairs. Ketokivi and Mantere (2006) discuss this problematics and after analyzing four articles representing different research designs they conclude that scholars using different research designs use the same three elementary forms of reasoning: abduction, induction and deduction.

al. 1990; Scudder & Hill 1998). Empirical research refers to research that is field-based and uses data gathered from naturally occurring situations or experiments. OM research has traditionally been analytical (mathematical modeling and simulation, see for example the literature review of Wacker 1998), and empirical research designs over mathematical models and simulations have been widely proposed (e.g., Flynn et al. 1990; Scudder & Hill 1998; Swamidass 1991).[44] In addition to the recent development of OM, the empirical research design is considered appropriate for the purpose of this research; manufacturing organizations and their integration with other functions are embedded in the empirical universe making empirical investigations possible (Swamidass 1991) (sometimes considered even necessary (Clegg & Hardy 1996; Daft 1983; Stablein 1996, p. 509)). But more importantly, it is considered in this research that only with empirical observations can we try to fully understand integration in organizations.

In this research, theories are approached from a falsification perspective (Popper 1959); only falsification of theories (as opposed to verification) is considered possible. Hence, it is not possible to prove and show that a theoretical statement present an absolute truth. This is somewhat in contrast to prior OM (e.g., Flynn et al. 1990) and contingency theory literature (e.g., Donaldson 2005), which suggest that theories are verified by empirical data, taking a rather strict positivist approach to science. The end result of the present research, then, is not a verified theory or a new theory but rather an improved, refined theory (e.g., Gioia & Pitre 1990; Melnyk & Handfield 1998). Like most organization studies, this research deals with middle-range theories (Bacharach 1989; Bourgeois 1979; Layder 1993; Merton 1968). Middle-range theories address middle-range phenomena and are defined as theories that fall between minor working hypotheses of early-phase research and grand over-arching theories that are often too general to be tested (Layder 1993; Merton 1968); this research deals with contingency theoretical arguments in the context of cross-functional integration at manufacturing plants. Middle-range theories describe the relationships between empirically approachable constructs, which can then be tested with empirical evidence (Layder

[44] In this research, it is perceived that different designs serve different purposes rather than one being better than the other. Furthermore, it is not suggested that empirical designs should supplement analytical studies, but rather serve as a complement (e.g., Porter 1991). Empirical studies can be used for example in developing parameters and distributions for analytical studies (e.g., Flynn et al. 1990).

1993). Testing those relationships requires replication and in order to make statistical generalizations, large-scale data are needed (Yin 1990, pp. 30-36).

In this research, the survey research design has been used to collect empirical data. Surveys are the prominent empirical research design in OM (Flynn et al. 1990; Malhotra & Grover 1998; Scudder & Hill 1998), and one of the most commonly used designs in organizational studies as well (Stablein 1996). In general, survey research includes the collection of information from a large group of informants (or population). Malhotra and Grover (1998) define three distinct characteristics of survey research: collection of information in some structured format, a standardized instrument for gathering information, and gathering information via a sample. In more specific terms, the research design of this dissertation can be classified as an explanatory survey (Malhotra & Grover 1998), which is aimed at finding causal relationships between constructs. Survey research is also a suitable data collection method for the paradigmatic assumptions made in the research (Burrell & Morgan 1979), as well as the research problem at hand (Flynn et al. 1990; Yin 1990). In the present research, survey is conducted by collecting data with written questionnaires. In the following, the survey data and data collection process are discussed in more detail.

4.2 DATA AND DATA COLLECTION

4.2.1 High Performance Manufacturing Survey

The data analyzed in this research were collected as part of the third round of the High Performance Manufacturing (HPM) research initiative (previously World-Class Manufacturing Project (for a detailed description of the project, see Schroeder & Flynn 2001)). The first round of HPM project was launched in the late 1980s to assess for example manufacturing practices and performance in three industries of electronics, machinery, and transportation (suppliers of automotive industry) in different countries. The research also addresses other topics, including operations strategies and organization design issues. The project has broadened both in terms of topic areas and participating countries over the years. The research is purely academic in nature: the measures are carefully developed with academic research purposes in mind and the data are available to the participating researchers only. Due to the breadth and depth of the research, the data allows careful analysis of various manufacturing-related issues at manufacturing plants both substantially and methodologically from different perspectives. During each round of data collection, prior round is carefully evaluated and significant attention is given to planning of the data collection. This is improved by the fact that the global research team is rather small, cooperation is close and there are several key persons who have been involved since the beginning of the project.

The HPM project team consists of researchers located in each of the participating countries. The global project team meets several times a year to discuss the research project and develop the research. The research team is further divided into smaller groups based on research interests. These topic groups work together to evaluate prior data in the focal topic area and to develop data collection instrument for that part. Hence, each participant can affect what kind of data is collected based on his/her research interests.

The data used in this research were collected from 236 plants in eight countries (Austria, Finland, Germany, Italy, Japan, Korea, Sweden, and the United States) between the years 2003 and 2006. The data represent plants operating in different types of manufacturing industries and located in different countries across the three main continents. Stratified sampling design (Forza 2002) was used. The preliminary idea was to collect data from 30 plants in each country (ten plants in each of the three industries). This requirement was, however, somewhat relaxed in the process of the data collection. It is acknowledged that there is some sampling error (Malhotra & Grover 1998) inherent because the stratification does not represent the proportion of plants in each country and industry in the population, but it is allowed to prevent any of the stratas to dominate the sample. Furthermore, the sampling was carried out so that around 50% of the plants are considered as world-class plants. Table 4-1 below presents the stratification of the sample.

Table 4-1. Stratification of the HPM sample

	Country								
Industry	AUT	FIN	GER	ITA	JPN	KOR	SWE	USA	Sum
Electronics	10	14	9	10	10	10	7	9	79
Machinery	7	6	13	10	12	10	10	11	79
Transportation	4	10	17	7	13	11	7	9	78
Sum	21	30	39	27	35	31	24	29	236

The response rate varied across countries, the average being approximately 65%. In order to achieve such a high response rate, plant managers were contacted in advance and asked to participate in the survey. In addition, each plant was promised a profile of responses in which the focal organization was compared to the rest of the sample in terms of for example strategy, manufacturing practices, and performance.

Throughout the history of the HPM project, the overall focus has been on world-class manufacturing practices. Hence, the sampling focused on mid-sized or larger manufacturing plants (for the distribution of plant size, see Figure 4-1).

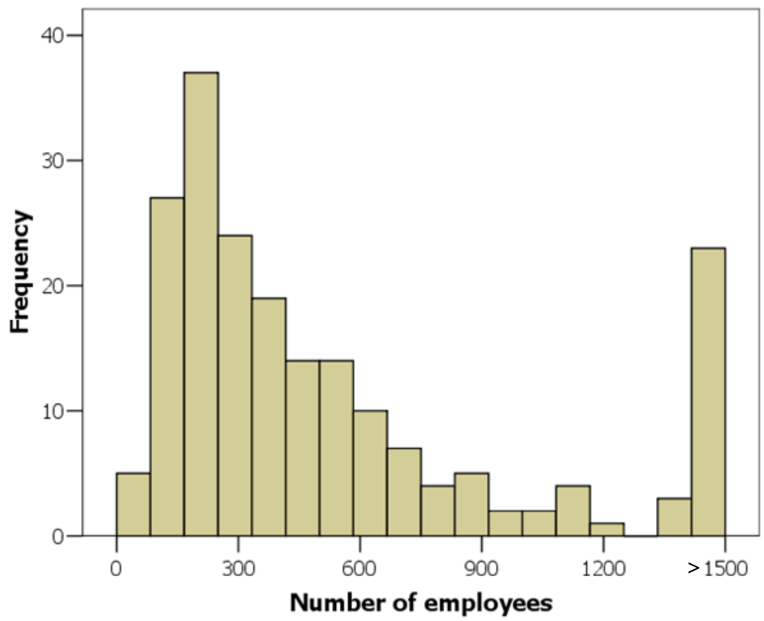

Figure 4-1. Distribution of plant size in the sample (total number of employees)

The data are mainly cross-sectional and includes altogether around 1040 variables, the majority of which were collected from multiple informants, allowing rigorous analysis both methodologically and substantially. The data include both objective and subjective measures (judgments and sentiments (Nunnally & Bernstein 1994, p. 50)), as well as absolute and comparative variables. Subjective data were collected with psychometric Likert scales. Many of the psychometric scales were developed for the first (late-1980s) and second round (mid-1990s) of the data collection and have been tested for reliability and validity (e.g., Flynn, Schroeder & Flynn 1999; Junttila [Ketokivi] 2000). In this research, only a small proportion of the data is used.

4.2.2 Data Collection

The data were collected with written survey questionnaires. The survey questionnaires were developed jointly by the global research team but a local research team was responsible for the data collection in each country. Significant attention was paid to the development of the data collection instrument. The instrument was translated to the local language in each country. Translation and back-translation were used to ensure consistency in the survey instrument across countries. Furthermore, the data collection instrument was pilot tested with both academics and managers in different countries.

Multiple respondents per plant were used for the data collection. The questionnaire was differentiated to focus on the specific expertise area of each respondent (i.e. the key informant method (Bagozzi, Yi & Phillips 1991)) to make sure that the respondent is most likely to have the requested information. In total, 12 different questionnaires were developed. These were distributed to 12-23 individuals in various organizational units and at different levels in the vertical organization (managers, supervisors, and direct labor). Titles of the informants include: Plant Accounting Manager (AC), Direct Labor (DL), Human Resources Manager (HR), Information Systems Manager (IS), Production Control Manager (PC), Inventory Manager (IM), Member of the Product Development Team (PD), Process Engineer (PE), Plant Manager (PM), Quality Manager (QM), Supervisor (SP), and Plant Superintendent (PS). For example, items dealing with the level of achieved integration were included in the questionnaires of the plant manager, plant superintendent, and process engineer because each of them is likely to have information about it, and this information is unique representing his or her perspective. The use of the key informant method allows each respondent to answer questions related to his or her specialty area, which increases the reliability of the research (Kumar, Stern & Anderson 1993). Of the sample, 97% of plants returned at least 12 surveys.

4.3 METHODS OF DATA ANALYSIS

For data analysis, statistical methods are used in this research. First, Confirmatory Factor Analysis (CFA) is used for construct operationalizations as well as for the assessment of reliability and validity. Then, multiple regression analysis is used as the main method for assessing the relationships between different constructs. Structural Equation Modeling (SEM) is mainly used for complementing the regression analyses. In the following, I discuss the main issues related to the different methods of analysis used in the research.

4.3.1 Confirmatory Factor Analysis

The data of this research has been collected by using mainly multi-item psychometric scales. Factor analysis is used for operationalizing the theoretical constructs from the observed variables as well as for the assessment of reliability and validity.

There are two types of factor analysis: Principle Component Analysis (PCA) and Principle Factor Analysis (PFA), depending on how the variables are related to the constructs. Although factor analysis is an important and widely used technique, it is often misused in terms of how the variables are treated (Nunnally & Bernstein 1994, p. 452) and, hence, it is briefly discussed here. The selection of the appropriate type of factor analysis is made based on both the objective of the analysis and the prior knowledge about the variance (Hair, Anderson, Tatham & Black 1998, p. 102). Total variance can be divided into three parts (Hair et al. 1998, p. 100; Nunnally & Bernstein 1994)[45]:

Total variance = Common variance + specific variance + error variance

Common variance refers to the variance in a variable that is shared with all variables in the analysis. The rest of the variance is unique variance, which is divided into specific and error variance. *Specific variance* is systematic variance associated with only one specific variable, whereas *error variance* refers to the variance due to unreliability in the data gathering process, measurement error, or a random component in the measured phenomenon.

PCA attempts to explain common variance with linear combinations of variables, which results in treating unique variance as residual not explained the by factors (Hair et al.

[45] Although the selection of whether to use PCA or PFA should be done on the basis of theoretical reasons, the empirical results suggest that CFA leads to less bias than PCA (Little, Lindenberger & Nesselroade 1999).

1998, p. 131; Nunnally & Bernstein 1994, p. 466). It is more appropriate when the aim is to predict or to extract the number of factors with a maximum portion of variance of the original data, and when error variance is known and not significant (Hair et al. 1998, p. 100). PFA, on the other hand, separates common variance from unique variance (Nunnally & Bernstein 1994, p. 467) and it is suitable when the aim is to identify theoretical constructs, with little knowledge about the variance (Hair et al. 1998, p. 102). Hence, PFA is suitable for the construct operationalizations in this research. In this research, Confirmatory Factor Analysis (CFA) type of PFA is used. In CFA, the relationships between observed variables and the theoretical construct are first determined and then a specific estimation method is used to estimate how the data fit the pre-specified structure of the construct (Bollen 1989; Hair et al. 1998, p. 91; Nunnally & Bernstein 1994, p. 451). In this research, CFA is conducted with structural equation modeling (e.g., Bollen 1989, Ch. 7). The method is discussed in Section 4.3.4 below.

4.3.2 The Classical Linear Regression Model

The hypothesis-testing part of this research mainly rests on multiple regression analysis. The multiple regression method refers to a statistical method used to explain variation in a single dependent variable with variation in multiple independent variables (e.g., Hair et al. 1998). Several different estimation methods can be used in multiple regression, depending on the behavior of the data, most popular of which is Ordinary Least Squares (OLS).

Multiple linear regression using OLS estimation is called the Classical Linear Regression Model (CLRM). It consists of five assumptions about the way in which the observations are generated. These assumptions need to be assessed before the actual analysis, in order to assess the appropriateness of the OLS estimation. The assumptions are as follows (Kennedy 2003, pp. 48-49; Kutner, Nachtsheim, Neter & Li 2005, p. 103):

1) The dependent variable can be calculated as a linear function of a set of independent variables and a disturbance term. In addition, the coefficients of the independent variables in the regression equation are assumed constant;

2) The expected values of the residuals are zero;

3) The residuals have the same variance (problem of heteroscedasticity), are not correlated with one another (problem of autocorrelation), and are normally distributed;

4) The observations of the independent variable are fixed in repeated samples; and

5) The number of observations is greater than the number of independent variables and there is no exact linear relationship between the independent variables (problem of multicollinearity).

Violations of the assumptions lead to a situation in which the OLS estimator is no longer considered optimal. Furthermore, depending on which of the assumptions is violated, different kinds of problems arise, which can then be approached with different methods.

Typical violations in the context of this research are related to the assumption of homoscedasticity of the residuals and to the assumption of fixed observations of the independent variables. When the assumption of nonspherical residuals (i.e. the residuals are homoscedastic and follow a normal distribution, assumption 3) is violated, CLRM is referred to as the General (or Generalized) Linear Model (GLM). Although the OLS estimator is still unbiased, it is not efficient (i.e. minimum variance). Despite the fact that the OLS estimator is unbiased, it can lead to false conclusions when statistical inferences are made (Cohen, Cohen, West & Aiken 2003, p. 479; Kennedy 2003, p. 134). An efficient and unbiased estimator then is Generalized Least Squares (GLS), in which the weighted sum of the residuals is minimized rather than the sum of squared residuals (Kennedy 2003, p. 135). In this research, GLS estimation is used in most parts of the hypothesis testing because of the type of violations of the CLRM assumptions. On the other hand, violation of the assumption of fixed observations (assumption 4) is approached in a different way. Rather than using another estimation method, minimizing the effect of violation is emphasized by paying attention to the issue of measurement reliability. In addition, the potential effect of violation of this assumption is assessed as additional tests of robustness of the results.

In this research, emphasis is put on the potential violations of the assumptions and the potential violations are assessed in each estimated model (Chapter 5) to determine if the OLS estimator is appropriate in the specific case.

4.3.3 Ordinal Regression

Ordinal regression (cumulative logit model, parallel regression model, proportional odds model) is a specific type of regression method which can be used in case the dependent variable is ordinal. Because it is not widely used in OM (for an example in OM, see Ketokivi & Schroeder 2004a), the basic assumptions and estimation method is explained here. In the model, ordered responses are treated simply as category rankings. An underlying assumption is that the distance between two categories is not necessarily the same (Kennedy 2003, p. 263; Powers & Xie 2000, p. 201), leading to nonspherical residuals (i.e. violating assumption 3 of homoscedasticity and normality of the residuals). Thus, the OLS estimator is no longer optimal, calling for an alternative estimation model.

The cumulative logit model for an ordinal variable with J categories is (Kutner et al. 2005, p. 616; McCullagh 1980):

$$\ln\left[\frac{P(Y_i \le j)}{1 - P(Y_i \le j)}\right] = \alpha_j + X_i'\beta \quad \text{for j = 1, …, J – 1}$$

In the above equation $P(Y_i \le j)$ refers to the cumulative probability rather than to a specific category probability $P(Y_i = j)$.

In the logit model there is no analytic solution for calculating the coefficients because of the nonlinear transformation. Iteration with the Maximum Likelihood (ML) function can then be used (Cohen et al. 2003, p. 498; Hair et al. 1998, p. 278). The goal is to find estimates of α_j and $\boldsymbol{\beta}$ that maximize the joint probability of obtaining the observed value (Powers & Xie 2000, p. 217).

Ordinal regression does not make any assumptions on the dependent variable; the categorization can be arbitrary, and the distance between different categories does not necessarily need to be the same (only their ordinality is assumed (Cohen et al. 2003, p. 523)). Ordinal regression makes two assumptions that need to be assessed: (i) the assumption on non-existence of multicollinearity and (ii) the assumption on parallel lines. The assumption on parallel lines refers to the hypothesis that the independent variables have the same impact on all the thresholds of the dependent variable. This can be tested with a Score test comparing the fit of a model in which a single slope is applied to the whole continuum versus an unconstrained model in which a different slope is permitted for cases below versus above each threshold (Cohen et al. 2003, p. 524). The null hypothesis is that the parallel slopes model applies, meaning that the independent variables have the same impact on all the thresholds. If the χ^2-statistic is not significant, the assumption of parallel slopes is met.

In ordinal logistic regression, the overall model fit is assessed with the χ^2-statistic (this test is analogous to the F-statistic test with OLS regression). The null hypothesis is that the location coefficients for all the independent variables in the model are zero (Norusis 2007, p. 79). A significant test statistic here means that the null hypothesis can be rejected and the model fits the data.

Unlike R^2 in the traditional OLS regression, there is no single accepted index of goodness of fit in ordinal regression (Cohen et al. 2003, p. 502). In this research, concordance index is used. Concordance index refers to the percentage of observations for which the estimated model predicts a correct value in the dependent variable (Agresti 1990; Kutner et al. 2005, p. 607). As an example, let us consider an ordinal dependent variable with 5 categories. A random guess would be correct in 20% of the observations because there are five categories in the dependent variable. If the estimated model predicts a correct category in the dependent variable for example in 50% of the observations (i.e. the prediction and the outcome are concordant) it can be concluded that the model fits the data or at least that it is better than a random guess.

The assessment of the individual coefficients is carried out by calculating the Wald statistic (Hair et al. 1998, p. 281) (analogous to the t-statistic in OLS). The Wald statistic refers to the ratio of the square of the estimate of regression coefficient β_j to the square of the estimate of its standard error, and it follows the χ^2 distribution with 1 degree of freedom (Cohen et al. 2003, p. 507). The null hypothesis is that the coefficient is zero (H_0: $\beta = 0$; H_a: $\beta \neq 0$) (Kutner et al. 2005, p. 578). A significant test statistic suggests that the null hypothesis is rejected and the focal coefficient is different from zero.

4.3.4 Structural Equation Modeling

Structural Equation Modeling (SEM) (latent variable structural equation modeling, analysis of covariance structures) is a method to represent, estimate, and evaluate models of linear relationships among a set of variables or constructs (e.g., Bollen 1989; Rigdon 1998; Shah & Goldstein 2006; Williams, Edwards & Vandenberg 2003). In fact, SEM is a generalization of all multivariate analysis techniques. Whereas the traditional regression models aim at prediction, the objective of SEM is to find whether the a priori specified model is suitable to the data (i.e. whether the covariance or correlation matrix derived from the data is consistent with a hypothetical matrix implied by the a priori specified model) (Bollen 1989, p. 10).

SEM makes a distinction between observed variables and theoretical constructs. In the SEM context, observed variables are usually referred to as measured variables or items, whereas theoretical constructs are called latent variables or factors. The SEM model, then, is defined as a hypothesis of a specific pattern of relations among a set of measured variables and latent variables, and it can be divided into two parts: a measurement model and a structural model. The *measurement model* specifies the causal relations between measured variables and the underlying latent variable. In this research, the measured variables are effect (reflective) indicators, because it is assumed that the measured variables are indicators of the underlying latent variable (i.e. the latent variable causes the measurement variable) rather than the measured variable causing the latent variables (formative, causal indicator) (Bollen 1989, p. 222; Bollen & Lennox 1991; Nunnally & Bernstein 1994, p. 447; Shah & Goldstein 2006). The measurement model is closely related to CFA with SEM. The *structural model* (also called the latent variable model), then, specifies the relations between the latent variables (Anderson & Gerbing 1982; Bollen 1989; Byrne 2001).

As the input for SEM, this research uses the covariance matrix (another option would be to use the correlation matrix but AMOS can only use the covariance matrix). The assessment of the output of SEM, on the other hand, can be divided into three parts of (i) the overall model fit, (ii) the measurement model fit, and (iii) the structural model fit (Shah & Goldstein 2006). Assessing the *overall model fit* is based on how close the covariance matrix implied by the model is to the covariance matrix derived from the data (Bollen 1989). The overall model fit is important because the parameter estimates are meaningful only when the model fit is acceptable. The assessment of the overall model fit relies on both the assessment of residual covariances and the assessment of the model fit (or misfit) indices. Both are needed because they are known to provide incompatible indications of the model fit, especially in case of small unique variance (Browne, MacCallum, Kim, Andersen & Glaser 2002). Residual covariance refers to the difference between the covariance matrix implied by the model and the sample covariance matrix, and hence, the residual covariance matrix close to zero is an indication of good model fit (Bollen 1989, p. 257). There are a number of different fit indices, several of which are suggested to be used simultaneously to estimate model fit (Shah & Goldstein 2006). In this research χ^2-statistic, root mean square error of approximation (RMSEA), and comparative fit index (CFI) are used. The χ^2-test assesses whether the predicted covariance matrix is statistically significantly different from the matrix implied by the data (Fornell & Larcker 1981)[46]; the specified model fits the data, when the χ^2-statistic is non-significant. RMSEA[47] is a measure of model misfit (Browne et al. 2002; Metsämuuronen 2006, p. 626). RMSEA indicates how much the estimated model is different from the theoretical one and decreases (limited by zero) the better the data fit the model. CFI[48], on the other hand, is a measure of incremental fit (Shah & Goldstein 2006) and it compares the model under study to the null model. The *measurement model fit* is estimated by assessing the reliability of the constructs, as well as the convergent and discriminant validity (Section 4.5). The *structural model fit*, on the other hand, is assessed by examining the sign, magnitude, and statistical significance of structural path coefficients.

There are several reasons for why SEM seems advantageous for the research at hand. First, because SEM assesses how well the pre-specified model fits the data, it is especially suitable for confirmatory hypothesis-testing purposes (Rigdon 1998; Shah &

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[46] Even though the χ^2-test is probably the most commonly used test of model fit, it is somewhat problematic. The test may indicate a good fit even though both the measures and the underlying theory are inadequate (Fornell & Larcker 1981). Hence, pure reliance on the χ^2-test of the model fit may result in accepting models in which there is in reality no relationship between the variables. A more typical problem, however, is that the χ^2-test suggests rejection of the model even when inspection of the residuals reveals that they are small in absolute value (Mulaik et al. 1989), indicating that the model in fact has good fit with the data.

[47] RMSEA can be computed as follows (Metsämuuronen 2006, p. 627): $RMSEA = \sqrt{\dfrac{\chi^2_{\text{model}} - DF_{\text{model}}}{N \cdot DF_{\text{model}}}}$, where χ^2_{model} and DF_{model} refer to the model of interest.

[48] CFI can be computed as follows (Rigdon 1998, p. 270): $CFI = 1 - \dfrac{\chi^2_{\text{model}} - DF_{\text{model}}}{\chi^2_{null} - DF_{null}}$, where χ^2_{model} and DF_{model} refer to the model of interest and χ^2_{null} and DF_{null} to the null model.

Goldstein 2006). Second, SEM allows the use of latent variables (Bollen 1989). Third, SEM models measurement errors explicitly (Bollen 1989; Rigdon 1998). Fourth, a typical problem in regression, multicollinearity, is resolved in SEM (Rigdon 1998). And finally, SEM enables simultaneous estimation of multiple equations, in contrast with regression and path-analytical techniques which typically focus on estimation of one path at the time (Junttila [Ketokivi] 2000, p. 129). SEM, however, requires both a larger sample size (~5-10 times the number of parameters to be estimated) than for example regression, and often involves unrealistic assumptions about the normality of the measured variables (Bollen 1989; Rigdon 1998). Assessing the data for normality is critical (although often ignored), because the use of estimation methods depends on the distributional properties of the data. In this research, Maximum Likelihood (ML) estimation is used. ML estimation assumes multivariate normal distribution of the variables (Bollen 1989; Hair et al. 1998, pp. 601, 605), but it has turned out to be appropriate even when this assumption is not met if there is no significant excess skewness or kurtosis in the items (Bollen 1989, p. 416; Hair et al. 1998, pp. 601, 605). However, when there assumption of multivariate normal distribution is not met, the χ^2-statistic and standard errors become untrustworthy and must be accompanied with other fit indices as well (Bentler & Chou 1987). The normality assumption is violated in this research, because the variables are measured on Likert-scales. In order to confirm the appropriateness of the ML estimation, descriptive statistics of the variables are analyzed to ensure that there is no significant excess skewness or kurtosis.

In this research, SEM is mainly used for CFA purposes only. The hypotheses are tested with multiple regression and some of them are then complemented with SEM, even though a majority of recent OM research on cross-functional integration heavily relies on SEM (e.g., Koufteros et al. 2005; Swink et al. 2007; Swink & Song 2007). One reason for not using SEM as the main method for hypothesis testing purposes is that all assessed models in this research include categorical variables[49], which makes the use of SEM more complicated (Bentler & Chou 1987). Although this limitation can be overcome by multi-group analysis (e.g., Byrne 2001), the limited sample size of the

[49] Examples of categorical variables in the estimated models include control variables of country of origin and industry. Justification for including these in the analysis are presented separately for each model (Chapter 5).

research does not allow for rigorous use of it. Relying purely on SEM when testing a hypothesis would, thus, potentially lead to false conclusions. But because SEM allows the testing of a model as a whole as well as the incorporation of the measurement error, it provides additional information to the multiple regression analysis.

4.4 CONSTRUCT OPERATIONALIZATIONS

In this section, I discuss how the constructs are operationalized. The main focus is on presenting the items representing the theoretical constructs. In case of multi-item scales, the appropriateness of CFA is assessed. In addition, justification for the operationalizations is presented by addressing the issue of content validity.

4.4.1 Introduction to the Operationalization of Constructs

In this research, the constructs are mainly operationalized with multiple items (for critique against the use of single-item scales, see for example Boyd, Gove & Hitt 2005). Existing and validated scales are used when available, but due to the lack of prior empirical research on the topic, for most constructs it is not possible. The constructs included in this research are presented in Table 4-2 below.

Table 4-2. Constructs included in the research

CATEGORY	CONSTRUCTS
Performance	Comparative performance (8 dimensions; manufacturing unit costs, product capability, conformance quality, development lead time, on-time product launch, volume flexibility, design flexibility, and product innovativeness)
Integration constructs	Achieved integration, requisite integration
Mechanisms of integration	Centralization, cross-functional information systems, cross-functional job rotation, cross-functional teams
Contingency factors	Customization of orders, product modularity, introduction of new technology, introduction of new products, inter-unit task interdependence
Control variables	Plant size, plant age, plant market share, value chain position

Mainly three informants were used for each item. Using multiple informants is considered appropriate in OM (Ketokivi & Schroeder 2004b). This is because managers are boundedly rational (March & Simon [1958] 1993) and respond to questions from their own perspective. Their responses then may or may not reflect what is going on in the organization as a whole. To avoid distorting unequal weighting of different organizational positions (in some organizations there were several respondents per position), first the arithmetic average of individual respondents representing the same organizational position was calculated (if many), and only after that the arithmetic average of organizational positions responding to the specific item was calculated to get the plant score.

The construct operationalizations are presented in the following. Content validity, referring to the extent to which the measurement items reflect the specific content of the construct (Flynn et al. 1990; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986), as well as inter-item correlations and descriptive statistics of items are assessed, as they affect the appropriateness of the factor analysis. Other dimensions of validity and reliability are discussed in Section 4.5.

4.4.2 Performance

In the existing literature on cross-functional integration, the measures of performance vary significantly depending somewhat on the level of observation. In the NPD context, performance has been measured by for example time-based performance measures (Swink 2000; Tatikonda & Montoya-Weiss 2001), product performance (Song & Xie 2000) and manufacturability (Swink 1999). Furthermore, at firm-level, performance has been measured for example by financial measures, including profitability (O'Leary-Kelly & Flores 2002) and overall company performance (Kahn & McDonough 1997a, 1997b).

There are basically two different ways to measure performance, objective and subjective, both of which have their strengths and weaknesses. Objective measures are based on the premise that the theoretical construct is defined the way it is measured (e.g., ROI, market share), and they have a strong tradition for example in the strategy literature. The problem with these measures of performance is that they are not manufacturing specific; they are to a great extent affected by factors outside manufacturing (Bozarth & Edwards 1997). Furthermore, the use of objective performance measures is questionable in hypothesis-testing research using multi-industry or multi-country data (Ketokivi & Schroeder 2004b) like the present research, although this can be overcome for example by standardization. But more importantly, using objective firm-level performance measures at plant level might make little sense; for example market performance of a firm could tell very little about the performance of a single plant in a multi-plant firm. Perceptual measures, on the other hand, are often used in OM and mainly rely on the assessment of comparative operational performance. The use of perceptual measures, however, has its disadvantages because it is for example not certain that the respondent will give an honest response, but rather a more socially desirable one.

In this research performance is operationalized as comparative manufacturing performance, because (i) manufacturing performance is a plant-level measure and thus suitable for the level of observation and (ii) because comparative measures are in general suggested to be more accurate than absolute measures (Nunnally & Bernstein 1994, p. 51). The Plant Manager (PM) was used as a single informant for the plant's comparative performance. Although perceptual measures of performance using a single informant should be avoided (Ketokivi & Schroeder 2004b), it is considered in this research that the PM has the best knowledge on how the plant compares to others in the industry. The PM was asked to give his opinion on how the plant compares to its competition in the industry, on a global basis (Scale: 1 = Poor; at low end of industry, 2 = Equivalent to competition, 3 = Average, 4 = Better than average, 5 = Superior) on the following items: (1) low manufacturing costs, (2) product capability and performance, (3) conformance quality, (4) development lead time, (5) on-time new product launch, (6) volume flexibility, (7) design flexibility, and (8) product innovativeness (for a similar type of measure, see for example Flynn & Flynn 1999; Ketokivi & Schroeder 2004a). Due to the multi-dimensionality of the performance construct (Ketokivi & Schroeder 2004b), different dimensions of performance are kept separate rather than operationalizing an overall performance construct (cf. Dean & Snell 1996; Leenders & Wierenga 2002; Tan & Vonderembse 2006). Descriptive statistics for different dimensions of performance are presented in Table 4-3 below.

Table 4-3. Descriptive statistics for performance dimensions

	Mean	Median	SD	Min	Max	Skew	Kurt	N
Low unit costs	3.20	3.00	0.89	1.00	5.00	0.04	-0.65	213
Product capability	3.89	4.00	0.76	2.00	5.00	-0.26	-0.33	214
Conformance quality	3.88	4.00	0.69	2.00	5.00	-0.16	-0.17	216
Development lead time	3.32	3.00	0.94	1.00	5.00	-0.36	-0.42	212
On-time product launch	3.35	3.00	0.86	1.00	5.00	-0.14	-0.15	210
Volume flexibility	3.87	4.00	0.78	1.00	5.00	-0.47	0.31	216
Design flexibility	3.91	4.00	0.74	2.00	5.00	-0.43	0.15	213
Product innovation	3.57	4.00	0.92	1.00	5.00	-0.19	-0.45	210

The descriptive statistics reveal that some caution must be retained when performance is included in the analysis. Since performance is measured as compared to others in the industry, the mean value should be around 3.00. However, it seems that the responses are slightly upward-biased. There is a potential explanation for this outside the measure of performance: due to the stratified sampling design, the sample includes a higher proportion of so-called world-class manufacturing plants (Hayes & Wheelwright 1984) than there are in the total population. This is likely to bias the performance of the sample upward. In addition, also social desirability might slightly bias the performance upward.

