In Pursuit of Supplier Knowledge

Leveraging capabilities and dividing responsibilities
in product and service contexts

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Leveraging capabilities and dividing responsibilities

in product and service contexts

Op Jacht naar de Kennis van Leveranciers

Het uitnutten van kunde en verdelen van verantwoordelijkheden

in de context van producten en diensten

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Chapter 1. General Introduction

1.1. Motivation

When Boeing discovered that the design and customization of its aircraft seats was suffering from delays at its suppliers it decided to look elsewhere (Hepher, 2018). It found a new source of knowledge and capabilities in a manufacturer of car seats, Adient, and is now working together to improve the efficiency of both the design and delivery of enough aircraft seats to fulfill its outstanding orders. As another example, Airbnb has been urging their hosts (acting as service providers) to behave more like a hotel, in order to provide a more consistent customer experience (Benner, 2017). Hence, the newest addition to the hospitality industry is forcing its 'suppliers' to redesign at least part of the services they offer, because, as one guest puts it: "The big downside of using Airbnb instead of a hotel is the risk, because of the potential lack of consistency" (Benner, 2017, p. 4).

Organizations are vertically disintegrated compared to the early 1900s, when Ford, for example, was organized across all industry boundaries from mining, transportation, car manufacturing, to marketing/distribution (Langlois and Robertson, 1989). Following from the examples cited above, there is this emerging notion that companies become increasingly reliant on their network of partners in production and (continuous) innovation of products and services. Organizations that operate in this way do not possess all the relevant knowledge and capabilities themselves, that is, through individualized knowledge located in their employees' minds (Nonaka, 1994). Firms rely on the transfer of knowledge between

organizations for extending their own knowledge base (Gulati, 1999), which takes place by 'applying', 'integrating', or 're-combining' knowledge outside the firm (Grant and Baden-Fuller, 2004). Hence the cover of this dissertation.

Boeing today relies on its network of component, sub-system, and service providers for the design and production of its aircraft (Tang, Zimmerman, and Nelson 2009; cf. Jacobides, MacDuffie, and Tae 2016). These suppliers, therefore, become an important source of knowledge and capabilities that can be leveraged for (open) innovation and improvement of products or services (Lichtenthaler and Lichtenthaler, 2009; West and Bogers, 2014). In such an environment, managing innovation and quality relies on the knowledge and expertise of these suppliers and requires internal capabilities for managing the knowledge integration process effectively (e.g., Brusoni, Prencipe, and Pavitt 2001; Takeishi 2002; Grant and Baden-Fuller 2004; Cabigiosu, Zirpoli, and Camuffo 2013).

The main objective of this dissertation is therefore to advance our collective scholarly theorization and practical managerial understanding of inter-organizational knowledge integration between buyers and suppliers for the innovation and improvement of products and services. In three empirical studies described hereafter, I examine the effects of supplier knowledge integration in NPD projects, the various ways in which buying organizations employ supplier and internal knowledge in service purchasing processes, and the interplay of roles, responsibilities, and capabilities for the effective management of service triadic operations.

In this introductory chapter, I provide a brief overview of the fields of research to which this dissertation relates (purchasing and supply management, and innovation management) and the contexts in which this research takes place. Next, I introduce two theoretical perspectives on knowledge integration as a starting point for the theoretical and empirical work in this dissertation. Finally, I outline the

chapters of this dissertation that integrate these streams and provide an overview of the methodology, prior to concluding.

1.2. Background

The interface between a company and its suppliers of components, products, and services is the purchasing department, which therefore fulfills a boundary-spanning role for the (knowledge) interface between buyers and suppliers (Araujo et al., 2003; Brandon-Jones and Knoppen, 2018; van der Valk and Wynstra, 2014; Wynstra et al., 2000). Purchasing and supply management (PSM) therefore is "the design, initiation, control, and evaluation of processes within and between organizations, aimed at acquiring inputs from suppliers at the most favorable conditions" (van Raaij, 2016, p. 13; Wynstra, 2006, p. 17). Purchasing in practice and academia has moved from operational 'buying' to tactical 'procurement' and now into 'strategic sourcing' (Brandon-Jones and Knoppen, 2018; Cousins et al., 2008; Ellram and Carr, 1994). Under the strategic perspective, the purchasing function and activities need to be integrated with overall firm strategy and operationalized in a context of supply networks (Spina et al., 2013). According to the Purchasing Excellence Framework (or MSU+), one of the strategic functions of purchasing is *the integration of suppliers into the development of new products* [and services, red.] (see NEVI, 2002, p. 59 or Axelsson et al., 2005b, p. 5).

More generally, visual representations of purchasing processes from practice or academia start with the discovery and specification of a (tangible) business need, subsequently translated into purchasing specifications (Chen et al., 2017; van Weele, 2010). In this dissertation, I study questions related to who, how, when and what to define up-front and what role one or more suppliers can play in and during this process (Azadegan and Dooley, 2010; Hartley et al., 1997; Selviaridis et al., 2013; van der Valk and Rozemeijer, 2009; Wynstra et al., 2012). This specification stage is critical for the successful development of new products and services, but

relies heavily on access to external know-how and know-about (Kogut and Zander, 1992).

Innovation, on the other hand, is defined as 'the development and implementation of new ideas', in particular, over time, by people, and in an institutional context (Van de Ven, 1986, p. 590). Innovation often takes place by, and is represented in, multiple, interdependent, partially overlapping, but linearly progressing stages of e.g., new product development, —see for example Figure 2.1 in Chapter 2—as in Handfield et al. (1999) or in the Stage-Gate® process (Cooper, 2008). Such linearly progressing models of NPD are typically employed in the supplier involvement literature to date to conceptualize the progression of time over the course of the project, but other, non-linear and iterative, models may better represent complex reality. Linear models, for present purposes, highlight that suppliers can be involved during any of the phases of product development—and hence for different purposes (Monczka et al., 2000). For example, involving suppliers in idea generation can lead to new and fresh ideas for innovation processes (Bidault et al., 1998a), whereas involving suppliers in technical assessment may lead to the early discovery of (potential) manufacturing issues (Swink, 1999).

The intersection of these two fields of research provides a meaningful starting point to investigate the integration of supplier knowledge in product and service development. Specifically, as innovation changes product or service designs, purchasing of new materials, components, or suppliers from (potentially new) suppliers is required. Furthermore, supplier relationships can be leveraged for innovation through joint projects and other forms of collaboration (Bidault et al., 1998a; Monczka et al., 2000). This has led some to argue for early involvement of suppliers and purchasing personnel specifically in new product development (LaBahn and Krapfel, 2000; Lakemond et al., 2001; Mikkelsen and Johnsen, 2018; Parker et al., 2008; Wynstra, 1998). In other words, purchasing becomes a

boundary-spanning actor for the efficient and effective development of new products, by bridging and connecting internal and external parties.

While much research has been conducted to investigate the effects of supplier involvement on new product development performance, the concepts are scattered and the evidence is mixed (Eisenhardt and Tabrizi, 1995; Hartley et al., 1997; Johnsen, 2009). Therefore, the first contribution of this dissertation is a structured literature review and meta-analysis of the literature, to unravel supplier involvement and its effects on new product development efficiency and effectiveness, in *Chapter 2*. The literature on supplier integration in new product development is sufficiently abundant for a structured review, but this is not the case outside the traditionally investigated (assembly-based) manufacturing industries, such as automotive and electronics.

Therefore, the context of supplier integration is a second gap in the literature that we (empirically) address. Research about supplier knowledge integration in the development of *services* is scant (Holmlund et al., 2016; Sampson and Spring, 2012a). However, services contribute more than 80% to GDP in advanced industrial countries and most employees effectively work in service organizations (The World Bank, 2015; Wynstra et al., 2017). Given the lack of scholarly attention for the role and capabilities of suppliers in purchasing and innovating services, I conduct two exploratory investigations into supplier knowledge integration in the development and sourcing of business services. Business services are exchanged between organizations, hence, between a service provider and a business customer (Axelsson and Wynstra, 2002). Buying business services is complex because purchasers often lack specific 'sourcing' capabilities and may 'know less than they buy' (Axelsson et al., 2005a; Flowers, 2007; Hendry, 2002). These services can be purchased for the internal use by the business customer itself, such as cleaning services (*Chapter 3*) or for the purpose of end-customers/consumers in service triads, such as catering

at university campuses (*Chapter 4)*, see Wynstra, Axelsson, and van der Valk 2006; Wynstra, Spring, and Schoenherr 2015.

1.3. Theoretical perspectives

Each chapter in this dissertation builds upon its own distinct literature and theories, which are introduced in each chapter separately (and outlined in more detail below). In this introductory chapter, I review two theoretical perspectives to set the scope of my research and introduce some important concepts that emerge from the literature on knowledge integration.

The Knowledge-Based View highlights that knowledge is a firm's most precious resource (Grant, 1996; Nonaka, 1994) and relatedly, that firms build alliances, such as joint buyer-supplier product development, to apply diverse knowledge bases for the creation of new products, services, and processes (Grant and Baden-Fuller, 2004). Knowledge includes knowing how (or know-how) and knowing about (or information), is additive and can therefore be aggregated, and is a valuable source for production (Grant, 1996; Kogut and Zander, 1992). While the creation of knowledge is individual, the application of knowledge for the design, development, and production of products and services is a collective activity that is often embedded in *(intra-)*organizational forms (Grant, 1996; Kogut and Zander, 1992) and is further strengthened by *inter*-organizational social interaction (Nonaka, 1994). In summary, the development of (new) products and services depends critically on accessing and applying existing knowledge through the recombination of both internal and external knowledge bases.

Building on the dynamic capabilities view, we can also understand knowledge integration from suppliers through the lens of two distinct, yet related, capabilities (Amit and Schoemaker, 1993; Lichtenthaler and Lichtenthaler, 2009; West and Bogers, 2014). Dynamic capabilities are a firm's potential to adapt to changing environments, in particular through sensing and seizing opportunities (Barreto,

2010; Teece, 2007). Two dynamic capabilities for leveraging external sources of knowledge and innovation have been identified previously and are relevant here (Lichtenthaler and Lichtenthaler, 2009): absorptive capacity and connective capacity. First, absorptive capacity is the ability to expand the firm's knowledge base by acquiring or obtaining external knowledge, in our case: from suppliers (Cohen and Levinthal, 1990). Second, connective capacity is the ability to exploit and retain existing external knowledge through relationships, by controlling access to knowledge held by others, in our case: suppliers (Kogut and Zander, 1992; Lichtenthaler and Lichtenthaler, 2009; Loasby, 1998). Therefore, organizational capabilities for the integration of knowledge from suppliers have to be considered, in particular related to absorbing of and connecting to external knowledge.