4.4.3 Integration Constructs

Achieved integration. Prior OM research has mainly conceptualized integration as the extent of use of various integration mechanisms. Hence, no previously validated scale was available that would fit the definition of achieved integration and the context of the present research. The operationalization of achieved integration was developed for this research, because a proper operationalization was not found in the existing literature. Following the definition of achieved integration, the items used to operationalize it reflect the extent to which the functions work together in a coordinated manner (Lawrence & Lorsch [1967] 1986). The achieved level of cross-functional integration was asked from three informants (PM, PS, PE). Building on the definition of Lawrence and Lorsch ([1967] 1986) and the operationalizations used by Leenders and Wierenga (2002) and Song et al. (1997) as well as extending the operationalization used by Hausman et al. (2002), each informant was asked to assess the following statements (Table 4-4) on a scale from 1 to 7 (Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Neutral, 5 = Slightly agree, 6 = Agree, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-4. Items and standardized factor loadings for achieved integration

Measurement item		Loading
AI1	The functions in our plant are well integrated.	.82
AI2	Problems between functions are solved easily in this plant.	.76
AI3	Functional coordination works well in our plant.	.82
AI4	The functions in our plant work well together.	.85
AI6	Our plant's functions coordinate their activities.	.74
AI7	Our plant's functions work interactively with each other.	.81

In this research it is considered that all items reflect the definition of achieved integration rather well, giving support to the appropriateness of the operationalization in terms of content validity. The inter-item correlations are above 0.54 and significant at 0.01 level. Further on, the MSA = 0.92 and the Bartlett test score is significant (p = 0.00, χ^2 = 863.94 with DF = 15), pointing to appropriateness of the factor analysis. Both the skewness [-0.90; -0.59] and kurtosis [0.01; 1.75] of the items are moderate, pointing to appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-4 above. The factor scores were calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

Requisite integration. Due to the fact that empirical assessments of requisite integration are basically non-existent (Section 3.1.1), no previously validated scale was available to operationalize the construct. The items used to operationalize the requisite integration reflect the degree to which different functions *need* to be integrated or whether they can operate rather independently. This is clearly different from typical operationalizations of integration, which mainly assess the use of integration mechanisms. Each of the items were asked from three informants (the respondent categories varied per item and included PM, PS, PE, DL, and QM). Each informant was asked to assess the following statements (Table 4-5) on a scale from 1 to 7 (Scale: 1 = Strongly disagree, …, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-5. Items and standardized factor loadings for requisite integration

Measurement item		Loading
RI1	We do not interact with other functions, in order to achieve our goals. (reversed item) (PM, PS, PE)	.60
RI2	Other functions do not need to know about manufacturing in this plant. (reversed item) (PM, PS, PE)	.55
RI3	We believe each person should be accountable for his or her own job; engineers design products, the manufacturing staff makes them and the quality staff makes sure they meet specifications. (reversed item) (DL, PM, QM)	.36

The operationalization of requisite integration builds on the idea of Thompson ([1967] 2003) in that requisite integration reflects the type of interdependence of the functional units: when the type of interdependence changes to a more demanding one (i.e. from pooled to sequential and further to reciprocal), the level of requisite integration increases. Although requisite integration and interdependence are closely related, they are perceived as theoretically separate constructs. Requisite integration can be measured on a continuous scale which allows for more rigorous analysis, especially as the empirical use of Thompson's Guttman scale has been criticized (cf. McCann & Galbraith 1981, pp. 63-64; Nunnally & Bernstein 1994, pp. 74-75).

In this research it is considered that the items do reflect rather well the definition and idea of requisite integration. Hence, the operationalization of the construct is appropriate in terms of content validity. The inter-item correlations are above 0.16 and significant at 0.01 level. Although the MSA is rather low (0.58), the Bartlett test score is significant (p-value = 0.00; χ^2 = 42.60 with DF = 3), pointing to appropriateness of the factor analysis. Both skewness of the items [-1.24; 0.34] and kurtosis [-0.87; 1.64] are moderate, pointing to the appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-5 above. The factor scores were calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

4.4.4 Mechanisms of Integration

Out of the number of integration mechanisms identified in the prior literature (Section 3.1.1), four were selected for the analysis of this research. The selected integration mechanisms include vertical (centralization) and horizontal ones (cross-functional information systems, cross-functional job rotation, and cross-functional teams). The integration mechanisms also differ in their capacity to facilitate information processing, and simultaneously in the terms of the costs their implementation and use pose to the organization. The integration mechanisms are presented in increasing order of information processing capacity and costs (Galbraith 1994).

In this research, the adoption of a particular integration mechanism is assessed as the intensity of use rather than whether a particular mechanism is adopted or not (e.g., Ettlie 1995; Ettlie & Reza 1992) because it is emphasized that the level of adoption of a mechanism, such as information systems, can vary. Previous OM literature assessing integration has to some extent included items referring to the use of several mechanisms, such as job rotation and cross-functional teams in the same construct (e.g., Swink 2000). In this research different mechanisms are operationalized separately because it is perceived that different mechanisms can be utilized to a varying extent independently of each other.

Centralization of decision making. The construct operationalization for centralization is based on Hage and Aiken (1967) and has been validated before (Junttila [Ketokivi] 2000). The items used to operationalize centralization reflect the degree to which individuals at lower levels in the organization are allowed to make decisions or whether the decision making at the plant is centralized. Centralization of decision making was asked from three informants (DL, HR, SP). Each informant was asked to assess the following statements (Table 4-6) on a scale from 1 to 7 (Scale: 1 = Strongly disagree,…, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-6. Items and standardized factor loadings for centralization of decision making

Measurement item		Loading
CE1	Even small matters have to be referred to someone higher up for a final answer.	.90
CE2	This plant is a good place for a person who likes to make his own decisions. (reversed item)	.40
CE3	Any decision I make has to have my boss's approval.	.85
CE4	There can be little action taken here until a supervisor approves a decision.	.74

The items reflect the centralization of decision making at the plant and could be applied to different levels of analysis (e.g., plant, function, team). However, they are likely to reflect the general degree of centralization also regarding functional decisions. Hence, in this research it is considered that the operationalization of the construct is appropriate in terms of content validity. The inter-item correlations are above 0.31 and significant at 0.01 level. Further on, the MSA is high (0.78) and the Bartlett test score is significant (p-value = 0.00; χ^2 = 396.62 with DF = 6), pointing to appropriateness of the factor analysis. The skewness [-0.20; 0.33] and kurtosis of the items [-0.84; 0.53] are low, pointing to the appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-6 above. The factor scores were calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

Information systems. The use of information systems as an integration mechanism was measured with the extent of application of various information systems allowing cross-functional information sharing. The Plant Information Systems Manager (IS) was used as the sole informant. The informant was asked to provide an answer to whether the following application areas were supported by software: (i) demand planning, (ii) design (CAD, CAE), (iii) project management, and (iv) groupware tools. The use of information systems was operationalized as a summated scale of the above items (0 = none of the applications is supported by software, 4 = all the four application areas are supported by software) and then standardized. The use of a single informant was considered suitable here because the question is straightforward and the Plant Information Systems Manager was considered the most knowledgeable informant about the use of the systems.

The operationalization of the information systems construct is somewhat problematic. However, in this research it is considered that the four information systems used to operationalize the construct describe at least the extent to which the plant is able to use information systems for the processing of information across functions. Some care must be taken when including the construct in the analysis, as it is recognized that a greater extent of use of information systems does not necessarily mean that information is shared across functions or that information that is processed is useful for the decision making (Galbraith 1994).

Cross-functional job rotation. Job rotation across functions is one way of creating informal lateral relations (Galbraith 1994) and it has been used in various integration scales in OM (e.g., Ettlie 1995; Swink et al. 2007). Questions regarding job rotation were asked from three informants (HR, PM, PS). Each informant was asked to assess the following statements (Table 4-7) on a scale from 1 to 7 (Scale: 1 = Strongly disagree,…, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-7. Items and standardized factor loadings for cross-functional job rotation

Measurement item		Loading
JR1	Frequent rotation of managers between functions is normal practice in this plant.	.73
JR2	Managers permanently specialize in one function at our plant. (reversed item)	.60
JR3	Most of the managers here have had positions in more than one function.	.80
JR4	Our managers have not worked outside of their own areas, for the most part. (reversed item)	.77
JR5	Managers are frequently rotated to broaden their skill level.	excluded
JR6	Managers often specialize in the same job for many years.	excluded

The first four items reflect the extent to which the rotation of managers across functions is used at the plant. The last two items were excluded from the construct for content validity reasons; they do not reflect the rotation across functions but rather across jobs in general. For job rotation to act as a mechanism of integration in the cross-functional context, it is essential that job rotation takes place *across* functions. Inter-item correlations for the included items are above 0.44 and significant at 0.01 level. Further on, the MSA is high (0.79) and the Bartlett test score is significant (p-value = 0.00; χ^2 = 309.57 with DF = 6), pointing to appropriateness of the factor analysis. The skewness of the items [-0.38; 0.42] and kurtosis [-0.66; -0.39] are low, pointing to appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-7 above. The factor scores were calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

Cross-functional teams. Cross-functional teams are a form of more formal lateral structures (Galbraith 1994). Also cross-functional teams have been used in integration scales in OM (e.g., Ettlie 1995). The use of cross-functional teams was measured with a single item. Three informants (PD, PE, SP) were asked to assess the following statement on a scale from 1 to 7 (Scale: 1 = Strongly disagree,…, 7 = Strongly agree): "We work in teams, with members from a variety of areas (marketing, manufacturing, etc.) to introduce new products". The plant score was calculated as the arithmetic average of responses of the three respondents and then standardized. Although using a single-item construct is problematic, it is considered appropriate here because the question reflects the extent of use of multifunctional teams. Furthermore, three informants were used to avoid single-informant bias. Content-wise the item is quite satisfactory, although it is recognized that the construct might not capture all sides of the extent to which cross-functional teams are used at the plant because cross-functional teams as integration mechanisms can be used in other than just new product introduction purposes.

4.4.5 Contingencies

Customization of orders. Customization of orders refers to the extent to which the plant customizes products or manufactures a commodity product and it reflects the number of exceptions in the manufacturing task (Vickery, Dröge & Germain 1999). Three informants (PE, PM, PS) were asked to assess the importance of the goal "Rapid customization of orders" on a scale from 1 to 5 (Scale: 1 = Least important,…, 5 = Absolutely crucial). Although a single-item construct, the operationalization seems to capture the extent of customization rather well, although it is notable that a plant might emphasize customization but not rapid customization.

Product modularity. Product modularity refers to the extent to which the product is designed so that there are common and compatible components (Salvador 2007) and it reflects the extent to which changes in the existing products can be made with prior knowledge on the issue (Koufteros et al. 2002). Product modularity was asked from three informants (IM, PD, PE). Each informant was asked to assess the following statements (Table 4-8) on a scale from 1 to 7 (Scale: 1 = Strongly disagree,…, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-8. Items and standardized factor loadings for product modularity

Measurement item		Loading
MO1	Our products are modularly designed, so they can be rapidly built by assembling modules.	.66
MO2	We have defined product platforms as a basis for future product variety and options.	.54
MO3	Our products are designed to use many common modules.	.89
MO4	When we make two products that differ by only a specific feature, they generally require only one different subassembly/component.	.36
MO5	We do not use common assemblies and components in many of our products. (reversed item)	.60

The items used to operationalize product modularity reflect the degree to which the products manufactured at the plant are designed with modules to accommodate product variety. Hence, it is considered that the operationalization of the construct is appropriate in terms of content validity. All inter-item correlations are above 0.22 and significant at 0.01 level. Further on, the MSA is high (0.77) and the Bartlett test score is significant (p-value = 0.00; χ^2 = 282.12 with DF = 10), pointing to appropriateness of the factor analysis. Both the skewness [-0.69; -0.32] and kurtosis [-0.46; 0.57] of the items are low, pointing to the appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-8 above. The factor scores were calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

Introduction of new manufacturing technology. Introduction of new manufacturing technology refers to the extent to which the plant emphasizes new technology. It reflects the extent to which the manufacturing task is understandable (Olson et al. 2001).

Questions regarding the degree to which the plant introduces new technologies were asked from three informants (PE, PM, PS). Each informant was asked to assess the following statements (Table 4-9) on a scale from 1 to 7 (Scale: 1 = Strongly disagree,…, 7 = Strongly agree) (see Appendix B for item descriptive statistics).

Table 4-9. Items and standardized factor loadings for introduction of new manufacturing technology

Measurement item		Loading
NT1	We pursue long-range programs, in order to acquire manufacturing capabilities in advance of our needs.	.62
NT2	We make an effort to anticipate the potential of new manufacturing practices and technologies.	.80
NT3	Our plant stays on the leading edge of new technology in our industry.	.63
NT4	We are constantly thinking of the next generation of manufacturing technology.	.85

The items reflect the extent to which the plant emphasizes the development and introduction of new manufacturing technology. The inter-item correlations are above 0.35 and significant at 0.01 level. Further on, the MSA is high (0.78) and the Bartlett test score is significant (p-value = 0.00; χ^2 = 339.82 with DF = 6), pointing to appropriateness of the factor analysis. The skewness of the items is low [-0.85; -0.45] and kurtosis only moderate [-0.19; 1.10], pointing to appropriateness of the ML-estimation. The standardized factor loadings of the CFA are presented in Table 4-9 above. The factor scores were then calculated with the regression method (Bollen 1989, p. 305; Hair et al. 1998, p. 119).

Introduction of new products. Rate of new product introductions reflect the extent of potential cross-functional decisions that are made at the plant (Fine 1998). In order to evaluate the rate at which the plant introduces new products, the process engineer (PE) was asked to provide information about what percentage of the plant sales came from products introduced in the five years prior to the data collection. It was excepted that the higher the percentage of sales from products introduced during the past five years, the more emphasis the plant puts on introduction of new products.

Inter-unit task interdependence. In order to evaluate the task interdependence within the plant, a member of the Product Development Team (PD) was asked to assess the interdependence in a typical NPD project by selecting the statement that most closely described the product development process (Table 4-10):

Table 4-10. Operationalization of inter-unit task interdependence

The product development process can be described by the following four stages:

1. Concept development/idea generation
2. Product planning/technical and market feasibility
3. Detailed design development and prototypes
4. Manufacturing process development/pilot production

Check the statement below that most closely describes your product development process:
The four stages were sequential.
The four stages were sequential with some overlap.
The four stages had significant overlap.
The four stages were carried out simultaneously.

The operationalization reflects the typology of Thompson ([1967] 2003). The content analysis of the items suggests that for the first two categories, the interdependence is sequential by nature, whereas the last two categories refer to reciprocal interdependence (or even team interdependence). The construct was then operationalized as a binary variable, which had the value of 0 when the interdependence was sequential and the value of 1 when the interdependence was reciprocal.

The use of a single informant, especially in case of a single item, is usually considered troublesome (e.g., Ketokivi & Castañer 2004) but it was considered to be appropriate here because an objective measure is used and because PD is likely to have the best knowledge on the whole project. Furthermore, it was assumed that a typical NPD project reflects the overall functional relationship when tasks crossing functional boundaries are carried out at the plant. Focusing purely on the NPD context is recognized as a limitation of the measure.

4.4.6 Control Variables

Size of the plant. The size of the organization (plant) was measured by calculating the natural logarithm of the number of employees in the year the survey was completed. This follows the operationalization of size in organizational studies (Child 1973a) and in OM (e.g., Ketokivi & Castañer 2004; Ketokivi & Schroeder 2004c; Liu, Shah & Schroeder 2006). The number of employees includes both the number of hourly personnel and the number of salaried personnel. A single informant (AC) was used.

Plant age. Plant age was calculated directly as 2007 – year when the plant was originally built. A single informant (PE) was used.

Market share. Market share was operationalized as the average market share of all products manufactured at the plant. The PM was asked to provide an answer to the following question: "What percent of market share does the plant have? Compute this as the average of all product lines for the relevant market the plant serves".

Position in the value chain. Value chain position was determined on the basis of the extent of different type of customers the plant had. A single informant (IM) was asked to assess the percentage of sales to the following customers: (1) end consumers, (2) retailers, (3) wholesalers, (4) distributors, (5) assemblers, and (6) manufacturers (in total 100%). The plant's value chain position was operationalized as a continuous variable (weighted average of customer type) where a low value presents a downstream position (end consumers as main customers) and a high value presents an upstream position (manufacturer as main customers) (for a similar type of operationalization, see the measure of process type by Flynn & Flynn (1999)).

4.4.7 Summary of Construct Operationalizations

In Table 4-11 below, a summary of the construct operationalizations is presented, including the type of measure used, the number of items used for operationalizing the construct, as well as the informants used for measuring the items. The construct descriptive statistics are presented in Appendix B.

Table 4-11. Summary of construct operationalizations

Construct	Type of measure	Number of items	Informants
Performance			
Unit costs, product capability, conformance quality, development lead time, on-time product launch, volume flexibility, design flexibility, innovativeness	Subjective	8 (items kept separate)	PM
Integration constructs			
Achieved integration	Subjective	6	PM, PS, PE
Requisite integration	Subjective	3	PM, PS, PE, DL, QM
Integration mechanisms			
Centralization	Subjective	4	DL, HR, SP
Information systems	Objective	1	IS
Job rotation	Subjective	4	HR, PM, PS
Cross-functional teams	Subjective	1	PD, PE, SP
Contingencies			
Customization of orders	Subjective	1	PE, PM, PS
Product modularity	Subjective	5	IM, PD, PE
Introduction of new technology	Subjective	4	PE, PM, PS
Introduction of new products	Objective	1	PE
Inter-unit task interdependence	Subjective	1	PD
Control variables			
Plant size	Objective	1	AC
Plant age	Objective	1	PE
Market share	Objective	1	PM
Value chain position	Objective	1	IM

Next, the issues of validity and reliability are discussed and it is assessed whether the level of validity and reliability are adequate for the purposes of the present research.

4.5 ASSESSMENT OF VALIDITY AND RELIABILITY

The ability to find significant relationships correctly among constructs depends on the ability to measure the constructs adequately. This is related to validity and reliability. The purpose of this section is to discuss and assess the issues of validity and reliability (for excellent reviews of reliability and validity assessment in OM, see for example Koufteros 1999; O'Leary-Kelly & Vokurka 1998). Although often analyzed simultaneously, validity and reliability are distinct; high reliability does not imply high validity. In the following, I first present the concept of measurement error. After that, I discuss and assess content validity, unidimensionality, reliability, convergent validity, discriminant validity, and finally nomological validity.

4.5.1 Introduction to Validity and Reliability Assessment

Measurement reliability is a matter of degree and refers to the absence of measurement error (Churchill 1979; Fink 1995, p. 46; Nunnally & Bernstein 1994, p. 213). All measures reflect not only a theoretical construct but also measurement error, which has been recognized as a serious problem for example in social sciences (Bagozzi & Yi 1991; Bagozzi et al. 1991). Measurement error refers to the degree to which the observed value of a variable does not represent its "true" value (Bagozzi & Yi 1991; Churchill 1979; Hair et al. 1998, p. 9; Nunnally & Bernstein 1994, p. 212):

Observed value = true value + measurement error.

Measurement error can be further divided into components of systematic error and random error; systematic error refers to either a constant error affecting all observations equally, or a bias affecting only certain types of observations. There are a number of sources of measurement error, including item sampling, false data entry, inability or willingness of respondents to provide accurate information, scale type, and subjectivity in scoring of responses (Bagozzi & Yi 1991; Bagozzi et al. 1991; Hair et al. 1998, p. 9; Nunnally & Bernstein 1994, pp. 249-251). Both systematic and random error attenuate the correlations among variables (Hair et al. 1998, p. 9; Nunnally & Bernstein 1994, p. 240) and they can lead to false conclusions in terms of both not finding existing relationships or finding relationships that do not exist (Bagozzi et al. 1991; Bollen 1989).

Validity generally refers to the degree to which the variance in a measure is attributed to variations in the variable and not some other factor (Churchill 1979; Fink 1995, p. 49; Vokurka & O'Leary-Kelly 2000) and it measures the scientific utility of the measuring instrument, i.e. how well the instrument measures what it is supposed to measure (Flynn et al. 1990; Ketokivi & Schroeder 2004b). That is, validity refers to the *use* of the instrument in the context in which it is applied, not to the instrument itself (Nunnally & Bernstein 1994, pp. 84, 112). Like reliability, also validity is a matter of degree. Several components of validity, all of which need to be assessed, have been discussed in the literature. In Table 4-12 below, a summary of the different aspects of reliability and validity is presented, including the definitions, type (theoretical or empirical), and available methods of assessment, as well as the methods of assessment used in this research.

Table 4-12. Definitions of and methods for the assessment of dimensions of validity and reliability

DIMENSION AND DEFINITION	TYPE	AVAILABLE ASSESSMENT METHODS	METHOD USED IN THIS RESEARCH
Content validity The extent to which the measurement items reflect the specific content (Flynn et al. 1990; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Theoretical	Expert review, analysis of content (Venkatraman & Grant 1986)	Expert review, content analysis
Unidimensionality The extent to which the set of measurement items refer to one and only one construct (Hair et al. 1998, p. 584; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Theoretical and empirical	CFA or EFA (Gerbing & Anderson 1988; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Item analysis, inter-item correlations, CFA (fit of single-factor model)
Convergent validity The degree to which multiple methods of measuring a construct with different methods provide the same results, i.e. are in agreement (Bagozzi & Phillips 1982; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Theoretical and empirical	MTMM matrix, CFA (Bagozzi & Phillips 1982; Bagozzi et al. 1991; Venkatraman & Grant 1986)	Item analysis, inter-item correlations, CFA (factor loadings)
Discriminant validity The extent to which different constructs are unique, i.e. differ from other constructs (O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Theoretical and empirical	MTMM, inter-construct correlations (Bagozzi & Phillips 1982; Bagozzi et al. 1991)	Inter-construct correlations
Nomological validity The degree to which predictions from a theoretical network are confirmed (O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Theoretical and empirical	Correlations, regressions, causal modeling (Venkatraman & Grant 1986)	Regression, SEM
Measurement reliability The consistency of results of multiple measurements, i.e. absence of measurement error (indicates the relationship between the observed and true scores) (Nunnally & Bernstein 1994; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986)	Empirical	Cronbach's α, composite reliability (CR), average variance extracted (AVE) (Hair et al. 1998, pp. 611-612)	Composite reliability (CR)

In management research, also in OM, more attention has been called for validity and reliability considerations (Boyd et al. 2005; Koufteros 1999; Malhotra & Grover 1998; Scandura & Williams 2000). In this research, both are carefully examined. Each of the dimensions is discussed and assessed in the following.

4.5.2 Content Validity

Content validity deals with the specific content or domain of the construct (Bollen 1989, p. 185; Fink 1995, p. 50; Flynn et al. 1990; Nunnally & Bernstein 1994; O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986; Yin 1990), including the assessment of two issues: (i) whether the items measure something in common and (ii) whether the items cover all sides of the construct (Flynn et al. 1990; Nunnally & Bernstein 1994, p. 102). For the purposes of this research, previously validated constructs were used when available (see construct operationalizations for details). Furthermore, the constructs were formed with multiple measurement items to improve content validity, because the use of single-item constructs is appropriate only when one measure perfectly represents the construct (Bollen 1989, p. 17; Flynn et al. 1990; Nunnally & Bernstein 1994, p. 66; Venkatraman & Grant 1986). Third, the constructs were pre-tested with managers and academics in different countries to enhance content validity. As a final step, the author analyzed the content of the constructs for the purposes of the present research (see discussion in Section 4.4 above).

4.5.3 Construct Validity

Construct validity refers to the correspondence between the construct and the operational procedure to measure that construct, i.e. the extent to which the operationalization measures the theoretical concept which it is intended to measure (Bagozzi 1984; Bagozzi & Phillips 1982; Bagozzi et al. 1991; Bollen 1989, p. 188) and it includes the assessment of unidimensionality, measurement reliability, and convergent and discriminant validities (O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986). In this research, CFA-based approach for the assessment of construct validity is used (see for example O'Leary-Kelly & Vokurka 1998).

Unidimensionality. Unidimensionality refers to the dimensionality of a multi-item construct (Gerbing & Anderson 1988), suggesting that there is only a single latent construct underlying the multiple items. The assessment of unidimensionality has sometimes been overlooked in OM (Koufteros 1999). In addition, the assessment of unidimensionality has sometimes (although falsely) relied on Cronbach's α (e.g., Spina et al. 2002). This is not appropriate, however, because Cronbach's α is a measure of reliability, which *assumes* unidimensionality of the underlying construct (Anderson & Gerbing 1982; Gerbing & Anderson 1988; Hair et al. 1998, p. 611). Thus, unidimensionality needs to be confirmed before the assessment of reliability.

The assessment of unidimensionality is critical, because treating multidimensional constructs as unidimensional is not meaningful and can lead to false conclusions when assessing the relationship of the construct with others (Anderson & Gerbing 1982; Gerbing & Anderson 1988; O'Leary-Kelly & Vokurka 1998). In this research, unidimensionality was assessed in two parts. First, the items for each construct were analyzed content-wise to assess whether they were related to a single underlying construct. Second, CFA was conducted assessing the fit of a single-factor model. The fit of the single-factor model was assessed with several indices, including χ^2-statistic with degrees of freedom (DF) and the subsequent p-value, 90% confidence interval for RMSEA, and CFI. A summary of the assessment of unidimensionality (fit statistics of a single-factor model) is presented in Table 4-13 below.

Table 4-13. Summary of tests of unidimensionality of theoretical constructs

	χ^2-statistic	DF	p-value	90% CI for RMSEA	CFI
Integration constructs					
Achieved integration	8.376	9	0.497	[0.000; 0.070]	1.000
Requisite integration	2.176	2	0.337	[0.000; 0.132]	0.995
Integration mechanisms					
Centralization	2.949	2	0.229	[0.000; 0.145]	0.998
Information systems	N/A				
Job rotation	2.408	2	0.300	[0.000; 0.136]	0.999
Cross-functional teams	N/A				
Contingencies					
Customization of orders	N/A				
Product modularity	3.200	5	0.669	[0.000; 0.071]	1.000
Introduction of new technology	1.804	2	0.406	[0.000; 0.125]	1.000
Introduction of new products	N/A				
Task interdependence	N/A				

As a conclusion, the analysis of the constructs suggests that the constructs are unidimensional; all fit indices point to a good fit of a single-factor model.

Measurement reliability. Measurement reliability refers to the absence of measurement error (Churchill 1979; Fink 1995, p. 46; Nunnally & Bernstein 1994, p.

213). Although measurement error can never be totally eliminated, minimizing its effect is important. One way to decrease the measurement error, also used in the research at hand, is to use multi-item scales (Churchill 1979; Gerbing & Anderson 1988; Nunnally & Bernstein 1994). Furthermore, the assessment of reliability is not possible when single-item constructs are used. Reliability is assessed by the consistency between multiple items (Bollen & Lennox 1991; Hair et al. 1998, p. 117; Nunnally & Bernstein 1994, p. 213; O'Leary-Kelly & Vokurka 1998): do multiple measurements give consistent results or are the results attenuated by measurement error? Measurement reliability is a characteristic of the measurement method rather than the construct.

Cronbach's α is only one of the many ways of assessing reliability, although most frequently used in OM. It is based on inter-item correlations (Churchill 1979; O'Leary-Kelly & Vokurka 1998) and is suitable when the construct values are calculated as summated scales (α refers to the relation of the item variance and variance of the sum scale). In this research, the construct values for the purpose of regression analysis were calculated as regression-based factor scores (Hair et al. 1998, p. 119), and therefore, α was not a proper measure of reliability. Instead, composite reliability (CR)[50] was used. Composite reliability refers to the degree to which a set of items are consistent in their measurement of a construct (Koufteros 1999). A summary of calculated composite reliabilities is presented in Table 4-14.

[50] $CR = \frac{(\sum \text{standardized loading})^2}{(\sum \text{standardized loading})^2 + \sum \varepsilon_j}$ (Hair et al. 1998, p. 612)

Table 4-14. Summary of composite reliabilities for the theoretical constructs

	Number of items	Composite reliability
Integration constructs		
Achieved integration	6	0.95
Requisite integration	3	0.51
Integration mechanisms		
Centralization	4	0.87
Information systems	4	N/A
Job rotation	4	0.77
Cross-functional teams	1	N/A
Contingencies		
Customization of orders	1	N/A
Product modularity	5	0.96
Introduction of new technology	4	0.97
Introduction of new products	1	N/A
Task interdependence	1	N/A

All the composite reliabilities except one (requisite integration) can be considered appropriate, pointing to high measurement reliability. In terms of the often-used threshold of 0.70 for reliability (Hair et al. 1998, p. 612), the only potential concern is requisite integration with CR = 0.51. However, Nunnally and Bernstein (1994, pp. 214, 249) suggest that a satisfactory level of reliability depends on the way the measurement tool is used. Very high reliability (even over 0.80) is needed when a status of some object is rated (e.g., the IQ of an individual). On the other hand, when comparisons across groups are made, as is the case in this research, they suggest that it is "a waste of time to increase reliability" (Nunnally & Bernstein 1994, p. 265). Furthermore, although reliability is important to psychological measurements, Nunnally and Bernstein (1994, p. 214) consider validity as more important and claim that the search for reliable measures often causes people to replace relatively valid but somewhat unreliable measures with less valid ones. Hence, it is considered that for the purposes of the present research, the level of reliability of the constructs is satisfactory.

Due to the fact that country differences are frequently found significant when assessing multi-country data, composite reliabilities were calculated also separately for each country in order to assess how generalizable the results were across countries (Malhotra, Agarwal & Peterson 1996; Nunnally & Bernstein 1994, p. 214). Country-level composite reliabilities are presented in Table 4-15 below (due to missing data, it is not possible to calculate all composite reliabilities at the country level).

Table 4-15. Composite reliabilities of constructs across countries

	AUT	FIN	GER	ITA	JPN	KOR	SWE	USA
Achieved integration	0.95	0.97	0.96	0.96	0.95	0.96	0.92	0.95
Requisite integration	-	0.72	0.51	0.45	0.70	-	0.50	0.49
Centralization	0.95	0.92	0.93	0.84	-	-	0.86	0.89
Job rotation	0.82	-	0.83	0.88	0.82	-	0.85	0.91
Product modularity	-	0.70	0.77	0.87	0.71	0.79	0.76	0.64
Introduction of new technology	0.70	0.90	-	0.87	0.86	0.86	0.74	0.87

The analysis suggests that the reliabilities of the constructs are to a great extent rather similar across countries. This indicates that there should not be any excess measurement error in some countries. There is, however, some concern, as the single-factor model of the CFA analysis does in some cases produce inappropriate solution (e.g., requisite integration for the data of Austria and Korea). There are no problems in terms of this in 84% of the cases, and hence it is concluded that the factorial invariance is at least to a great extent appropriate. Subsequently, the results of the research are generalizable across the country groups in the data set.

Convergent validity. Convergent validity refers to the degree to which multiple methods of measuring a construct provide the same results (Anderson & Gerbing 1982; Bagozzi & Yi 1991; Bagozzi et al. 1991; O'Leary-Kelly & Vokurka 1998): do the methods converge? Methods here refer to multiple items used to operationalize a construct. Several methods were used to ensure that the convergent validity is satisfactory. First, existing and validated measures were used when available (see Construct Operationalizations). Secondly, inter-item correlation matrices were analyzed for each construct in order to identify potential low correlations among items measuring one construct. Finally, CFA was used to examine the factor loadings.

All the inter-item correlations are statistically significant at 0.01 level, providing evidence for convergent validity (Churchill 1979). The factor loadings were then assessed (for individual factor loadings, see Section 4.4). Factor loadings range from 0.36 to 0.90 and are on average 0.69. All factor loadings are statistically significant, pointing to at least weak convergent validity (Bagozzi & Yi 1991; Koufteros 1999). In addition, of all factor loadings, 58% exceed 50% in trait reliability, pointing to strong convergent validity (Bagozzi & Yi 1991). Therefore, the convergent validity is considered satisfactory.

Discriminant validity. Discriminant validity refers to the degree to which the measures of different constructs are unique (Bagozzi et al. 1991; Campbell & Fiske 1959; Churchill 1979; O'Leary-Kelly & Vokurka 1998). If the measures of two or more latent variables are unique, then the correlations among the constructs should not be close to one (Bagozzi et al. 1991; Nunnally & Bernstein 1994; O'Leary-Kelly & Vokurka 1998).

Several methods were used to ensure that the discriminant validity is satisfactory. First, existing and validated measures were used when available (see Construct Operationalizations). Secondly, inter-construct correlations were analyzed. Finally, CFA was conducted simultaneously on several constructs. The CFA analyses were carried out in three separate parts: (i) for integration construct items, (ii) for integration mechanism construct items and (iii) for contingency factor items. A summary of inter-construct correlations (r, absolute value) with the upper bound for 95% confidence interval and CFA-based correlations (absolute value) with the upper bound for 95% confidence interval are presented in Table 4-16.

Table 4-16. Summary of inter-construct correlations (absolute values)

	r	Upper bound for 95% CI	CFA-based r	Upper bound for 95% CI (CFA)
Integration constructs				
Achieved integration – Requisite integration	0.332	0.441	0.555	0.637
Integration mechanisms				
Centralization – Job rotation	0.117	0.241	0.139	0.262
Centralization – Information systems	0.149	0.278	0.152	0.274
Centralization – Cross-functional teams	0.230	0.347	0.245	0.361
Information systems – Job rotation	0.092	0.224	0.102	0.226
Information systems – Cross-functional teams	0.136	0.266	0.138	0.261
Job rotation – Cross-functional teams	0.153	0.276	0.175	0.296
Contingency factors				
Customization – Product modularity	0.109	0.233	0.119	0.243
Customization – New technology	0.146	0.268	0.158	0.280
Customization – New products	0.005	0.132	0.003	0.131
Customization – Interdependence	0.030	0.157	0.020	0.147
Product modularity –New technology	0.224	0.341	0.271	0.385
Product modularity – New products	0.003	0.130	0.011	0.138
Product modularity – Interdependence	0.009	0.136	0.014	0.141
New technology – New products	0.123	0.246	0.123	0.246
New technology – Interdependence	0.020	0.147	0.019	0.146
New products – Interdependence	0.042	0.168	0.029	0.156

The inter-construct correlations are far from the value of 1. The calculated inter-construct correlations across the factors (absolute value) are at the highest 0.33, pointing to high discriminant validity. Furthermore, the 95% confidence interval upper bounds for absolute values of correlations were calculated using Z-transformation. The 95% CI upper bounds are at the highest 0.44, which further points to high discriminant validity. The absolute values for CFA-based inter-construct correlations point to discriminant validity, the highest inter-construct correlation in the CFA model is 0.56 with the upper bound for 95% confidence interval of 0.64. These further indicate high discriminant validity.

4.5.4 Nomological Validity

Nomological validity refers to the degree to which predictions from a theoretical network are confirmed (O'Leary-Kelly & Vokurka 1998; Venkatraman & Grant 1986). Basically this means hypothesis testing: is a construct related to other constructs as hypothesized? This is examined in the following chapter (Chapter 5).

CHAPTER 5
HYPOTHESES AND STATISTICAL ANALYSIS

In this chapter I present the empirical analysis. The chapter is divided into three main sections: assessment of the integration-performance relationship, assessment of the interrelations of the integration dimensions, and assessment of the antecedents of integration. I start each section by formulating a theoretical proposition, followed by the development of the proposition into empirically testable hypotheses. The main focus is on presenting the statistical analysis and discussing the statistical results. The fourth section focuses on sensitivity analysis of the statistical results. In the final section, I present a summary of the findings.

The theoretical framework illustrating the focal concepts in this research and their interrelationships is presented in Chapter 3 (Figure 3-3). In this chapter, three propositions[51] are formulated from the framework, each proposition addressing one of the identified research needs (Section 2.1.4). The propositions are then developed into empirically testable hypotheses and tested with the survey data. Following the logico-science mode of thought underlying variance theories, explanations are built backward from observed outcomes to prior causally significant events (Aldrich 2001; Van de Ven 2007, p. 147). Hence, the assessment of the theoretical framework proceeds from the

[51] Following the distinction between variables and constructs (Section 4.4), this research also makes a distinction between theoretical *propositions* (nonobservable hypothesis (Bagozzi & Phillips 1982)) presented in the language of theory and *hypotheses* (empirical propositions (Bagozzi 1984)) explicated in the language of observable variables (Bacharach 1989).

final outcome (performance) to organization design, and finally to contingencies affecting organization design.

5.1 EFFECT OF INTEGRATION ON PERFORMANCE

5.1.1 Proposition 1. Integration – Performance Relationship

Achieved integration refers to unity in effort of the different functions. From the information processing perspective, high achieved integration means that accurate information within the functions is available and the organization is able to gather, interpret, and synthesize information in the context of organizational decision making when needed (Tushman & Nadler 1978). Whereas the requirements for integration mechanisms vary among organizations, the contingency theory suggests that high achieved integration is needed for the organization to operate effectively (Galbraith 1973; Lawrence & Lorsch [1967] 1986): if the various organizational units are able to process relevant information when making decisions, more consistent action is possible, making the organization into a unified whole and enabling it to perform better. Therefore, it is hypothesized as follows:

> **Proposition 1:** The level of achieved integration has a positive effect on performance.

The purpose of the Proposition 1 is to clarify the integration-performance relationship by proposing that how well the organizational units function as a whole matters in terms of performance, rather than a more extensive use of integration mechanisms.

5.1.2 Development of Empirically Testable Hypotheses

The proposition is further developed into empirically testable hypotheses. Instead of operationalizing an overall performance measure, the multi-dimensionality of the performance construct is taken into account (e.g., Ketokivi & Schroeder 2004b). Out of a number of operational performance dimensions used in the OM literature, eight dimensions are included in the subsequent analysis. The dimensions of manufacturing performance included in the analysis are: unit cost of manufacturing, product capability and performance, conformance quality, development lead time, on-time new product launch, volume flexibility, design flexibility, and product innovativeness. The development of Proposition 1 into empirically testable hypotheses is presented in the following.

Manufacturing unit costs are mainly determined before the end of the new product development project (Gerwin 1993). In addition, the costs determined in the beginning of the development project tend to accelerate in the later stages (Liker et al. 1999). From the information processing perspective, the role of product and process design is significant in terms of manufacturing costs. For example, the capacity to process information between manufacturing and R&D is important, so that R&D is aware of current manufacturing capabilities (manufacturability of the product) and can make design decisions for the positive impact on the firm's ability to reduce excess costs, such as scrap and rework costs (Tan & Vonderembse 2006). Furthermore, the capacity to process information between manufacturing and R&D is essential, so that manufacturing is in the know about changes in product characteristics to ensure an optimal manufacturing process. In addition, manufacturing may suggest ways to design the product for ease of manufacturing (Koufteros et al. 2001). Therefore, achieved integration of manufacturing and R&D is likely to have a positive effect on performance in terms of manufacturing costs. On the other hand, if there are continuous conflicts between the functional units, for example between operations and R&D functions in terms of the goals of a NPD project, continuous managerial efforts are needed in order to align the decisions and ensure sharing of required and relevant information. This will directly increase the manufacturing costs. Therefore, it is hypothesized:

> **H1a.** Achieved integration has a positive effect on manufacturing cost performance.

Much like manufacturing costs, also product capabilities are determined before the end of the development project (Gerwin 1993), even at very early stages in the development project. Again information processing between manufacturing and R&D is needed to make sure that R&D is well aware of the current manufacturing capabilities and the manufacturability of the product ("downstream-friendly solutions" (Wheelwright & Clark 1992)). This is important, as the fit between product design specifications and manufacturing capabilities will lead to higher product performance (Swink & Calantone 2004) and higher product quality (Koufteros et al. 2001; Swink 1999). On the other hand, when integration is not achieved and there is lack or inaccuracy of information or lack of capacity to process information between R&D and manufacturing, the product might not function as designed due to potential problems in manufacturing. This will lead to lower product capability and performance. Therefore, it is hypothesized:

> **H1b.** Achieved integration has a positive effect on product capability and performance.

Conformance quality refers to the extent to which the manufactured product to meets the design specifications. From the information processing perspective, both product design and agreed product specifications are significant in terms of high conformance quality. When marketing and R&D have the knowledge of manufacturing capabilities, both the design of the product and the customer specifications can take that into account (Gerwin 1993; Swink & Calantone 2004). Hence, what is manufactured reflects what the customer actually wants and the products can be manufactured to meet the specifications; in the words of Ettlie (1997, p. 37), “aspiration [market needs] and reality [manufacturing capabilities] are brought together”. On the other hand, when integration is not achieved and there are conflicting views or lack of information between R&D which is responsible for designing the product, manufacturing which is responsible for making it and marketing being responsible for making contracts with the customer, because the dominance of one or the other perspective throughout the NPD stages, there can be deficiencies in the ability to deliver successfully what the firm has promised (Swink & Song 2007). Therefore, it is hypothesized:

> **H1c.** Achieved integration has a positive effect on conformance quality.

Involving manufacturing early in the NPD process can significantly speed up the process in a number of ways, including for example process development. Slow or inadequate process development can have a negative impact on the quality and speed of prototype development and testing, leading to delays or repetitions of tests (Calantone et al. 2002). This will further increase the development time or delay the product launch due to additional actions that need to be taken before the product launch. Integration of manufacturing in the NPD process helps to accelerate the process by eliminating steps (Eisenhardt & Tabrizi 1995), preventing delays, and speeding up the times for ramp-up (Wheelwright & Clark 1992). For example, information sharing between multifunctional teams is suggested to lead to earlier problem detection and subsequently to shorter development time (Eisenhardt & Tabrizi 1995). However, involving manufacturing in the very early stages of the NPD process has its risks, because a too detailed level of interaction and extensive information sharing can easily lead to delays in the development process (Gerwin 1993). Furthermore, when there is lack of information processing among functions, additional steps in the development process are needed, including for example numerous re-iterations of product-process development to ensure manufacturability, which leads to an increase in the development time and potential delays in the product launch. Therefore, it is hypothesized:

> **H1d.** Achieved integration has a positive effect on development lead time performance.

> **H1e.** Achieved integration has a positive effect on on-time new product launch.

Flexibility can be divided into two separate dimensions (Hayes & Wheelwright 1984, p. 40): volume flexibility, referring to the ability to quickly and efficiently adjust output to match the demand, and design flexibility, referring to the ability to handle changes in product design quickly and efficiently.

From the information processing perspective, a high level of achieved integration between manufacturing and marketing means that manufacturing has better and more accurate information about market demand in terms of product volume and variety. With the actual information about market demand, manufacturing can address the requisite manufacturing capacity more effectively, including changes in volume and design characteristics (Swink & Song 2007). Furthermore, information processing between manufacturing, R&D, and marketing helps in designing the manufacturing system so that it can easily accommodate a variety of product configurations and volume fluctuations if needed, now and also in the future, in order to accommodate both higher design flexibility and higher volume flexibility. Therefore, it is hypothesized:

> **H1f.** Achieved integration has a positive effect on volume flexibility.

> **H1g.** Achieved integration has a positive effect on design flexibility.

Finally, product innovation refers to the capability of the firm to introduce new products and new features in existing products (Koufteros & Marcoulides 2006; Koufteros et al. 2001; 2002). Early involvement of manufacturing and marketing in product development can stimulate thinking and boost creative ideas and new features in products (Burns & Stalker [1961] 1968; Gerwin 1993; Tan & Vonderembse 2006). The reason for this lays in the bounded rationality assumption; due to their cognitive limitations, organizational members (and hence individual functions) within an organization differ in terms of the information and knowledge they possess (Conner & Prahalad 1996) and in terms of the issues they focus their attention to (Dougherty 1992). Subsequently, all functions may have a unique insight into innovation; for example manufacturing and marketing have experience and knowledge of the downstream and they can offer ideas that attract customers. Therefore, it is hypothesized:

H1h. Achieved integration has a positive effect on innovativeness.

After formulating the empirically testable hypotheses, a conceptual model illustrating the hypotheses can be constructed.

5.1.3 Model for Assessing the Relationship between Integration and Performance

The eight formulated hypotheses propose a positive relationship between achieved integration and the different dimensions of comparative performance. The performance model is presented in Figure 5-1 below. It is important to note that although the effect of achieved integration on all performance dimensions included in the analysis is assumed to be positive, it is not assumed that the relationships are equal in strength (e.g., the effect of achieved integration on volume flexibility might be stronger than the effect of achieved integration on design flexibility). In this research, however, no hypotheses about the relative strength of the relationships are presented.[52]

[52] Some authors have used manufacturing strategy as a moderating variable when assessing for example the effect of certain manufacturing practices on performance (e.g., Ketokivi & Schroeder 2004a). This reflects in general the strategic contingency argument (Dean & Snell 1996), proposing that different manufacturing practices are used to achieve high performance on different dimensions. In this model strategy is not included as a moderator variable, because it is assumed that achieved integration is useful in terms of performance despite the manufacturing strategy the plant emphasizes. That is, it is not assumed that there are strategic reasons for a higher level of achieved integration, but rather that it is as important for all strategies.

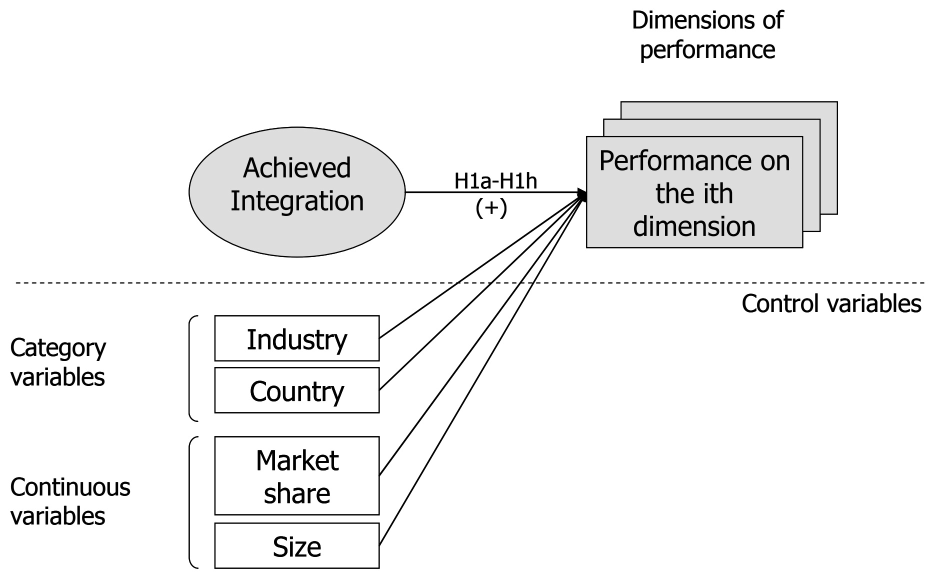

Figure 5-1. Performance model for Proposition 1

When assessing the relationship between achieved integration and performance, the following variables are added as control variables in the model: country of plant location, industry, size of the plant, and market share of the plant. Although there is no theoretical explanation for why country and industry would affect the results, they are included as control variables for two reasons. First, the country and industry variables control the possible sample heterogeneity and, secondly, prior empirical research has found differences in integration-performance relationships across countries and industries (e.g., Kahn & McDonough 1997b), and hence it is appropriate to control their effect. Plant size, on the other hand, is included as a control variable because intuition suggests that as plant size increases, integration becomes harder to achieve and because prior empirical research has found significant effects of size on the integration-performance relationship (e.g., Swink et al. 2005). In addition, intuition suggests that a greater market share correlates positively with performance, making it appropriate to control also for its effect.

5.1.4 Method of Analysis

The independent variable (achieved integration) is measured on an ordinal scale of 1-5 from three respondents and can thus be considered continuous. The control variables include both continuous (size and market share) and dichotomous variables (industry and country). The dependent variables (performance dimensions), on the other hand, are discrete and measured on an ordinal scale of 1-5 using a single respondent. This sets limits for the method of analysis: the ordinal scale of the dependent variable violates the OLS assumption of normal and homoscedastic residuals (see Section 4.3.2). The violation of the homoscedasticity assumption was detected by plotting the residuals against the independent variable of achieved integration (Kennedy 2003, p. 137). Visual inspection of the residual plots reveals that the magnitudes of the residuals do not remain the same on different values of the independent variable, pointing to heteroscedasticity. Because the dependent variable is measured on the ordinal scale and independent variables include both continuous and dichotomous variables, *ordinal regression* is used.[53]

Although ordinal regression does not make any assumptions regarding the distribution of the residuals like CLRM, two assumptions need to be assessed: (1) the non-existence of collinearity (Assumption 5, see Section 4.3.2), which is assessed before estimating the model, and (2) the assumption of parallel lines, which is assessed after estimating the model. In this research, the existence of collinearity would mean the following: achieved integration is highly correlated with size and market share (continuous control variables), and achieved integration is highly correlated with the country and industry variables (dichotomous control variables).

The correlations among the independent variable and continuous control variables are presented in Table 5-1 below (country and industry variables are excluded from the table due to space limitations).

[53] The design is actually ordinal analysis of covariance (ANCOVA) (Kutner et al. 2005, p. 329) with the continuous covariates of theoretical interest and qualitative factors playing a role of a control variable, whereas in a traditional ANCOVA model the qualitative factors are of interest and quantitative covariates are introduced primarily to reduce the variance in error terms. However, the term ordinal regression is used here to emphasize the ordinal scale of the dependent variable and the underlying estimation procedure and to avoid confusion with the variables which are of focal interest in the analysis.

Table 5-1. Pearson correlations of variables for Proposition 1

	Mean	SD	N	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Independent variable													
1. Achieved Integration	0.00	0.96	234										
Dependent variables													
2. Low unit costs	3.20	0.89	213	0.28**									
3. Product capability	3.89	0.76	214	0.14*	0.20**								
4. Conformance quality	3.88	0.69	216	0.19**	0.27**	0.49**							
5. Development lead time	3.32	0.94	212	0.20**	0.23**	0.34**	0.27**						
6. On-time product launch	3.35	0.86	210	0.24**	0.30**	0.40**	0.34**	0.65**					
7. Volume flexibility	3.87	0.78	216	0.33**	0.27**	0.16*	0.18**	0.35**	0.40**				
8. Design flexibility	3.91	0.74	213	0.16*	0.21**	0.27**	0.17*	0.39**	0.36**	0.56**			
9. Innovativeness	3.57	0.92	210	0.09	0.27**	0.55**	0.33**	0.51**	0.46**	0.30**	0.37**		
Control variables													
10. Size (ln)	6.00	1.00	201	0.15*	0.21**	0.10	0.03	0.10	0.15*	0.06	-0.04	0.11	
11. Market share	25.76	20.66	190	-0.09	0.10	0.12	0.02	0.06	0.04	0.02	0.09	0.16*	-0.04

** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

The following conclusions can be made. First, the correlations between achieved integration and continuous control variables of size and market share are low (0.15 and -0.09 respectively). Second, only one of the correlations between achieved integration and the categorical controls is statistically significant at $\alpha = 0.05$ level, and the correlations are in absolute terms on average 0.06 and at maximum 0.15, and hence not high. A further look at Variance Inflation Factors (VIF)[54] and Condition Indices[55] suggests that collinearity should not be a problem (VIFs at maximum 1.66 and CIs at maximum 21.64, see Hair et al. 1998, p. 220). Thus, the first assumption of ordinal regression is satisfied.

5.1.5 Statistical Analysis

Model estimation. Due to the argument that performance is multidimensional, a separate model is needed for each dimension. In total eight models were estimated, one for each dependent variable (for a similar type of analysis, see for example Flynn et al. 1999; Ketokivi & Schroeder 2004a). Country and industry variables were entered in the model as dummy variables using indicator coding (Hair et al. 1998, p. 167). The results of the ordinal regression analysis are presented in Table 5-2 (see Appendix C for detailed mathematical results). The table includes the β-coefficients for the independent and control variables as well as the model fit indices. All variables are entered in the models simultaneously. The significance tests for the independent variable are one-tailed and for the control variables two-tailed.

[54] The Variance Inflation Factor (VIF) is a measure of the effect of other independent variables on a regression coefficient (Hair et al. 1998, pp. 220-221), that is, how much the variance of the estimated regression coefficients are inflated as compared to the situation where the independent variables are not linearly related (Kutner et al. 2005, p. 408).

[55] Condition Index (CI) refers to the collinearity of combinations of variables in the data set (Hair et al. 1998, pp. 220-221).

Table 5-2. Results of ordinal regression models for Proposition 1

	Dimension of performance							
	Unit costs	Product capability	Conformance quality	Development lead time	On-time product launch	Volume flexibility	Design flexibility	Innovativeness
Hypothesis	H1a (+)	H1b (+)	H1c (+)	H1d (+)	H1e (+)	H1f (+)	H1g (+)	(H1h+)
Control variables								
Size	0.447 *	0.300	0.141	0.159	0.219	0.000	0.187	0.529 **
Market share	0.013 +	0.011	0.002	0.002	0.003	0.003	0.015 +	0.020 **
Austria	-0.985	-1.096	-1.456 *	-0.042	0.537	0.936	0.456	-0.762
Finland	-0.390	-0.469	-0.384	0.098	0.544	1.275 *	0.447	-0.184
Germany	-1.078 +	-0.544	-0.789	-0.110	-0.113	-0.031	-0.257	-0.624
Italy	-1.620 **	0.536	-0.481	0.311	1.166 *	1.253 *	0.113	-0.333
Japan	-0.752	0.118	-0.879	-0.257	-0.054	0.737	0.960	0.619
Korea	-0.922	-0.505	0.433	0.643	1.212	1.246	1.131	0.993
Sweden	-0.629	0.378	-0.817	0.848	0.929	1.202 +	0.456	-0.421
USA	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
Electronics	0.233	0.306	0.229	-0.079	0.490	-0.218	-0.227	-0.769 *
Machinery	0.028	-0.786 *	-0.114	-0.243	0.073	0.072	-0.016	-0.923 *
Transportation	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
Theoretical variable								
Achieved integration	0.620 **	0.166	0.351 *	0.288 *	0.450 **	0.749 **	0.342 *	0.104
Model indices								
χ^2-statistic	37.812	24.381	13.449	12.561	27.344	31.601	13.484	25.609
DF	12	12	12	12	12	12	12	12
p-value	0.000	0.018	0.337	0.402	0.007	0.002	0.335	0.012
Concordance index	45.8%	53.7%	55.1%	39.0%	53.1%	55.1%	57.8%	45.7%

[a] This parameter is set to zero because it is redundant.

** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

Model assessment. The models are assessed in three parts. First, the χ^2-statistic of the overall model fit is significant (p-value < 0.05) in five of the models, suggesting that the null hypothesis of no relationship between the independent variables and the dependent variable (i.e. all the coefficients in the model are zero) should be rejected. Thus, the model fits the data well in five cases (unit costs, product capability, on-time product launch, volume flexibility, and innovativeness). [56]

Second, the concordance index (Agresti 1990; Kutner et al. 2005, p. 607) ranges between 39.0% and 57.8%, giving support to the conclusion that the model explains the dependent variable rather well. Thus, it can be concluded that although the model is simple, it is satisfactory in terms of its predictive power.

Finally, ordinal regression assumes that the independent variables have the same impact on all the thresholds of the dependent variable. The χ^2-statistics for the assumption of parallel slopes (Cohen et al. 2003, p. 524) is not significant (p > 0.05) in four of the eight models (development lead time, volume flexibility, design flexibility, and innovativeness), suggesting that the null hypothesis of the parallel slopes model is retained, and the independent variables have the same impact on all the thresholds. In the four other models (unit costs, product capability, conformance quality, and on-time product launch) the assumption of parallel slopes is not met. However, the χ^2-statistics in these models is not extremely high and, thus no further action is taken.

A summary of the model fit statistics is presented in Table 5-3 below.

Table 5-3. Summary of model fit statistics for Proposition 1

	Overall fit			Concordance	Parallel lines		
	χ^2	DF	p	index	χ^2	DF	p
Unit costs	37.812	12	0.000	45.8%	58.147	36	0.011
Product capability	24.381	12	0.018	53.7%	54.094	24	0.000
Conformance quality	13.449	12	0.337	55.1%	54.709	24	0.000
Development lead time	12.561	12	0.402	39.0%	44.052	36	0.168
On-time product launch	27.344	12	0.007	53.1%	66.907	36	0.001
Volume flexibility	31.601	12	0.002	55.1%	31.988	36	0.660
Design flexibility	13.484	12	0.335	57.8%	32.292	24	0.120
Innovativeness	25.609	12	0.012	45.7%	32.828	36	0.620

[56] Due to the ordinal regression method used, statistical power was estimated using the procedure presented by Agresti (1990, pp. 241-243). Calculation of statistical power with the sample size of 236 and using $\alpha = 0.05$ suggests that the power is 1.000 in all the estimated eight models.

Point estimate assessment. The point estimates in Table 5-2 indicate that achieved integration is statistically significant in six of the eight models (unit costs, conformance quality, development lead time, on-time product launch, volume flexibility, and design flexibility). Statistical significance[57] here suggests that the hypothesis of no relationship between the independent and dependent variables should be rejected. Furthermore, in each of these cases, the β-coefficient of achieved integration is positive. Thus, the results presented in Table 5-2 provide empirical support for six of the eight hypotheses (H1a and H1c - H1g), and suggest that higher achieved integration has a positive effect on the competitive manufacturing performance in the dimensions of unit costs ($p = 0.00$), conformance quality ($p = 0.02$), development lead time ($p = 0.04$), on-time product launch (0.00), volume flexibility ($p = 0.00$), and design flexibility ($p = 0.02$). No support was found to the hypotheses that achieved integration has a positive effect on product capability and performance (H1b, $p = 0.16$) or product innovativeness (H1h, $p = 0.26$). In addition, some of the control variables show statistical significance. However, no hypotheses were presented regarding the control variables, and thus they are not further assessed here to avoid post-hoc explanations.

5.1.6 Summary and Discussion of the Findings

In this section, I have tested the effect of achieved integration on different dimensions of performance. Table 5-4 summarizes the empirical findings of the section. The table includes the p-value of the point estimate for the effect of achieved integration on each dimension of performance, the subsequent decision regarding each hypothesis, and the magnitude of the effect (i.e. effect size (Abelson 1995, Ch. 3; Mazen, Graf, Kellogg & Hemmasi 1987))[58].

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[57] Due to ordinal regression, Wald statistic (Hair et al. 1998, p. 281) is used to assess the statistical significance.

[58] Due to the ordinal regression model, the magnitude of the effect of achieved integration on performance is not directly the β-coefficient. The magnitude of the effect is calculated from the cumulative odds ratio (Kutner et al. 2005, p. 616; Powers & Xie 2000, pp. 75-76). When the achieved integration increases by one unit, the probability that performance increases in a higher category can be calculated with the formula: $\left(\frac{\exp(\beta(AI+1))}{\exp(\beta \cdot AI)}-1\right)100\%=(\exp(\beta)-1)\cdot 100\%$.

Table 5-4. Summary of the results for the performance model

HYPOTHESIS		RESULT[a]	EFFECT SIZE
Achieved integration has a positive effect on …			
H1a.	Unit cost of manufacturing	Supported (0.00)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 65.0%.
H1b.	Product capability and performance	Rejected (0.16)	-
H1c.	Conformance quality	Supported (0.02)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 58.7%.
H1d.	Development lead time	Supported (0.04)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 57.1%.
H1e.	On-time new product launch	Supported (0.00)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 61.1%.
H1f.	Volume flexibility	Supported (0.00)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 67.9%.
H1g.	Design flexibility	Supported (0.02)	An increase of one unit in achieved integration increases the odds of performance increasing to a higher category by 58.5%.
H1h.	Product innovativeness	Rejected (0.26)	-

[a] The number in parenthesis refers to the p-value of the β-coefficient for achieved integration in the regression model.

The effect of achieved integration on the different dimensions of comparative manufacturing performance is rather strong: the β-coefficient for achieved integration is statistically significant at $\alpha = 0.01$ level in three out of the eight models and at $\alpha = 0.05$ level in three other models. Even though achieved integration does have a positive effect on six of the eight performance dimensions estimated, a conclusion that the effect of achieved integration is equal across performance dimensions is not justified. The β-coefficients for the achieved integration in those models vary from 0.29 to 0.75, indicating that although the sign of the coefficient is the same, the magnitude of the effects is not similar.[59] Hypotheses regarding the relative magnitudes of the effect of

[59] Due to the ordinal regression, the β-coefficients are not directly comparable because of the non-linear transformation (i.e. β-coefficient of 0.20 does not mean that the effect of the variable is twice the effect of a variable with β-coefficient of 0.10).

achieved integration on different dimensions of performance were not presented, and thus it is not assessed here.

The results do not offer support to the effect of achieved integration on product capability and innovativeness. A potential reason for this is that manufacturing performance was operationalized as performance relative to competitors (i.e. how well the plant performs when compared to others in the industry) rather than as absolute manufacturing performance. Therefore, although an increase in the level of achieved integration would somewhat increase the product capability and innovativeness performance in absolute terms, it might not lead to significant increase in performance compared to others in the industry. The reason for this is that there might be other more important factors than the state of achieved integration, such as personnel characteristics and the innovative environment of the firm that might increase the innovativeness of the plant or the product capabilities. In addition, the plant level of observation might be a reason for the low effect of achieved integration on product innovation. Not every firm competes through manufacturing in general (Hayes & Wheelwright 1984), and especially, not all plants have been assigned the role of being highly innovative (Skinner 1974).

A look at the overall model fit statistics (Table 5-3) points out that there is a relationship between the independent variable and the dependent variable, because the test statistic (χ^2) is statistically significant at $\alpha = 0.05$ level in five of the models. There are two potential explanations for why the data does not fit the model in three cases: the construct achieved integration is not reliable (the measurement error is high) or there are other (non-modeled) factors affecting the particular performance dimension. The first potential explanation is not likely in this research because the construct achieved integration shows high reliability (CR = 0.95). On the other hand, it is rather likely that the three models are not statistically significant, because there are other factors besides achieved integration and the modeled control variables affecting competitive performance, such as manufacturing practices (cf. Ketokivi & Schroeder 2004a).

In addition, the results point out two important issues regarding plant performance. First, positive correlations among the dimensions suggest that there are no trade-offs between different performance dimensions (cf. Schmenner & Swink 1998). Second, the inter-item correlations of performance dimensions further justify the use of the multidimensional performance construct: although the correlations among the performance dimensions are statistically significant, they are far from the value of 1 (the correlations are statistically significant at $\alpha = 0.05$ level, vary between 0.16 and 0.65 and are on average 0.34, see Table 5-1 above), which gives no reason to assume that they have one underlying construct. This supports the argument that there is no overarching operational performance measure. Rather, performance is multidimensional, consisting of different types of performances.

As a summary, two conclusions can be made. First, although the estimated performance model is rather simple in that only the level of achieved cross-functional integration within a plant is used to explain variations in the comparative manufacturing performance, the model shows satisfactory explanatory power. Achieved integration has a positive effect on unit cost, conformance quality, development lead time, on-time product launch, volume flexibility, and design flexibility. Second, manufacturing performance is a multidimensional construct, and operationalizing it with a single construct is not appropriate.

5.2 CONCEPT OF INTEGRATION

The results of the Section 5.1 suggest that the level of achieved integration has a positive effect on several dimensions of performance. But what is the role of integration mechanisms and how are the different dimensions of integration related? In this section, all three integration concepts, namely achieved integration, integration mechanisms and requisite integration are discussed, addressing the notion of fit in Figure 3-3.

5.2.1 Proposition 2. Achieved Integration, Integration Mechanisms, and Requisite Integration

The information processing perspective to organizations suggests that in effective rational organizations, there is a fit between the information processing needs and information processing capacity of the organization. Because of bounded rationality (March & Simon [1958] 1993), the organizational members have cognitive limits. Subsequently, they focus their attention to their immediate sub-environment only (March & Simon [1958] 1993; Ocasio 1997). This restricts the information processing capacity of the organization. When the capacity of the organization to process information is less than the need for information processing, there is uncertainty in decision making, which interferes with the rationality of the decisions. Organizations implement various integration mechanisms to reduce uncertainty and ensure that different units have all the relevant and accurate information when making decisions, and increase their ability to process information (Thompson [1967] 2003). However, due to the costs of information (Cyert & March 1992), rational organizations do not put excess effort on increasing the information processing capacity. Therefore, it is hypothesized as follows:

> **Proposition 2:** A fit between the level of requisite integration and the use of vertical and horizontal integration mechanisms has a positive effect on the level of achieved integration.

Proposition 2 aims to clarify the concept of integration by addressing all the three identified integration dimensions and proposing that depending on the level of requisite integration, different integration mechanisms can be used to achieve a given level of achieved integration.

5.2.2 Development of Empirically Testable Hypotheses

Discussion of fit. There is no clear definition for the concept of fit. Before developing Proposition 2 into empirically testable hypotheses, defining the theoretical meaning for the concept of fit is essential, because it has direct consequences on the operationalization of fit, and subsequently on the formulation of hypotheses (in addition, the conceptualization of fit has direct consequences on the appropriate method of analysis). Even though fit is one of the central concepts in the contingency theory, it still remains very problematic (for critique on the notion of fit, see for example Schoonhoven (1981)); and the concept of fit has been considered even as the root cause for questioning the rationale of the contingency theory (Van de Ven & Drazin 1985). Drazin and Van de Ven (1985; Van de Ven & Drazin 1985) propose three interpretations of fit: fit as selection, fit as interaction, and systems approach to fit. Venkatraman (1989) extends this to six different perspectives: fit as mediation, fit as moderation, fit as matching, fit as gestalts, fit as profile deviation, and fit as covariation. Fit as matching, moderation, and profile deviation seem equivalent to Drazin and Van de Ven's (1985; Van de Ven & Drazin 1985) perspectives of fit, respectively.

Traditionally, OM scholars studying integration have operationalized fit as moderation and studied the effect of a third variable on the relationship between integration and performance (e.g., O'Leary-Kelly & Flores 2002; Swink 2000; Swink & Nair 2006). However, there is no consistent evidence for this mainstream view of the contingency theory operationalizing fit as moderation between context and design and linking it to performance (cf. for example the moderating effect of innovativeness in O'Leary-Kelly & Flores 2002; Song & Xie 2000). One potential reason for the inconsistency in the empirical results is multicollinearity that is often inherent in the analysis of fit as moderation with interaction terms. Furthermore, based on their empirical investigations, Drazin and Van de Ven (1985; Van de Ven & Drazin 1985) propose that it is perhaps the moderation form of fit with the interaction approach rather than the contingency theory as such that should be questioned.

Following the theoretical ideas of Galbraith (1973, 1977), Lawrence and Lorsch ([1967] 1986), and Thompson ([1967] 2003), and the theoretical discussion in Chapter 3, two different conceptualizations of fit seem appropriate for Proposition 2: fit as congruence and fit as mediation.[60] There are, however, two significant problems related to the conceptualization of fit as congruence in the context of this research. First, conceptualizing fit as congruence does not make it possible to assess the relationship between all the three constructs explicitly; the positive effect of fit on performance is merely assumed. Rather, in this context conceptualizing fit as congruence makes an implicit assumption that a fit between the level of requisite integration and the use of integration mechanisms lead to a higher level of achieved integration. Second, including control variables in the model of fit as congruence is not possible. However, for example country controls is important here because prior research has found differences in the use of integration mechanisms across countries (e.g., Ettlie & Trygg 1995). In order to take these considerations into account, fit is conceptualized as mediation: the

[60] Although fit as profile deviation has also been used in prior OM literature (e.g., Das et al. 2006 in supplier integration context), it is not appropriate here because contingency theorists propose the use of the Cartesian approach (Donaldson 2001, pp. 141-144) rather than the configuration approach. According to the Cartesian approach, organizations can score differently on each dimension (i.e. the degree of use of a particular integration mechanism), and hence, the focus is on assessing the use of different mechanisms independently rather than consistency/fit in the use of a bundle of integration mechanisms. An underlying assumption in the Cartesian approach is the principle of equifinality (Donaldson 2001, p. 143; Tushman & Nadler 1978); integration mechanisms are seen as alternative (although not random) ways of achieving integration so that the same outcome can be achieved in different ways (cf. Mintzberg 1979, p. 8). Conceptualizing fit as mediation takes the Cartesian approach to integration mechanisms.

antecedent construct is requisite integration and the consequent construct is achieved integration. The mediating constructs, the extent of use of various integration mechanisms, are used in response to the information processing requirements in order to increase the capacity to process information to achieve effectiveness (i.e. high level of achieved integration). Fit is conceptualized on a scale referring to a degree of fit or misfit.

After specifying the exact conceptualization of fit for the present research, Proposition 2 can be reformulated as follows:

> **Proposition 2a.** Integration mechanisms mediate the relationship between requisite integration and achieved integration.

Formulation of hypotheses. The proposition is further developed into empirically testable hypotheses. Out of a number of integration mechanisms identified in the prior literature, four mechanisms are included in the subsequent empirical analysis: centralization, plant-level information systems, cross-functional job rotation, and cross-functional teams. These mechanisms resemble closely the different categories of integration mechanisms presented by Galbraith (1973), and are presented in order of increasing capacity to process information and increasing complexity and cost. To formulate empirically testable hypotheses, each integration mechanism is analyzed separately to assess its advantages and disadvantages in achieving cross-functional integration (Table 5-5). The discussion below follows the information processing perspective taken in this research, although many of the integration mechanisms can be assessed and used for behavioral purposes as well.