A different perspective builds on the more practice-oriented literature on Purchasing and Supply Management. In particular, an early stream of research into supplier knowledge integration in new product development focusses on the development of (component) specifications (e.g., Clark, 1989; Liker et al., 1996). These studies, along with subsequent research, investigate the division of labor and task responsibilities for *product development* between a buyer and a supplier (Hartley et al., 1997; Takeishi, 2002; Wynstra et al., 2012). As described above, a purchasing process begins with the specification of (business) needs and a translation into purchasing requirements, which can be more functional or more technical, depending on the level of detail provided. Relatedly, the literature on task and knowledge partitioning focusses on the responsibilities for product development that have to be set in accordance with the division of knowledge between buyers and suppliers (Takeishi, 2002; von Hippel, 1990). Therefore, integrating knowledge from suppliers into the development of new products and services also concerns the appropriate division of responsibilities in the development process.

Before presenting the outline of the dissertation and the research questions related to each of the chapters, Table 1.1 provides the definitions of the key concepts investigated in this dissertation.

Table 1.1. The definitions of key concepts used in the dissertation.

CONCEPT	DEFINITION	REMARKS
Purchasing and Supply management	Design, initiation, control, and evaluation of activities within and between firms aimed at acquiring inputs from suppliers at the most favorable conditions (Van Raaij, 2016, p. 13).	Similar terms: sourcing, procurement, buying. For consistency, purchasing (and supply) management is used throughout.
Innovation (process)	The development and implementation of new ideas', in particular, over time, by people, an in and institutional context (Van de Ven, 1986, p. 590).	For example: new product development project, new service development process.
Supplier Involvement	The participation of suppliers in the buyer's process of developing a new product or service (cf. Handfield et al. 1999).	In chapter 2, we distinguish between the Extent and the Moment of Supplier Involvement.
Knowledge	Information (knowing what something means) and know-how (knowing how to do something) (Kogut and Zander, 1992, p. 386).	

Table 1.1 (continued).

CONCEPT	DEFINITION	REMARKS
Dynamic Capability	The firm's potential to (timely) adapt to changing environments or circumstances, through sensing and seizing opportunities and threats (Barreto, 2010, p. 271).	Effectively revolves around three distinct processes: to sense (explore) and to seize (exploit) opportunities, and to recombine existing resources (retain).
Absorptive Capacity	The ability of the firm to explore external sources of knowledge and innovation (Lichtenthaler and Lichtenthaler, 2009, p. 1319).	The focus is on the knowledge acquisition by the firm, i.e., the active transfer of knowledge between organizations.
Connective Capacity	The ability of the firm to retain knowledge in inter-organizational relationships (Lichtenthaler and Lichtenthaler, 2009, p. 1320).	The focus is on the application of knowledge through the re-combination of (mostly existing) knowledge bases.
(Division of) **Responsibilities**	Who performs the tasks of design and development among buyer and supplier (cf. Takeishi, 2002, p. 322).	Building on task partitioning (Von Hippel, 1990) and supplier development responsibility (Clark, 1989; Wynstra et al., 2012).

1.4. Dissertation Outline

1.4.1. Supplier Involvement in NPD: a meta-analysis

In *Chapter 2*, I study supplier involvement in New Product Development. A large stream of research has focused on how suppliers can be involved during the development of new (mainly physical) products, under the umbrella of 'Early Supplier Involvement' (Johnsen, 2009). However, it remains unclear what early supplier involvement is due to a proliferation of ambiguous and quite different terminology (Dowlatshahi, 1998; Hartley et al., 1997; Koufteros et al., 2010, 2007). Secondly, empirical findings are scattered showing mainly positive but also negative outcomes of involvement on NPD performance and for different levels of performance (cf. Eisenhardt and Tabrizi, 1995; Hartley et al., 1997; Hoegl and Wagner, 2005). More research is therefore needed to empirically address the following research question:

RQ1. What are the effects of supplier involvement on NPD performance?

The second chapter of this dissertation addresses this question through a meta-analysis[1]. In this chapter, we thus provide insights into the sense and non-sense of early supplier involvement in new product development. We distinguish between two types (or dimensions) of supplier involvement, related to absorptive capacity (early involvement) and connective capacity (extensive involvement), respectively. In summary, buyers can pursue supplier knowledge in product development through early and extensive involvement, which lead to different NPD performance outcomes.

[1] A meta-analysis is a statistical technique to pool and explore empirical evidence from the literature for a given hypothesis. More details on meta-analysis methodology and meta-analytical thinking are introduced separately in the Addendum to this dissertation.

1.4.2. A Taxonomy of Sourcing Business Services: A qualitative comparative analysis

In *Chapter 3*, I study the integration of supplier knowledge in business services. Buyers of business services may not possess the required knowledge or capabilities to effectively develop service specifications independently (Axelsson et al., 2005a; Lindberg and Nordin, 2008). However, the quality of business services depends critically on the development of proper and clear specifications (Tate and Ellram, 2012; van der Valk and Rozemeijer, 2009). We also know that organizations approach this problem in different ways, depending on their relational and structural characteristics and on the specific service context (cf. Karatzas et al., 2016; Meuer, 2014). Therefore, we study the following research question:

RQ2. What is the role of relational, structural, and service-specific determinants of quality in outsourced business services?

In the third chapter, we therefore conduct a comparative study of 48 facility services, which support the primary activities of an organization by organizing and executing services on (tangible) assets, for example office cleaning services. Different organizations achieve success in different ways, for example through developing internal sourcing capabilities (Axelsson et al., 2005a; Selviaridis et al., 2011) or by leveraging a supplier relationship to access knowledge and service capabilities (Sousa and da Silveira, 2017; Tate and Ellram, 2012; van der Valk and Rozemeijer, 2009). Therefore, combinations of relational, structural, and service-specific conditions represent distinct ways in which buyers achieve high quality business services and our investigation reveals several important 'archetypes' of successful outsourcing of business services.

1.4.3. Design and Operation of Service Triads: A multiple-case study

Finally, *chapter 4* introduces buyer-supplier-customer collaborations for innovation in the context of service triads. Service triads are supply networks in

which a buyer delegates responsibility for interacting with its customers for some focal service to an external supplier (cf. Wynstra et al., 2015). Previous research on service triads has primarily focused on a set of structural and configurational considerations, such as governance structures and buyer roles (Carson et al., 1997; Li and Choi, 2009; van der Valk and van Iwaarden, 2011). Instead, our investigation is informed by the dynamic and evolving nature of service operations and knowledge integration. The main research question that we therefore pursue in this chapter is:

RQ3. How does a service triad evolve and operate during and following an innovation of the services and/or servicing?

We examine the development of new services and servicing through a dynamic and processual lens related to the member-to-member exchanges underlying any productive service system (Andersson-Cederholm and Gyimóthy, 2010; Shepherd and Suddaby, 2017), specifically leveraging structuration theory (Giddens, 1984; Stones, 2005) and service operations management insights (Roth and Menor, 2003; Victorino et al., 2018). Building upon qualitative interview data and secondary data underlying four service triads from Dutch university contexts, we provide a novel approach to quantifying and visualizing the exchange-based nature of service triad operations. This approach leads to a number of theorizing propositions about the effective formation and functioning of service triad operations.

1.4.4. Summary of dissertation chapters

To provide a clear overview of the various chapters and their individual contribution to the main topic of this dissertation, I introduce Table 1.2. This Table lists for each chapter its title and aim, main theoretical perspectives and empirical research methodology.

Table 1.2. Dissertation chapters outline.

Chapter	Title	Aim	Theoretical perspectives	Method	Data	Target & Status
2	Supplier Involvement in New Product Development: A meta-analysis	Theory-testing: What are the effects of supplier involvement on NPD performance?	Dynamic Capabilities & Open Innovation: External Knowledge Management Capabilities	Systematic Review and Meta-Analysis	11,420 NPD observations from prior research	Operations & Supply Chain Management (OSCM) 2nd round R&R at an OSCM journal
3	A Taxonomy of Quality in Outsourced Business Services: A qualitative comparative analysis	Theory elaboration: What is the role of relational, structural, and service-specific determinants of quality in outsourced business services?	Relational View & Contingency Theory	Qualitative Comparative Analysis	48 facility services, data gathered from informants using questionnaires	(Service) Operations and Purchasing Working Paper
4	Design and Operation of Service Triads: A multiple-case study	Theory building: How does a service triad evolve and operate during and following an innovation of the services and/or servicing?	Service Operations Management & Structuration Theory	Grounded Theory / Process Research	4 service triads, data gathered from informants using interviews and other data	Service Operations / Supply Chain Management 1st round under review at OSCM journal

1.5. Methodological contributions

A second line of contributions in this dissertation stems from emphasis on appropriate research methodology to tackle the problems and questions posed in each chapter. Therefore, beyond the substantive and theoretical contributions on the topic of supplier knowledge integration that are outlined above, I will provide a short summary of these methodological considerations here, which are also displayed in Table 1.2. In general, I employ a variety of both quantitative and qualitative research strategies to achieve the different aims as identified above.

First, in chapter two, we conduct a meta-analysis of the literature on supplier involvement in NPD because most recent papers on the topic have quoted the 'mixed findings' as a reason to conduct further research. Therefore, beyond merely asking: *is there an effect?* we are also interested in exploring and explaining the heterogeneity in effect sizes that is so abundant in our fields of study. The execution of this meta-analysis is furthermore the culmination of years of interest and work on meta-analytical reviews and software. I have co-developed a free and simple tool for meta-analysis in Microsoft Excel: *Meta-Essentials*. This tool, which is further described in the paper in the Addendum (w/ Henk van Rhee and (the late) Tony Hak) provides two contributions in this dissertation. First, *Meta-Essentials* is used as a tool to quickly explore scientific evidence on a subject and obtain a sense of what the data shows. I have used the tool in this way for *Chapter 2* and the Addendum includes an example data set building on that chapter. Second, due to superior graphical capabilities and transparent calculations, the tool provides an introduction to 'the new statistics' and meta-analytical thinking (Calin-Jageman and Cumming, 2018), of which I am an advocate. The purpose of such thinking is not just to weigh the evidence and generate an overall effect, but also, and more explicitly, to explore the inherent heterogeneity of effect sizes and the mixed nature of empirical evidence. While the Addendum could have performed a role also as one of the main chapters, I have elected to include it in the dissertation separately

as it does not address the main topic and only supports *one* of the methodologies employed here. In addition, note that the reported meta-analysis in Chapter 2 has been performed using packages in R rather than the *Meta-Essentials* tool, as the former allows us to model interdependent samples in clusters and to conduct meta-regression using multiple contingency factors.

Second, in chapter three, we present a taxonomy of buyer-supplier relationships with high business-to-business service quality using Qualitative Comparative Analysis (Fiss, 2011; Meuer, 2014; Ragin, 2014, 2008). Applying the comparative logic and configurational method allows us to pursue how combinations of relational, structural, and service characteristics lead to a set of equifinal and asymmetric configurations that produce high business service quality. In terms of methodology, we are one of the first to complement the standard test for necessity of individual conditions in QCA (cf. Schneider and Wagemann, 2012) with a more sensitive analysis of single necessary conditions (Dul, 2016a, 2016b; Vis and Dul, 2018). We also present p-values for consistency of the configurations based on an adjusted permutation test for false-positives (Braumoeller, 2015), which have thus far not been reported in prior QCA (management) research, potentially due to the high chance that false-positive results cannot be ruled out—as in our case.

Third, in chapter four, we study service triads using data, mainly, from interviews. Using the interview transcripts and other data sources, we then apply an analytical approach inspired by process research methods to reconstruct the processes of service triad formation and functioning as a sequence of events, in this case, interactions between members of the triad (Shepherd and Suddaby, 2017; Tsoukas, 2009a). This approach allows us to complement the process research in a quantitative way by analyzing participation of members in service design and provision and provide visualizations to support this view. Such quantification and visualization can subsequently also be used in complement to service blueprinting (Bitner et al., 2008) or Process-Chain-Network Analysis (Sampson, 2012) and other

approaches to support service design. By complementing qualitative data with quantitative analysis, future research is invited to study the processual and dynamically evolving nature of service operations in novel and myriad ways.

1.6. Declaration of contribution

The author of this dissertation is responsible for the majority of the work across all the chapters. The general introduction (Chapter 1) and general discussion (Chapter 5) have been written independently by the author. For the other chapters, I declare and acknowledge the contribution of others as follows.

Chapter 2: The majority of the work in this chapter has been conducted by the author. I developed the research idea and question, I collected the data (from prior empirical studies), conducted the meta-analysis, and interpreted the findings. The first promotor and a research assistant participated in various stages with coding and categorizing the research papers for the meta-analysis. The promotors were also involved in crafting the manuscript for submission and revisions.

Chapter 3: The majority of the work in this chapter has been conducted independently by the author. I developed the research idea and sought connection with the industry organization Facility Management Netherlands (FMN) for this joint study. I then developed the measurement instrument and conducted a pre-test among academics and practitioners. FMN contacted their members to participate in the study and we invited them to an online questionnaire platform to collect the data. I then independently analyzed the data and interpreted the findings, resulting in the current manuscript, with substantial contributions by both promotors.

Chapter 4: The majority of the work in this chapter has been conducted by the author. I developed the research question in consultation with the first promotor and I collected the data, including case selection and interviewing with the help of university purchasing department heads. Most of the interviews were transcribed from audio by an external agency. I then, with extensive support and co-authorship

from dr. Larry Menor during my research visit to Ivey Business School, analyzed the data, iterated between the data and the emerging theory and crafted the manuscript.

Addendum: This chapter is a software review of a free and simple tool for meta-analysis that the author of this dissertation has (co-)developed. The author of this dissertation is first author of the paper, while both the paper and the package have been co-developed with Henk van Rhee (equal contributors) and developed under close supervision by Tony Hak.

I am deeply indebted to all my co-authors and other contributors for their collaborations. I alone am responsible for any omissions and mistakes.

1.7. Conclusion

In this dissertation, I study how buying firms pursue supplier knowledge in the development of new products and services. Overall, the research in this dissertation contributes to our understanding of how organizations can employ the knowledge and capabilities of their suppliers. On the one hand, this research contributes to theorizing insights related to organizations' access and retention of external knowledge in buyer-supplier relationships through absorptive and connective capacities (Grant and Baden-Fuller, 2004; Kogut and Zander, 1992; Lichtenthaler and Lichtenthaler, 2009), as well as other, sourcing-related internal capabilities (Axelsson et al., 2005b). On the other hand, this research provides empirical insights used to a) test existing theoretical perspectives using large-scale meta-analytical data, b) elaborate scholarly understanding in a new (business service) context using exploratory informant responses in a medium-sized sample, and c) build novel theorizing findings using qualitative and processual insights from close interaction with informants. Using this variety of approaches has allowed me, and will continue to inspire future research, to study inter-organizational phenomena in contexts in dire need of more empirical research and theorizing.

Chapter 2. Supplier Involvement in New Product Development: A meta-analysis[2]

This chapter of the dissertation is under embargo and therefore not publicly available.

[2] This chapter is currently under review at an Operations/Supply Chain Management journal. Earlier versions of this study were presented at the following conferences/seminars:

Suurmond, R., J.Y.F. Wynstra, and J. Dul (2018). The sense and non-sense of (Early) Supplier Involvement: a meta-analysis. In: *Proceedings of 27th Annual Meeting of International Purchasing and Supply Education and Research Association* in Athens, Greece. (Runner-up Best Conference Paper award).

Suurmond, R., and J.Y.F. Wynstra (2016) The sense and non-sense of Early Supplier Involvement. Presented at the *6th International Supply Management Congress* (November 2016) in Rotterdam, The Netherlands.

Suurmond, R., J.Y.F. Wynstra, and J. Dul (2015). Exploring the variance: a meta-analysis of supplier involvement in product development. Presented at the *8th EurOMA Publishing Workshop* at ESADE, Barcelona, Spain.

Chapter 3. A Taxonomy of Quality in Outsourced Business Services: A qualitative comparative analysis[7]

This chapter of the dissertation is under embargo and therefore not publicly available.

[7] Earlier versions of this study were presented at the following conferences/seminars:

Suurmond, R., and J.Y.F. Wynstra (2018). Buyer-Supplier co-development of business service specifications in the sourcing process. In: *Proceedings of 27th Annual Meeting of International Purchasing and Supply Education and Research Association* in Athens, Greece.

Suurmond, R. (2018). Hoe eerder, hoe beter!? Samenwerken met je leverancier voor goede facilitaire diensten. [The earlier, the better!? Collaborating with your supplier for good facility services]. Presented at *FMN Connect XL: Discover New Ambitions* (November 2018).

Chapter 4. Design and Operation of Service Triads: A multiple-case study[9]

This chapter of the dissertation is under embargo and therefore not publicly available.

[9] This chapter is currently under review at an Operations Management journal. Earlier versions of this study were presented at the following conferences/seminars:

Suurmond, R., L.J. Menor, and J.Y.F. Wynstra (2018). Managing service triad operations: examining member-to-member exchanges in service design and service provision. In: *Proceedings of the 25th annual EurOMA conference* in Budapest, Hungary.

Suurmond, R., L.J. Menor, and J.Y.F. Wynstra (2017). Innovation processes and structures in service triads. In: *Academy of Management Proceedings* Vol. 2017, No. 1. DOI: 10.5465/AMBPP.2017.14107

Suurmond, R. and J.Y.F. Wynstra (2016). Value co-creation in service triads. In: *Proceedings of the 25th Annual Frontiers in Service Conference* in Bergen, Norway.

Chapter 5. Discussion and Conclusion

5.1. Conclusions

The aim of this dissertation is to advance scholarly theorization and managerial understanding on the integration of supplier knowledge in product and service contexts. Accessing and leveraging knowledge from outside organizational boundaries is a challenging issue in many industries. For example, companies such as Quooker (boiling-water tap) search for ways to overcome the not-invented-here syndrome and others, such as FrieslandCampina (dairy-cooperative), integrate supplier innovativeness as a criterion into supplier selection models. Famous industry examples originate from the Japanese (automotive) practices to rely on their network of trusted suppliers for co-producing innovative car models, such as Toyota and Honda. Hence, external partners and in particular suppliers possess a wealth of (specialized) knowledge that organizations pursue.

The research addresses the exploration and retention of external knowledge in and through buyer-supplier relationships. Integrating supplier knowledge in products and services means to apply or embody knowledge held by a supplier of a component or service into the overall product or service design. This includes not just sharing technological roadmaps or collaboration about process (re-)engineering, but more importantly embedding external knowledge into product/service design specifications.

In this dissertation, I conduct research at the intersection of innovation management and purchasing & supply management about supplier knowledge integration. Most research to date in both these fields has been conducted in the context of industrial, manufacturing industries. Therefore, the first research question, in *Chapter 2*, addressed the effect of supplier involvement in new product development. In order to also advance these fields in the context of *services*, I conducted two exploratory analyses on knowledge integration in services, first for services consumed by organization internally, in *Chapter 3*, and second for services procured in buyer-supplier-end user service triads, in *Chapter 4*. The studies also addressed various stages of theoretical development: mainly theory testing in *Chapter 2*, theory elaboration in *Chapter 3*, and theory building in *Chapter 4*. In combination, these studies provide an overview of the effects (the *what*) and the mechanisms (the *how*) of supplier knowledge integration in products and services.

In *Chapter 2*, I studied the effects of knowledge integration capabilities on product development performance using a meta-analysis of the scientific literature. I found based on 51 studies representing 10,000+ observations that, in contrast to much of the prior emphasis on Early Supplier Involvement, newly developed products *do not* perform better if suppliers are involved in earlier phases of the product development process (cf. Bidault et al., 1998b; Dowlatshahi, 1998; Johnsen, 2009; McIvor and Humphreys, 2004; Parker et al., 2008). This shows that buyers that absorb innovative ideas and concepts from suppliers (Cohen and Levinthal, 1990; Lichtenthaler and Lichtenthaler, 2009) struggle to translate ideas into valuable commercialized products. On the other hand, I found that projects in which suppliers assume a larger role for developing product/component specifications directly are more efficient (e.g., shorter time-to-market) and more effective (e.g., higher product quality). This means that buyers that connect to external knowledge by way of delegating design responsibilities are able to effectively pursue supplier knowledge

in product development (Clark, 1989; Johnsen, 2009; Lichtenthaler and Lichtenthaler, 2009; Wynstra et al., 2012).

In *Chapter 3*, I developed a taxonomy of quality in outsourced business services, based on a qualitative comparative analysis of relational, structural, and service-specific antecedents. I found based on a set of 48 outsourced facility services that high quality in outsourced business services can be achieved in various ways, which are described as 'Innovations', 'Collaborations', and 'Professionals'. From the perspective of supplier knowledge integration, this study shows that buying organizations can access, apply, or retain knowledge and experience from suppliers to overcome a lack of internal, business-service-specific, sourcing capabilities (Axelsson et al., 2005b). On the other hand, some organizations and in particular large or public institutions with established purchasing procedures are also able to achieve high quality service performance from suppliers without specific relational practices for supplier knowledge integration during the service sourcing process (cf. Karatzas et al., 2016). This chapter contributes, firstly, by illustrating how quality is shaped in the context of outsourced service provision, and secondly, that relational, integrated, and cooperative approaches are not always beneficial (Karatzas et al., 2016; Kim et al., 2015; van der Valk and Rozemeijer, 2009).