Table 5-5. Advantages and disadvantages of integration mechanisms assessed in this research (Daft & Lengel 1986; Galbraith 1970, 1973, 1994; McCann & Galbraith 1981)

INTEGRATION MECHANISM	ADVANTAGES	DISADVANTAGES
Centralization of functional decision-making	Simplifies decision making because only one unit/person is responsible for it and has access to all the relevant information and an overall perspective of the whole organization	The decision-making unit/person becomes easily overloaded with information and information-processing requirements, can limit creativity and action due to a single perspective taken in the decision making
Plant-level information systems	Allows processing of additional and more rich information across organizational units fast and easy without overloading the hierarchy	Requires significant investments when designed and implemented, as well as time for adjustment, can provide too much information too often and overload the decision-maker, requires more computer time and clerical work
Job rotation of managers across functions	Creates a wider contact network for the manager being rotated, allowing easier and more informal communication with other departments leading to more effective information-processing	Requires time and effort to learn the new tasks and time to develop the job rotation practices
Cross-functional teams	Reduces hierarchical overload, creates potential for more creative ideas due to the heterogeneity of the problem-solving team, makes identifying and contacting cross-functional peers easier, which facilitates information sharing across organizational boundaries, reduces equivocality	Requires time and effort to develop the team structure and select the people, and time to adjust to work as a team, as well as time to maintain, easily overloads the team members when joint problem-solving is on a more day-to-day basis

Requisite integration → Integration mechanisms. Centralization of decision making as an integrative mechanism in general means that the decisions are limited at senior levels in the organization (Child 1973b). Within the context of this research centralization refers to assigning the locus of decision making regarding functional issues to plant level. Centralization simplifies the decision making process. It also ensures that the decision maker has access to all relevant information. Following the arguments of the attention-based theory (Ocasio 1997), the plant-level decision maker engages in information processing across all functional interfaces rather than in the immediate functional environment, hence facilitating information processing across the functions. However, when the requirements for information processing in the functions are significant, the hierarchy becomes overloaded because one person or department does not have enough capacity to process all the required information (Galbraith 1970). This can result for example in delays in decision making or decisions that are made on the basis of incomplete information. Therefore, it is hypothesized:

> **H2a.** The level of requisite integration has a negative effect on the extent of centralization of functional decisions to plant level.

In order to further facilitate information processing when the requirements become more intense, the organization can use other lateral mechanisms to promote information processing across functional boundaries. Lateral mechanisms can be divided into information systems, informal relations, and formal lateral structures.

Information systems are an integral way of promoting information processing in organizations (Galbraith 1994, pp. 52-54). Within the context of this research, information technologies such as the World Wide Web, e-mails, and group tools provide an opportunity to contact people in different functional units easily. In addition to promoting informal communication, information systems can also be used to facilitate information sharing involving the transfer of mainly numeric data (Daft & Lengel 1986). Organizational members can use information systems to find, analyze, and send and share more information effectively, accurately, and rapidly. When implemented at plant level, the information systems allow for information sharing across functional boundaries, responding to the call for more information processing capabilities due to intense requisite integration without overloading the hierarchy (Galbraith 1973, p. 30). In the OM context information systems include also for example access to computer-aided design (CAD) and computer-aided manufacturing (CAM) (e.g., Koufteros et al. 2002). Information systems also provide manufacturing information and reduce uncertainty for example in terms of how well the product is selling. Although providing an efficient mechanism for information processing, information systems pose significant monetary costs to the organization, require time and clerical work, and can provide too much information, overloading the decision maker (Galbraith 1973). Hence, when the requirements for information processing across functions are less significant, fewer investments are needed for plant-level information systems and simpler systems are likely to satisfy the information-processing needs. Therefore, it is hypothesized:

> **H2b.** The level of requisite integration has a positive effect on the extent of use of plant-level information systems.

Informal relationships between the members of different functional units are an integral part of the information processing capacity of the organization. Although informal relationships refer to a kind of voluntary and unplanned decentralized coordination, organization designers can increase the odds that voluntary contacts across organizational units occur (Galbraith 1994, pp. 44-45). One way of enhancing informal contacts across functional areas is the cross-functional job rotation of managers. Cross-functional job rotation of managers provides managers direct contacts across organizational units (Daft & Lengel 1986; Galbraith 1973, 1994), creating a verbal information network among the managers (Edström & Galbraith 1977). This allows them to exchange information and views, facilitating both subjective and objective data, which reduces especially equivocality (Daft & Lengel 1986). For example, a manufacturing manager who has spent a few years in the sales department, can serve as an excellent interface between manufacturing and sales as he or she knows the key personnel and knows who to contact in which issues, and is familiar with the sales culture and language. However, the development of cross-functional managerial job rotation practices requires managerial time and, furthermore, learning the new job takes both time and effort of the rotated managers (Galbraith 1973, pp. 49, 56). Hence, when the requirements for information processing across functions are less significant, less emphasis is needed on cross-functional job rotation, and simpler mechanisms, such as centralization, are likely to satisfy the information processing needs. Therefore, it is hypothesized:

> **H2c.** The level of requisite integration has a positive effect on the extent of use of cross-functional job rotation.

When the requirements for information processing and joint problem solving are on a more day-to-day basis, communication using information systems and informal network easily overload the decision maker, much like in the case where only centralization is used (Galbraith 1973, pp. 17, 53). Further information processing requirements can be facilitated by developing more stable lateral organizational structures, such as cross-functional teams, integrator roles and task forces (e.g., Galbraith 1994; Lawrence & Lorsch [1967] 1986). Teams, integrators, and task forces can actively exchange data across organizational units and provide a greater amount of information for decision making than face-to-face meetings (Daft & Lengel 1986). Within the context of this research, cross-functional teams provide a formal forum for mutual information sharing across functional boundaries, facilitating information processing in the organization. From the information processing perspective, the main advantage of cross-functional teams is the ability to reduce equivocality by building understanding and agreement between members belonging to different functional units (Daft & Lengel 1986). In addition, cross-functional teams bring together members with different stocks of knowledge, skills, and experience (Conner & Prahalad 1996), increasing the richness of the information being processed. Cross-functional teams, however, require time and effort to develop and select people (Galbraith 1973, p. 56) and time to adjust to work as a team, as well as time to maintain (Galbraith 1994, p. 37). Hence, when the requirements for information processing across functions are less significant, less emphasis is needed for the development of cross-functional teams, and simpler integration mechanisms are likely to satisfy the information processing needs. Therefore, it is hypothesized:

> **H2d.** The level of requisite integration has a positive effect on the extent of use of cross-functional teams.

Integration mechanisms → achieved integration. Due to the bounded rationality assumption (March & Simon [1958] 1993, p. 173), the attention-based theory of the firm (Ocasio 1997) argues that organizational members engage in information processing in the areas in their immediate environment. Within the context of this research this means that for example the members of the manufacturing function focus mainly on processing manufacturing-related information because of their limited cognitive abilities. Centralization of functional decision making as an integrative mechanism allows functional decisions to be made based on a top level (plant) perspective. The plant-level decision maker pays attention to the overall organization rather than a single functional environment. Subsequently, the plant-level decision maker has more complete information on the issues going on in the organization as a whole, which reduces sub-goal pursuit. On the other hand, if the locus of decision making is at the functional level, the decisions are made from perspective of that particular function with the expense of the overall organization. From the information processing perspective, the reason for this is the cognitive limits of the members rather than opportunistic behavior; although intendedly rational, the members are only limitedly rational (March & Simon [1958] 1993). Based on this, it is hypothesized:

> **H2e.** The extent of centralization of functional decisions to plant level has a positive effect on the level of achieved integration.

Plant-level information systems serve as facilitators of informal contacts between organizational members located in different functions, and also enhance the sharing, disseminating and processing of information in an accurate and timely fashion across units when completing a task (Galbraith 1973, 1994). Subsequently, information systems increase the information the members possess outside their immediate functional environment, and hence the organizational members are able to complete their tasks based on information from all functions. This reduces sub-goal pursuit due to the cognitive limitations of boundedly rational organizational members (March & Simon [1958] 1993) by directing actions and decision making for organizational-level purposes. On the other hand, when plant-level information systems crossing functional boundaries have not been implemented, there is for example no mediator for efficient processing of for example numeric data between functions. Based on the discussion above, it is hypothesized:

> **H2f.** The extent of use of plant-level information systems has a positive effect on the level of achieved integration.

Managerial job rotation across functions enhances cross-functional information processing, because the organizational members have more direct contacts in different functional units, enabling them to engage in informal communication with other departments (Galbraith 1973, p. 49). This is needed for example in the case a specific expert needs to be located for problem solving or when information is required from other functions. Furthermore, rotating managers across functions increases the knowledge and enhances the information the member possesses outside his or her immediate functional environment. This reduces sub-goal pursuit that arises due to the cognitive limitations of boundedly rational managers (March & Simon [1958] 1993). On the other hand, when managers have first-hand experience only in their immediate function, it restricts their knowledge, actions, and perspective to decision making to the context of the single function rather than the whole organization. Based on this, it is hypothesized:

> **H2g.** The extent of use of cross-functional job rotation has a positive effect on the level of achieved integration.

Cross-functional teams are a form of a more formal lateral structure for cross-functional communication (Galbraith 1994). Due to bounded rationality, the organizational members have different knowledge (Conner & Prahalad 1996). Furthermore, because of their cognitive limitations, the members are not able to absorb the entire cumulated knowledge of others, leading to a situation where different members always possess different stocks of knowledge (Conner & Prahalad 1996). Due to information asymmetry, the organization as a whole is in conflict (March & Simon [1958] 1993), which in this context means that the goals and subsequent decisions of the various organizational units might not be in line with the overall goal of the organization. Cross-functional teams provide a forum in which knowledge is exchanged and problems and conflicting perspectives are solved, reducing sub-goal pursuit without overloading the hierarchy and facilitating information processing across functions. On the other hand, when cross-functional teams have not been formed, the organizational members do not have a formal platform for information processing across functions. This can lead to engagement in information processing only in areas in their immediate environment and subsequent sub-goal pursuit. Based on this it is hypothesized:

> **H2h.** The extent of use of cross-functional teams has a positive effect on the level of achieved integration.

Mediation. Together, the hypotheses (H2a-H2d and H2e-H2h) imply that integration mechanisms mediate the relationship between the level of requisite integration and the level of achieved integration. An important part of the analysis is also to test the mediation effect directly. Therefore, it is hypothesized:

> **H2i.** The relationship between the level of requisite integration and the level of achieved integration is mediated by the use of integration mechanisms.

After formulating the empirically testable hypotheses, a conceptual model can be constructed.

5.2.3 Model for Assessing the Concept of Integration

The formulated hypotheses propose a positive mediating role of plant-level information systems, cross-functional job rotation, and cross-functional teams in mediating the relationship between requisite integration and achieved integration. The role of centralization is more complicated: while it is hypothesized that the relationship between requisite integration and centralization is negative, the relationship between centralization and achieved integration is assumed positive. The mediation model is presented in Figure 5-2 below.

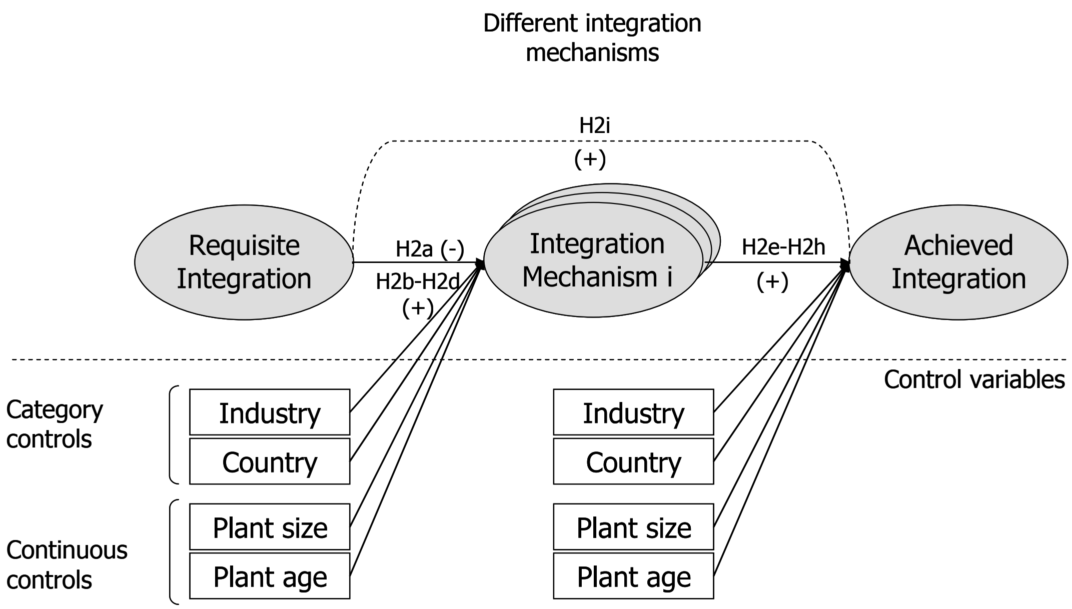

Figure 5-2. Mediation model for Proposition 2

When assessing the mediating role of integration mechanisms on the relationship between requisite integration and achieved integration, the following variables are added as controls: country of plant location, industry, size of the plant, and plant age. The country and industry variables are included as controls in order to control the potential sample heterogeneity, and because prior empirical research has found differences especially in terms of the use of various integration mechanisms across countries and industries (e.g., Ettlie & Trygg 1995). Furthermore, the effect of country variables on the use of integration mechanisms could be strong due to the cultural effects for example on Hofstede's (1980) dimensions of power distance and individualism – collectivism. Plant size is included as a control variable because the results of the classical contingency studies point out the effects of size on organization design (Blau 1970; Child 1972b, 1975; Pugh et al. 1969b), and because intuition suggests that as the plant size increases, integration becomes more difficult to achieve due to higher specialization and differentiation. Classical contingency studies have also found the effect of plant age for example on the extent of centralization (Pugh et al. 1969b). In addition, plant age is suggested to be positively related to integration mechanisms and achieved integration, because an older plant has had more time to adjust itself to its operating conditions (Donaldson 2001).

5.2.4 Method of Analysis

The conceptual model posits that integration mechanisms function as mediators between the level of requisite integration and the level of achieved integration. The mediation effect is usually tested with path analysis (Alwin & Hauser 1975; Baron & Kenny 1986; Duncan 1966; Venkatraman 1989). Path models are defined as ones that include unidirectional causal flows (Maruyama 1998, p. 29), and they allow the researcher to decompose the effect of one variable on another into direct, indirect, and total effects. A simple form of mediation effect is depicted in Figure 5-3 below. In the figure, path *c* refers to the direct effect of X on Y and path *ab* (X → M → Y) to the indirect effect.[61]

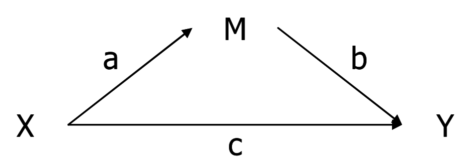

Figure 5-3. Presentation of fit as mediation form

Baron and Kenny (1986) present three conditions that a variable must meet in order to function as a mediator:[62] (i) variations in the levels of the antecedent variable

[61] The indirect effects indicate how much of a given effect occurs because of the manipulation of the antecedent variable of interest leading to changes in other variables which in turn change the consequent variable (Alwin & Hauser 1975). The magnitude of the indirect pathway is estimated by multiplying together the path coefficients along the pathway (Maruyama 1998, p. 40).

[62] For a similar empirical investigation in the OM context, see for example Swink et al. (2005).

significantly account for variations in the presumed mediator, (ii) variations in the mediator significantly account for variations in the consequent variable, and (iii) the mediator significantly decreases the direct relationship between the antecedent and the consequent variables (in case of a full mediation model, the direct effect must be decreased to zero when the mediating variables are entered). In the context of Proposition 2 this can be tested as follows:

> **Step 1:** The level of requisite integration must have a significant effect on the intensity of use of centralization, plant-level information systems, cross-functional job rotation, and cross-functional teams.
>
> **Step 2:** The level of requisite integration must have a significant effect on the level of achieved integration.
>
> **Step 3:** The intensity of the use of centralization, plant-level information systems, cross-functional job rotation, and cross-functional teams must have a significant effect on the level of achieved integration. Furthermore, the relationship between the level of requisite integration and the level of achieved integration must reduce significantly when the use of centralization, information systems, job rotation, and cross-functional teams are entered into the model.

The antecedent variable (the level of requisite integration) is measured on an ordinal scale of 1-5 from three respondents and can thus be considered continuous. The mediating variables (integration mechanisms) are operationalized as the intensity of use of a mechanism rather than as a dichotomy (in use / not in use), and include both continuous and ordinal variables. Centralization, job rotation, and cross-functional teams are all measured on an ordinal scale of 1-5 from three respondents and hence can be considered continuous. The use of information systems, on the other hand, is ordinal. The mediating variables are treated independently, following the Cartesian approach (Donaldson 2001, pp. 141-144). The consequent variable (the level of achieved integration) is continuous. All theoretical variables are standardized to decrease the potential problem of multicollinearity. The controls include both dichotomous (country, industry) and continuous variables (plant size and age). These issues set limits for the method of analysis.

First, plotting the residuals against the independent variable reveals that the magnitudes of the residuals do not remain the same on different values of the independent variable, pointing to heteroscedasticity, and so the assumption of normal and homoscedastic residuals of the OLS estimator (see Section 4.3.2) is violated. Therefore, the General Linear Model (GLM)[63] with GLS (Kennedy 2003, p. 135) is more appropriate than the OLS estimator. Second, due to the ordinal scale of the construct information systems, ordinal regression is used to assess the relationship between requisite integration and information systems. Third, due to the high inter-correlations among the mediating variables, a separate model is estimated for each integration mechanism in Step 1 (there are altogether four models in Step 1). In addition, the results of the reliability analysis suggest that some measurement error is inherent in the independent variables, which creates problems in terms of the fourth assumption of CLRM, because measurement error in the independent variables makes the independent variable stochastic, leading to a biased OLS estimator (Kennedy 2003, p. 140). The potential effect of measurement error is analyzed in Section 5.4.

Although GLM does not make any assumptions regarding the distribution of the residuals, the assumption of non-existence of multicollinearity needs to be assessed (Assumption 5, see Section 4.3.2). In this research, the existence of multicollinearity would mean the following:

- Requisite integration is highly correlated with plant size and age (continuous control variables in Step 1 and Step 2);
- Requisite integration is highly correlated with country and industry variables (categorical control variables in Step 1 and Step 2);
- Requisite integration, centralization, information systems, job rotation, and cross-functional teams are highly correlated with each other (theoretically interesting variables in Step 3)

[63] Similarly, as in testing Proposition 1, the design is analysis of covariance (ANCOVA) or multivariate analysis of covariance (MANCOVA) (Kutner et al. 2005, p. 329).

- Requisite integration, centralization, information systems, job rotation, and cross-functional teams are highly correlated with plant size and age (continuous control variables in Step 3)

- Requisite integration, centralization, information systems, job rotation, and cross-functional teams are highly correlated with the country and industry variables (categorical control variables in Step 3)

Correlations among the antecedent variable, the mediating variables, the consequent variable and the continuous control variables are presented in Table 5-6 below. Country and industry variables are excluded from the table due to space limitations.

Table 5-6. Descriptive statistics and Pearson correlations of variables for Proposition 2

	Mean	SD	N	1.	2.	3.	4.	5.	6.	7.
Antecedent variable										
1. Requisite integration	0.00	1.00	233							
Mediating variables										
2. Centralization	0.00	0.95	236	-0.42**						
3. Information systems	0.00	1.00	211	0.21**	-0.15*					
4. Job rotation	0.00	0.91	234	0.15*	-0.17^{+}	0.09				
5. Cross-functional teams	0.00	0.97	236	0.13*	-0.07	0.26**	0.18**			
Consequent variable										
6. Achieved integration	0.00	0.96	234	0.33**	-0.15*	0.31**	0.11	0.43**		
Control variables										
7. Size (ln)	6.00	1.00	201	-0.07	0.13^{+}	0.33**	0.09	0.19**	0.15*	
8. Plant age	41.51	28.09	197	0.15*	-0.21**	0.07	0.09	-0.08	0.04	0.09

** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

The following conclusions regarding Step 1 and Step 2 can be made. First, the correlations between requisite integration and continuous control variables of size and age are low (-0.07 and 0.15, respectively). Second, there are statistically significant correlations between the requisite integration and categorical control variables (5 out of 11 correlations are statistically significant at $\alpha = 0.05$ level); the correlations are in absolute terms on average 0.13 and at maximum 0.36. A further look at the VIFs and CIs suggest that there should not be a problem of (multi)collinearity in Step 1 and Step 2 (VIFs at maximum 2.09; CIs at maximum 21.58 and the highest value related to the constant).

For Step 3, the following conclusions can be made. First, the correlations between the requisite integration and integration mechanisms are somewhat alarming (8 out of 10 correlations are statistically significant at $\alpha = 0.05$ level). The correlations are in absolute terms on average 0.19 and at maximum 0.42. This represents a typical problem of multicollinearity when mediating models are tested with regression, which leads to reduced power in the test of the coefficients (Baron & Kenny 1986). Second, the correlations of requisite integration and integration mechanisms with the continuous control variables are in absolute terms on average 0.13 and at maximum 0.32 (3 out of 10 correlations are statistically significant at $\alpha = 0.05$ level). Third, the correlations of requisite integration and integration mechanisms with the categorical control variables are also somewhat alarming (19 out of 55 correlations are statistically significant at $\alpha = 0.05$ level). The correlations, however, are on average 0.11 and at maximum 0.38. A further look at the VIFs and CIs suggests that multicollinearity should not be a significant problem in Step 3 (VIFs at maximum 2.43; CIs at maximum 23.00 and the highest value related to the constant).

Hence, it can be concluded that multicollinearity should not be a significant problem.

5.2.5 Statistical Analysis

Step 1: Requisite integration → integration mechanisms. First, four models linking requisite integration to each of the integration mechanisms are estimated (H2a-H2d), one for each integration mechanism. The results of the regression analysis are presented in Table 5-7 (see Appendix D for detailed mathematical results). The table includes the β-coefficients for the independent and control variables, as well as the model fit indices.

All variables are entered in the model simultaneously. The significance tests for the theoretical variable are one-tailed and for the control variables two-tailed.

Table 5-7. Summary of the results of GLM on integration mechanisms (4 models)

	Centralization	Info systems	Job rotation	Teams
Hypothesis	H2a (-)	H2b (+)	H2c (+)	H2d (+)
Intercept	0.462		-1.093 *	-0.884
Control variables				
Size	-0.082	0.501 **	0.234 **	0.157 +
Age	-0.001	-0.004	0.002	-0.003
Austria	-0.633 *	-0.748	-0.170	0.292
Finland	-0.708 **	-0.192	-0.590 *	-0.016
Germany	-0.393 +	-1.352 *	-0.679 *	0.114
Italy	0.708 **	-1.217 *	-1.078 **	-0.218
Japan	0.853 **	0.382	0.110	-0.146
Korea	0.894 **	2.636 **	-0.338	-0.187
Sweden	-0.546 *	0.385	-0.865 **	0.301
USA	0[a]	0[a]	0[a]	0[a]
Electronics	-0.062	-0.023	0.166	0.254
Machinery	-0.011	0.315	-0.061	-0.051
Transportation	0[a]	0[a]	0[a]	0[a]
Theoretical variable				
Requisite integration	-0.135 *	-0.013	0.223 **	0.173 *
Model fit indices				
F-statistic	12.498	37.235 [b]	6.011	1.814
DF	12	12	12	12
p-value	0.000	0.000	0.000	0.050
R^2	48.2%	41.7% [c]	30.9%	11.9%
Adjusted R^2	44.4%	N/A	25.8%	5.3%

[a] This parameter is set to zero
[b] Due to ordinal regression, the value refers to the χ^2 –statistic.
[c] Due to ordinal regression, the value refers to the concordance index.
** $p < 0.01$; * $p < 0.05$; + $p < 0.10$

The overall fit of the estimated models is assessed with F-statistic (for information systems χ^2-statistic is used due to ordinal regression). The test statistic is significant (p-value < 0.05) in all the models, suggesting that the null hypothesis of no relationship between the independent variables and the dependent variable should be rejected. Hence, at least some of the independent variables in the models are different from zero. Furthermore, R^2 varies between 11.9% and 48.2%, and the concordance index for the information systems is 41.7%, giving support to the conclusion that the models explain variance in the dependent variable adequately and there is a linear relationship between the independent and the dependent variables.

The point estimates in Table 5-7 above indicate that requisite integration is statistically significant in three of the four models (centralization, job rotation, and cross-functional teams). Statistical significance here suggests that the hypothesis of no relationship between the independent and dependent variable should be rejected. Furthermore, in three of the models, the sign of the β-coefficient of requisite integration is as hypothesized: negative for centralization and positive for job rotation and cross-functional teams. For information systems, the β-coefficient is negative and opposite to what was hypothesized. Thus, the results in Table 5-7 give empirical support to three of the four hypotheses (H2a, H2c, H2d) and suggest that plants which have greater requirements for integration have implemented cross-functional job rotation ($p = 0.00$), and cross-functional teams ($p = 0.01$) to a greater extent and are simultaneously less centralized ($p = 0.02$). No support was found to the hypothesis that plants with a higher level of requisite integration have implemented plant-level information systems to a greater extent (H2b, $p = 0.47$). Thus, the first test for the mediation effect is partially satisfied. Figure 5-4 illustrates the use of integration mechanisms depending on the level of requisite integration.[64]

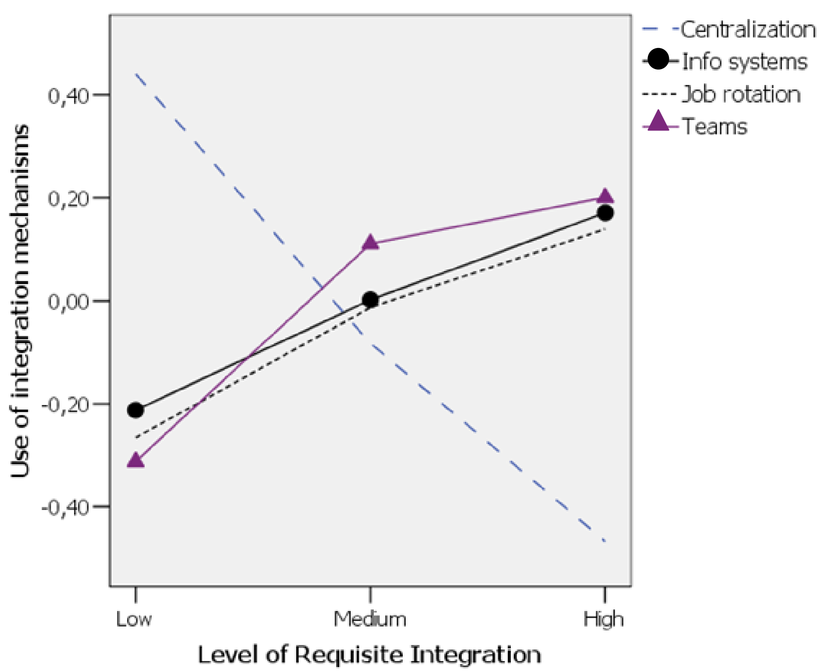

Figure 5-4. Use of integration mechanisms on different levels of requisite integration

[64] For the graphical illustration, requisite integration has been divided into categories of low, medium and high, representing 33% and 66% quartiles. The subsequent cut-off points of requisite integration are -0.3677 and 0.5448.

In addition, some of the control variables show statistical significance; especially the country and size effects are strong. No hypotheses were formulated in terms of the effect of size or country of origin on the assessed relationships, and hence, in order to avoid post-hoc explanations, they are not further assessed here.

Step 2 and Step 3: Mediation effect of integration mechanisms on the relationship between requisite integration and achieved integration. The mediation effect can be divided into two types: partial and full mediation (Venkatraman 1989). Within the context of this research, the partial mediation hypothesis suggests that variation accounted on the level of achieved integration is partially due to the use of integration mechanisms and partially due to the level of requisite integration. The full mediation hypothesis, on the other hand, suggests that the level of requisite integration is related to the level of achieved integration only because of the use of integration mechanisms.

Also in this part of the analysis, the assumption of normal and homoscedastic residuals of the OLS estimator (see Section 4.3.2) is violated. Hence, also the mediating effect of integration mechanisms on the relationship between requisite integration and achieved integration is assessed with GLM (H2e-H2h).

The effect of integration mechanisms on achieved integration is estimated simultaneously, i.e. including all four mechanisms in the model at once (for a similar type of analysis, see for example Leenders & Wierenga 2002). This approach is considered more advantageous than a separate analysis (separate model for each mechanism) because it allows for comparison of the relative effects of the mechanisms as well (although no explicit hypothesis about this has been made in the present research). Altogether seven separate models are estimated. First, in Model 1 the level of requisite integration is used to explain variation in the level of achieved integration (Step 2), and in Model 2 the level of requisite integration and the use of integration mechanisms are used to explain variation in the level of achieved integration (Step 3). In Model 3 only the use of integration mechanisms are employed to explain variation in the level of achieved integration, reflecting the full mediation model for comparison.

The results of the hierarchical GLM analysis are presented in Table 5-8 (see Appendix D for detailed mathematical results). The table includes the β-coefficients for the control and theoretical variables, as well as the model fit indices. The theoretical variables are standardized[65]. The significance tests for the theoretically interesting independent variables are one-tailed and for the control variables two-tailed.

Table 5-8. Results of GLM on achieved integration

	Model 1 No mediation	Model 2 Partial mediation	Model 3 Full mediation
Intercept	-0.169	0.424	0.220
Control variables			
Size	0.046	-0.064	-0.030
Age	0.002	0.004	0.003
Austria	-0.041	-0.326	-0.161
Finland	-0.300	-0.408	-0.270
Germany	-0.415	-0.502 *	-0.380
Italy	0.125	0.349	0.392
Japan	0.423 +	0.584 *	0.415
Korea	0.550	0.880 **	0.529
Sweden	-0.261	-0.387	-0.456
USA	0[a]	0[a]	0[a]
Electronics	-0.131	-0.210	-0.167
Machinery	-0.348 *	-0.340 *	-0.250
Transportation	0[a]	0[a]	0[a]
Theoretical variables			
Requisite integration	0.403 **	0.335 **	
Centralization		-0.177 *	-0.216 **
Info systems		0.029	0.023
Job rotation		0.100 +	0.150 *
Cross-functional teams		0.298 **	0.335 **
Model fit indices			
F-statistic	4.027	6.135	4.155
DF	12	16	15
p-value	0.000	0.000	0.000
R^2	23.1%	40.2%	29.6%
Adjusted R^2	17.4%	33.6%	22.5%

The overall fit of the estimated models is assessed with F-statistic. The test statistic is significant (p-value < 0.05) in Models 1-3, suggesting that the null hypothesis of no relationship between the independent variables and the dependent variable should be rejected. Hence, at least some of the independent variables are different from zero. Second, the R^2 in the Models 1-3 varies from 23.1% and 40.2%, giving support to the conclusion that the independent variables are able to explain variance in the dependent variable (in comparison, R^2 in a model including only control variables is 7.3%). The

[65] Due to standardization of the theoretically interesting variables, the β-coefficients represent the relative impact on the dependent variable of a change in one standard deviation in each variable. However, the coefficients must be interpreted with caution, to assess the relative importance and only over the range of values for which sample data actually exist (Hair et al. 1998, p. 188). Kutner et al. (2005, p. 216) suggest the use of the term *partial* β-coefficients because the coefficients represent the partial effect of the predictor on the mean response of the dependent variable when the other predictors are kept constant.

partial mediation Model 2 seems to explain variation in the dependent variable best, giving immediate preliminary support to the partial mediation model.

The point estimates regarding Model 2 (partial mediation model) in Table 5-8 above indicate that the β-coefficients of two out of the four integration mechanisms (job rotation and cross-functional teams) are in the hypothesized direction and statistically significant. Statistical significance here suggests that the hypotheses of no relationship between the independent and the dependent variables should be rejected. The β-coefficient for centralization is statistically significant but negative, and contrary to what was hypothesized. Hence, the results presented in Table 5-8 provide empirical support for two of the four hypotheses (H2g, H2h) and suggest that greater extent of cross-functional job rotation ($p = 0.07$) and cross-functional teams ($p = 0.00$) are associated with higher level of achieved integration. No support was found to the hypothesis that a greater extent of plant level information systems is associated with a higher degree of achieved integration (H2f; $p = 0.34$), and furthermore, centralization was found to have a rather strong negative effect on achieved integration (H2e; $p = 0.02$).

The results also give support to the mediation effect (H2i). The β-coefficient for requisite integration in Model 1 is statistically significant and positive (Step 2). According to the final condition for the mediation role of integration mechanisms on the relationship between requisite integration and achieved integration, the association between requisite integration and achieved integration should reduce significantly when integration mechanisms are entered into the model (Model 2) (Baron & Kenny 1986). As required by the test of the mediation effect, the absolute value of the β-coefficient of requisite integration is reduced after adding integration mechanisms in the model (Model 2). However, the decrease in the β-coefficient is only marginal and the coefficient is statistically significant ($p = 0.00$) in both Model 1 and Model 2, giving support to the partial mediation effect (in contrast to full mediation).

Although the regression analysis provides evidence for the mediation effect, a more formal test is still needed (Baron & Kenny 1986; Venkatraman 1989). A test statistic developed by Sobel is a test for the relative proportion of the indirect and the direct effect.[66] The Sobel test gives a z-value = 2.76 (two-tailed p-value < 0.01), indicating that the mediation effect is significant.

Finally, Models 4 and 5 below (Table 5-9) estimate the relative independent mediation effect of job rotation and cross-functional teams on the level of achieved integration.