In *Chapter 4*, I subsequently investigated innovated services that are contracted and provided in buyer-provider-end user service triads using a multiple-case study. Building on insights from service operations management and structuration theory (Cho and Menor, 2010; Giddens, 1984; Stones, 2005; Victorino et al., 2018), we were able to reconstruct the process of service design and provision as a sequence of interactions between members of the triad (cf. Langley, 1999; Tsoukas, 2009a). We found that managing quality in service triads revolves around collectively and individually held responsibilities for *defining*, *designing*, *delivering*, and *diagnosing* quality (Cho and Menor, 2010; Menor, 2015). Furthermore, the buying organization

played a dual operational role as an intermediating customer to the service provider and as a secondary provider to the end customer. Therefore, quality in innovated outsourced services can be enhanced by leveraging a dual-purpose capability that is both dynamic and operational (Helfat and Winter, 2011) by the service buyer for the purposes of diagnosing service quality for improving or innovating the service triad. In summary, managing service triads revolves around operational member-to-member exchanges for deciding and acting—i.e., design and provision—on services and servicing choices.

In combination, these studies provide novel theoretical and empirical insights of supplier knowledge integration that also have implications for the wider fields of research related to before. This research is among the first to incorporate 'knowledge capacities', specifically absorptive and connective capabilities, in the research on supplier involvement in innovation. This provides a stronger theoretical basis for a phenomenon that has received ample attention, also in practice, but that—thus far—has not been consistently related to any 'grand theory' (cf. Spina et al., 2013). Furthermore, the studies have provided empirical insights into the development of services, which thus far has received scant attention in the literature. Our findings show that inter-organizational phenomena, including supplier knowledge integration but also others, can be fruitfully studied in the context of (business) services. As the context of services is huge and continuous to grow, it is in dire need of our collective scholarly attention.

5.2. Practical Implications

After concluding about the scientific and theoretical contributions of this research, it is important to also acknowledge the practical implications of this work. Pursuing knowledge from suppliers in the development of products and services is a critical issue for organizations globally and for both innovation and purchasing managers. However, the current state-of-the-art is lacking in the description of

specific and actionable knowledge integration mechanisms. I highlight the main implications of this dissertation for business practice here.

First, our research shows that organizations with connective capacity to access knowledge from suppliers have superior innovation performance. In developing new products, this implies setting only functional component specifications and delegating detailed or technical designs to suppliers, see Chapter 2. In sourcing business services, similarly, organizations can achieve high service performance by connecting with their existing supplier, or involving a (new) supplier in early discussions, or delegating quality design and definition to a supplier, see Chapter 3. However, some larger or public organizations are constrained by law in their use of relational practices and may instead resort to the development of adequate internal sourcing capabilities. In buyer-supplier-end customer service triads, finally, buyers need to fulfil a dual role as both a contractual customer of the service provider and an operational service provider to the end customer, which requires novel capabilities and (purchasing) skills, see Chapter 4.

Second, our research shows mixed findings on organizations' absorptive capacity for obtaining external ideas and concepts from suppliers, in particular in Chapters 2 and 3. In developing new products, our findings show that *early supplier involvement* does not lead to better products, while it does contribute to development efficiency, see Chapter 2. This implies that while technical or manufacturing issues may be discovered earlier—which is also worthwhile to pursue—effective integration of supplier knowledge into the final product or its component requires a more sophisticated approach, including more supplier responsibility for (component) development. In sourcing for facility services, which are not a core competence for most buying organizations, early supplier involvement is a necessary-but-not-sufficient condition for the very highest levels of service quality, see Chapter 3. It is also a core or contributing factor to quality in most outsourced

business services, unless the buyer is very professional and mature, as in large or public purchasing organizations.

5.3. Limitations

The research presented in this dissertation, alongside more specific limitations of the individual chapters, has three general limitations. First, this research focuses conceptually on the *inter-organizational* level of knowledge integration, in particular in *projects* for the development of new products or services. Alternatively, an individual/inter-personal level could have been productively employed to investigate how buyers and suppliers individually or in joint teams collaborate to exchange knowledge (Hoegl and Wagner, 2005; Kiratli et al., 2016). This could have also opened up opportunities to investigate behavioral contingencies of knowledge integration, such as building trust (Lai et al., 2011; Smets et al., 2013) and aligning goals between team members (Dwyer et al., 1987; Yan and Dooley, 2013). However, the focus on the inter-organizational project level in this dissertation allows us to test and challenge some conventional ideas about knowledge integration in product development and subsequently pursue extensions in the context of services at the same level of analysis.

A second limitation arises from the data, which comes often from single informants (but see Chapter 4) and common method bias may therefore be a severe cause of endogeneity, explaining variance in both the independent and dependent variables in the study (Ketokivi and McIntosh, 2017; Roberts and Whited, 2013). While this limitation could not technically be overcome in the meta-analysis described in Chapter 2 (due to prevailing limitations in the prior research), we provide a conceptual (temporal) and theoretical justification (Hume, 1882) of the posited effects of supplier involvement in product development. In the subsequent chapters, we use substantial and theoretical insights to unravel the mechanism of knowledge integration further based on qualitative data, less susceptible to specific

endogeneity threats, which in the final chapter takes the form of process research with data from multiple informants for each case (Langley, 1999).

Third, the data examined in this research has not been gathered from 'best-in-class' or 'cool' business cases, which would be phenomenologically exciting for theorizing, but rather from more 'mundane' cases, for example the services each of us experiences on a daily basis. This means that while the findings could generalize to the majority of common business practice, elite organizations may behave differently and reach different outcomes, which would be a subject for future research.

5.4. Future Research

In this research, I have researched the integration of supplier knowledge in both product development and service contexts. However, future research can extend this research and test the generalizability of the propositions emanating from it, in particular in other service sectors. Further theory-testing research in similar or different populations of businesses will also contribute to the advancement of our proposed theorization and (exploratory) empirical analyses. As a first step, we conducted exploratory investigations in business-to-business facility services (*Chapter 3*) and buyer-supplier-end user service triads (*Chapter 4*), which are alternatively labelled 'instrumental' and 'component' services respectively (Wynstra et al., 2006). That leaves fruitful ground for further research in semi-manufactured and consumption services, which serve as inputs to a buying organization's operational processes, but do not affect customers downstream. Similarly, our meta-analysis of supplier involvement in new product development (*Chapter 2*) builds upon data from primarily assembly-based manufacturing operations, and could be extended by conducting primary empirical research in more complex capital equipment or other contexts with both high complexity and high (technological) uncertainty (Johnsen, 2009; Mikkelsen and Johnsen, 2018). I

believe the time is not yet ripe to pursue a systematic review and meta-analysis of supplier knowledge integration in the context of services, however, as this research is only just emerging and few theory-testing studies have been conducted to date (cf. Storey et al., 2016).

Furthermore, I have researched primarily how *buying* organizations integrate supplier knowledge into products and services. Subsequent research, however, can also start on the other end of the buyer-supplier dyad by investigating how suppliers involve their business customers in the development of new technology or components, for which research is scant (Takeishi, 1998; Yeniyurt et al., 2013). In addition, while developing connective and absorptive capacities for knowledge integration represents a first step, more research is required to understand the conditions under which suppliers are willing to work with their customers, including on customer attractiveness (cf. Hüttinger et al., 2012; Schiele et al., 2011), motivation, trust, and incentives (cf. Lai et al., 2011; Smets et al., 2013; Yan et al., 2018), and governance and contracting for joint development (cf. Smets et al., 2013; van der Valk et al., 2016; Yan et al., 2018).

Figure A.1. Forest Plot in Meta-Essentials

Addendum. Introduction, Comparison, and Validation of *Meta-Essentials*: A free and simple tool for meta-analysis[12]

Abstract

We present a new tool for meta-analysis, *Meta-Essentials*, which is free-of-charge and easy to use. In this paper, we introduce the tool and compare its features to other tools for meta-analysis. We also provide detailed information on the validation of the tool. Though free-of-charge and simple, *Meta-Essentials* automatically calculates effect sizes from a wide range of statistics and can be used for a wide range of meta-analysis applications, including subgroup analysis, moderator analysis, and publication bias analyses. The confidence interval of the overall effect is automatically based on the Knapp-Hartung adjustment of the DerSimonian-Laird estimator. However, more advanced meta-analysis methods such as meta-analytical structural equation modelling and meta-regression with multiple covariates are not available. In summary, *Meta-Essentials* may prove a valuable resource for meta-analysts, including researchers, teachers, and students.

[12] This paper has been published in the current version as Suurmond, Van Rhee, and Hak (2017). Introduction, Comparison, and Validation of Meta-Essentials: A free and simple tool for meta-analysis. *Research Synthesis Methods*, Vol. 8, Iss. 4. See: https://doi.org/10.1002/jrsm.1260. Open Access.

A.1. Introduction

The term meta-analysis refers to a range of methods to provide an overview of effects for the relationship between an independent and a dependent variable (Borenstein et al., 2009; Glass, 1976). In this paper, we present a new tool for meta-analysis: *Meta-Essentials*, which functions as a set of spreadsheet workbooks. The tool can be downloaded from the accompanying website (www.meta-essentials.com), which also provides an elaborate (online) user manual (van Rhee et al., 2015), a guide on how to interpret the results of meta-analysis (Hak et al., 2016), and answers to frequently asked questions. *Meta-Essentials* is suitable for meta-analysis of a wide range of effect sizes as it automatically calculates effect sizes from commonly reported statistics. The basic results of meta-analysis are presented using a forest plot and accompanying statistics, including confidence and prediction intervals (see Figure A.1 for an example). The tool also supports additional analyses including subgroup analysis, moderator analysis, and various publication bias analyses.

There are many existing tools to aid researchers in conducting a meta-analysis. Each of the tools is suitable for a specific purpose and limited in other areas. Most prominently, some programs are not freely available (e.g., CMA, MIX Pro) and others require syntax for conducting meta-analysis (e.g., packages for R, commands for Stata, and syntaxes for SPSS). These two aspects limit the tools' suitability for some users. Although there are other software tools that are available free-of-charge and do not require programming skills (e.g., OpenMeta[Analyst] and RevMan), we found they have some limitations of their own, which we will discuss in detail later.

In summary, we think *Meta-Essentials* is particularly useful as a tool that is available free-of-charge[13], does not require programming skills, is relatively

[13] *Meta-Essentials* itself is available free-of-charge and open source (licensed under Creative Commons BY NC SA, http://creativecommons.org/licenses/by-nc-sa/4.0/). *Meta-Essentials* works with Microsoft Excel, which requires a license, but it can also be used with the freely

comprehensive as it handles many effect sizes and standard meta-analysis methods, and is adaptable and extendable to their preferences. On the other hand, users may find *Meta-Essentials* of limited use for more advanced meta-analysis methods, such as meta-analytical structural equation modeling and meta-regression with multiple covariates, and for more accurate estimators of between-study variance (e.g., restricted maximum likelihood and Paule-Mandel).

In this paper, we will describe the features and limitations of *Meta-Essentials* in detail. We first introduce the design of the tool as a set of workbooks (Section 2). Next, we compare its features against other known meta-analysis tools (Section 3). Furthermore, we describe how the tool was validated (Section 4) and finally discuss the usefulness and applicability of *Meta-Essentials* (Section 5). A worked example of a meta-analysis in the tool is provided in Appendix A-A.

A.2. Introducing Meta-Essentials

Meta-Essentials is a set of seven workbooks each designed to serve a special purpose. The structure of all workbooks is similar. Each workbook consists of six sheets. The input sheet is for inserting data. Next, there are four output sheets: one for the main meta-analysis (forest plot), one for subgroup analysis, one for moderator analysis, and one for several publication bias analyses. All the calculations and procedures between the user-provided inputs and the tool-generated outputs are separately available in the calculation tab.

Each workbook is designed for different types of effect sizes, i.e., a set of workbooks, rather than a single workbook, for two main reasons. First, different types of research designs can be used to investigate a relationship. Each research design leads to a different type of effect size, and there are many different effect size

available WPS office 2016 Free (https://www.wps.com/office-free) or Microsoft Excel Online (https://office.live.com/start/Excel.aspx).

measures (Ellis, 2010). For example, let us consider the following research question: *What is the effect of acetaminophen (X) on headache severity (Y)?* One researcher may conduct an experiment by providing one group with acetaminophen and one group with a placebo, and measure headache severity in both groups. The *difference* between headache severity in the treatment and control groups is one answer to the research question. However, another researcher may conduct an observational study by surveying a population of patients on the amount of acetaminophen intake and the severity of the headaches they experience subsequently. The *correlation* between intake of acetaminophen and headache severity provides *another* answer to the research question, even though no strong causal inferences can be drawn from this observational study. The two research designs (of the *d*-family and *r*-family, respectively) lead to different types of effect sizes because they present different types of answers (Ellis, 2010). Second, studies with the same research design often present their results using different statistics, which makes effect size calculations from input data more complex. As we aimed to design a simple tool for meta-analysis, we developed several workbooks to serve a different effect size type and to enable easy effect size calculation from a wide range of inputs. Therefore, users of *Meta-Essentials* cannot 'mix and match' continuous, binary, and correlational data in one meta-analysis, in contrast to, for example, CMA.

The workbooks, other than the *generic* Workbook 1, are organized in two families: the *d*-family and the *r*-family (Ellis, 2010), see Table A.1. The *d*-family (Workbooks 2, 3, and 4) applies when effect sizes indicate group differences, as in experimental designs. Workbook 2 is designed to meta-analyze studies that compare groups on dichotomous outcomes or binary data. Effect sizes for these types of data are odds ratios, risk ratios, and risk differences. Workbooks 3 and 4 are designed to meta-analyze studies that compare groups on continuous outcomes. Effect sizes for these types of data are standardized mean differences: Cohen's *d* and Hedges' *g*. Workbook 3 applies when the treatment and control groups are independent, i.e.,

different people across the treatment and control groups. Workbook 4 applies when groups are dependent, as in paired (pre-post) experimental designs, i.e., the same people before and after their treatment. Separate workbooks for these types are required due to differences in the calculation of the effect size. Note that raw (unstandardized) mean differences are not automatically calculated in Workbooks 3 and 4; users can use Workbook 1 for those applications, provided the outcomes are measured on the same scale.

The *r*-family (Workbooks 5, 6, and 7) applies when effect sizes indicate association between variables. If both independent and dependent variables are continuous, a measure of association is the Pearson product moment correlation coefficient, but other types exist as well (Ellis, 2010). Workbook 5 is designed to meta-analyze correlation coefficients, Workbook 6 is for partial correlations, and Workbook 7 for semi-partial correlations. The latter two types of correlation coefficients are applied when zero-order correlations are not reported in the primary articles, and data are instead provided in the form of regression models and tables (see Aloe, 2014; Aloe and Becker, 2012). Since regression coefficients are sensitive to the inclusion of (different) control variables between studies, it is preferable to conduct meta-analysis on (semi-)partial correlation coefficients (Aloe, 2014). In Workbook 5, Fisher's *r*-to-*z* transformation (and back) is automatically applied (Fisher, 1928); in Workbook 6, this is provided as an option, but more research is required to validate this transformation for partial correlations.

Researchers should select the workbook that is most appropriate for their data, based on Table A.1. The user can insert data on the input tab and the workbooks automatically calculate the appropriate effect sizes (when necessary). Researchers can also add information on study-level characteristics in the respective columns that will subsequently be used in subgroup or moderator (meta-regression) analysis. Appendix A-A provides a worked example of a meta-analysis in *Meta-Essentials*.

Table A.0.1: The seven Meta-Essentials workbooks.

	File name	Type of effect	Effect size measure	Example
Generic	1 Effect size data.xlsx	Any, as long as directly comparable	Mean Difference (for example)	
d-family	2 Differences between independent groups - binary data.xlsx	Difference between two independent groups with binary outcome	Odds ratio, risk ratio, or risk difference	Counts of patients that survived or died cancer after an experimental versus control treatment.
	3 Differences between independent groups - continuous data.xlsx	Difference between two independent groups with continuous outcome	Standardized mean difference: Cohen's d or Hedges' g	The difference between the performance of sports teams that received intensive training and those that did not receive intensive training
	4 Differences between dependent groups - continuous data.xlsx	Difference between two dependent groups with continuous outcome	Standardized mean difference: Cohen's d or Hedges' g	The difference between the performance of sports teams before and after receiving intensive training
r-family	5 Correlational data.xlsx	Correlation between two variables	(Zero-order) correlation coefficient	The relationship between age and income
	6 Partial correlational data.xlsx	Relation between two variables, controlled for other variable(s) in both predictor and outcome	Partial correlation coefficient	The relationship between age and income, controlled for socio-economic status, assuming socio-economic status is related to both age and income
	7 Semi-partial correlational data.xlsx	Relation between two variables, controlled for other variable(s) in outcome	Semi-partial correlation coefficient	The relationship between age and income, controlled for education, assuming education is related to income, but not age

A.3. Structured comparison of meta-analysis tools

In this section, we compare the features of *Meta-Essentials* to other available software tools, to examine the contribution of the tool and describe its limitations. Since the publication of previous reviews of meta-analysis tools (Bax et al., 2007; Schmid et al., 2013), several tools have been updated and new tools developed. In this comparison, we review features similar to Bax et al. (2007) and Schmid et al. (2013). We retrieved the required information from these two previous reviews, documentation accompanying each tool (websites, books, articles, user guides, etc.), and by performing meta-analyses with each tool.

A.3.1. Meta-analysis tools

To determine which tools besides *Meta-Essentials* to include in the comparison, we employed two criteria. First, we included tools that scholars have been using for research, and exclude tools that primarily designed for educational purposes, such as MIX Lite with only built-in data sets. Second, we included tools that scholars from multiple disciplines have been using frequently and recently, and exclude therefore, for instance, MetAnalysis, MetaWin, PhyloMeta, WEasyMA, and macros for SAS. We thus include the following tools (in alphabetical order): CMA (Borenstein et al., 2009), commands for Stata (discussed by Palmer and Sterne, 2016), MIX Pro (Bax, 2016), OpenMeta[Analyst] (Wallace et al., 2012), RevMan (Review Manager, 2014), packages for R (meta: Schwarzer, 2007; and metafor: Viechtbauer, 2010), and syntaxes for SPSS (Field and Gillett, 2010; Wilson, 2010).

A.3.2. Comparison

We assessed the basic characteristics, supporting material, input, method settings, and output of each tool. Each of these aspects is important to examine the usefulness and applicability of tools for meta-analysis. Appendix A-B provides a

detailed overview of the features of the software for meta-analysis included in our comparison.

Basic characteristics

A clear difference between the various tools is whether they are stand-alone tools or whether an additional tool is required to use the meta-analysis software. Stand-alone tools can be commercial (CMA) or freeware (OpenMeta[Analyst] and RevMan). Tools developed on top of other software programs are also available: plugins for Microsoft Excel (MIX Pro), packages for R (meta and metafor), syntaxes for IBM SPSS Statistics (provided by Field and Gillett, 2010; Wilson, 2010) and commands for Stata (discussed by Palmer and Sterne, 2016). These tools themselves are available for free, but operate on commercial statistical software (except packages for R, which are completely free-of-charge). *Meta-Essentials* can be used with the freely available WPS Office Free or Excel Online, or the commercial Microsoft Excel. Table A.2 provides an overview of the tools based on whether they are free or commercial and on whether they have a graphical user interface or rely on syntax.

All tools run on Microsoft Windows, although OpenMeta[Analyst] is not available for 32-bit versions of Microsoft Windows. Most tools, except CMA and MIX Pro[14], also run on Mac OS.

Supporting material

General information about the tools can be found in books or articles. Most programs also offer more specific and technical documentation, such as tutorials, help, formulae, and FAQs, online.

[14] CMA and MIX Pro can be run on Mac OS using a Windows emulator.

Table A.2: A categorization of software for meta-analysis.

	Freeware	**Freeware on commercial platform**	**Commercial**
Graphical User Interface	OpenMeta (Wallace et al., 2012) RevMan (Higgins and Green, 2011) WPS Office / Excel Online: Meta-Essentials (this paper)	Excel: Meta-Essentials (this paper)	CMA (Biostat Inc., 2014) MIX PRO (Bax, 2016)
Syntax	R: meta (Schwarzer, 2007) R: metafor (Viechtbauer, 2010)	Stata (Palmer and Sterne, 2016) SPSS (Field and Gillett, 2010; Wilson, 2010)	

Input

All programs can conduct meta-analysis using pre-calculated effect sizes and their standard errors, i.e. 'generic' effect sizes. In addition, some programs are able to calculate effect sizes based on a range of input data. MIX Pro, OpenMeta[Analyst], and RevMan include this feature for effect sizes of the *d* family but offer only limited support for calculating effect sizes of the *r* family, as they lack the commonly applied Fisher *r*-to-*z* transformation and effect size calculations for (semi-)partial correlations. The syntaxes for SPSS can only process pre-calculated effect sizes with their standard errors.

CMA has the unique feature of 'mixing and matching' effect sizes from different effect-size families. However, CMA's developers readily acknowledge

(Borenstein et al., 2009, p. 45) that one needs to make certain assumptions for these conversions that are not always appropriate.

Method settings

Next, we investigated how the tool is operated, possibly adapted, and which methods for estimating the weights of individual studies are available. Tools that are controlled using syntax require some programming skills. Conversely, tools with a graphical user interface (GUI) require no programming skills; see Table A.2. Some of these GUI tools (specifically, CMA, MIX Pro, and RevMan) have relatively limited possibilities of adapting or extending procedures and (graphical) output. *Meta-Essentials* is fully adaptable by anyone with modest Microsoft Excel knowledge, and OpenMeta[Analyst] can also be adapted but this requires programming skills (source code publicly available on GitHub). Tools based on general statistical software can inherently be extended and adapted using the full capabilities of the statistical software.