Table 5-9. Results of GLM on achieved integration including integration mechanisms separately

	Model 4	Model 5
Intercept	0.026	0.154
Control variables		
Size	0.004	-0.011
Age	0.002	0.004
Austria	-0.010	-0.147
Finland	-0.195	-0.294
Germany	-0.294	-0.457 +
Italy	0.317	0.205
Japan	0.404	0.477 *
Korea	0.610 +	0.618 *
Sweden	-0.107	-0.371
USA	0[a]	0[a]
Electronics	-0.161	-0.224
Machinery	-0.338 *	-0.330 *
Transportation	0[a]	0[a]
Theoretical variables		
Requisite integration	0.363 **	0.339 **
Centralization		
Info systems		
Job rotation	0.179 **	
Cross-functional teams		0.365 **
Model fit indices		
F-statistic	4.321	6.936
DF	13	13
p-value	0.000	0.000
R^2	26.0%	36.0%
Adjusted R^2	20.0%	30.8%

The results of the relative independent mediation effect (Table 5-9 above) suggest that although each integration mechanism partially mediates the relationship between requisite integration and achieved integration, all mechanisms are required to explain the complete mediation effect.

[66] The basic form of the Sobel test is: $\text{Sobel test statistic} = \frac{ab}{\sqrt{a^2 se_b^2 + b^2 se_a^2}}$, where a and b are path coefficients as in Figure 5-3 and se_a and se_b are the standard error of the coefficients a and b respectively, which can then be extended to a model including several mediation variables. The test can be treated as the z-test and, hence, a test statistic larger that 1.96 is significant at the 0.05 level indicating that there is mediation effect.

Estimation of the model as a whole using SEM. For assessment of the conclusions made on the basis of regression analysis, the mediation model is also estimated as a whole using SEM integrating the separate analyses above. In the SEM analysis, one model is estimated rather than conducting a multi-group analysis.[67]

Three different nested models (Anderson & Gerbing 1988; Bentler & Chou 1987; Hair et al. 1998, p. 613) are estimated using ML estimation (for model fit statistics, see Table 5-10 below). The *null model* (Model 1) posits that all variables in the model are uncorrelated. In this research it means that requisite integration, four separate integration mechanisms and achieved integration are unrelated to each other. The χ^2-statistic of the null model is 150.49 on 15 degrees of freedom ($p = 0.00$), suggesting that the null model is misspecified. Hence, the model fit statistics of the null model suggest that there are significant correlations among the variables as expected.

Second, the *full mediation model* hypothesizes that integration mechanisms mediate the relationship between requisite integration and achieved integration and that there is no direct relationship between requisite integration and achieved integration. The fit of the full mediation model is better than the fit of the null model, although the fit of the full mediation model is not very good ($\chi^2 = 26.69$; DF = 7; CFI = 0.85; RMSEA = [0.07; 0.16]).

Finally, the *partial mediation model* hypothesizes that there is a partial mediation effect of integration mechanisms on the relationship between requisite integration and achieved integration. The overall fit of the partial mediation model is significantly better than for the null model and appropriate ($\chi^2 = 12.57$; DF = 6; CFI = 0.95; RMSEA = [0.00; 0.11]). Thus, the partial mediation model fits the data.

Determining the model that provides best fit can be done by simply calculating the difference between the χ^2 -statistics and test the statistical significance of that with the degree of freedom, which is being the difference in the number of coefficients to be

[67] As was pointed out in Section 4.3.4, it is possible to include for example country controls in SEM, estimating the model with multi-group analysis (i.e. estimating the model separately for each country). However, due to the sampling design, each country is represented by only around 30 plants, and hence multi-group analysis is not considered appropriate (or even mathematically possible in some cases).

estimated for the models (Anderson & Gerbing 1988; Bentler & Chou 1987; Hair et al. 1998, p. 618).

Table 5-10. Goodness of fit statistics for structural equation models and model comparison

Model fit statistics					
	χ^2 –statistic	DF	p-value	90% CI for RMSEA	CFI
1. Null model	150.488	15	0.000	[0.168; 0.225]	N/A
2. Full mediation model	26.694	7	0.000	[0.067; 0.155]	0.848
3. Partial mediation model	12.573	6	0.050	[0.000; 0.112]	0.949
Model comparison					
	$\Delta\chi^2$ –statistic	Δ DF	p-value	Preferred model	
1. Null – 2. Full mediation	123.794	8	0.000	Full mediation model	
2. Full – 3. Partial	14.121	1	0.000	Partial mediation model	

Based on the comparison of the model fit statistics above, it can be concluded that although none of the estimated models fits the data very well, the partial mediation model provides the best fit. After testing the fit of the hypothesized model, the specific hypotheses made in the hypothesized model are tested. Table 5-11 below provides the ML parameter estimates, as well as their level of statistical significance for each of the hypothesized paths. The significance tests are one-tailed.

Table 5-11. Summary of structural equation model tests for the mediation model

Hypothesis and hypothesized path				Unstandardized coefficient
H2a.	Requisite integration	→ (-)	Centralization	-0.398 **
H2b.	Requisite integration	→ (+)	Info systems	0.207 **
H2c.	Requisite integration	→ (+)	Job rotation	0.144 **
H2d.	Requisite integration	→ (+)	Cross-functional teams	0.227 **
H2e.	Centralization	→ (+)	Achieved integration	0.045
H2f.	Info systems	→ (+)	Achieved integration	0.007
H2g.	Job rotation	→ (+)	Achieved integration	0.250 **
H2h.	Cross-functional teams	→ (+)	Achieved integration	0.259 **
H2i.	Requisite integration	→ (+)	Achieved integration	0.236 **

** $p < 0.01$; * $p < 0.05$; $^+$ $p < 0.10$

Out of the 9 tests, 7 paths are significant. The first set of hypotheses (H2a-H2d) predicts that the level of requisite integration is associated with the extent of use of integration mechanisms. The results give support to the hypotheses that requisite integration has a negative effect on the level of centralization ($p < 0.01$) and a positive effect on the level of information systems ($p < 0.01$), cross-functional job rotation ($p < 0.01$), and cross-functional teams ($p < 0.01$).

The second set of hypotheses (H2e-H2h), on the other hand, predicts that the extent of use of integration mechanisms is positively associated with the level of achieved integration. The results give support to two of the four hypotheses: greater extent of use of cross-functional job rotation ($p < 0.01$) and cross-functional teams ($p < 0.01$) are associated with a higher level of achieved integration. The effect of the use of centralization on the level of achieved integration is positive as hypothesized, but not significant (H2e: $p = 0.24$) and similarly, a greater use of information systems is positively, but not statistically significantly related to the level of achieved integration (Hf: $p = 0.45$).

The results give support to the mediation effect. The direct effect of requisite integration on achieved integration is strong ($p < 0.01$). The indirect effect, on the other hand, is rather low (0.078), but is partly due to the negative path of requisite integration - centralization. The total effect of requisite integration on achieved integration is 0.314. In particular, cross-functional job rotation and cross-functional teams partially mediate the relationship between requisite integration and achieved integration. Figure 5-5 below illustrates the path coefficients of the estimated model. Statistically significant paths ($\alpha = 0.05$) are marked with solid lines and insignificant paths with dotted lines in the figure.

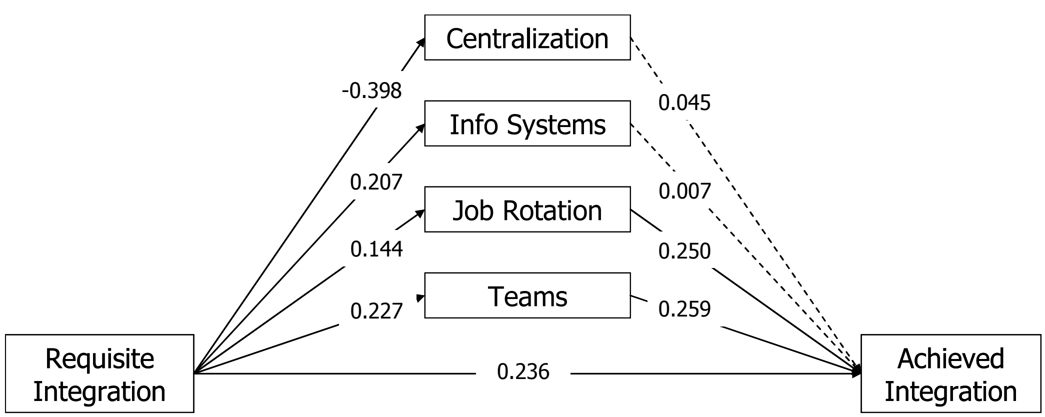

Figure 5-5. Results for the mediation model using structural equation modeling

As a conclusion, the results of the structural equation modeling give support to the partial mediation effect of integration mechanisms and are to a great extent in line with the results of the regression analysis.

5.2.6 Summary and Discussion of the Findings

In this section, I have tested the mediating role of four integration mechanisms on the relationship between the level of requisite integration and the level of achieved integration, using both regression and structural equation modeling methods of analysis. Table 5-12 summarizes the findings regarding Proposition 2.

Table 5-12. Summary of statistical analysis results for Proposition 2

Assessed relationship and hypothesized association[a]		Result of regression analysis	Result of SEM
H2a.	Requisite integration – Centralization (-)	Supported	Supported
H2b.	Requisite integration – Plant-level information systems (+)	Rejected	Supported
H2c.	Requisite integration – Cross-functional job rotation (+)	Supported	Supported
H2d.	Requisite integration – Cross-functional teams (+)	Supported	Supported
H2e.	Centralization – Achieved integration (+)	Rejected	Rejected
H2f.	Plant-level information systems – Achieved integration (+)	Rejected	Rejected
H2g.	Cross-functional job rotation – Achieved integration (+)	Supported	Supported
H2h.	Cross-functional teams – Achieved integration (+)	Supported	Supported
H2i.	Requisite integration – Achieved integration (mediation)	Supported	Supported

[a] Hypothesized direction of the relationship is presented in brackets.

The effect of requisite integration on the extent of use of different integration mechanisms is rather strong. Even though requisite integration has an effect on the extent of use of several integration mechanisms, the effect is not similar. Whereas the level of job rotation and cross-functional teams is higher when the level of requisite integration is higher, the effect of requisite integration on the extent of centralization is the opposite; plants characterized by a higher level of requisite integration are less centralized. Also the magnitude of the effect of requisite integration on the use of various integration mechanisms is far from similar. Hypotheses regarding the relative magnitude of the effect of requisite integration on the extent of use of different integration mechanisms were not presented, and thus this is not further investigated here.

The effect of integration mechanisms on the level of achieved integration is also rather strong. A higher level of job rotation and cross-functional teams are associated with a higher level of achieved integration. The magnitude of the effect of the use of various integration mechanisms on the degree of achieved integration is far from similar, although positive.

The findings indicate that at least some integration mechanisms mediate the relationship between requisite integration and achieved integration; the mediation effect is strong especially for cross-functional job rotation and cross-functional teams. The results suggest that the estimated model is a partial mediation model: requisite integration affects the achieved integration both directly and via integration mechanisms.

There are several potential reasons for not getting support for the full mediation effect. First, requisite integration and achieved integration are highly correlated, which makes the statistical detection of the mediation effect very hard. Second, the use of regression analysis to estimate a mediating relationship makes the assumption that there is no measurement error in the mediating variable (Baron & Kenny 1986), which is an unrealistic assumption in this research. The presence of measurement error in the mediating variable tends to underestimate the mediator and overestimate the effect of the independent variable on the dependent variable, which might further explain the observations. Thirdly, it may be that managers in plants that have significant needs for integration place more emphasis on it, and are also able to achieve higher level of integration. Finally and maybe most importantly, in this research integration is approached mainly from the information processing perspective. Hence, other explanations than the information processing perspective for the relationship between requisite integration and achieved integration are left to the direct effect rather than the mediation effect.

The effect of centralization and information systems on the level of achieved integration is very low. There are three potential reasons for this. First, the operationalization of information systems construct is somewhat problematic and might not fully represent the construct. Furthermore, there might be variations in the extent of use of individual information systems (as is assumed to be the case in the other integration mechanisms), which the measurement does not capture. Second, the use of information systems more or less allows for information processing between functions but does not necessary mean that the functions do process information or that the information being processed is useful (e.g., Galbraith 1994). Finally, the low effect of centralization and information systems indicates that there are no standard integration solutions that fit all situations; centralization of some decisions and applying information systems to some purposes are more suitable to some situations than others.

As a conclusion, the extent of use of cross-functional job rotation and cross-functional teams mediate the relationship between the level of requisite integration and the level of achieved integration. The results indicate that the relationship between requisite integration and achieved integration is partially mediated by integration mechanisms, so that the level of requisite integration also has an effect on the level of achieved integration. However, at this point it is important to note that it is never possible to *prove* causation (Bollen 1989, p. 38); although the results do give some support to the partial mediation model, there might still be other models that fit the data.

5.3 DRIVERS FOR REQUISITE INTEGRATION

The results of the previous sections suggest that the level of achieved integration has a positive effect on performance and that the use of integration mechanisms mediate the relationship between the level of requisite integration and the level of achieved integration. But where do the requirements for integration arise from? In this section the antecedents of integration are discussed by addressing the drivers for requisite integration in Figure 3-3.

5.3.1 Proposition 3. Integration Requirements

The level of requisite integration refers to the requirements for integration efforts. Following the arguments of the early contingency theorists (Lorsch & Lawrence 1970; 1972a; March & Simon [1958] 1993; Thompson [1967] 2003), the main driver of the integration requirements can be traced to the interdependence of the organizational units. Due to interdependence with other units, manufacturing is open to influences that it cannot predict, having to cope with uncertainty. According to the information processing perspective, the greater the uncertainty, the greater the amount of information that must be processed between organizational units (Galbraith 1973, p. 4), which creates a greater need for integration. Specifically, reciprocal interdependence of the organizational units gives rise to a need for lateral integration efforts, because it require mutual adjustment and joint effort (Thompson [1967] 2003; Van de Ven et al. 1976).

Proposition 3. High reciprocal interdependence of the organizational units has a positive effect on the level of requisite integration.

Proposition 3 aims to clarify the drivers for requisite integration by proposing that organizational units characterized by a more advanced type of interdependence are associated with higher requirements for integration.

5.3.2 Development of Empirically Testable Hypotheses

Discussion of technology and task. Rather than just assessing whether organizations characterized by reciprocal interdependence of functional units have a higher level of requisite integration, the interesting question is why some organizations are characterized by reciprocal interdependence. Thompson ([1967] 2003, pp. 15-18) suggests that interdependence is a result of technology. Technology, however, is not a specific variable as such but a broad concept and must be clearly specified.

There is a close connection between technology and the task of the organization (Keller (1994) even uses the concept of task technology). In order to accomplish its task, the organization must divide it into a hierarchy of means and ends (March & Simon [1958] 1993). Activities at any given level then serve as the means (technology) to accomplish the end (task) at the level above (Gerwin 1981). Going down the hierarchy, the activities become more clearly specified, and at the manufacturing level, technology actually refers to what is usually called manufacturing technology (e.g., Woodward [1965] 1994). Hence, there is no clear distinction between task and technology but they are closely related (in the OM context, a good example is the product-process matrix of Hayes and Wheelwright 1984). Integrating the discussions of previous authors (Lawrence & Lorsch [1967] 1986; Thompson [1967] 2003), it is argued that the task of the organization is the major determinant of requisite integration.

Task contingencies in organization theory literature. The properties of tasks introduced in the prior literature include for example uncertainty, predictability, complexity, routineity, analyzability, controllability, and variety (e.g., Drazin & Van de Ven 1985; Gerwin 1981; Lawrence 1981; Perrow 1967; Tushman & Nadler 1978; Van de Ven 1976; Van de Ven & Delbecq 1974; Van de Ven et al. 1976). The task properties often mean different things to different authors or remain ill-defined (e.g., Tushman & Nadler 1978). Lawrence (1981) tries to clarify the concept of uncertainty due to the criticism that his earlier work with Lawrence (i.e. Lawrence & Lorsch 1967, [1967] 1986) has received and suggest that it can be divided into two sources: task complexity and task unpredictability. Lawrence (1981), however, still remains somewhat unclear in terms of how the dimensions are defined. Building on the work of Lawrence (1981) and based on the literature review of contingency theory, it is possible to integrate the dimensions of task uncertainty to task unpredictability and task complexity, both of which then have several dimensions, and according to the information processing perspective affect the information processing requirements in organizations. These are discussed and defined, as well as related to prior work in the following.

Building for example on the behavioral theory of organizations (March & Simon [1958] 1993) and Woodward's ([1965] 1994) empirical results, Perrow (1967) makes a distinction between two aspects of a task: number of exceptions and unanalyzability.[68] Unanalyzability is defined as the nature of the search process when exceptions occur and it can vary from analyzable, referring to a situation when it can be conducted on an analytical and logical basis, to unanalyzable, when the problem is vague and poorly conceptualized. These together form task unpredictability. However, whereas Lawrence (1981) relates unpredictability to the rate of change and ignorance of cause-effect relationships, in this research it is perceived that the number of exceptions is more important in affecting task unpredictability rather than the rate of change. This is because the rate of change can be constant, causing little unpredictability.

Building on Perrow (1967), Van de Ven and colleagues (Drazin & Van de Ven 1985; Van de Ven 1976; Van de Ven & Delbecq 1974; Van de Ven et al. 1976) introduce the dimensions of task variability and task difficulty (see also Galbraith 1977), which can be related to Perrow's dimensions of the number of exceptions and unanalyzability, respectively. In addition, other terminologies exist (e.g., the fit novelty and fit analyzability of Adler (1995) and the fit variety and explicitness of Gerwin (1981)) but they can mainly be mapped on the dimensions of variability and difficulty, which are used in the research at hand. Together, variability and difficulty are sometimes referred

[68] Although the dimensions are distinct, Perrow (1967) discusses them also concurrently on a scale from routine to non-routine: a routine task has few exceptions and the problems occurring are analyzable, whereas non-routine tasks have many exceptions and the problems are unanalyzable.

to form task uncertainty (Drazin & Van de Ven 1985; Van de Ven et al. 1976). Although subsumed under the concept of task uncertainty, variability and difficulty are clearly distinct dimensions and should remain so also in the operationalizations of task uncertainty (cf. Song et al. 1997; Van de Ven et al. 1976). In this research, however, it is perceived that task variability and task difficulty do not fully capture all the dimensions creating task uncertainty.

Another intermediating contingency for task uncertainty suggested in this research is task complexity. Like the concept of uncertainty, also the concept of complexity has been defined in a number of ways; Rivkin (2001) reports 41 different definitions. In the decision making literature, complexity has been defined for example as having a great number of elements and great interaction of those elements (e.g., Rivkin 2001). Lawrence (1981) builds on this and conceptualizes complexity in the structural context, making a distinction between the number of variables and interdependence. Interdependence can be analyzed on dimensions of pooled, sequential, reciprocal, or team following the distinction made by Thompson ([1967] 2003, pp. 15-18) and Van de Ven and colleagues (1976). Task complexity, then, increases as the number of variables increases or the type of interdependence becomes more demanding, or both. Figure 5-6 illustrates the contingencies.

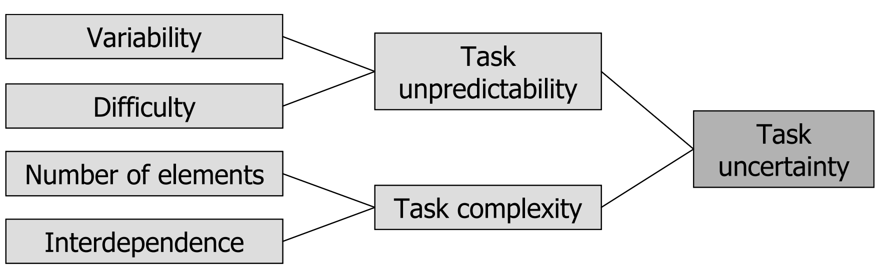

Figure 5-6. Conceptualization of task contingencies of uncertainty and complexity

This conceptualization of uncertainty closely resembles the conceptualization made by Bensaou and Venkatraman (1995) in the supply integration context. They perceive task uncertainty to arise from three constructs of analyzability (difficulty in the Figure 5-6 above), variety (variability in Figure 5-6 above) and interdependence. Recently, also Bozarth et al. (2007) has used a rather similar conceptualization of complexity in the supply chain context defining detail complexity as the number of elements in a system and dynamic complexity as the unpredictability driven partly by interconnectedness of parts of the system. In the following, the different dimensions of tasks are discussed in the context of this research in order to form empirically testable hypotheses. The discussion follows the information processing perspective (Galbraith 1973) and focuses on how the different contingencies affect the information processing requirements, and subsequently increase the integration requirements between manufacturing and other functions.

Task variability in the cross-functional context. Task variability refers to the frequency of exceptions in completing a task (Perrow 1967). The focal issue here is not the rate of change (rate of change can be constant, referring to low uncertainty) but rather the extent to which exceptions involve different issues to be solved or different methods of completing the work each time they are encountered, as it affects the degree to which the processes for completing the task can be preplanned (see for example Van de Ven 1976).

From the manufacturing perspective, in the cross-functional context, task variability can be related to the customization of outputs (see also Scott 1998, p. 233; Wheelwright & Clark 1992). Customization of outputs means that there are exceptions in the manufacturing task, so that the output changes in an unexpected manner (Vickery et al. 1999). When the degree of customization is high, the manufacturing task is unpredictable; manufacturing cannot be preplanned. This creates uncertainty in the manufacturing organization. For example, in case of high extent of customization of orders, the information processing needs between manufacturing and marketing are increased; more information as well as greater details about product specifications describing customer orders (Forza & Salvador 2002) is needed. On the other hand, when there are no modifications in the products, manufacturing activities are predictable and subsequently less uncertain and can be preplanned, requiring less information processing with other functions. Based on this, it is hypothesized:

> **H3a.** The degree of customization of orders (task variability) has a positive effect on the level of requisite integration.

Task difficulty in the cross-functional context. Task difficulty refers to the analyzability of the work to be performed and the extent to which there is a known procedure that specifies the sequence of steps to be followed in performing the task when exceptions occur (Perrow 1967; Van de Ven & Delbecq 1974). The task is considered difficult when extensive time and effort is needed in problem-solving in order to complete the task (Perrow 1967; Van de Ven 1976; Van de Ven et al. 1976) or when task processes do not have knowable outcomes (Thompson [1967] 2003; Van de Ven et al. 1976). This is the case especially when the product is new. In the context of cross-functional integration at a manufacturing plant where the exceptions are related to the customization of manufacturing outputs, product newness and subsequent task difficulty can be related to product modularity.[69]

Modular products are defined as product systems that are built from separable components, which can also be combined to different product systems (Salvador 2007). When the product modularity is high, changes in products can be made quickly because much of the manufacturing knowledge is transferred from earlier experience (Koufteros et al. 2002). Furthermore, the upfront work, meaning the development of shared understanding of customer needs and flexible manufacturing process to accommodate product modularity, reduces uncertainty concerning the work process, key module designs and required manufacturing capabilities (Koufteros et al. 2002). Hence, product modularity reduces both manufacturing technical uncertainty and market uncertainty, leading to lower information processing requirements with other functions. On the other hand, when product modifications (exceptions) require engineering re-work, the task of manufacturing becomes more unpredictable in terms of for example required capabilities, and more information processing is required with other functions to ensure that the manufacturing is able to complete its task. Based on this, it is hypothesized:

> **H3b.** The degree of product modularity has a negative effect on the level of requisite integration.

Number of elements in the cross-functional context. The number of elements refers to the number of variables in decision making. In the cross-functional context, this can in particular be related to number of issues requiring cross-functional decision making in completing a task. The number of issues, however, is not equivalent to

[69] In the NPD context product newness has been discussed in terms of the quantity of unique components in the new product to be manufactured (e.g., Clark 1989; Griffin 1997).

unpredictability; the number of issues can be high but constant. There are two factors related to the number of issues, which increase the complexity of the manufacturing task in the cross-functional context including new technology introduction and new product introduction. Whereas the factors related to task variability and difficulty are related to changes in current products and operations, the contingencies here are more related to innovation and new products.

A well-established typology in the innovation literature is the distinction between incremental and radical innovations (Christensen 1997). Radical innovations have been linked to tasks involving new technology (Ettlie, Bridges & O'Keefe 1984). From the manufacturing perspective, the technology can be related to manufacturing technology in particular. Development of new technology increases the need for information processing between functions for the following reasons. First, constant development of new technology makes the task of manufacturing less understandable (Olson et al. 2001), because for example in the ramp up of a new product based on new technology, the manufacturing personnel has less experience to draw on when problems arise and they need to spend more time looking for successful solutions. Second, the development of new technology is often related to concentrated expertise and technological knowledge (Allen et al. 1979; Ettlie et al. 1984). Hence, there is uncertainty related to for example the product-process interface (Olson et al. 2001); it is uncertain whether products can we produced with the new technology according to required timelines and quality. This creates a need for information processing across functional units in order to avoid uninformed decisions. On the other hand, when there are only moderate changes in the manufacturing technology, there is less need for information processing between functions: the members can rely on past experience for example in product development and sales, and the risk of uninformed decisions is lower (Olson et al. 2001). In a similar vein, the number of variables can also be linked to the rate of changes in the products to be manufactured (Fine 1998; Takeuchi & Nonaka 1986). Based on this, it is hypothesized:

> **H3c.** Constant development of new manufacturing technology has a positive effect on the level of requisite integration.

> **H3d.** The rate of new product introduction has a positive effect on the level of requisite integration.

Task interdependence in the cross-functional context. The final characteristic of the manufacturing task is task interdependence, which in the context of this research refers to the interdependence of the manufacturing function with other functions in completing a specific task. Tasks can vary in terms of (in increasing order of complexity) pooled, sequential, reciprocal, and team interdependence (Thompson [1967] 2003, pp. 15-18; Van de Ven et al. 1976), although in the manufacturing context, there is always at least sequential interdependence between functions, for example because the product needs to be designed before it can be manufactured.

In particular reciprocal interdependence of manufacturing with the other functions (and as a direct consequence also team interdependence, which involves reciprocal aspects interdependence) creates information processing needs among the functions. This is because completing the task is affected by decisions and actions taken by other functions, or needs even joint effort, which creates uncertainty in completing the task (Galbraith 1973). On the other hand, if the manufacturing is more autonomous in completing its task characterized by sequential interdependence, it can be preplanned requiring less information processing with other units. This is because the manufacturing unit has total control and knowledge of the factors in completing the task. Based on this, it is hypothesized:

> **H3e.** Reciprocal task interdependence has a positive effect on the level of requisite integration.

After formulating the empirically testable hypotheses, a theoretical model can be constructed.

5.3.3 Model for Assessing the Antecedents of Integration

The hypotheses presented above propose that the task characteristics of task variability, task difficulty, number of elements, and task interdependence have an effect on the level of requisite integration.

The requisite integration model is presented in Figure 5-7.

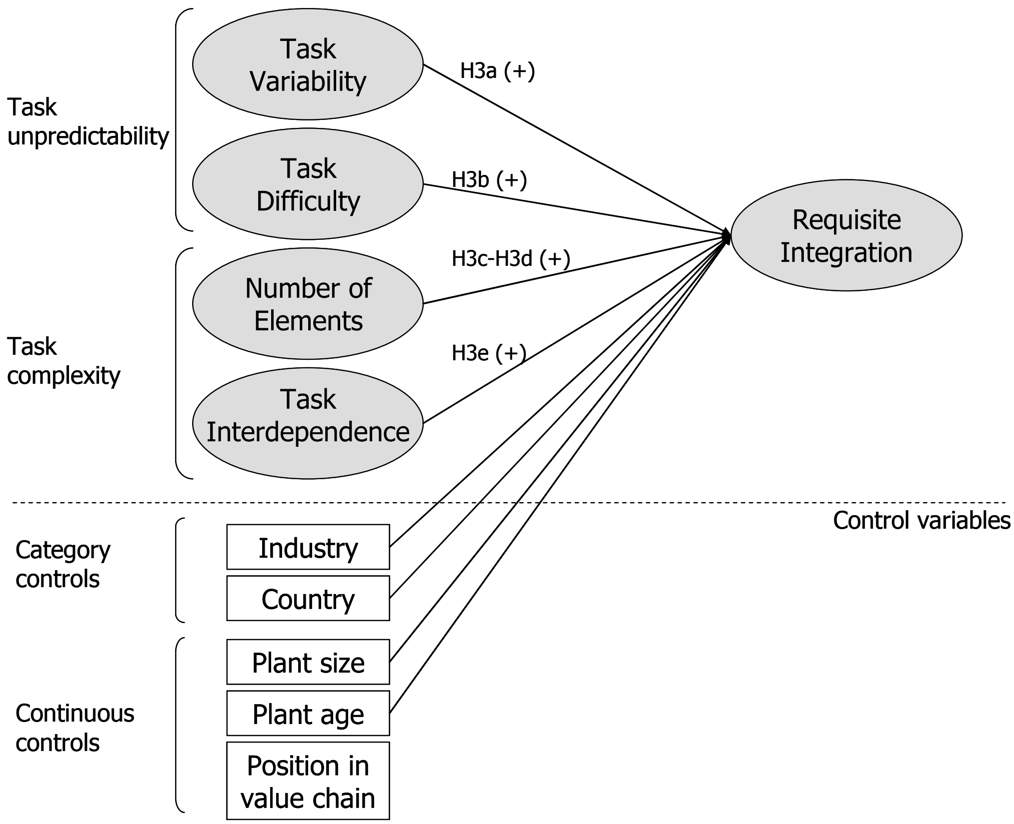

Figure 5-7. Requisite integration model for Proposition 3

When assessing the effect of task variability, task difficulty, number of elements, and task interdependence on the level of requisite integration, several variables are added as controls in the model, including the country of plant location, industry, size, age, and value chain position. The country and industry controls are included to control potential sample heterogeneity. Furthermore, on the basis of for example Hofstede's (1980) cultural dimension of individualism – collectivism, it is likely that the country of origin matters because managers in more collectivistic countries might consider the requirements for integration to be higher. In addition, plant size is included as a control because increased size indicates increased organizational complexity (Child 1972b; Pugh et al. 1969b). Plant age is included in the model because intuition suggests that older plants have had more time to adjust their organization structure to the integration requirements. Finally, value chain position is included as a control because Lawrence (1981, p. 331) suggests that the intensive technologies presented by Thompson ([1967] 2003), related to reciprocal interdependence, may be located near the end-users, which implies that the analysis of requisite integration analysis may be more applicable to companies located in the downstream of the supply chain.

5.3.4 Method of Analysis

Both the theoretically interesting independent variables and the control variables include continuous and categorical variables. The single dependent variable (the level of requisite integration) is measured on an ordinal scale of 1-5 from three respondents and can be considered continuous. Plotting the residuals against the independent variables reveals that the magnitudes of the residuals do not remain the same on different values of the independent variables, pointing to heteroscedasticity, and hence the assumption of normal and homoscedastic residuals of the OLS estimator (see Section 4.3.2) is violated. Furthermore, because of problems related to the measurement of the independent variables (partly single-item measures are used) and the subsequent measurement error, there are likely to be violations in Assumption 4 of CLRM. The potential effect of measurement error is analyzed in Section 5.4. The General Linear Model (GLM)[70] with GLS (Kennedy 2003, p. 135) is more appropriate than the OLS estimator.

Although the GLM does not make any assumptions regarding the distribution of the residuals, the potential problem of multicollinearity needs to be assessed (Assumption 5, see Section 4.3.2). In this research, the existence of multicollinearity would mean the following: (i) the contingency factors are highly correlated with each other, (ii) the contingency variables are highly correlated with the plant size, age, and value chain position (continuous control variables), and (iii) the contingency variables are highly correlated with the country and industry variables (categorical control variables).

The correlations between the independent and continuous control variables are presented in Table 5-13 (country and industry variables are excluded from the table due to space limitations).

[70] Similarly, as in testing Proposition 1, the design is analysis of covariance (ANCOVA) or multivariate analysis of covariance (MANCOVA) (Kutner et al. 2005, p. 329).

Table 5-13. Pearson correlations of variables for Proposition 3

	Mean	SD	N	1.	2.	3.	4.	5.	6.	7.	8.	9.
Independent variables												
1. Customization of orders	3.63	0.71	234									
2. Product modularity	0.00	1.00	234	0.110^{+}								
3. Development of new technology	0.00	1.00	234	0.157*	0.237**							
4. Development of new products	59.19	30.43	186	-0.005	0.003	0.123^{+}						
5. Task interdependence	0.44	0.50	200	0.030	0.025	-0.019	0.042					
Dependent variable												
6. Requisite integration	0.00	1.00	233	0.087	0.033	0.184**	0.077	0.130^{+}				
Control variables												
7. Size (ln)	6.00	1.00	201	0.065	-0.009	0.352**	0.184*	-0.049	-0.065			
8. Age	41.51	28.09	197	0.064	-0.090	-0.063	-0.067	0.009	0.152*	0.090		
9. Value chain position	3.33	1.78	186	0.156*	0.106	0.013	-0.007	0.167*	0.124^{+}	0.085	0.213**	

** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

The following conclusions can be made. First, some of the correlations between the contingency variables are rather strong and statistically significant (2 out of 10 are statistically significant at $\alpha = 0.05$ level). The correlations, however, are in absolute terms on average 0.08 and at maximum 0.24, and can be considered only moderate at best. Second, also some of the correlations of the contingency variables with continuous control variables (size, age, value chain position) are statistically significant (4 out of 15 correlations are statistically significant at $\alpha = 0.05$ level). The correlations are in absolute terms on average 0.09 and at maximum 0.35, and hence moderate. Finally, also some of the correlations of the contingency variables with the categorical control variables are statistically significant (16 out of 55 are statistically significant at $\alpha = 0.05$ level). The correlations are in absolute terms on average 0.10 and at maximum 0.31, and hence only moderate at best. The VIFs are low (VIFs at maximum 2.98), giving further support to the conclusion that multicollinearity is not a significant problem. Also the CIs are not alarming in terms of the potential multicollinearity problem (the CIs are at maximum 32.86, but the highest value is related to the constant). This suggests that the assumptions of the GLM are satisfied.

5.3.5 Statistical Analysis

Model estimation. A summary of the GLM results is presented in Table 5-14 (for further details, see Appendix E). The table includes the β-coefficients for the independent and control variables, standard error, t-statistic and the subsequent p-values, partial etas, as well as the model fit indices. The significance tests for the independent variable are one-tailed and for the control variables two-tailed. All variables are entered in the model simultaneously.