Regarding the featured methods for estimating between-study variance, all tools provide the DerSimonian-Laird method-of-moments estimator (DerSimonian and Laird, 1986). However, other estimators of between-study variance achieve more satisfactory performance across a range of situations (Chung et al., 2013; Sidik and Jonkman, 2007; Veroniki et al., 2016). Based on previous simulation studies and empirical investigations, Veroniki et al. (2016) recommend the Paule-Mandel (PM) estimator (Hardy and Thompson, 1996; Thompson and Sharp, 1999), supported by meta(for), MIX Pro, and OpenMeta[Analyst], and the restricted maximum likelihood (REML) estimator (Hardy and Thompson, 1996; Thompson and Sharp, 1999), supported by CMA, commands for Stata, metafor, OpenMeta[Analyst], and the syntax for SPSS by Wilson. *Meta-Essentials* only provides the DerSimonian-Laird estimator because other estimators involve multiple iterations, which Microsoft Excel does not support unless these are

programmed using macros, which we wanted to avoid for transparency and security reasons.

For dichotomous data (i.e., results presented in 2x2 tables) three common methods of weighting effect sizes exist (Inverse Variance, Mantel-Haenszel, and Peto). Most tools offer all three weighting methods, except MIX Pro (which does not offer the Peto method) and the syntaxes for SPSS (which only offer the inverse variance method). A second choice when meta-analyzing dichotomous data is the choice of effect size to conduct the meta-analysis on. Deeks (2002) and Fleiss and Berlin (2009) show the mathematical properties of the odds ratios to be preferable for meta-analysis, compared to risk ratios or risk differences. However, the latter effect sizes can be more easily interpreted by both academics and practitioners (Cummings, 2009; Deeks, 2002; Sinclair and Bracken, 1994) and researchers often confuse the odds ratio with the risk ratio (Zhang and Yu, 1998). Therefore, some authors suggest conducting meta-analyses in odds ratios and subsequently transforming the outcomes into effect size measures that can be easier understood (Borenstein et al., 2009; Fleiss and Berlin, 2009; Localio et al., 2007). Implementing such a method requires the transformation of the combined effect size in odds ratio into the risk ratio or risk difference, using, e.g., the substitution method (Daly, 1998; Zhang and Yu, 1998). Subsequently, the confidence and prediction intervals need to be transformed. This can be done, assuming that a statistical test of the overall effect would produce the same result, regardless of the effect size measure employed in the meta-analysis. This procedure has not been extensively validated and should therefore be used cautiously, especially when baseline risk in individual studies is high, and when odds ratios are large (McNutt, 2003). It has been included in *Meta-Essentials* (the exact formulas are described by van Rhee and Suurmond 2015), but not in any of the other packages.

Output

By default, most meta-analysis tools provide a confidence interval (CI) of the overall effect based on a normal distribution. However, this distribution is not always accurate because it disregards the uncertainty of the heterogeneity estimator (τ^2), which leads to too narrow CIs especially when sample sizes (N) are small or the number of studies (k) is small (Sánchez-Meca and Marín-Martínez, 2008). Therefore, some tools allow the user to choose the Student's t distribution for CIs (CMA and MIX Pro). The nominal coverage of CIs can be further improved by using the Knapp-Hartung adjustment (KNHA) (also known as weighted variance or Hartung-Knapp-Sidik-Jonkman method, Inthout et al., 2014; Sanchez-Meca et al., 2008). It provides better coverage of CIs than the normal distribution, quantile approximation, or Student's t distribution (Sánchez-Meca and Marín-Martínez, 2008). The weighted variance method, using the Hartung-Knapp adjustment (KNHA) with a Student's t distribution to estimate the confidence interval of the overall effect, is available in OpenMeta[Analyst], in meta and metafor, in Stata, in the regression module of CMA 3.0, and the default in *Meta-Essentials*.

Forest plots that show the dispersion of effect sizes and accompanying prediction intervals which express this dispersion are key to state-of-the-art meta-analysis (Hak et al., 2016; Kiran et al., 2017; Riley et al., 2011). All tools, except the macros for SPSS, provide a forest plot with a few easy steps. However, prediction intervals are not supported by all tools. The prediction interval offers "a convenient format for expressing the full uncertainty around inferences, since both magnitude and consistency of effects may be considered" (Higgins et al., 2009, p. 139). If we assume that all studies provide estimates of different true effects, we must also assume that no single overall effect size can express these different true effects' best (Higgins et al., 2009). Therefore, the prediction interval accurately embraces the notion of heterogeneity and the dispersion of true effects (Riley et al., 2011). *Meta-Essentials* provides the prediction interval by default and automatically

includes it in the forest plot (see the green line in Figure A.1). Prediction intervals are not available in CMA[15], MIX Pro, and syntaxes for SPSS.

All tools offer subgroup analysis, which allow a user to run separate meta-analyses on subsets of the included studies. All tools, except RevMan, also feature meta-regression, although *Meta-Essentials* and MIX PRO only offer it for a single covariate.

Publication bias analyses help researchers to estimate the threat of unpublished or undiscovered research reports for the validity of a meta-analysis. A basic funnel plot is available in most programs except in OpenMeta[Analyst]. More (sensitivity) tests and plots are available in all programs except in OpenMeta[Analyst], RevMan, and syntaxes for SPSS. In *Meta-Essentials*, packages for R, syntaxes for SPSS, and commands for Stata, additional plots and tables can be generated based on user specifications.

A.4. Validation

We extensively validated *Meta-Essentials* by comparing the results of a meta-analysis with CMA (v. 2.0, Biostat, 2014), the metafor package for R (metafor version 1.9-8, Viechtbauer, 2010; R Development Core Team, 2008; v.3.2.5), and MIX Pro (v. 2.0.1.4, Bax, 2011). In order to validate the formulas and results from *Meta-Essentials*, we compared the results of equivalent analysis across these programs based on five data sets: generic effect sizes, binary data, group differences between independent and dependent groups, and correlation coefficients. The data sets contain fictitious but realistic data from 12-18 'studies' and Appendix A-C provides an example of such a data set for correlation coefficients. The other data sets are similar if not equal to the default entries in the input tabs provided in the

[15] CMA provides a separate Excel workbook on its website to calculate prediction intervals based on CMA output. See also (Borenstein et al., 2017).

distribution of *Meta-Essentials*. We ran a meta-analysis on each of these data sets using the four programs and compared the results to the extent possible. In all cases, weights (both fixed and random), heterogeneity (DerSimonian-Laird), overall effect size, confidence interval (*t* distribution; KNHA[16]), prediction interval[17], subgroup analysis, and meta-regression (one covariate) were exactly equal (to at least six decimals).

Publication bias analyses (fixed effect) led to small differences among the programs, also between MIX Pro, CMA, and metafor. Funnel plots appear the same, except in MIX Pro, where confidence intervals are plotted around zero, and not around the combined effect size. Trim-and-fill methods are equal in CMA and in *Meta-Essentials*, but sometimes slightly different in MIX Pro and metafor due to the numbers of iterations. Egger's regression test is exactly equal for all programs. Begg & Mazumdar's rank correlation test is exactly equal for MIX Pro, CMA, and *Meta-Essentials*, but metafor automatically corrects Tau for both ties and continuity which leads to small differences. Standardized residuals and their histograms, and the Gailbraith (radial) plot are exactly equal in *Meta-Essentials* and metafor, but are not available in CMA. MIX Pro instead plots a standard normal distribution by default and does not calculate the width of bins for standardized residuals histograms. Normal quantile plots are not the same between the tools: MIX Pro does not plot all the data points; CMA does not provide a normal quantile plot; and *Meta-Essentials* calculates normal quantiles based on *(rank-1/3)/(k+1/3)*, which is considered better than *(rank-0.5)/k* as incorporated in metafor (Hyndman and Fan, 1996). The l'Abbe plot, applicable to binary data only, appears to be the same in MIX Pro, metafor and *Meta-Essentials*, but is not available in CMA. Rosenthal's

[16] For validation purposes, we examined the results in metafor using the Knapp-Hartung adjustment (knha) using a Student's t distribution. In MIX Pro and CMA, results were different because of the employed standard normal distribution, but recalculation using the Knapp-Hartung adjustment (KNHA) shows equivalent results.
[17] Only in metafor and *Meta-Essentials*, not available in MIX Pro and CMA.

Failsafe N (CMA, metafor, *Meta-Essentials*) and Orwin's Failsafe N (CMA, *Meta-Essentials*) are also equal.

We could not directly validate the effect size *calculations* for (semi-)partial correlations, as these are not available in any of the other tools. However, we checked these effect size calculations in a spreadsheet obtained through personal communication with Aloë (based on the formulas in Aloë, 2014; Aloë and Becker, 2012).

We further validated the tool by conducting an actual (non-fictitious) meta-analysis on the effect of communication (face-to-face vs virtual) on team performance, which was run as a data set in all four programs. Results revealed no other differences between tools than those previously described. Finally, numerous meta-analyses have been conducted with the tool and no problems have been reported to us, some of which have been published[18].

A.5. Discussion

In this paper, we have introduced the *Meta-Essentials* workbooks for meta-analysis in Microsoft Excel. In the previous sections, we compared the features of this software to other tools for meta-analysis and provided more information on the validation of the program. In this final section of the paper, we discuss our conclusions on the usefulness and applicability of *Meta-Essentials* as a tool for meta-analysis.

First, *Meta-Essentials* is a comprehensive tool for meta-analysis, in the sense that many features have been incorporated that are also available in other tools or that have been suggested as methods for meta-analysis. Some of these features are subject to debate or are not appropriate in some contexts. For example, researchers

[18] An updated list is maintained at: http://www.erim.eur.nl/research-support/meta-essentials/references-to-meta-essentials.

disagree as to *whether* and *which* publication bias analyses can accurately detect (or even remedy) the threat of unpublished studies with small effect sizes (see Rothstein et al., 2006). In *Meta-Essentials,* these publication bias analyses can be conducted and can even be run using a random effects model, which is often not appropriate (Lau et al., 2006; Sterne et al., 2011). Furthermore, the use of a substitution method between odds ratios and risk ratios, as discussed in section 3.2.4, has not been extensively validated (yet) and is not appropriate when baseline risk or odds ratios are high (McNutt, 2003). It is the user's responsibility to ensure that the settings and parameters of statistical software are appropriate in their context.

Second, *Meta-Essentials* operates as a 'black-box' by default, meaning that users do not observe the procedures or formulas in the main output tabs. Nonetheless, the procedures and formulas are openly available in the 'calculation' tab. We recommend unexperienced users not to make changes to the formulas or procedures. However, as the tool is available as open source, advanced users and experienced meta-analysts can adapt the formulas and build added functionality to the tool.