Table 5-14. Results of GLM analysis for Proposition 3

	Hypoth.	Estimate	S.E.	t	p-value	η^2
Intercept		-1.698	0.858	-1.979	0.051	0.039
Control variables						
Size		0.112	0.108	1.041	0.301	0.011
Age		-0.001	0.003	-0.261	0.794	0.001
Value chain position		-0.016	0.052	-0.298	0.766	0.001
Austria		0.668	0.351	1.906	0.060	0.036
Finland		0.464	0.306	1.519	0.132	0.023
Germany		0.244	0.307	0.795	0.428	0.007
Italy		0.201	0.299	0.670	0.504	0.005
Japan		-0.723	0.327	-2.208	0.030	0.048
Korea		-1.688	0.583	-2.894	0.005	0.080
Sweden		-0.144	0.347	-0.415	0.679	0.002
USA		0[a]				
Electronics		-0.075	0.190	-0.396	0.693	0.002
Machinery		0.392	0.198	1.982	0.050	0.039
Transportation		0[a]				
Theoretical variables						
Customization of orders	H3a (+)	0.257	0.132	1.948	0.027	0.038
Product modularity	H3b (-)	-0.051	0.082	-0.618	0.269	0.004
Introduction of new technology	H3c (+)	0.300	0.088	3.423	0.001	0.109
Introduction of new products	H3d (+)	0.004	0.003	1.441	0.077	0.021
Task interdependence	H3e (+)	0.166	0.160	1.040	0.150	0.011
Model indices						
F-statistic		4.166				
DF		17				
p-value		0.000				
R^2		42.5%				
Adjusted R^2		32.3%				

[a] This parameter is set to zero because it is redundant.

Model assessment. The overall fit of the estimated models is assessed with the F-statistic. The test statistic is significant, suggesting that the null hypothesis of no relationship between the independent variables and the dependent variable should be rejected. Hence, at least some of the independent variables are different from zero. Second, R^2 = 42.5% gives support to the conclusion that the independent variables are able to explain variance in the dependent variable.

Point estimate assessment. The point estimates in Table 5-14 above indicate that two of the five contingencies, namely customization of orders and introduction of new technology, are statistically significant at $\alpha = 0.05$ level, and the introduction of new products is significant at $\alpha = 0.10$ level. Statistical significance here suggests that the hypothesis of no relationship between the independent and dependent variables should be rejected. Furthermore, in each of these cases, the β-coefficient of the contingency variable is positive as hypothesized. Although the point estimates are in the hypothesized direction for all contingencies, getting support to the hypotheses seems difficult. The results thus give empirical support to three of the five hypotheses (H3a, H3c, H3d) and suggest that a higher degree of customization of orders and introduction of new technology and new products lead to a higher level of requisite integration. No support is found to the hypotheses that product modularity would be associated with a lower level of requisite integration (H3b, $p = 0.27$) or that task interdependence (H1e, $p = 0.15$) would be associated with a higher level of requisite integration. In addition, some of the control variables show statistical significance. However, no hypotheses were presented including the control variables.

5.3.6 Summary and Discussion of the Findings

In this section, I have tested the effect of various contingencies on the level of requisite integration. The effects of the contingencies on the level of requisite integration are somewhat weak: the β-coefficient for the contingencies is statistically significant at $\alpha = 0.05$ for two of the five variables and at $\alpha = 0.10$ for one of the variables, suggesting that a higher level of customization of orders and introduction of new technology, as well as introduction of new products lead to higher requirements for integration.

The negative effect of product modularity and the positive effect of reciprocal task interdependence on the level of requisite integration are very low. One potential reason for why product modularity was not found to have a linear effect is that the effect is in fact curvilinear: when product modularity increases, the level of requisite integration decreases, but at very high levels of product modularity the level of requisite integration is again high. The reason for the increase in the level of requisite integration at high levels of product modularization is that it is likely to require high integration in order to develop the product to be highly modular.

Although individual effects of the contingencies are rather low, the overall model explains well the variance on the level of requisite integration. As the results suggest, the control factors play a very significant role in explaining variance on the level of requisite integration, whereas the theoretical contingencies have significantly weaker explanatory power. One of the reasons for this is that the variance of control variables, especially country and industry controls, is relatively high, giving them more power in explaining variance on the level of requisite integration. Another reason for the differences on the level of requisite integration across industries could be that in some industries manufacturing has been found to be a significant source of innovation. This would increase the level of requisite integration between manufacturing and R&D. This could indeed be the reason why the level of requisite integration is significantly higher in machinery (as compared to transportation), whereas in electronics it is lower (Florida (1997) reports that manufacturing is the major source of innovation in 37.5% of firms in the auto industry and 14.5% of firms in the electronics industry).

As a summary, two conclusions can be made. First, plants facing high integration requirements are characterized by a greater focus on customization of orders and higher emphasis on new technology and new products. Second, when assessing the effect of task unpredictability and task complexity on the aspects of organization design, it is important to be specific about the operationalization of the contingencies because the aspects of unpredictability and complexity are different in different contexts.

5.4 SENSITIVITY ANALYSIS

Measurement error attenuates the correlations between the independent variable(s) and the dependent variable(s) (Hair et al. 1998, p. 9; Kennedy 2003, p. 160; Nunnally & Bernstein 1994, p. 240). Whereas the errors in the dependent variable are incorporated in the residual term, the errors in the independent variable can cause problems leading to false conclusions in terms of both not finding existing relationships or finding relationships that do not exist (Bagozzi et al. 1991; Bollen 1989). The existence of measurement error is especially critical in multiple regression, because measurement error in one of the independent variables can affect not just the coefficient of that particular variable but also the coefficients of variables free of measurement error (Bollen 1989, p. 166).

Measurement error is a significant issue in the research at hand, as in social research in general. In order to address the robustness of the results, an assessment of whether measurement error affects the results of the research is appropriate.[71] This means

[71] Nunnally and Bernstein (1994, p. 258) point out that it is important to understand that the reason for low correlation among variables is more often related to theoretical reasons than for low reliability.

assessing whether the results of the analysis change when measurement error inherent in the variables is taken into account.

There are two separate cases in which the assessment of the potential effect of measurement error is needed. First, organizational variables in general are likely to include measurement error, and the empirical investigations of reliability also point this out (Section 4.5.3). Second, single-item constructs are likely to have measurement error because they are rarely a perfect estimate of the construct (Anderson & Gerbing 1988; Bollen 1989, p. 17; Nunnally & Bernstein 1994, p. 66). The empirical estimation of reliability of a single-item construct, however, is not possible. Measurement error is problematic in this research because regression analysis, which is used to assess the relationships between constructs assumes perfect reliability (i.e. measurement error is zero). This is a somewhat crude assumption, especially as it is known that the constructs are not perfectly reliable (see Section 4.5.3). The effect of measurement error on statistical results can be assessed by SEM, modeling each independent construct as a latent variable with one indicator (variable) and fixing the reliability of the independent constructs to a certain value (calculated empirically, if possible) (Hair et al. 1998, p. 600; Hancock 1997). [72]

Proposition 1. In the empirical assessment of Proposition 1, the independent variable (achieved integration) is highly reliable (CR = 0.95). Hence, it can be concluded that there is no significant measurement error and so the results are likely to remain the same when the measurement error is taken into account. In order to confirm this, the model was estimated with SEM, modeling the achieved integration as a latent variable and fixing its reliability to 0.95. In Table 5-15 the results of ordinal regression analysis as well as SEM are presented.

[72] In practice, fixing the reliability means that the loading value is specified as the square root of reliability, and when covariance matrix is used for estimation, the loading value is specified as the square root of reliability times the standard deviation. In addition, the error term of the variable is specified as (1.00-reliability) * standard deviation of the variable. (Hair et al. 1998, p. 600; Hancock 1997).

Table 5-15. Sensitivity analysis for Proposition 1

Performance dimension	Result of ordinal regression analysis	Results of SEM[a]
Unit costs	0.620 **	0.255 **
Product capability	0.166	0.114 *
Conformance quality	0.351 *	0.147 **
Development lead time	0.288 *	0.197 **
On-time product launch	0.450 **	0.216 **
Volume flexibility	0.749 **	0.285 **
Design flexibility	0.342 *	0.146 **
Innovativeness	0.104	0.089

[a] The reliability of achieved integration is fixed to 0.95 (determined empirically)
** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

With exception to the absolute values of the coefficients, the results of the SEM analysis are similar to the ordinal regression analysis; in all eight models the coefficient of achieved integration is positive, as in ordinal regression, and also the statistical significance of the coefficients largely reflect the results of the ordinal regression. However, it is important to note that SEM assumes that the variables are continuous even though the dependent variable in each of the models is ordinal.

Proposition 2. In the empirical assessment of Proposition 2, the independent variable requisite integration has somewhat low reliability (0.51). Two of the four mediating variables are measured with multi-item scales (centralization and cross-functional job rotation) and have high reliabilities of 0.87 and 0.77, respectively. Both constructs are modeled as latent variables with reliabilities fixed to the empirically determined value.

For two of the mediating variables (information systems and cross-functional teams), the assessment of reliability is not possible. The reliability of information systems and cross-functional teams is fixed to 0.70. The choice of fixing reliability to 0.70 is somewhat arbitrary but reflects the standard for the lowest appropriate reliability in studies of hypothesis testing type (in contrast to exploratory ones) (Hair et al. 1998, p. 118). In Table 5-16, the results of the original regression analysis, SEM estimating the model as a whole, and SEM accommodating measurement error are presented.

Table 5-16. Sensitivity analysis for Proposition 2

Estimated path	Results of regression analysis	Result of SEM (measurement error assumed zero)	Results of SEM[a] (measurement error taken into account)
Requisite integration – Centralization	-0.135 *	-0.398 **	-0.605 **
Requisite integration – Info systems	-0.013	0.207 **	0.348 **
Requisite integration – Job rotation	0.223 **	0.144 **	0.252 **
Requisite integration – Cross-functional teams	0.173 *	0.227 **	0.436 **
Centralization – Achieved integration	-0.177 *	0.045	0.244 *
Info systems – Achieved integration	0.029	0.007	-0.053
Job rotation – Achieved integration	0.100 $^{+}$	0.250 **	0.254 **
Cross-functional teams – Achieved integration	0.298 **	0.259 **	0.244 **
Requisite integration – Achieved integration	0.335 **	0.236 **	0.458 **

[a] The reliabilities of requisite integration, centralization, and job rotation are fixed to 0.51; 0.87; 0.77, respectively (determined empirically), and the reliabilities of information systems and cross-functional teams to 0.70
** $p < 0.01$; * $p < 0.05$; $^{+}$ $p < 0.10$

The results of the SEM analysis are to a great extent similar to the analysis assuming zero measurement error; the path coefficients have the same sign as the coefficients of the SEM analysis assuming zero measurement error except for information systems. Furthermore, also the statistical significance of the coefficients largely reflect the results of the original SEM analysis. Differences are in the strength of the coefficients of paths between requisite integration and integration mechanisms. And when compared to the regression analysis, major differences are in the relationships requisite integration - information systems and centralization - achieved integration; regression analysis suggests these to be negative, whereas when measurement error is taken into account the relationships are strongly positive.

Proposition 3. In the empirical assessment of Proposition 3, the independent variables include both multi-item and single-item scales. The constructs of product modularity and introduction of new technology are highly reliable, with composite reliabilities of 0.96 and 0.97 respectively. Customization of orders, introduction of new products, and interdependence, on the other hand, are single-item constructs, the reliability of which cannot be assessed empirically. Following the previous analysis, the reliabilities of these three constructs is fixed to 0.70. In Table 5-17, the results of the original regression analysis and SEM accommodating measurement error are presented.

Table 5-17. Sensitivity analysis for Proposition 3

Contingency	Results of regression analysis	Results of SEM[a]
Customization of orders	0.183 *	0.084
Product modularity	-0.051	-0.018
Introduction of technology anticipation	0.300 **	0.178 **
Introduction of new products	0.004	0.048
Interdependence	0.166 +	0.278 *

[a] The reliabilities of product modularity and new technology anticipation are fixed to 0.96 and 0.97, respectively (determined empirically), and the reliabilities of other contingencies to 0.70

** $p < 0.01$; * $p < 0.05$; + $p < 0.10$

The results are to great extent in line with the results of the regression analysis. The coefficients have the same sign as those of the regression analysis and the statistical significance of the coefficients is about the same. Differences are customization of orders, which is no longer statistically significant and reciprocal task interdependence, which is now statistically significant at $\alpha = 0.05$ level. SEM, however, assumes that the variables are continuous, even though in the analysis reciprocal task interdependence is in fact dichotomous.

As a summary, it can be concluded that in terms of the sign and statistical significance, the conclusions made based on models assuming perfect reliability are to a great extent the same as when measurement error is taken into account. Hence, it is likely that measurement error has not affected the results of the regression analysis except for the effect of requisite integration on the use of information systems and the effect of centralization on achieved integration.

5.5 CONCLUSION AND SUMMARY OF THE STATISTICAL ANALYSIS

In this chapter I have focused on presenting the results of the empirical analysis. Each section of the chapter focused on empirical assessment of one of the three identified research gaps; integration-performance relationship, clarification of the integration concept, and antecedents of integration. Finally, I also presented some empirical analysis that was considered relevant in terms of the validity of the research results.

A summary of the theoretical propositions, as well as a summary of the results are presented in Table 5-18 below.

Table 5-18. Summary of the propositions and results

PROPOSITION	RESULTS
P1. The level of achieved integration has a positive effect on plant performance.	A higher level of achieved integration is related to a higher level of performance in dimensions of unit costs, conformance quality, development lead time, on-time product launch, volume flexibility, and design flexibility.
P2. Integration mechanisms mediate the relationship between requisite integration and achieved integration.	Integration mechanisms mediate the relationship between requisite integration and achieved integration; when the requirements for integration are high and more demanding, firms tend to use integration mechanisms of cross-functional job rotation and cross-functional teams more extensively to achieve a higher level of integration while being less centralized.
P3. High reciprocal interdependence of the organizational units has a positive effect on the level of requisite integration.	The results suggest that firms face greater requirements for integration efforts if they emphasize customization of orders, and focus on new technology and new product introduction.

The results thus give strong support to Proposition 1 and 2 and moderate support to Proposition 3. The focus of this chapter has been merely on presenting the analysis and discussing the statistical results in the empirical domain. In the next chapter, the focus of the discussion shifts back to theory; the research results are discussed in the theoretical domain.

CHAPTER 6
DISCUSSION

In this chapter I discuss and assess the research. The chapter is divided into four sections. First, I present the results of the empirical analysis. Rather than focusing on the statistical analysis, the focus in this section is on theoretical discussion: what is the meaning of the results in terms of theoretical explanations? The discussion focuses on the results at the level of the proposition rather than at the level of individual hypotheses. I also review Case Boeing in light of the research results. In the second section, I discuss the contribution of the research to Operations Management and Organization Theory literature, as well as managerial implications. In the third section, I assess the limitations of the research. Finally, in the fourth section, I present a detailed research agenda building on the theoretical discussion, limitations of the research as well as ideas developed during the research.

6.1 DISCUSSION OF THE RESULTS

In the following, I discuss the results of this research. The discussion is divided into three parts, following the structure of the empirical section: (i) the effect of integration on performance, (ii) the concept of integration, and (iii) the antecedents of integration. The discussion is mainly in the theoretical domain and focuses on drawing together the insights from the empirical analysis, pointing out the implications of the results, and comparing the results with previous research.

6.1.1 Effect of Integration on Performance

A majority of the previous OM research on cross-functional integration has empirically assessed the relationship between integration and performance. Although prior research is extensive in numbers, it has been suggested that the integration-performance relationship is still elusive (Barki & Pinsonneault 2005). In this research, I have focused on the performance effects of cross-functional integration by:

1. Emphasizing the multidimensionality of manufacturing performance, and

2. Clarifying the integration-performance relationship by suggesting that due to the costs of integration mechanisms and variations in the need for integration, the use of integration mechanisms does not necessary always lead to better performance. Instead, dimension of achieved integration in particular increases performance.

Multidimensionality of manufacturing performance. The research results give systematic empirical evidence for the multidimensionality of manufacturing performance. Even though the different manufacturing performance dimensions are positively correlated with each other, it is not possible to argue for a single unidimensional manufacturing performance construct. The correlations are only modest at best giving strong evidence that plants score differently on different dimensions of performance. This finding is particularly interesting because prior OM research has not been in agreement about the fundamental nature of manufacturing performance; some have argued for unidimensionality of the construct (e.g., Dean & Snell 1996), while others have argued for multidimensionality (e.g., Ketokivi & Schroeder 2004a).

The evidence for multidimensionality of manufacturing performance has wide implications, because performance is inherent in most of the empirical work done in the OM area. Operationalizing different dimensions of performance with only one measure (and subsequently assessing the focal problem with only one model) would immediately lead to misspecifications of the theoretical models; the theoretically interesting constructs can have different effects on different dimensions of performance, and hence, each performance dimension requires a separate model. The results of this research suggest that although achieved integration has an increasing effect on all the eight performance dimensions, the effect is far from similar. Within the context of this research, multidimensionality means that if operational performance had been operationalized with only one overall performance measure and the analysis had been squeezed into one single regression model, it would have been ignored that integration can be more important in terms of some dimensions of performance than in terms of others.

The multidimensionality of manufacturing performance has other implications as well. Namely, assuming that manufacturing performance is a unidimensional construct disregards in general the theory of manufacturing strategy (e.g., Flynn et al. 1999; Hayes & Wheelwright 1984), echoing the strategic contingency argument (Dean & Snell 1996); firms compete by differentiation in terms of product offerings, some of them emphasizing low cost, others flexibility or innovation, and subsequently choose manufacturing practices that reflect those priorities (Skinner 1969). The positive correlations among the performance dimensions also give some empirical evidence for the cumulative capabilities model, suggesting that there are no trade-offs in performance (Schmenner & Swink 1998).

Integration-performance relationship. The first fundamental finding is that cross-functional integration has value; the effect of integration on manufacturing performance is strong and positive. Second, the empirical results provide systematic evidence for the positive effect of the level of achieved integration, in particular, on different dimensions of comparative manufacturing performance. The results thus imply that when there is unity in effort among different functional units, then the plant performs on average better than its rivals in terms of manufacturing costs, conformance quality, development lead time, on-time new product launch, volume flexibility, and design flexibility. The integration dimension of achieved integration is, thus, highly important to understand.

The results giving strong evidence for the positive effect of achieved integration on performance are important and interesting in the sense that this research has called for a somewhat different conceptualization of integration than taken in the mainstream OM research. The main stream OM research has assessed the performance effects of integration by operationalizing integration as the use of integration mechanisms (e.g., Ettlie 1995; Narasimhan et al. 2005), while this research has followed the contingency theory of organizations (e.g., Lawrence & Lorsch [1967] 1986) and suggested that the dimension of achieved integration has direct effects on performance. Considering that the dimension of achieved integration matters in terms of performance rather than the use of integration mechanisms also acknowledges the idea that the use of integration mechanisms can be ineffective (Swink & Song 2007); investments in integration mechanisms does not necessarily mean that they are implemented or used properly.

The results of this research are in line with the prior empirical OM research assessing achieved integration (although they rarely use the term), including Hausman et al. (2002) and Parente et al. (2002) who report a positive effect of manufacturing-marketing integration on competitive performance and customer satisfaction in the context of on-going operations, respectively. The results are also in line with prior work in the NPD context, including Song et al. (1997) who observed a strong positive effect of achieved integration on NPD performance and Sherman et al. (2000) who observed a positive effect of the level of achieved R&D-manufacturing integration on competitive product development cycle time. This research complements these empirical investigations because the effect of achieved integration is assessed on a number of performance dimensions. In addition, the results give support to the seminal contingency theoretical arguments of Lawrence and Lorsch ([1967] 1986), as well as to the information processing arguments (Galbraith 1973; Tushman & Nadler 1978); when the functions work well together, the organization is able to perform better.

To conclude, the research offers insight into the effects of cross-functional integration on performance. Although the results provide systematic and strong evidence for the positive effect of achieved integration on different dimensions of manufacturing performance, more work remains to be done in the area. Especially theoretical arguments for the relative importance of achieved integration on different performance dimensions are still weak: does achieved integration have a stronger effect on some dimensions of manufacturing performance than on others and why? The empirical results give preliminary evidence for this. This is interesting because a direct implication of it is that achieving cross-functional integration is more important for some firms than for others; the importance of achieving cross-functional integration depends on what dimensions of performance the firm is competing on.

6.1.2 Concept of Integration

A majority of previous OM research on cross-functional integration has treated integration as unidimensional. In addition, there has been a lack of consensus in defining integration, and subsequently, the operationalizations of integration in the empirical research have been highly diverse. In this research, I have focused on the concept of integration by:

1. Emphasizing the multidimensionality of integration, and
2. Clarifying the concept of integration by suggesting that there is a clear distinction between dimensions of achieved integration, integration mechanisms, and requisite integration.

Multidimensionality of integration. The first fundamental finding is that the concept of integration is multidimensional; plants score differently on different dimensions of integration. Although variations in the dimensions of integration, namely the level of achieved integration, the use of integration mechanisms, and the level of requisite integration are not random, it is not possible to argue for one single underlying integration construct. This finding is interesting, because prior OM research has for the most part not acknowledged the multiple aspects of integration. Much like the multidimensionality of performance, the multidimensionality of the concept of integration has direct implications for both conceptual and empirical OM research addressing integration. The implications are broad in the sense that they concern integration research in various contexts, including supply chain or international integration. Treating integration as unidimensional can easily lead to misinterpretations of the theoretical arguments, as well as misspecifications of the theoretical models; different integration dimensions have different relationships with other constructs, like performance. Subsequently, the empirical hypotheses must reflect this distinction. The results also have direct implications for operationalizations of integration; the items need to reflect the focal dimension being addressed in the hypothesis.

Although integration mechanisms represent one of the three distinct dimensions of the integration construct, the results further indicate that plants vary widely in the use of different integration mechanisms. This is an important finding in light of the debate between the Cartesian approach and the configuration approach (Donaldson 2001, pp. 141-144). The results give preliminary support for the Cartesian approach. The findings are important also in the sense that managers have at least some choice when designing the organization instead of being purely reactive, an issue that the contingency theory has been criticized for (for further discussion, see Hrebiniak 1981).

The nature of the concept of integration. The main result of the analysis is that integration mechanisms have a mediating role in the relationship between requisite integration and achieved integration. The results indicate that when the requirements for integration are high, plants tend to use elaborated lateral integration mechanisms (e.g., cross-functional job rotation and teams) more extensively, while simultaneously being less centralized, in order to reach a higher level of achieved integration. The results give support to the partial mediation role of integration mechanisms (Venkatraman 1989); the level of requisite integration has an effect on the level of achieved integration, indirectly through the use of integration mechanisms, and also directly.

This research is one of the first studies assessing all the three the dimensions of integration empirically. The results have strong implications to the OM research, which has been highly interested in integration but has mainly treated integration as unidimensional. Prior OM research has for the most part perceived integration in terms of integration mechanisms, assessing managerial tools for integration. The results of this research have implications to OM literature in particularly by providing insight and evidence for the role of integration mechanisms.

The results of this research are in line with the work of the few authors in OM who have assessed several integration dimensions simultaneously in the NPD context, including Song et al. (1997), who report that incentives as an integration mechanism have a strong positive effect on the level of achieved integration, as well as Leenders and Wierega (2002) whose results suggest that some lateral integration mechanisms have a positive effect on the level of achieved integration in the R&D-marketing dyad. Even more importantly, the results of this research complement the studies providing some preliminary evidence for the relative effect of different mechanisms in achieving integration, as well as by indicating that the use of different integration mechanisms is dependent on the level of requisite integration. Simultaneously, the research gives empirical evidence for the arguments of information processing scholars (Galbraith 1973; Tushman & Nadler 1978), and the intra-organizational arguments of the contingency theory (Lawrence & Lorsch [1967] 1986).

To conclude, the research provides insight into the concept of integration, indicating that organizations differ in terms of the level of requisite integration, the use of integration mechanisms, and the level of achieved integration. Even though the research results provide evidence for the partial mediating role of integration mechanisms on the relationship between requisite integration and achieved integration, more work remains to be done. This research has assessed the use of four integration mechanisms, although the number of available mechanisms is extensive. Hence, detailed analysis of other mechanisms is also needed. In addition, there is still little systematic evidence for the role of individual integration mechanisms; which of the mechanisms are most important in terms of achieved integration when the level of requisite integration is high? Which of the integration mechanisms reinforce the effect of each other and can be used simultaneously? Or even more importantly, do some of the mechanisms have a detrimental effect on each other?

6.1.3 Drivers for Requisite Integration

A majority of the prior OM research has treated cross-functional integration as an exogenous variable, assessing the effect of integration on other variables (different dimensions of performance) and paying little attention to the antecedents of integration. In this research, I have focused on the antecedents of integration by:

1. Emphasizing that organizations vary in terms of the requirements for the use of integration mechanisms, and

2. Addressing the drivers for requisite integration in the manufacturing context.

Variations in the need for integration. The first fundamental finding is that plants differ in terms of the requirements for integration. Although none of the plants is characterized by absolutely no need for integration across functions, there is substantial variation in the level of requisite integration; some plants need to put more emphasis on cross-functional integration than others. The finding is highly important, because prior research on integration in OM has not acknowledged the potential differences in the needs for integration, but rather perceived that integration is equally (and highly) important for all organizations (e.g., Pagell 2004).

The finding that plants differ in terms of the need for integration has another important implication as well. Acknowledging that organizations vary in the level of requisite integration echoes the argument that just like specialization, also integration can be pushed too far (Katz & Kahn [1966] 1978), which indicates that there are significant costs related to integration efforts. Due to the variations in the integration requirements as well as the costs of integration, it is not possible to argue for the use of integration mechanisms as best practice; different organizations have different needs for integration mechanisms and these needs have to be uncovered before designing the organization. By introducing the concept of requisite integration and empirically assessing it, this research complements prior OM research, which has suggested that there are potential costs related to integration (e.g., Song et al. 1998; Swink 1999, 2000) but as not empirically assessed when integration is more beneficial or essential.

Pointing out variations in the need for integration, the results provide empirical support for the intra-organizational contingency theory argument (Lawrence & Lorsch [1967] 1986; March & Simon [1958] 1993). Although conceptually distinct, the level of requisite integration is closely related to the underlying interdependence of the organizational units; a low level of requisite integration is an implication of sequential interdependence of the units, whereas a high level of requisite integration can be considered as an implication of reciprocal interdependence. The findings thus challenge the perspective of some scholars who argue that interdependence between different functions is always reciprocal by nature (e.g., Donaldson 2001; St. John & Rue 1991).

Drivers for requisite integration. The main result of the analysis is that the task contingencies matter in terms of the requirements for integration; the level of requisite integration is affected by task unpredictability and task complexity. The results imply that both task unpredictability and task complexity increase the requirements for integration in manufacturing plants.

This research has been one of the few studies to conceptualize integration as an endogenous variable and also one of the first attempts to assess the concept of requisite integration empirically. The results are important and interesting in the sense that they give support to the task-contingent organization design argument (Keller 1994; March & Simon [1958] 1993; Thompson [1967] 2003). Several authors who have suggested that there are contingencies affecting cross-functional integration have emphasized the role of external environmental contingencies, such as environmental uncertainty (e.g., O'Leary-Kelly & Flores 2002).

The results of this research are in line with the few empirical studies on the antecedents of integration. These include the work of Koufteros et al. (2001, 2002), which suggests that firms in high change environments tend to adopt a higher level of concurrent engineering. The results are also in line with prior research at NPD project level, including the preliminary empirical results of Adler (1995), which suggest that task unpredictability has an effect on cross-functional integration in the manufacturing-R&D context and the work of Swink and Calantone (2004), which suggests that technological novelty is associated with higher design-manufacturing integration. The results of this research are also in line with the work of Van de Ven et al. (1976) carried out at team level, suggesting that task uncertainty and interdependence affect the use of integration mechanisms. The results of this research also theoretically extend these studies by conceptualizing requisite integration as a mediating concept in the relationship between certain contingencies and integration mechanisms.

To conclude, the research offers insight into the antecedents of integration. Even though the results provide evidence for the positive effect of task unpredictability and task complexity on the requirements for integration, more work remains to be done in the area; which are the most critical contingencies affecting integration requirements in different contexts?

6.1.4 Case Boeing Revisited

In Chapter 1, I motivated this research by discussing the organizational integration challenge at the aircraft manufacturer Boeing. I pointed out that even though Boeing manufactures aircrafts that have been in production for several decades, cross-functional integration is a fundamental issue at Boeing, and has been addressed with highly elaborated integration mechanisms at multiple levels in the organization. After giving insight into the organization structure, I posed the following questions: what creates the requirements for integration and the subsequent integration challenge at Boeing? Why is integration such a fundamental issue and why are highly complex integration mechanisms needed at Boeing?

Let us briefly go back to the case example of Boeing and discuss its organization in light of the results of this research. Is it possible to explain the significant integration challenge at Boeing by the contingencies that were suggested in this research and found to be the drivers for requisite integration and the related reciprocal or team interdependence in the cross-functional context? What is the main driver for requisite integration in case Boeing?

The significant integration challenge and high integration requirements at Boeing can be traced especially to the high degree of customization of orders and reciprocal task interdependence. Customization of orders at Boeing is a major issue; even though the same 777 aircraft is ordered, different customers require for example different interior designs and different internal layouts of the aircraft. From the cross-functional integration point of view, changes in the interior designs such as seat covers and layouts of the seats are rather easy to manage. On the other hand, even small changes in the internal layouts, such as different size and location of food-preparation galleys, might change the center of gravity of the aircraft, indicating high reciprocal interdependence. Changes in the internal layouts like this are significant from the cross-functional integration point of view.

Changes in the aircrafts and the underlying reciprocal task interdependence create a significant integration challenge. Integration is required for example because even a small change, such as the location of the food preparation galley, requires major redesign efforts in different areas of the aircraft in order to ensure that the centre of gravity remains with the specified limits and the aircraft is safe to fly due to the underlying reciprocal interdependence. Hence, significant information processing among all the major functions is required. Integration is also needed to resolve conflicting views that arise between customer requirements and the ability of the design/manufacturing teams and its willingness to make changes especially in major customization areas like the cockpit; even small changes have significant implications to all areas of the aircraft.

To conclude, there are reciprocal interdependencies in the organization of Boeing, especially due to the high extent of customization of orders and task interdependence. These make the integration requirements across organizational units significant and highly challenging, requiring extensive managerial efforts. The other contingencies suggested to affect to requisite integration, namely product modularity, and emphasis of new technology and products, do not seem to be very important in the case of Boeing.

6.2 CONTRIBUTION AND IMPLICATIONS

This research has contributed to the understanding of designing manufacturing plant organizations. The research has provided both academic and managerial implications. On the academic side, the research has taken a holistic perspective in order to increase the understanding of integration addressing the issues of (i) the nature of the integration concept, (ii) the effects of integration, and (iii) the antecedents of integration. On the practical side, the research has increased the understanding of the issues managers should focus their attention on when designing organizations. The contribution of this research can be summarized as follows:

1. *Development of a theoretical framework* that defines the concept of integration, the effects of integration, and the antecedents of integration, laying out a clear foundation for future integration research in different contexts;

2. *Detailed incorporation of the work of early structural contingency theorists*, in particular the intra-organizational variant of Lawrence and Lorsch ([1967] 1986), to the cross-functional integration research in the manufacturing context;

3. *A holistic empirical investigation of the work of early structural contingency theorists* on integration, including a detailed analysis of the concept of requisite integration and the analysis of the relationships between different integration dimensions.

The first two points contribute especially to the OM literature, whereas the third point is a specific contribution to the OT literature. The last point has implications also for practitioners. In the following, I discuss the contribution of the research separately in terms of the specific audiences: OM literature, OT literature, and practitioners.

6.2.1 Contribution to Operations Management Literature

The main contribution of this research is to OM literature. The specific contribution includes (i) providing conceptual clarity to the concept of integration and the concepts of uncertainty and complexity in the OM context, (ii) conceptualizing and empirically assessing integration as an endogenous variable, and (iii) discussing and empirically assessing the intra-organizational variant of contingency theory in the OM context.

First, the research presents a detailed conceptualization of the integration construct, suggesting that integration is multidimensional and includes dimensions of requisite integration, integration mechanisms, and achieved integration. This brings clarity to the inconsistency inherent in prior definitions and operationalizations of integration. Ignoring the differences in the requirements for integration, as well as the multidimensionality of the integration concept might well give an explanation for the somewhat mixed results of prior empirical research assessing the performance implications of integration. Additionally, this research also clarifies the concepts of uncertainty and complexity in the OM context. These concepts have been operationalized in highly diverse ways. For example uncertainty has been operationalized as demand uncertainty (O'Leary-Kelly & Flores 2002), overall change in the industry (Koufteros et al. 2001), or overall predictability of market, competitor, and technological demands (Song et al. 1997) in the cross-functional integration research, making conclusions from prior empirical investigations difficult.

Second, this research is one of the first studies to conceptualize and assess integration as an endogenous variable (for an exception, see Swink and Calantone (2004)). Using the terminology of this research, integration as an endogenous variable refers to the assessment of requisite integration and the contingencies affecting it. Prior research acknowledging the idea of requisite integration and empirical investigations on it are rare. Some scholars have suggested that such factors as clockspeed (Fine 1998; Galbraith 1994) and total quality initiatives (Galbraith 1994) determine the level of needed integration, but very limited attention has been paid to the theoretical foundations of these arguments. Although some scholars implicitly acknowledge the idea of requisite integration (e.g., Gupta et al. 1986; O'Leary-Kelly & Flores 2002; Olson et al. 2001; Song & Xie 2000; Song et al. 1997, 1998), the focus is more on assessing the effects of integration empirically rather than the roots of integration requirements. Hence, the detailed theoretical and empirical assessment of the concept of requisite integration and its roots is a clear contribution to the field.

Finally, this research is to the best of my knowledge the first empirical investigation of the intra-organizational variant of the contingency theory presented by Lawrence and Lorsch ([1967] 1986). Although contingency theory has been widely applied in OM research, prior OM research has taken the comparative approach to contingency theory perspective, comparing for example cross-functional integration in various environments (e.g., Koufteros et al. 2001). Practically no attention has been paid to the entire pattern of intra-organizational differentiation and integration. Furthermore, even though the idea of a fit between information processing needs and information processing capacity has been supported in the OM context (e.g., Bensaou & Venkatraman 1995; Wheelwright & Clark 1992), it has not been under detailed empirical investigation in the cross-functional context. When discussing the ideas of early structural contingency theorists in the OM context, this research also simultaneously advances the theoretical discussion by emphasizing the importance of the a priori explanations for the relationships to be placed under empirical investigations.

6.2.2 Contribution to Organization Theory Literature

This research has contributed also to the OT literature. Whereas the main contribution to OM literature is both empirical and theoretical by nature, the contribution to OT is highly empirical. Despite the fact that the arguments and theorizing of early structural contingency theorists, such as Lawrence and Lorsch ([1967] 1986) and Thompson ([1967] 2003) have been widely diffused and applied and have served as a basis for fruitful theorizing, rigorous empirical investigations of their ideas have been limited. This research contributes to the contingency theory literature by providing a holistic empirical assessment of the intra-organizational contingency theory argument on integration, including an empirical assessment of the concept of requisite integration.

This research constitutes to the best of my knowledge the first attempt to address the concept of requisite integration and its roots empirically. Although Lawrence and Lorsch ([1967] 1986) introduced the idea of requisite integration, they were not able to make rigorous empirical investigations on it due to the limits of their data; all organizations in their data set were found to have a high level of requisite integration. Despite the great attention that has been paid to the work of Lawrence and Lorsch, the concept of requisite integration has not received significant interest, although the idea of it is inherent in some conceptual frameworks (e.g., Tushman & Nadler 1978). Most importantly, this research contributes to the contingency theory literature by providing the first empirical operationalization and assessment of the concept of requisite integration. This research provides empirical evidence for the argument that organizations vary in terms of the need for integration. The empirical evidence as well as the discussion of the concept of requisite integration provide a basis for future work.

Due to the limited attention to the concept of requisite integration, the empirical research grounding on the work of Lawrence and Lorsch ([1967] 1986) has addressed only some specific areas of the original arguments (e.g., Keller 1994; Van de Ven et al. 1976), even though the lack of research on the intra-organizational arguments has been pointed out (Gerwin 1981; Lawrence 1981). This research contributes to the contingency theory literature by providing a holistic empirical assessment of the intra-organizational contingency theory argument, including the inter-relationships of the three integration concepts. Grounding on statistical analysis of large-scale data, this research provides empirical evidence for the original theoretical arguments of the early structural contingency theorists. This research also provides some empirical support for the conceptual frameworks presented by Van de Ven (1976) and Tushman and Nadler (1978).

6.2.3 Managerial Implications

In addition to the academic contribution, the research also has implications for managers. This research draws attention of managers to organization design by pointing out that understanding integration is important and achieving integration matters in terms of performance.

The concept of requisite integration and its implications are highly relevant for practice. The notion of requisite integration addresses the question of when and to which extent managers need to develop advanced tools for management of the integration challenge. As the results of this research indicate, firms differ in terms of the need for integration; assessment of the level of requisite integration is crucial when designing the organization. Subsequently, the research has implications for the use of mechanisms of integration. Integration mechanisms, like cross-functional teams and advanced information systems, are not to be treated as best practice without further elaboration. This research suggests that managerial emphasis on complex advanced lateral mechanisms is not always needed; there is no standard situation in which equal emphasis on complex lateral mechanisms is needed. Rather, in some organizations the integration challenge can well be managed with less demanding and costly mechanisms, like centralization and standardization. Accordingly, management should wisely decide upon the portfolio of mechanisms developed in the organization.

The results of this research indicate that achieved integration has a positive effect on different dimensions of comparative manufacturing performance. The results of this research indicate that achieved integration does not have a similar effect on different dimensions of performance; achieved integration has a stronger effect on some performance dimensions than on others. This is managerially relevant, because the importance of integration, and subsequently the needed emphasis on reaching a high level of integration depend on which performance dimensions the managers perceive important; achieving integration is more essential on some dimensions than on others.

The present research is relevant for managers also in the sense that whereas the prior research has mainly looked at the state of integration in organizations (although this is in accordance with the universalist assumption to integration), this research takes a normative perspective. Rather than assessing the current organization design issues in firms, including integration mechanisms, this research focuses also on what should be the state of integration in organizations and how it can be achieved. The results further indicate that managers have some choice when designing their organization.

Finally, the ideas about and conceptualization of integration presented in this research have managerial implications in other contexts as well. The notion of requisite integration has implications for example for the management of global operations and supply chain management.

6.3 LIMITATIONS OF THE RESEARCH

Despite the contribution and implications, the research has some limitations. The limitations are divided into theoretical and empirical ones and discussed in the following.

6.3.1 Theoretical Limitations

The theoretical limitations of the research include issues related to (i) the concept of differentiation and (ii) the level of analysis.

This research has focused on integration. An intentional decision was made to assess organization design by focusing solely on the aspect of integration, taking the level of differentiation as given. The underlying assumption made in this research is that the related division of tasks has been made to minimize the interdependence of the organizational units (Galbraith 1977; Thompson [1967] 2003). It is, however, acknowledged that contrasting arguments to the assumptions of the early structural contingency theorists exist; firms have been found to divide the tasks so that they intentionally leave reciprocal interdependence in the organization, which affects also the level of differentiation. The reason for this is that sequential interdependence has been suggested to hinder for example innovativeness (e.g., Rivkin & Siggelkow 2003; Takeuchi & Nonaka 1986). This stream, however, takes a different perspective to organization design; a decision of interdependence or integration is made before the division of tasks. The question of how to divide the tasks and the subsequent variations on the level of differentiation is at least as important as the question of integration, and an entire research program could be developed to assess it (see Section 6.4). In order to manage the scope of the present research, the investigation of the division tasks and differentiation are left for further research.

Another limitation of this research is related to the level of analysis. A clear distinction between different functional interfaces is not made at manufacturing plant level. Rather, the level of analysis is *a* functional dyad between manufacturing and R&D or marketing and sales. However, for example the level of requisite integration could be different in the manufacturing-R&D interface than in the manufacturing-marketing interface within the plant. In addition, high achieved integration in the manufacturing-R&D interface is likely to be more important for some performance dimensions, whereas high achieved integration in the manufacturing-marketing is likely to be more important for others. The main reason for analyzing a general functional dyad was that a majority of the integration mechanisms are implemented and can be observed at plant level rather than at the level of a specific functional dyad; although there is likely to be some variation also within plants, the main differences are at plant level. Plants mainly differ in terms of for example their overall emphasis on plant-level information systems, cross-functional job rotation policies, or emphasis on centralization. It is also reasonable to assume that requisite integration or achieved integration can be assessed at plant level representing the overall conditions at the manufacturing plant.

6.3.2 Empirical Limitations

In addition to the broader theoretical limitations, the research also has some empirical limitations. These are related to (i) the perceptual measure of performance, (ii) the cross-sectional nature of the data, (iii) the common method bias, (iv) the operationalization of the concept of requisite integration, and (v) the data of single-plant firms.

Perceptual measure of performance. In this research, performance is measured with a perceptual measure of comparative manufacturing performance. Whether the respondent's response is a reflection of the true performance of the plant is questionable and can be placed under critique. Ketokivi and Schroeder (2004b) investigated the properties of the measurement instrument with the HPM data with MTMM analysis. The results of their analysis point to high validity of the instrument. An important observation of Ketokivi and Schroeder (2004b) is that rather than being a systematic bias, a majority of the method variance is random error. Whereas the effects of systematic bias are more critical, random error is incorporated into the error term in the regression analysis, and hence does not bias the regression estimates (Hair et al. 1998). Finding an objective measure of performance for the present research would be difficult. Using for example overall financial performance measures such as ROI is not appropriate because they are not manufacturing-specific but are to a great extent affected by other factors outside manufacturing (Bozarth & Edwards 1997). Furthermore, measuring financial performance of a manufacturing plant in a multi-plant firm might tell very little about the true performance of the plant. Nevertheless, the perceptual measure of performance still remains as one of the limitations of the present research. Another concern of the performance measure is related to using a single respondent when assessing performance with a perceptual measure (e.g., Ketokivi & Schroeder 2004b). However, as the performance in this research is comparative manufacturing performance, referring to how well the plant compares to others in the industry, the plant manager is considered to be the sole informant most likely to have proper knowledge in the issue.

Cross-sectional nature of data. The second limitation of the data can be related to its cross-sectional nature, which limits the possibility to address the dynamics of integration. For example Aldrich (2001) has recently called for longitudinal studies in organizational issues. Within the context of this research, longitudinal studies would address questions like: how fast does a change on the level of achieved integration have implications for performance? Or, when the level of requisite integration changes, how well are firms able to react in terms of integration mechanisms? The contingency theory has sometimes been criticized for its cross-sectional ("static") nature (e.g., Dewar & Hage 1978; for further discussion see Donaldson 1987; Kimberly 1980). Porter (1991), however, points out that cross-sectional studies are logically prior to longitudinal ones. Based on Porter's (1991) argument, the cross-sectional research approach can be justified; it is important to first build theoretical arguments and conduct rigorous empirical analysis of the arguments with cross-sectional data and only later develop and test those arguments in a dynamic context.

Common method bias. There is also a potential for common method bias referring to variance attributable to the measurement method rather than the underlying construct and it threatens the validity of the conclusions made (for detailed discussion, see Podsakoff, MacKenzie, Lee & Podsakoff 2003). One potential source of common method bias in this research is the use of common informants for both independent and dependent variables (potential for artificial covariance between the variables). Sources of common informant bias include for example consistency motif, social desirability, mood state, leniency bias (propensity to give stronger opinions on issues the respondent knows and likes) and acquiescence bias (yea-saying and nay-saying). For example, PM is used as an informant for both achieved integration (one of three informants) and performance (sole informant), which respectively represent the independent and the dependent variables in Proposition 1. For testing the potential effect of common informant bias, some of the statistical analyses were carried out by excluding the response of the plant manager from the items of achieved integration, but no effect on the results was found. Hence, the empirical analyses were carried out with plant level data using all the available information.

A second potential source of common method bias are item characteristics referring to the way in which the items are presented. Sources of item effects include for example item ambiguity, common scales, reverse-coded items, and item social desirability. In order to reduce item ambiguity, researchers made plant visits to present the research and to explain possible unclear questions. In order to reduce the potential to get socially more desirable responses, each questionnaire was returned in a sealed envelope and the answers were not revealed to others even within the focal plant and also the anonymity of the plants was retained. Although common scale anchors make it easier for the respondent to fill in the questionnaire, they also increase the potential for common method bias. In this research, majority of the scales were measured on a 7-point Likert scale but performance on a 5-point Likert scale to introduce variation in the scales. Furthermore, instead of bi-polar numerical scales, verbal scales were used to reduce the potential for socially desirable responses. In this research also several reverse-coded items were used to reduce response pattern biases although it is recognized that they also have their disadvantages. Nevertheless, despite the actions taken, item characteristics still remain a potential source of common method bias in this research.

Additional sources of potential method bias in this research are common item context effects referring to context-induced mood and intermixing of scale items (items of different constructs grouped together, which may decrease the intra-construct correlations and increase inter-construct correlations) and common measurement context effects referring to simultaneous measurement of and same survey for measuring independent and dependent variables.

Operationalization of requisite integration. In this research, the concept of requisite integration was operationalized as a reflective indicator (Bollen 1989; Shah & Goldstein 2006); it was assumed that the items are caused by some latent construct, which requires internal consistency among the items. The reflective mode is mainly (although sometimes mistakenly) used in OM. It allows for the detailed analysis of validity and reliability, whereas formative indicators are problematic because of the measurement and random error they contain (Shah & Goldstein 2006).

The choice between the reflective and the formative mode should, however, be done on purely theoretical reasons rather than empirical ones. A detailed assessment of the concept of requisite integration reveals that a potentially more correct way would have been to operationalize requisite integration as a formative indicator; requisite integration is a construct caused by the items rather than a construct causing the items. As an additional analysis, to assess whether the different operationalization would change the results, requisite integration was operationalized as a formative indicator (construct value calculated as an arithmetic average of the three items) and the empirical analysis involving requisite integration was carried out again. The statistical results remained the same in terms of the sign of the coefficients and their statistical significance as compared to the analysis presented in this dissertation. An explanation for this is that, although somewhat counterintuitive, the weighted average is highly correlated with the unweighted one (for discussion in the context of strategic weighting of operational performance, see Ketokivi & Schroeder 2004a).

Single-plant firms. Finally, a potentially less significant limitation of the research is related to the data of plants that represent the whole firm (i.e. single-plant firms). One of the respondent categories in the HPM survey is plant superintendent, which refers to a corporate-level informant. If the plant was a single-plant firm, the questionnaire of the plant superintendent was directed to the plant manager. Hence, in single-plant firms, the plant manager filled in two questionnaires, which may have led to a potential over-emphasis of the perspective of the plant manager for those items that were included in both questionnaires (the plant-level score used in the analysis was calculated as the arithmetic average of individual responses). This could have some effect on the plant scores in case of achieved integration and requisite integration, as well as some of the integration mechanisms for which the informants include both plant superintendent and plant manager. Double responses of a single informant were not removed in the case of a single-plant firm because the data did not provide information about that, and thus this remains a limitation of the present research.

6.4 PROPOSALS FOR FUTURE RESEARCH

This research has provided some insight into the phenomenon of cross-functional integration at manufacturing plants. The research also generates ideas for future research. These are discussed below in the form of a research agenda. Future research could address problems related to the following topics: (i) decision making factors for the division of tasks and differentiation, (ii) comparison of the drivers for requisite integration within manufacturing plants, (iii) differentiation and integration arguments in other manufacturing-related contexts such as MNC, and (iv) psychological perspective to integration.

6.4.1 Drivers for the Division of Tasks and Differentiation

A potentially very fruitful area of future research is the division of tasks and the subsequent differentiation addressing such questions as: what are the main decision making factors for the division of tasks? Why do all organizations not divide the tasks to minimize integration costs? What is the sequence of decision making regarding organization design? What exactly is the role of differentiation in organization design and the problem of integration in particular?

This research stream would nicely complement the present research by addressing one of its main limitations. The main difference would be the relaxation of the assumption that the division of tasks is made to minimize interdependence and the subsequent costs of integration (e.g., Galbraith 1977; Thompson [1967] 2003), which is the core assumption made for the purposes of the present research. Simultaneously, the assumption that the division of tasks is made first when designing the organization would be relaxed. Complementing the present research with the assessment of the division of tasks and differentiation is considered important; recent research has presented counterarguments for the division of tasks made to minimize integration needs (e.g., Rivkin & Siggelkow 2003).

Research addressing the division of tasks and differentiation could be assessed empirically by examining for example NPD projects which differ in terms of the division of tasks. This could involve multiple projects within a single firm in which manufacturing has been given different roles and which subsequently differ in terms of the level and nature of differentiation. Hypotheses could then be formulated, linking the division of tasks to project characteristics. Another way to address the issue of division of tasks could be to take a process perspective to organization design. This would include looking at the sequence of decision making and factors affecting it when designing organizations for multiple NPD projects within a single firm.

6.4.2 Comparative Research on the Drivers for Requisite Integration

Related to the present research, future research could engage in a comparative assessment of integration requirements within manufacturing plants and address such questions as: are there differences on the level of requisite integration across functional interfaces within manufacturing plants? Why are there differences in the functional interfaces within same organizations?

Although related to the present research, this would involve analyzing separately the issue of requisite integration and the related contingencies across the functional dyads within one organization. Hence, it would relax the assumption that an overall plant-level degree of requisite integration equally characterizes all interfaces, which was made for the purposes of the present research. Additionally, also other perspectives than just that of manufacturing could be taken, including the assessment of the marketing-R&D dyad. This would nicely build on the conceptual work of Gupta et al. (1986) and the empirical work of Song and Dyer (1995) on R&D-marketing integration.

The research could be carried out with case study methodology, conducting detailed analysis within a few manufacturing plants. The research could comprehensively address all functional interfaces and make comparisons between the level of requisite integration, as well as the contingencies of unpredictability and complexity in these interfaces. This research would well complement the present research and provide a deeper understanding of requisite integration and its roots in the cross-functional context.

6.4.3 Differentiation and Integration Argument in Other Manufacturing-Related Contexts

The present research has been one of the first attempts to empirically address the differentiation and integration argument of Lawrence and Lorsch ([1967] 1986) in the OM context. In the future, it would be interesting to assess the intra-organizational variant of the contingency theory also in other OM contexts, including for example international operations. The research could address such questions as: what are the drivers for differentiation and integration in the context of international operations? What are the decision making factors for the assignment of plant roles and why are there differences in the roles of manufacturing plants and ways of managing the network of plants within one company?

This research is somewhat related to the work done by International Business scholars, including for example Bartlett and Ghoshal (1989) and Nohria and Ghoshal (1997). International Business scholars have, however, mainly taken the headquarter perspective, analyzing overall firm activities rather than focusing on manufacturing. This research stream could explicitly address the drivers for differentiation and integration from the manufacturing perspective in a multi-plant network. The focus could be on the lateral dyads between manufacturing units located across the world rather than the vertical dyads between the headquarters and each local unit.

This research stream could be addressed empirically by performing detailed examination of manufacturing companies that have several plants across the world and looking at the sources of unpredictability and complexity in that context. In the first phase, case methodology could be used to identify the factors posing unpredictability and complexity in a handful of companies. This could then be complemented by testing the effects of these contingencies on differentiation and integration in a larger sample.

6.4.4 Integration as a Behavioral Phenomenon

Finally, future research could also extend and complement the present research by approaching integration from the behavioral perspective; perceiving integration as a way of alleviating the sub-goal pursuit that arises due to personal motives of the organizational members. Using the terminology of Ghoshal and Gratton (2002), this research stream would especially address social integration, which refers to the creation of collective bonds, and emotional integration, which refers to the creation of common identity and purpose. The following questions could be posed: which behavioral factors affect the requirements for integration? How can social and emotional integration be achieved in organizations? Especially interesting would also be to analyze organizations that have a low level of requisite integration: what characterizes these organizations?

This question is closely related to the research problem of the dissertation. The main difference is that rather than perceiving integration as an information processing phenomenon (Galbraith 1973), this research stream would conceptualize it differently by including the psychological aspects of it. For example, Lorsch and Morse (1974) suggest that including the behavioral perspective of the organizational members to the contingency theory is needed to gain a complete understanding of organization design. This research stream would also address the general call for more behavioral research in OM (e.g., Cummings 1977).

This research stream could be addressed in a rather similar vein as the present research. However, the operationalizations of the integration constructs need to be modified to reflect the different conceptualization of integration. In addition, re-development of the hypotheses to manifest the behavioral aspects of integration is needed. Other integration mechanisms, like incentives emphasizing the aspects of directing the behavior of the organizational members for the purposes of the firm (e.g., Barnard 1938) could also be included in the analysis. This research would nicely complement the present research and provide a more comprehensive understanding of integration.

6.5 CONCLUSIONS

One of the fundamental problem areas in Operations Management has been the emergence of "functional silos" and the related management of cross-functional interdependencies by integration. The present research was motivated by the observation that prior research seemed to lack understanding of what the nature of integration is, how integration is related to performance, and when integration is essential.

The contingency theoretical information processing perspective was chosen as the theoretical basis for the present research. Hypotheses were derived and tested with a sample of 236 manufacturing plants collected by the multinational High Performance Manufacturing survey. A majority of the hypotheses did get empirical support. The first key finding is that integration is not a unidimensional concept; there are three different integration dimensions of achieved integration, integration mechanisms, and requisite integration. The second key finding is that although achieved integration does have a positive effect on performance, the effect on different dimensions is far from similar; integration provides more value to certain performance dimensions. Finally, the third key finding is that organizations vary in terms of the requirements for integration; some organizations need to put more emphasis on integration than others in order to operate effectively.

This research has contributed to the existing literature in the domains of Operations Management and Organization Theory. In addition, the research has provided managerial implications. Although there are some limitations in the present research, the research has made a clear contribution to theory and practice, as well as provided ideas for future research. The results indicate that cross-functional integration is a major challenge and substantial effort is needed to manage the cross-functional interdependencies. As a direct consequence, some of the most relevant questions for the future include: is the functional division of tasks still feasible? Is there another, more effective way to divide the tasks in organizations from the point of view of integration?

To conclude, integration is essentially about bridging different organizations or organizational units which operate in and have adapted to their focal sub-environment limiting the information processing capacity of the whole system. Much like organizational units, also academic scholars tend to adapt to their domain, engaging in scholarly discussion only within their focal discipline; we as OM scholars have our own conferences and academic outlets, we tend to engage in literature search within the OM journals and look for contribution to the OM community. Although there is nothing wrong with this, it naturally limits the information processing capacity of the academic community. As this research indicates, scholars outside the OM domain have paid substantial attention to the phenomenon of cross-functional integration, considered as one of the fundamental problem areas in OM. Therefore, this research fundamentally challenges the idea that scholars can work only within the borders of their own discipline; we as OM scholars simply cannot ignore the work done in other academic domains, like OT. Much like the lack of integration in the cross-functional context, ignoring and overlooking the work done in other disciplines will lead to re-inventing the wheel or limited perspectives to interesting research problems. Hence, as a final conclusion, this research puts out a call for building bridges across academic domains like OM and OT, but in light of the concept of requisite integration only in areas where substantial advantages can be gained.

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APPENDIX A:
REVIEW OF EMPIRICAL RESEARCH ON CROSS-FUNCTIONAL INTEGRATION

Author (Year)	Context	Definition of or approach to integration	Sample	Results
Adler (1995)	Mfg-R&D in NPD project and mfg	Coordination	13 firms; USA; printed circuit boards and hydraulic tubing	Interdependence, project phase, uncertainty affect use of integration mechanisms
Bergen & McLaughlin (1988)	Mfg-R&D in NPD	Clarity of understanding, completeness of info, joint reward systems	65 projects (54 firms); UK, JPN, GER, USA; scientific instrument	Country affects integration
Calantone et al. (2002)	Mfg-mkt in NPD	Mutual understanding, cooperation	226 plants; USA; automotive	Mkt knowledge of mfg → integration (+); mfg evaluation of mkt communication → integration (+); uncertainty and rate of new product introduction do not affect the relationships
Droge et al. (2004)	Mfg-R&D in NPD (also customer, supplier)	No explicit definition (integration mechanisms)	57 firms; USA; first-tier suppliers of Big Three in automotives	Integration → time-to-market (+), time-to-product (+), responsiveness (+), financial performance (+)
Eisenhardt & Tabrizi (1995)	NPD	No explicit definition (e.g., info systems, teams, rewards)	72 projects in 36 firms; Europe, Asia, US; computers	Info systems → development lead time (+), teams → development lead time (-), rewards → development lead time (ns)
Erens & Hegge (1994)	Mfg-Mkt in ATO firms	Communication, information processing	1 firm; GER; X-ray medical equipment manufacturer	Bill-of-materials improves communication between mfg and sales functions and enhances quality of information
Ettlie (1995)	Mfg-R&D	Coordination, use of integration mechanisms	43 firms or divisions; USA; various industries	Integration affects sales/employee (+), development cycle time (ns), and benchmark design (+)
Ettlie (1997)	Mfg-R&D in NPD	Coordination in time and substance	126 firms; USA; various manufacturing industries	Integration → market need understanding (+)
Ettlie & Reifeis (1987)	Mfg-R&D	No explicit definition, refer to information sharing and common understanding	9 firms; USA; vehicles, turbine, auto, electronics, aeronautics, tooling	Focus on presenting different ways of achieving integration: cross-functional teams, info systems, centralization
Ettlie & Reza (1992)	Mfg-R&D (also supplier, customer)	Coordination, use of integration mechanisms	39 plants; USA; various industries	Integration → throughput time (ns), cycle time (ns), utilization (+), scrap (ns), volume flexibility (ns), part families flexibility (ns), reduction in service calls (ns)
Ettlie & Trygg (1995)	R&D-mfg in NPD	Coordination, use of integration mechanisms	316 firms; USA and SWE; durable goods	Compared the use of integration mechanisms across countries, some variation was found
Gerwin (1993)	Mfg-R&D in NPD	Collaboration, joint effort	4 largest firms; USA; computer and telecom	Trend that mfg joins NPD process in the front-end stage also in strategic matters, although does not need to join in all activities
Griffin & Hauser (1992)	Mfg, Mkt, R&D in NPD	Communication	2 NPD projects (1 firm); USA; automotive	QFD led to more communication in general and more communication between functions than phase-review development process but reduced communication from core development team to management

Haddad (1996)	Mfg-R&D (CE)	Coordination, info sharing, joint problem-solving	1 firm (longitudinal); USA; automotive	Adoption of CE → new products development time decreased
Hahn et al. (1994)	Mfg-Mkt	Cooperation and communication	1 firm (Huyndai); JPN; automotive	Successful integration by centralization and cross-functional teams
Hausmann et al. (2002)	Mfg-Mkt	Ability to work together in strategy implementation	215 + 175 executives; convenience samples at Stanford executive class	Integration affects mfg morale (ns) and mkt morale (ns); integration affects profit performance (+); integration affects competitive position (+)
Hull et al. (1996)	Cross-functional (CE)	Coordination (mechanisms)	12 firms (cases) + 74 firms (survey); USA; various industries	Time and cost performance affected by teams (ns), co-location (ns), and rewards (ns)
Kahn & McDonough (1997a)	Mfg, R&D, Mkt	Collaboration and interaction	514 functional managers; electronics	Collaboration affects department performance (mainly +), development performance (+), product management performance (+), and satisfaction (+); interaction affects department performance (ns), development performance (-/ns), product management performance (ns), satisfaction (-/ns); moderating effect of co-location not significant
Kahn & McDonough (1997b)	Mfg-Mkt (also Mkt-R&D) in global context	Collaboration and interaction	500 functional managers; USA, Europe, Far East; electronics	Collaboration is more important in terms of performance than interaction. Although differences do exists across countries, development of a global integration framework is possible
Kahn & Mentzer (1998)	Mfg-Mkt (also Mkt-R&D)	Collaboration and interaction	514 functional managers; electronics	Collaboration affects department performance (+/ns), company performance (+/ns), development performance (+/ns), product management performance (+), and satisfaction (+); interaction affects department performance (ns), company performance (ns), development performance (ns), product management performance (ns), and satisfaction (-/ns)
Ketokivi & Schroeder (2004c)	Cross-functional	Cooperation	164 plants; GER, ITA, JPN, UK, USA; automotive suppliers, machinery, and electronics	Strategy affects integration; structural contingency and institutional variables affect integration
Konijnendijk (1994)	Mfg-Mkt	Coordination	Survey 50 firms, cases 5 firms; Netherlands; industrial production	Interdependence varies within ETO firms depending on the issue at hand; different types of interdependence induces different integration mechanisms
Koufteros et al. (2001)	Mfg, Mkt, R&D (CE) in NPD	Coordination, info sharing, use of cross-functional teams	244 firms; USA; metal, machinery, electronics, transportation equipment	Integration affects quality (ns) and product innovation (+), uncertainty related to more integration
Koufteros et al. (2002)	Mfg, Mkt, R&D (CE) in NPD	Level of info sharing and trust, use of cross-functional teams	244 firms; USA; metal, machinery, electronics, transportation equipment	Integration affects quality (+) and innovation (+), platform strategy as moderator (+/-), uncertainty and equivocality → more integration
Koufteros et al. (2005)	CE (also customer, supplier) in NPD	Level of info sharing and trust, use of cross-functional teams	244 firms; USA; metal, machinery, electronics, transportation equipment	CE affects customer integration (+), supplier process and product integration (+); uncertainty and platform strategy were not found to affect the relationships

Koufteros & Marcoulides (2006)	Mfg, Mkt, R&D (CE) in NPD	Level of info sharing and trust, use of cross-functional teams	214 firms; USA; metal, machinery, electronics, transportation equipment	CE affects product innovation (+) and quality (+), cellular manufacturing moderates the effect of CE on quality but not the effect of CE on product innovation
Krohmer et al. (2002)	Mfg-mkt (also other mkt interfaces) at BU level	Influence, interaction	514 firms; USA, GER; packaged goods, electronics, machinery	Integration leads to effectiveness (+), efficiency (+), adaptiveness (+); environmental uncertainty moderates the relationships
Liker et al. (1999)	Mfg-R&D in NPD	No explicit definition (integration mechanisms)	74 firms; USA; various industries	Systems integration affected by hierarchy (-), formalization (-), info systems (ns), social mechanisms (ns), and rewards (ns)
Moffat (1998)	CE	Coordination (integration mechanisms)	53 development projects (14 firms); USA; telecom, auto, manufacturing process equipment	Organizational integration affects team task performance (ns) and team decision making effectiveness
Nahm et al. (2003)	General cross-functional	Level of communication	224 firms; metal products, machinery, electronics, transportation equipment	Time based mfg practices affected by level of communication (+) and locus of decision making (+), size does not affect the relationships; time-based mfg practices → plant performance (+)
Narasimhan et al. (2005)	Mfg-R&D	Communication of mfg knowledge to R&D, cooperation, use of integraton mechanisms	57 plants; USA; various industries	Capabilities (including integration) → performance
Nihtilä (1999)	Mfg-R&D in NPD	No explicit definition	5 cases (in 3 firms); electronics, software	The author explores integration mechanisms in use and the related managerial challenges
O'Leary-Kelly & Flores (2002)	Mfg-Mkt	The extent cooperation to arrive at mutually acceptable outcomes	121 firms; central USA; metal, industrial machinery, transportation industries	Effect of integration on profitability moderated by product innovation, on-time delivery, quality, and product breadth strategies and uncertainty but not by cost leadership strategy
Olson et al. (2001)	Mfg, Mkt, R&D in NPD	Cooperation	34 projects (9 firms); USA; electronics, food, fashion, engines, glass, health, filtration systems, office products, medical supplies	Stage and interface affects integration, innovation moderates the integration-performance relationship
Pagell (2004)	Cross-functional within operations	Process of interaction and collaboration, cooperation	11 plants; USA; various industries	Job rotation, communication, measurement and reward system affects level of consensus, level of consensus affects performance
Parente et al. (2002)	Mfg-Mkt	Connectedness, conflict, information sharing	3 firms; industrial machinery, automotive	Customer satisfaction affected by connectedness (+) and conflict (-), not by info sharing; product type moderates the integration-performance relationship

Pinto et al. (1993)	Cross-functional (in project team)	Cooperation	62 project teams; USA; hospitals	Cross-functional cooperation (CFC) affected by superordinate goals (+), project rules and procedures (+), organizational procedures (ns), physical proximity (+), accessibility (ns); CFC affects perceived task outcome (+), psycho-social outcomes (+)
Rho et al. (1994)	Mfg-Mkt	Interface congruence	39 firms; Korea; industrial product manufacturers	Integration mechanisms affects interface congruence (+); interface congruence affects operating costs (+), quality (ns), NPD (+), delivery (+)
Rondeau et al. (2000)	General cross-functional	"Process of lending elements of organization into a united whole"	265 firms; USA; furnitures, metals, industrial equipment, electronics, transportation, instrument	Time-based mfg practices affects standardization (+), formalization (+), routinization (ns), integration (+); competitive capabilities affected by standardization (+), formalization (ns), routinization (ns), integration (+)
Rusinko (1999)	Mfg-R&D in NPD	Coordination	56 plants; USA; metals, machinery, electronics, transportation equipment, instrumentation	NPD performance affected by rewards (+), rotation (-), formalization (+), co-location (ns)
Sawhney & Piper (2002)	Mfg-Mkt	Information flow	Field study 10 firms, survey 74 plants; USA; PCB industry	Integration quality leads to defect rate (-), lateness of deliveries (-), cost (ns), lead-time (ns); integration speed leads to defect rate (-), lateness of deliveries (-), cost (ns), lead time (-)
Sherman (2004)	Mfg-R&D (CE) in NPD	Coordination	24 projects in three phases (responses from 631-708 engineers); USA; defense offices and research labs	Use of integration mechanisms did not reduce coordinating problems significantly
Sherman et al. (2000)	Mfg-R&D (also R&D-Mkt/ customer/ supplier) in NPD	Info processing	65 firms; Scandinavia; high-tech industries	Integration → cycle time reduction (+)
Song & Montoya-Weiss (2001)	General cross-functional in NPD	Magnitude of interaction and communication, info sharing, coordination, joint involvement	533 projects; JPN	Technological uncertainty moderates the relationships between integration and marketing proficiency, marketing intelligence, technical proficiency, financial performance
Song et al. (1997)	Mfg, R&D, and Mkt in NPD	Cooperation, coordination of behavior	598 responses (122 mfg, 185 mkt, 291 R&D); various countries; high-tech industries	Integration affects NPD performance (+); integration affected by internal facilitators (+) and external forces (ns)
Song & Parry (1997)	Mfg, R&D, and Mkt in NPD	Level of unity of effort	788 Japanese , 612 US projects (716 firms); various industries	Integration → proficiency in all stages of the NPD process (+) in Japan and USA
Song et al. (1998)	Mfg, R&D, and Mkt in NPD	Coordination, joint involvement	256 responses in 16 firms (68 mfg, 93 mkt, 95 R&D); USA; various industries	Integration leads to new product effectiveness (+/-/ns), integration leads to new product efficiency (+/-/ns), stage of NPD project moderates the relationships