Third, we recommend the tool for use in both research and teaching. For research, *Meta-Essentials* is an excellent choice for users who are not familiar with general statistical software and programming language, those looking for a free, yet comprehensive meta-analysis tool, and users that want to 'quickly' explore the literature on their topic of interest. *Meta-Essentials* has indeed been used for recently published meta-analyses (see section 4). Additionally, *Meta-Essentials* can be used as an educational instrument to teach students in 'new statistics' and meta-analytical thinking (as suggested by Cumming and Calin-Jageman, 2016). We have also used the tool in an undergraduate course on research methods, where student teams conducted small-scale meta-analyses of about five to ten studies. We found that students quickly learn the purpose and usefulness of meta-analysis, as others

have also reported (Li et al., 2014), and that a free and simple tool for meta-analysis supports this learning process.

Fourth, we readily admit that *Meta-Essentials* is not the best tool currently available on the market for all users and/or purposes. Users already familiar with Stata or R can easily use such general-purpose statistical software (Palmer and Sterne, 2016; Schwarzer et al., 2015). RevMan and OpenMeta[Analyst] are two alternative free meta-analysis tools that can be used without programming skills. Specific limitations of *Meta-Essentials* are that it lacks capabilities for more advanced analyses, such as general linear models, network meta-analysis, meta-analytical structural equation modeling, hierarchical subgroup analyses, and meta-regression with multiple covariates, most of which can easily be conducted using a variety of packages in R or commands in Stata. Additionally, *Meta-Essentials* uses the DerSimonian-Laird estimator of between-study variance for the random effects models, which has been shown to be sub-optimal in some situations. Other tools provide other between-study variance estimators to choose from.

In conclusion, we present *Meta-Essentials* as a new tool for meta-analysis. It is a set of workbooks for Microsoft Excel that is available free-of-charge and does not require programming skills. It is comprehensive because it can handle many effect size types and meta-analysis methods, and is adaptable and extendable to user preferences. However, some more advanced meta-analysis methods are not available. Therefore, it provides sufficient capabilities for conducting meta-analysis for many users, including researchers, teachers, and students.

Appendix A-A: Worked example in *Meta-Essentials*

To download the software, go to www.meta-essentials.com. You can open the spreadsheets using WPS Office Free, Excel Online, or Microsoft Excel.

For this example, we will use a data set of 12 studies[19] on the effect of *Early Supplier Involvement* on *New Product Development project performance*. The data is available in Table AA.1 below. The hypothesis is that earlier involvement of suppliers leads to higher NPD project performance due to the integration of the supplier's knowledge and expertise before design choices are finalized. The data consists of correlation coefficients and sample sizes, as well as the origin of the data (continent) and the data collection/publication year of the study (mean centered on 2009).

Step 1: Choose the appropriate workbook

In this case, our data consists of correlation coefficients, so based on Section A.2 and Table A.1 of this paper, we choose: 5 Meta-Essentials Correlational data.xlsx. See Figure AA.1.

Name	Type	Compressed size	Password protected	Size
1 Meta-Essentials Effect size data 1.1	Microsoft Excel Worksheet	386 KB	No	470 KB
2 Meta-Essentials Differences between independent groups - binary data 1.1	Microsoft Excel Worksheet	523 KB	No	626 KB
3 Meta-Essentials Differences between independent groups - continuous data ...	Microsoft Excel Worksheet	387 KB	No	467 KB
4 Meta-Essentials Differences between dependent groups - continuous data 1.1	Microsoft Excel Worksheet	362 KB	No	459 KB
5 Meta-Essentials Correlational data 1.1	Microsoft Excel Worksheet	357 KB	No	434 KB
6 Meta-Essentials Partial correlational data 1.1	Microsoft Excel Worksheet	381 KB	No	458 KB
7 Meta-Essentials Semi-partial correlational data 1.1	Microsoft Excel Worksheet	371 KB	No	450 KB
How to interpret results of meta-analysis 1.0	Adobe Acrobat Document	730 KB	No	784 KB
Meta-analyze dichotomous data	Adobe Acrobat Document	412 KB	No	430 KB
User manual for Meta-Essentials workbooks for meta-analysis 1.0	Adobe Acrobat Document	923 KB	No	1.051 KB

Figure AA.1. Choose the appropriate workbook.

[19] Note that the study by Yan & Kull (2015) provides two separate effect sizes for China and the US, respectively, which we will treat as independent observations for present purposes.

Table AA.1. The example data set.

Study name	Correlation	Number of subjects	Continent	Pub Year (centered)
(Tessarolo, 2007)	0.25	154	Europe	-2
(Parker et al., 2008)	0.35	116	North-America	-1
(Lin, 2009)	0.23	111	Asia	0
(Koufteros et al., 2010)	0.23	191	North-America	1
(Perols et al., 2013)	0.09	116	Europe	4
(Yan and Dooley, 2013)	-0.02	214	North-America	1
(Lau et al., 2010)	0.29	251	Asia	1
(Yan and Kull, 2015: China)	0.04	210	Asia	1
(Yan and Kull, 2015: US)	0.02	206	North-America	1
(Brulot, 2007)	0.17	137	Europe	-2
(Yan, 2011)	-0.04	425	North-America	1
(Laseter and Ramdas, 2002)	0.11	50	North-America	-10

Step 2: Insert the data

Once the workbook is opened, we go to the Input Tab of the workbook and delete all the data that is currently there (this is just fictional data). We insert the study names, the effect size and the number of subjects (sample size). Note that the Fisher *r*-to-*z* transformation is automatically applied, so we insert sample sizes but not standard errors (as usual in meta-analysis). Using the example data set provided, we can simple copy the data and paste-as-values. We also insert the continent as subgroups and publication year as moderator, for subsequent analysis. If this is done correctly, the input tab should like Figure AA.2.

#	Study name	Include study	Correlation	Number of subjects	Sufficient data	Subgroup	Moderator
1	Tessarolo	Yes	0.25	154	Yes	Europe	-2
2	Parker	Yes	0.35	116	Yes	North-America	-1
3	Lin	Yes	0.23	111	Yes	Asia	0
4	Koufteros et al	Yes	0.23	191	Yes	North-America	1
5	Perols et al	Yes	0.09	116	Yes	Europe	4
6	Yan & Dooley	Yes	-0.02	214	Yes	North-America	1
7	Lau et al	Yes	0.29	251	Yes	Asia	1
8	Yan & Kull China	Yes	0.04	210	Yes	Asia	1
9	Yan & Kull US	Yes	0.02	206	Yes	North-America	1
10	Brulot	Yes	0.17	137	Yes	Europe	-2
11	Yan	Yes	-0.04	425	Yes	North-America	1
12	Laseter & Ramdas	Yes	0.11	50	Yes	North-America	-10

Figure AA.2. Insert the data.

If performance of Microsoft Excel is slow while inputting data, we can (temporarily) set 'Calculation Options' to 'Manual' under 'Formulas', and press 'Calculate Now' when we are done with inputting data, see Figure AA.3. This will ensure all calculations for the meta-analysis are conducted. You can also use WPS Office instead.

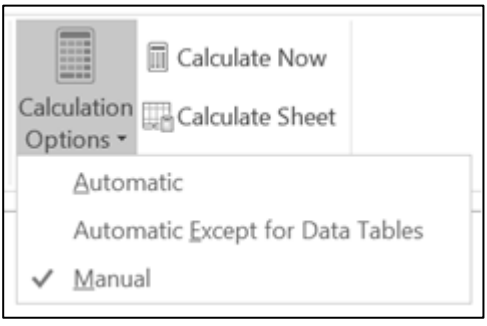


Figure AA.3. Set calculations to manual and use calculate now.

Step 3: Run a basic meta-analysis

To examine the results of the meta-analysis, we go to the next tab of the workbook: Forest Plot. This tab consists of three main parts. On the left, a table with the main results (and settings) of the meta-analysis can be found, including the Combined Effect Size, its confidence and prediction intervals, and heterogeneity

statistics. In the middle, a tabular overview with the studies included in the analysis can be found, including effect sizes, confidence intervals, and weights. Finally, on the right, the forest plot with the individual studies and the combined effect size can be found. See Figure AA.4.

From this main analysis, we can find that the average effect of early involvement on NPD project performance is positive (r = 0.14) and that the confidence interval does not overlap with zero, thus our hypothesis is supported. The effect sizes are not homogeneous and between-study variability is present in the data (I^2 = 72%); the prediction interval shows that the next study result is likely to find an effect size between -0.14 and +0.40, which is quite a broad range.

The next steps, 4a and 4b, are optional and their usefulness may depend on the purpose of the meta-analysis, theoretical and methodological arguments, and the availability of additional data at the study level subgroups, moderators).

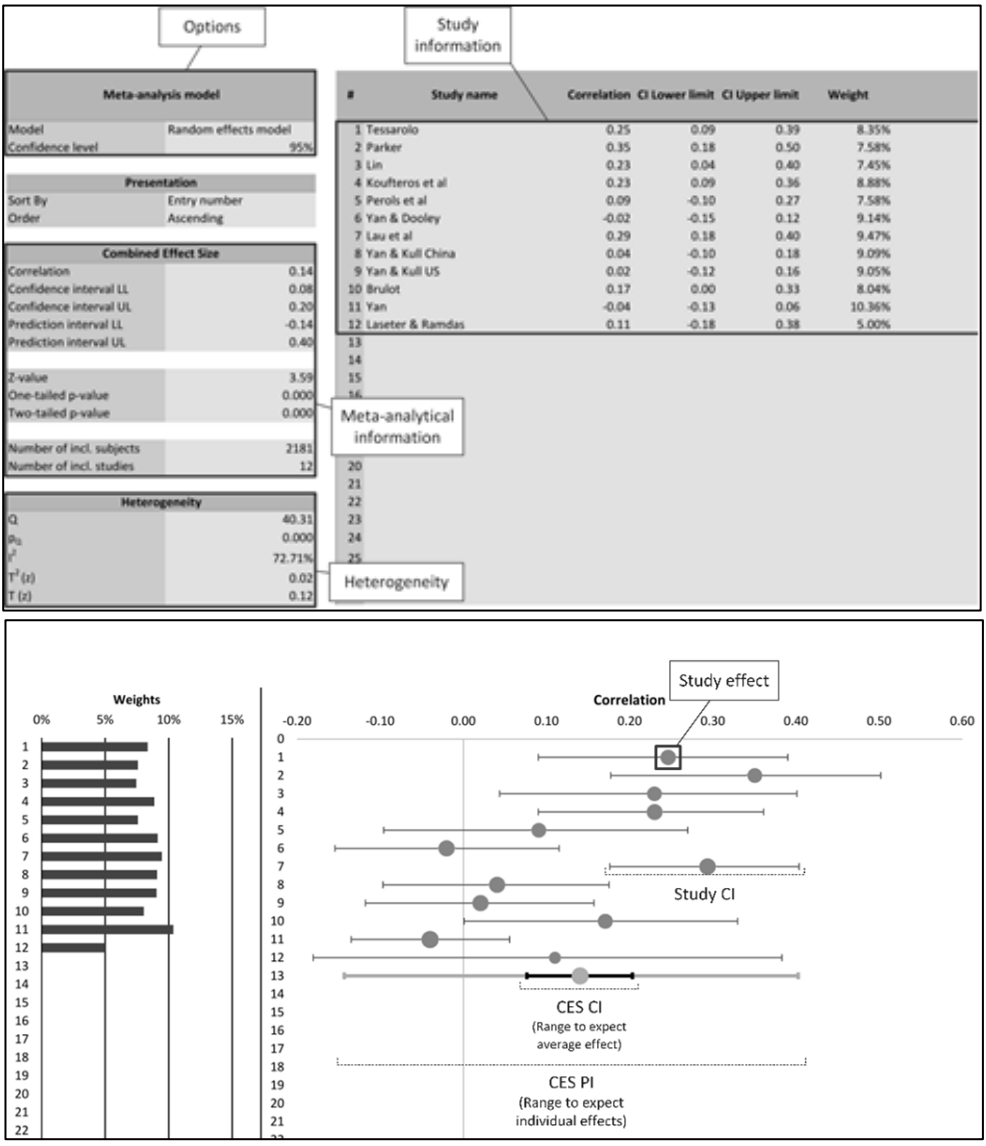


Figure AA.4. Results of a basic meta-analysis.