Song & Xie (2000)	Mfg, R&D, and Mkt in NPD	The level of unity in effort, info sharing	788 Japanese, 612 US projects; various industries	Integration affects new product performance (+), product innovation moderates the relationships (+/-)
Spencer & Cox (1994)	Mfg-Mkt	Information sharing, harmonizing	3 firms; USA; computer, window covering, computer modem	Type and nature of competition affects integration
StJohn & Rue (1991)	Mfg-Mkt	Consensus	15 firms; USA; carpet industry	Consensus affects performance (+); consensus affected by hierarchy (ns), rules (ns), planning (+), meetings (ns), liaison roles (ns), task forces (ns)
St.John et al. (1999)	Mfg-Mkt	Coordination, actions taken to achieve cohesion	48 firms (54 mfg, 73 mkt managers); international; various industries	International strategy affects conflict (ns); strategy affects pattern of integration mechanisms (more complex strategies → more complex mechanisms used)
Swink (1999)	Mfg-R&D in NPD (also supplier integration)	Coordination of timing and substance	91 NPD projects; USA; various discrete, fabricated and assembled products industries	Integration affects new product manufacturability (+); integration moderates the relationship technological uncertainty - new product manufacturability (+)
Swink (2000)	Mfg-Mkt in NPD	Coordination of timing and substance	136 NPD projects; USA; various manufacturing industries	Integration affects NPD time goal achievement (ns), NPD quality goal achievement (+), NPD financial goal achievement (ns); moderating effect of new product technological innovativeness on integration - NPD goal achievement: time (+), quality (ns), financial (ns)
Swink (2002)	Mfg-R&D in NPD	Coordination	130 NPD projects; USA; various manufacturing industries	On-time performance affected by cross-functional teams (ns), IT (ns), co-location (ns)
Swink & Calantone (2004)	Mfg-R&D in NPD	Methods for knowledge sharing	137 NPD projects; USA; various manufacturing industries	Integration affects quality (+), integration mediates the effect of technology novelty and product org. complexity on quality
Swink & Nair (2006)	Mfg-R&D	Communication of mfg knowledge to R&D, cooperation, use of integration mechanisms	224 plants; USA; various discrete and assembled product industries	Integration moderates the relationship between process AMT on cost efficiency (-), quality (+), delivery (+), product flexibility (ns), process flexibility (+); and planning AMT on cost efficiency (-), quality (ns), delivery (ns); process flexibility (ns), product flexibility (+)
Swink et al. (2005)	Mfg-R&D (also supplier, strategy)	Interaction, collaboration	57 plants; USA; various industries	Integration leads to cost efficiency (+), process flexibility (+), new product flexibility (+); relationship between integration and new product flexibility moderated by strategic integration
Swink et al. (2007)	Product-process technology in plant (also strategy, customer, supplier)	A process including activities that acquire, share and consolidate strategic knowledge and information	224 plants; USA; discrete and assembled product industries	Integration affects market performance (-), customer satisfaction (ns), cost efficiency (ns), quality (+), delivery (ns), process flexibility (ns), new product flexibility (+)

Swink & Song (2007)	Mfg-Mkt in NPD	Coordination of timing and substance	467 NPD projects; USA; various industries	Integration affects competitive advantage (+) and project length (+/ns)
Swink et al. (2006)	Mfg-R&D in NPD	Collaboration	137 NPD projects; USA; various industries	Integration affects project efficiency (ns)
Takeutchi & Nonaka (1984)	General cross-functional in NPD	No explicit definition (cross-functional teams)	Various industry examples	Discuss the importance of cross-functional teams and other cross-functional approaches and how essential they are for all firms
Tan & Vonderembse (2006)	Mfg-R&D (CE) in NPD	Info sharing	240 firms; USA; plastics, metal, industrial machinery, transportation, instruments	CE affects CAD usage (+); CE affects product development performance (+)
Tatikonda & Montoya-Weiss (2001)	Mfg-Mkt in NPD	Info processing, process formality, concurrency, adaptability	120 projects (57 firms); USA; assembled goods	Concurrency affects quality (+), cost (+), time-to-market (+); formality affects quality (+), cost (ns), time-to-market (+); adaptability affects quality (+), cost (ns), time-to-market (+); technological uncertainty did not moderate the relationships
Vandevelde & Van Dierdonck (2003)	Mfg-R&D in NPD	Coordination	53 firms; various industries	Formalization affects smooth production start up (+)
Whybark (1994)	Mfg-Mkt	Marketing influence on manufacturing	375 firms; USA, Europe, Asia; machine, textile	Stage and activity affect level of integration; customer closeness affects level of integration (+)

APPENDIX B:
DESCRIPTIVE STATISTICS

Item Descriptive Statistics for Multi-item Scales

	Mean	Median	SD	Min	Max	Skew	Kurt	N
Achieved integration								
AI1	5.335	5.333	0.741	2.000	7.000	-0.890	1.506	234
AI2	4.989	5.000	0.884	1.000	7.000	-0.898	1.753	234
AI3	5.232	5.333	0.740	3.000	6.667	-0.649	0.246	234
AI4	5.317	5.333	0.713	3.333	7.000	-0.589	0.012	234
AI5	5.373	5.333	0.676	3.000	6.667	-0.669	0.678	234
AI6	5.433	5.583	0.731	2.667	7.000	-0.716	0.812	234
Requisite integration								
RI1	5.682	5.667	0.739	2.333	7.000	-0.886	1.636	233
RI2	5.946	6.000	0.823	3.000	7.000	-1.244	1.591	234
RI3	3.322	3.275	1.253	1.125	6.583	0.339	-0.874	236
Centralization								
CE1	3.228	3.250	0.934	1.000	5.625	0.183	-0.508	236
CE2	3.568	3.542	0.688	1.000	5.667	-0.204	0.533	236
CE3	3.052	2.963	0.983	1.250	5.917	0.325	-0.381	236
CE4	3.561	3.588	0.966	1.500	5.713	-0.081	-0.839	236
Job rotation								
JR1	3.324	3.333	1.269	1.000	6.667	0.419	-0.655	234
JR2	3.983	4.000	1.162	1.000	7.000	0.234	-0.432	234
JR3	4.822	5.000	1.167	1.667	7.000	-0.380	-0.386	234
JR4	4.535	4.667	1.078	2.000	7.000	-0.220	-0.553	234
Product modularity								
MO1	4.481	4.500	1.206	1.000	6.667	-0.323	-0.459	234
MO2	4.884	5.000	1.022	1.000	7.000	-0.483	0.255	235
MO3	4.522	4.667	1.185	1.000	7.000	-0.459	-0.063	235
MO4	4.787	5.000	1.055	1.000	7.000	-0.693	0.569	235
MO5	4.727	5.000	1.194	1.500	6.667	-0.523	-0.438	235
Introduction of new technology								
NT1	4.739	4.667	1.078	1.500	7.000	-0.483	-0.199	234
NT2	5.465	5.667	0.787	2.667	7.000	-0.853	1.097	234
NT3	5.053	5.000	1.036	2.000	7.000	-0.454	0.009	234
NT4	5.178	5.333	0.919	2.667	7.000	-0.501	-0.092	234

Construct Descriptive Statistics

	Mean	Median	SD	Min	Max	Skew	Kurt	N
Integration constructs								
Achieved integration	0.000	0.142	0.958	-3.830	2.223	-0.689	0.814	234
Requisite integration	0.000	0.026	1.000	-2.849	2.108	-0.404	-0.235	233
Integration mechanisms								
Centralization	0.000	0.050	1.000	-2.294	2.867	-0.003	-0.548	236
Info systems	0.000	0.230	1.000	-2.465	1.128	-0.693	-0.236	211
Job rotation	0.000	-0.023	1.000	-2.429	2.619	0.068	-0.298	234
Teams	0.000	0.137	1.000	-3.280	1.935	-0.555	0.158	235
Contingencies								
Customization	3.634	3.667	0.712	1.500	5.000	-0.578	0.041	234
Product modularization	0.000	0.076	1.000	-2.920	2.352	-0.281	-0.232	234
New technology	0.000	0.039	1.000	-2.986	2.050	-0.444	0.105	234
New products	59.185	67.500	30.428	0.000	100.0	-0.255	-1.273	186
Interdepend-ence	0.435	0.000	0.497	0.000	1.000	0.264	-1.950	200
Control variables								
Plant size	6.009	5.914	1.001	3.932	10.64	0.903	1.830	201
Plant age	41.513	37.000	28.086	4.000	180.0	1.879	5.469	197
Plant market share	25.755	20.000	20.657	0.500	100.0	1.228	1.469	190
Value chain position	3.326	3.000	1.777	1.000	6.000	0.227	-1.411	186

APPENDIX C:
RESULTS OF ORDINAL REGRESSION FOR THE PERFORMANCE MODEL (PROPOSITION 1)

Unit Costs

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.447	0.178	6.330	0.012
	Market share	0.013	0.008	3.018	0.082
	AUT	-0.985	0.707	1.941	0.164
	FIN	-0.390	0.576	0.459	0.498
	GER	-1.078	0.555	3.777	0.052
	ITA	-1.620	0.599	7.320	0.007
	JPN	-0.752	0.577	1.698	0.192
	KOR	-0.922	0.881	1.094	0.295
	SWE	-0.629	0.608	1.068	0.301
	USA	0 [a]			
	Electronics	0.233	0.376	0.386	0.535
	Machinery	0.028	0.365	0.006	0.939
	Transportation	0 [a]			
	Achieved Integration	0.620	0.171	13.105	0.000

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	426.540			
Final	388.729	37.812	12	0.000

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	388.729			
General	330.582	58.147	36	0.011

Product Capability and Performance

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.300	0.185	2.643	0.104
	Market share	0.011	0.008	1.744	0.187
	AUT	-1.096	0.741	2.190	0.139
	FIN	-0.469	0.599	0.613	0.434
	GER	-0.544	0.571	0.909	0.340
	ITA	0.536	0.599	0.799	0.371
	JPN	0.118	0.597	0.039	0.843
	KOR	-0.505	0.967	0.273	0.601
	SWE	0.378	0.633	0.356	0.551
	USA	0 [a]			
	Electronics	0.306	0.385	0.631	0.427
	Machinery	-0.786	0.382	4.237	0.040
	Transportation	0 [a]			
	Achieved Integration	0.166	0.168	0.979	0.161

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	369.025			
Final	344.644	24.381	12	0.018

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	344.644			
General	290.550	54.094	24	0.000

Conformance Quality

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.141	0.180	0.611	0.434
	Market share	0.002	0.008	0.081	0.776
	AUT	-1.456	0.739	3.880	0.049
	FIN	-0.384	0.592	0.421	0.516
	GER	-0.789	0.570	1.917	0.166
	ITA	-0.481	0.600	0.645	0.422
	JPN	-0.879	0.599	2.152	0.142
	KOR	0.433	0.895	0.234	0.629
	SWE	-0.817	0.629	1.685	0.194
	USA	0 [a]			
	Electronics	0.229	0.385	0.354	0.552
	Machinery	-0.114	0.374	0.093	0.760
	Transportation	0 [a]			
	Achieved Integration	0.351	0.169	4.346	0.019

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	356.292			
Final	342.842	13.449	12	0.337

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	342.842			
General	288.134	54.709	24	0.000

Development Lead Time

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.159	0.174	0.836	0.360
	Market share	0.002	0.008	0.065	0.799
	AUT	-0.042	0.695	0.004	0.951
	FIN	0.098	0.566	0.030	0.862
	GER	-0.110	0.539	0.041	0.839
	ITA	0.311	0.574	0.293	0.588
	JPN	-0.257	0.568	0.205	0.651
	KOR	0.643	0.906	0.504	0.478
	SWE	0.848	0.595	2.030	0.154
	USA	0 [a]			
	Electronics	-0.079	0.366	0.047	0.828
	Machinery	-0.243	0.358	0.459	0.498
	Transportation	0 [a]			
	Achieved Integration	0.288	0.161	3.191	0.037

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	443.877			
Final	431.316	12.561	12	0.402

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	431.316			
General	387.264	44.052	36	0.168

On-time Product Launch

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.219	0.178	1.513	0.219
	Market share	0.003	0.008	0.143	0.705
	AUT	0.537	0.711	0.570	0.450
	FIN	0.544	0.599	0.824	0.364
	GER	-0.113	0.554	0.042	0.838
	ITA	1.166	0.590	3.907	0.048
	JPN	-0.054	0.581	0.009	0.926
	KOR	1.212	0.933	1.687	0.194
	SWE	0.929	0.613	2.300	0.129
	USA	0 [a]			
	Electronics	0.490	0.383	1.632	0.201
	Machinery	0.073	0.368	0.039	0.843
	Transportation	0 [a]			
	Achieved Integration	0.450	0.167	7.230	0.004

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	407.865			
Final	380.521	27.344	12	0.007

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	380.521			
General	313.615	66.907	36	0.001

Volume Flexibility

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.000	0.180	0.000	0.999
	Market share	0.003	0.008	0.154	0.695
	AUT	0.936	0.739	1.603	0.206
	FIN	1.275	0.603	4.467	0.035
	GER	-0.031	0.572	0.003	0.957
	ITA	1.253	0.610	4.220	0.040
	JPN	0.737	0.601	1.500	0.221
	KOR	1.246	0.910	1.877	0.171
	SWE	1.202	0.632	3.615	0.057
	USA	0 [a]			
	Electronics	-0.218	0.386	0.319	0.572
	Machinery	0.072	0.374	0.037	0.848
	Transportation	0 [a]			
	Achieved Integration	0.749	0.176	18.066	0.000

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	383.648			
Final	352.047	31.601	12	0.002

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	352.047			
General	320.060	31.988	36	0.660

Design Flexibility

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.187	0.184	1.023	0.312
	Market share	0.015	0.008	3.143	0.076
	AUT	0.456	0.750	0.368	0.544
	FIN	0.447	0.608	0.539	0.463
	GER	-0.257	0.581	0.196	0.658
	ITA	0.113	0.616	0.033	0.855
	JPN	0.960	0.613	2.452	0.117
	KOR	1.131	0.979	1.336	0.248
	SWE	0.456	0.640	0.506	0.477
	USA	0 [a]			
	Electronics	-0.227	0.392	0.335	0.563
	Machinery	-0.016	0.381	0.002	0.966
	Transportation	0 [a]			
	Achieved Integration	0.342	0.172	3.959	0.023

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	345.896			
Final	332.412	13.484	12	0.335

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	332.412			
General	300.120	32.292	24	0.120

Product Innovation

Parameter Estimates

		Estimate	Std. Error	Wald	p-value
Location	Size	0.529	0.178	8.796	0.003
	Market share	0.020	0.008	6.635	0.010
	AUT	-0.762	0.703	1.174	0.279
	FIN	-0.184	0.584	0.099	0.753
	GER	-0.624	0.547	1.301	0.254
	ITA	-0.333	0.576	0.335	0.563
	JPN	0.619	0.573	1.167	0.280
	KOR	0.993	0.871	1.299	0.254
	SWE	-0.421	0.601	0.491	0.484
	USA	0 [a]			
	Electronics	-0.769	0.378	4.124	0.042
	Machinery	-0.923	0.368	6.296	0.012
	Transportation	0 [a]			
	Achieved Integration	0.104	0.161	0.413	0.260

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	p-value
Intercept Only	426.397			
Final	400.789	25.609	12	0.012

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	p-value
Null Hypothesis	400.789			
General	367.961	32.828	36	0.620

APPENDIX D:
RESULTS OF MULTIPLE REGRESSION ANALYSIS FOR THE MEDIATION MODEL (PROPOSITION 2)

Requisite integration – Centralization

Tests of Between-Subjects Effects

Dependent Variable: Centralization

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	84.229	12	7.019	12.498	0.000	0.482	1.000
Intercept	0.682	1	0.682	1.214	0.272	0.007	0.195
Size	0.808	1	0.808	1.438	0.232	0.009	0.222
Age	0.080	1	0.080	0.142	0.707	0.001	0.066
Country	51.081	1	7.297	12.994	0.000	0.361	1.000
Industry	0.122	1	0.061	0.109	0.897	0.001	0.066
Requisite Integration	2.489	1	2.489	4.432	0.018	0.027	0.553
Error	90.420	161	0.562				
Total	175.743	174					
Corrected Total	174.649	173					

R Squared = 0.482 (Adjusted R Squared = 0.444)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Centralization

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	0.462	0.462	0.998	0.320	0.006	0.168
Size	-0.082	0.069	-1.199	0.232	0.009	0.222
Age	-0.001	0.002	-0.377	0.707	0.001	0.066
AUT	-0.633	0.281	-2.257	0.025	0.031	0.612
FIN	-0.708	0.234	-3.021	0.003	0.054	0.852
GER	-0.393	0.235	-1.671	0.097	0.017	0.383
ITA	0.708	0.230	3.075	0.002	0.055	0.864
JPN	0.853	0.232	3.670	0.000	0.077	0.954
KOR	0.894	0.312	2.868	0.005	0.049	0.814
SWE	-0.546	0.256	-2.133	0.034	0.027	0.564
USA	0[b]					
Electronics	-0.062	0.144	-0.433	0.665	0.001	0.072
Machinery	-0.011	0.147	-0.075	0.940	0.000	0.051
Transportation	0[b]					
Requisite Integration	-0.135	0.064	-2.105	0.018	0.027	0.553

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Requisite integration – Information Systems (Ordinal regression)

Parameter Estimates

Location		B	Std. Error	Wald	p-value
	Size	0.501	0.183	7.510	0.006
	Age	-0.004	0.006	0.368	0.544
	AUT	-0.748	0.721	1.076	0.300
	FIN	-0.192	0.585	0.107	0.743
	GER	-1.352	0.607	4.965	0.026
	ITA	-1.217	0.598	4.145	0.042
	JPN	0.382	0.618	0.382	0.536
	KOR	2.636	0.826	10.190	0.001
	SWE	0.385	0.647	0.355	0.551
	USA	0[a]			
	Electronics	-0.023	0.362	0.004	0.950
	Machinery	0.315	0.386	0.669	0.413
	Transportation	0[a]			
	Requisite Integration	-0.013	0.163	0.007	0.467

Link function: Logit.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	DF	p-value
Intercept Only	448.135			
Final	410.900	37.235	12	0.000

Link function: Logit.

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	DF	p-value
Null Hypothesis	410.900			
General	296.459	114.441	36	0.000

Requisite integration – Job Rotation

Tests of Between-Subjects Effects

Dependent Variable: Job rotation

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	56.479	12	4.707	6.011	0.000	0.309	1.000
Intercept	7.363	1	7.363	9.404	0.003	0.055	0.862
Size	6.547	1	6.547	8.362	0.004	0.049	0.820
Age	0.406	1	0.406	0.518	0.473	0.003	0.110
Country	25.930	7	3.704	4.731	0.000	0.171	0.994
Industry	1.516	2	0.758	0.968	0.382	0.012	0.216
Requisite Integration	6.815	1	6.815	8.704	0.002	0.051	0.835
Error	126.055	161	0.783				
Total	182.565	174					
Corrected Total	182.533	173					

R Squared = .309 (Adjusted R Squared = .258)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Job rotation

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	-1.093	0.546	-2.001	0.047	0.024	0.512
Size	0.234	0.081	2.892	0.004	0.049	0.820
Age	0.002	0.003	0.720	0.473	0.003	0.110
AUT	-0.170	0.331	-0.513	0.609	0.002	0.080
FIN	-0.590	0.277	-2.134	0.034	0.027	0.564
GER	-0.679	0.278	-2.442	0.016	0.036	0.680
ITA	-1.078	0.272	-3.964	0.000	0.089	0.976
JPN	0.110	0.274	0.401	0.689	0.001	0.068
KOR	-0.338	0.368	-0.917	0.360	0.005	0.149
SWE	-0.865	0.302	-2.862	0.005	0.048	0.812
USA	0[b]					
Electronics	0.166	0.170	0.975	0.331	0.006	0.163
Machinery	-0.061	0.174	-0.349	0.728	0.001	0.064
Transportation	0[b]					
Requisite Integration	0.223	0.076	2.950	0.002	0.051	0.835

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Requisite integration – Cross-functional Teams

Tests of Between-Subjects Effects

Dependent Variable: Cross-functional teams

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	18.185	12	1.515	1.814	0.050	0.119	0.874
Intercept	2.066	1	2.066	2.474	0.118	0.015	0.346
Size	2.924	1	2.924	3.501	0.063	0.021	0.460
Age	1.032	1	1.032	1.235	0.268	0.008	0.197
Country	4.506	7	0.644	0.771	0.613	0.032	0.325
Industry	2.971	2	1.485	1.778	0.172	0.022	0.368
Requisite Integration	4.115	1	4.115	4.926	0.014	0.030	0.597
Error	134.474	161	0.835				
Total	152.747	174					
Corrected Total	152.659	173					

R Squared = .119 (Adjusted R Squared = .053)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Cross-functional teams

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	-0.884	0.564	-1.568	0.119	0.015	0.344
Size	0.157	0.084	1.871	0.063	0.021	0.460
Age	-0.003	0.003	-1.111	0.268	0.008	0.197
AUT	0.292	0.342	0.854	0.394	0.005	0.136
FIN	-0.016	0.286	-0.055	0.956	0.000	0.050
GER	0.114	0.287	0.396	0.693	0.001	0.068
ITA	-0.218	0.281	-0.778	0.438	0.004	0.121
JPN	-0.146	0.283	-0.516	0.606	0.002	0.081
KOR	-0.187	0.380	-0.491	0.624	0.001	0.078
SWE	0.301	0.312	0.963	0.337	0.006	0.160
USA	0[b]					
Electronics	0.254	0.175	1.451	0.149	0.013	0.303
Machinery	-0.051	0.179	-0.286	0.775	0.001	0.059
Transportation	0[b]					
Requisite Integration	0.173	0.078	2.220	0.014	0.030	0.597

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Model 1: No Mediation

Tests of Between-Subjects Effects

Dependent Variable: Achieved Integration

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	31.980	12	2.665	4.027	0.000	0.231	0.999
Intercept	0.328	1	0.328	0.496	0.482	0.003	0.108
Size	0.251	1	0.251	0.379	0.539	0.002	0.094
Age	0.696	1	0.696	1.052	0.307	0.006	0.175
Country	11.674	7	1.668	2.520	0.017	0.099	0.871
Industry	3.222	2	1.611	2.434	0.091	0.029	0.485
Requisite Integration	22.169	1	22.169	33.496	0.000	0.172	1.000
Error	106.559	161	0.662				
Total	139.481	174					
Corrected Total	138.539	173					

R Squared = .231 (Adjusted R Squared = .174)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Achieved Integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	-0.169	0.502	-0.336	0.737	0.001	0.063
Size	0.046	0.075	0.615	0.539	0.002	0.094
Age	0.002	0.002	1.026	0.307	0.006	0.175
AUT	-0.041	0.305	-0.133	0.894	0.000	0.052
FIN	-0.300	0.254	-1.180	0.240	0.009	0.217
GER	-0.415	0.256	-1.626	0.106	0.016	0.366
ITA	0.125	0.250	0.500	0.618	0.002	0.079
JPN	0.423	0.252	1.678	0.095	0.017	0.385
KOR	0.550	0.339	1.624	0.106	0.016	0.365
SWE	-0.261	0.278	-0.941	0.348	0.005	0.155
USA	0[b]					
Electronics	-0.131	0.156	-0.842	0.401	0.004	0.133
Machinery	-0.348	0.160	-2.182	0.031	0.029	0.583
Transportation	0[b]					
Requisite Integration	0.403	0.070	5.788	0.000	0.172	1.000

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Model 2: Partial Mediation

Tests of Between-Subjects Effects

Dependent Variable: Achieved Integration

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	52.129	16	3.258	6.135	0.000	0.402	1.000
Intercept	0.186	1	0.186	0.350	0.555	0.002	0.090
Size	0.396	1	0.396	0.746	0.389	0.005	0.138
Age	1.308	1	1.308	2.463	0.119	0.017	0.344
Country	15.073	7	2.153	4.054	0.000	0.163	0.984
Industry	2.719	2	1.360	2.560	0.081	0.034	0.505
Requisite Integration	13.393	1	13.393	25.217	0.000	0.147	0.999
Centralization	2.444	1	2.444	4.603	0.017	0.031	0.568
Info Systems	0.088	1	0.088	0.166	0.342	0.001	0.069
Job Rotation	1.088	1	1.088	2.048	0.077	0.014	0.296
Cross-functional Teams	10.432	1	10.432	19.642	0.000	0.119	0.993
Error	77.540	146	0.531				
Total	130.258	163					
Corrected Total	129.669	162					

R Squared = .402 (Adjusted R Squared = .336)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Achieved Integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	0.424	0.483	0.878	0.381	0.005	0.141
Size	-0.064	0.075	-0.864	0.389	0.005	0.138
Age	0.004	0.002	1.569	0.119	0.017	0.344
AUT	-0.326	0.294	-1.110	0.269	0.008	0.197
FIN	-0.408	0.248	-1.645	0.102	0.018	0.372
GER	-0.502	0.249	-2.020	0.045	0.027	0.519
ITA	0.349	0.253	1.379	0.170	0.013	0.278
JPN	0.584	0.255	2.290	0.023	0.035	0.624
KOR	0.880	0.331	2.659	0.009	0.046	0.752
SWE	-0.387	0.275	-1.408	0.161	0.013	0.288
USA	0[b]					
Electronics	-0.210	0.144	-1.455	0.148	0.014	0.304
Machinery	-0.340	0.152	-2.230	0.027	0.033	0.601
Transportation	0[b]					
Requisite Integration	0.335	0.067	5.022	0.000	0.147	0.999
Centralization	-0.177	0.082	-2.145	0.017	0.031	0.568
Info Systems	0.029	0.070	0.407	0.342	0.001	0.069
Job Rotation	0.100	0.069	1.431	0.077	0.014	0.296
Cross-functional Teams	0.298	0.067	4.432	0.000	0.119	0.993

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Model 3: Full Mediation

Tests of Between-Subjects Effects

Dependent Variable: Achieved Integration

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	38.510	15	2.567	4.155	0.000	0.296	1.000
Intercept	0.021	1	0.021	0.035	0.853	0.000	0.054
Size	0.088	1	0.088	0.142	0.707	0.001	0.066
Age	1.070	1	1.070	1.732	0.190	0.012	0.258
Country	10.693	7	1.528	2.472	0.020	0.105	0.862
Industry	1.539	2	0.769	1.245	0.291	0.017	0.268
Centralization	3.689	1	3.689	5.970	0.008	0.039	0.680
Info Systems	0.057	1	0.057	0.092	0.381	0.001	0.060
Job Rotation	2.542	1	2.542	4.114	0.022	0.027	0.522
Cross-functional Teams	13.505	1	13.505	21.857	0.000	0.129	0.996
Error	91.445	148	0.618				
Total	130.484	164					
Corrected Total	129.955	163					

R Squared = .296 (Adjusted R Squared = .225)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Achieved Integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	0.220	0.519	0.423	0.673	0.001	0.070
Size	-0.030	0.080	-0.376	0.707	0.001	0.066
Age	0.003	0.003	1.316	0.190	0.012	0.258
AUT	-0.161	0.315	-0.511	0.610	0.002	0.080
FIN	-0.270	0.266	-1.015	0.312	0.007	0.172
GER	-0.380	0.267	-1.424	0.156	0.014	0.293
ITA	0.392	0.273	1.437	0.153	0.014	0.298
JPN	0.415	0.273	1.521	0.130	0.015	0.327
KOR	0.529	0.349	1.516	0.132	0.015	0.325
SWE	-0.456	0.292	-1.559	0.121	0.016	0.341
USA	0[b]					
Electronics	-0.167	0.155	-1.078	0.283	0.008	0.188
Machinery	-0.250	0.162	-1.540	0.126	0.016	0.334
Transportation	0[b]					
Centralization	-0.216	0.088	-2.443	0.008	0.039	0.680
Info Systems	0.023	0.076	0.303	0.381	0.001	0.060
Job Rotation	0.150	0.074	2.028	0.022	0.027	0.522
Cross-functional Teams	0.335	0.072	4.675	0.000	0.129	0.996

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Model 4: Mediation Model of Job Rotation

Tests of Between-Subjects Effects

Dependent Variable: Achieved Integration

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	35.997	13	2.769	4.321	0.000	0.260	1.000
Intercept	0.007	1	0.007	0.012	0.914	0.000	0.051
Size	0.002	1	0.002	0.003	0.957	0.000	0.050
Age	0.518	1	0.518	0.808	0.370	0.005	0.145
Country	9.880	7	1.411	2.202	0.037	0.088	0.813
Industry	2.958	2	1.479	2.308	0.103	0.028	0.463
Requisite Integration	17.075	1	17.075	26.643	0.000	0.143	0.999
Job Rotation	4.017	1	4.017	6.269	0.007	0.038	0.701
Error	102.542	160	0.641				
Total	139.481	174					
Corrected Total	138.539	173					

R Squared = .260 (Adjusted R Squared = .200)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Achieved Integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	0.026	0.500	0.053	0.958	0.000	0.050
Size	0.004	0.075	0.053	0.957	0.000	0.050
Age	0.002	0.002	0.899	0.370	0.005	0.145
AUT	-0.010	0.300	-0.034	0.973	0.000	0.050
FIN	-0.195	0.254	-0.768	0.444	0.004	0.119
GER	-0.294	0.256	-1.149	0.252	0.008	0.208
ITA	0.317	0.258	1.231	0.220	0.009	0.232
JPN	0.404	0.248	1.625	0.106	0.016	0.365
KOR	0.610	0.334	1.826	0.070	0.020	0.443
SWE	-0.107	0.280	-0.382	0.703	0.001	0.067
USA	0[b]					
Electronics	-0.161	0.154	-1.045	0.298	0.007	0.180
Machinery	-0.338	0.157	-2.148	0.033	0.028	0.569
Transportation	0[b]					
Requisite Integration	0.363	0.070	5.162	0.000	0.143	0.999
Job Rotation	0.179	0.071	2.504	0.007	0.038	0.701

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

Model 5: Mediation Model of Cross-functional Teams

Tests of Between-Subjects Effects

Dependent Variable: Achieved Integration

Source	Type III Sum of Squares	DF	Mean Square	F	p-value	Partial Eta Squared	Observed power[a]
Corrected Model	49.936	13	3.841	6.936	0.000	0.360	1.000
Intercept	0.002	1	0.002	0.004	0.949	0.000	0.050
Size	0.015	1	0.015	0.027	0.869	0.000	0.053
Age	1.442	1	1.442	2.604	0.109	0.016	0.361
Country	15.170	7	2.167	3.913	0.001	0.146	0.980
Industry	2.947	2	1.474	2.661	0.073	0.032	0.522
Requisite Integration	15.271	1	15.271	27.577	0.000	0.147	0.999
Cross-functional Teams	17.956	1	17.956	32.425	0.000	0.169	1.000
Error	88.603	160	0.554				
Total	139.481	174					
Corrected Total	138.539	173					

R Squared = .360 (Adjusted R Squared = .308)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Achieved Integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	0.154	0.463	0.334	0.739	0.001	0.063
Size	-0.011	0.069	-0.165	0.869	0.000	0.053
Age	0.004	0.002	1.614	0.109	0.016	0.361
AUT	-0.147	0.279	-0.528	0.598	0.002	0.082
FIN	-0.294	0.233	-1.265	0.208	0.010	0.242
GER	-0.457	0.234	-1.954	0.052	0.023	0.493
ITA	0.205	0.229	0.893	0.373	0.005	0.144
JPN	0.477	0.231	2.064	0.041	0.026	0.537
KOR	0.618	0.310	1.994	0.048	0.024	0.509
SWE	-0.371	0.255	-1.456	0.147	0.013	0.305
USA	0[b]					
Electronics	-0.224	0.144	-1.562	0.120	0.015	0.342
Machinery	-0.330	0.146	-2.256	0.025	0.031	0.611
Transportation	0[b]					
Requisite Integration	0.339	0.065	5.251	0.000	0.147	0.999
Cross-functional Teams	0.365	0.064	5.694	0.000	0.169	1.000

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.

APPENDIX E:
RESULTS OF MULTIPLE REGRESSION ANALYSIS FOR THE REQUISITE INTEGRATION MODEL (PROPOSITION 3)

Tests of Between-Subjects Effects

Dependent Variable: Requisite integration

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[a]
Corrected Model	42.152	17	2.480	4.166	0.000	0.425	1.000
Intercept	2.376	1	2.376	3.993	0.048	0.040	0.507
Size	0.645	1	0.645	1.084	0.301	0.011	0.178
Age	0.041	1	0.041	0.068	0.795	0.001	0.058
Country	16.840	7	2.406	4.042	0.001	0.228	0.981
Industry	3.825	2	1.912	3.213	0.045	0.063	0.601
Value chain position	0.053	1	0.053	0.089	0.766	0.001	0.060
Customization of orders	2.258	1	2.258	3.795	0.027	0.038	0.487
Product modularity	0.227	1	0.227	0.382	0.269	0.004	0.094
Introduction of new technology	6.972	1	6.972	11.714	0.001	0.109	0.923
Introduction of new products	1.235	1	1.235	2.075	0.077	0.021	0.297
Task interdependence	0.644	1	0.644	1.082	0.150	0.011	0.178
Error	57.135	96	0.595				
Total	106.545	114					
Corrected Total	99.286	113					

R Squared = .425 (Adjusted R Squared = .323)

[a] Computed using $\alpha = 0.05$

Parameter Estimates

Dependent Variable: Riequisite integration

Parameter	B	Std. Error	t	p-value	Partial Eta Squared	Observed power[a]
Intercept	-1.698	0.858	-1.979	0.051	0.039	0.500
Size	0.112	0.108	1.041	0.301	0.011	0.178
Age	-0.001	0.003	-0.261	0.794	0.001	0.058
Value chain position	-0.016	0.052	-0.298	0.766	0.001	0.060
AUT	0.668	0.351	1.906	0.060	0.036	0.471
FIN	0.464	0.306	1.519	0.132	0.023	0.324
GER	0.244	0.307	0.795	0.428	0.007	0.124
ITA	0.201	0.299	0.670	0.504	0.005	0.102
JPN	-0.723	0.327	-2.208	0.030	0.048	0.589
KOR	-1.688	0.583	-2.894	0.005	0.080	0.817
SWE	-0.144	0.347	-0.415	0.679	0.002	0.070
USA	0[b]					
Electronics	-0.075	0.190	-0.396	0.693	0.002	0.0678
Machinery	0.392	0.198	1.982	0.050	0.039	0.501
Transportation	0[b]					
Customization of orders	0.257	0.132	1.948	0.027	0.038	0.487
Product modularity	-0.051	0.082	-0.618	0.269	0.004	0.094
Introduction of new technology	0.300	0.088	3.423	0.001	0.109	0.923
Introduction of new products	0.004	0.003	1.441	0.077	0.021	0.297
Task interdependence	0.166	0.160	1.040	0.150	0.011	0.178

[a] Computed using $\alpha = 0.05$

[b] This parameter is set to zero because it is redundant.