Step 4a: Run a subgroup analysis

In subgroup analysis, we run a separate meta-analysis on the studies for each of the subgroups to examine any differences between subgroups. As subgroups, we inserted the origin of the data: the continent of the world (Asia, Europe, or North America). Go to the next tab of the workbook: Subgroup Analysis. Again, the tab consists of three main parts: a table with the main results (and settings) of the subgroup analysis, a table with the individual studies and subgroup results, and a forest plot with individual studies, subgroups, and combined effect size. Some parts of this tab are 'hidden' and can be revealed by clicking on the plus-sign on top of the orange columns, see Figure AA.5.

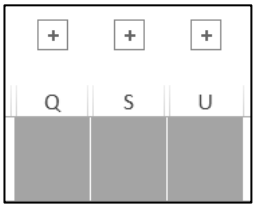


Figure AA.5. Hide and reveal tables or figures in the subgroup analysis tab.

From this subgroup analysis, we find that the subgroups do not differ much from each other (r = 0.19 for Asia, 0.18 for Europe, and 0.10 for North America, and all confidence intervals overlap), see Figure AA.6. Note that we only have a few studies per continent and therefore the results of this analysis should be treated with caution. We also observe that heterogeneity of effect sizes is somewhat, but not fully, explained by the origin of the data (pseudo-R^2 = 21% and $Q_{between}$ = 8.35, p = 0.02). Thus, even though the confidence intervals of the subgroups overlap, there is some evidence that origin of data moderates the effect of early involvement on NPD project performance.

Meta-analysis model	
Between subgroup weighting	Random effects
Within subgroup weighting	Random effects (Tau separate for subgroups)
Confidence level	95%

Combined Effect Size	
Correlation	0.16
Confidence interval LL	0.10
Confidence interval UL	0.21
Prediction interval LL	0.10
Prediction interval UL	0.21
Number of incl. subjects	2181
Number of incl. studies	12

Subgroup heterogeneity	
$Q_{within,\ fixed}$	31.97
$P_{Q,within}$	0.000
$Q_{between,\ fixed}$	8.35
$P_{Q,between}$	0.015
$Q_{total,\ fixed}$	40.31
$P_{Q,total}$	0.000
R^2	20.71%

#	Study name / Subgroup name	Correlation	CI Lower limit	CI Upper limit	Weight	Q	p_Q	I^2	T^2	T	PI LL	PI UL
1	Lin	0.23	0.04	0.40	28.95%							
2	Lau et al	0.29	0.18	0.40	36.19%							
3	Yan & Kull China	0.04	-0.10	0.18	34.86%							
4	**Asia**	**0.19**	**-0.68**	**0.84**	**17.94%**	**8.03**	**0.02**	**75.08%**	**0.02**	**0.13**	**-0.94**	**0.97**
5	Tessarolo	0.25	0.09	0.39	37.94%							
6	Perols et al	0.09	-0.10	0.27	28.39%							
7	Brulot	0.17	0.00	0.33	33.67%							
8	**Europe**	**0.18**	**-0.38**	**0.64**	**55.23%**	**1.68**	**0.43**	**0.00%**	**0.00**	**0.00**	**-0.38**	**0.64**
9	Parker	0.35	0.18	0.50	15.43%							
10	Koufteros et al	0.23	0.09	0.36	17.68%							
11	Yan & Dooley	-0.02	-0.15	0.12	18.12%							
12	Yan & Kull US	0.02	-0.12	0.16	17.98%							
13	Yan	-0.04	-0.13	0.06	20.15%							
14	Laseter & Ramdas	0.11	-0.18	0.38	10.64%							
15	**North-America**	**0.10**	**-0.08**	**0.28**	**26.82%**	**22.26**	**0.00**	**77.54%**	**0.02**	**0.14**	**-0.31**	**0.48**
16	**Combined effect size**	**0.16**	**0.10**	**0.21**		**40.31**	**0.00**	0.73	**0.02**	**0.12**	**0.10**	**0.21**
17												
18												
19												
20												
21												
22												

Table with studies and subgroups

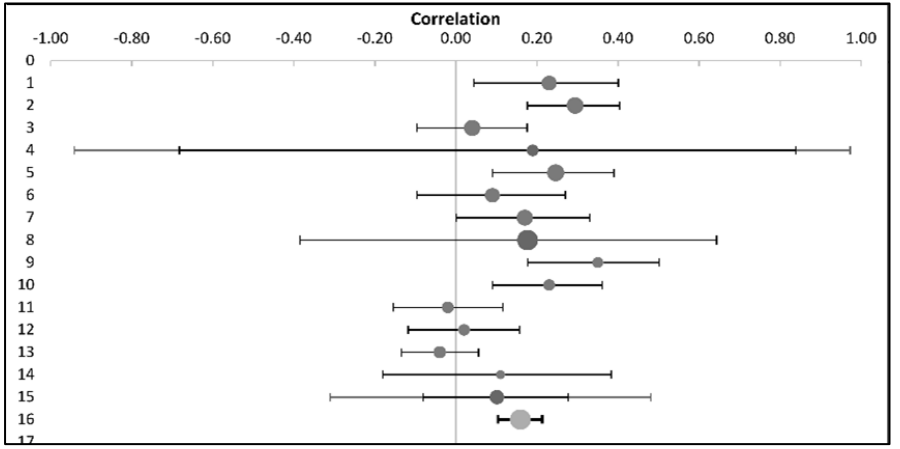


Figure AA.6. Results of a subgroup analysis.

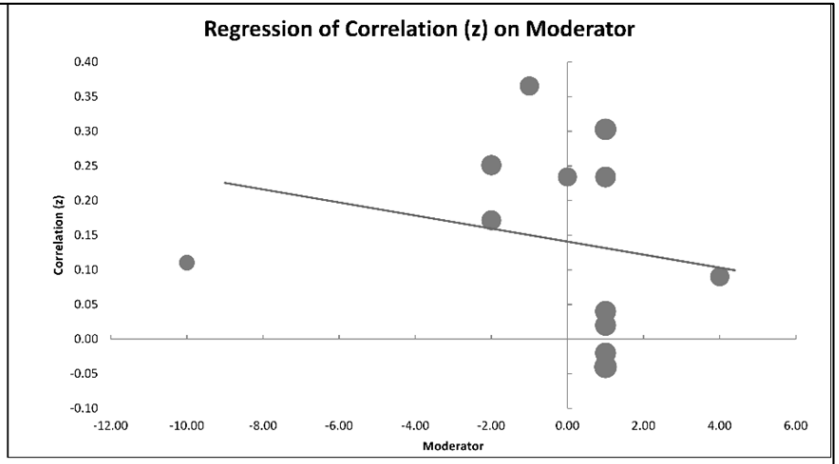
Step 4b: Run a moderator analysis (meta-regression)

In moderator analysis, we run a weighted linear regression of effect sizes on the moderator. As moderator, we inserted the year of publication to examine whether reported effect sizes in the literature are becoming smaller over time. We go to the next tab of the workbook: Moderator Analysis. The tab consists of two main parts: a table with the individual studies, and a bubble plot and table with the results of the meta-regression.

From this moderator analysis, we can find that effect sizes do not change over time: the regression coefficient (β=-0.01) is small, its confidence interval overlaps with zero and explained variance (R^2 = 4%) is very small, see Figure AA.7. Note that we included mean-centered publication years, rather than absolute values, to improve the visibility of the plot and the meaningfulness of the intercept (otherwise the plot would range from the year 0 to the year 2500).

Analysis model	
Model	Random effects
Confidence level	95%

Study name	Moderator	Correlation (z)	Weight
Tessarolo	-2.00	0.25	8.35%
Parker	-1.00	0.37	7.57%
Lin	0.00	0.23	7.45%
Koufteros et al	1.00	0.23	8.88%
Perols et al	4.00	0.09	7.57%
Yan & Dooley	1.00	-0.02	9.14%
Lau et al	1.00	0.30	9.48%
Yan & Kull China	1.00	0.04	9.10%
Yan & Kull US	1.00	0.02	9.06%
Brulot	-2.00	0.17	8.04%
Yan	1.00	-0.04	10.38%
Laseter & Ramdas	-10.00	0.11	4.99%



	B	SE	CI LL	CI UL	β	Z-value	p-value
Intercept	0.14	0.04	0.05	0.23		3.31	0.001
Moderator	-0.01	0.02	-0.04	0.02	-0.20	-0.60	0.545

Fit statistics random model	Q (Sum of squares)	df	p-value
Model	0.37	1	0.545
Residual	9.05	10	0.528
Total	9.41	11	0.584

Mean square	F-Value	p-value
0.37	0.40	0.539
0.90		

Combined effect size	0.14
T^2 (method of moments estimation)	0.02
R^2	3.89%

Figure AA.7. Results of a meta-regression analysis.

Step 5: Run a publication bias analysis

Publication bias analysis can be used to detect the effect of the non-publication of small and insignificant research findings. As in the subgroup tab, further analyses are 'hidden' and may be revealed by clicking on the plus-sign on top of the orange columns. There are six types of publication bias analysis in *Meta-Essentials*, but we only discuss the funnel plot here. The usefulness of publication bias analysis is under discussion among academics, but on the other hand it is very common to provide some type of this analysis in published meta-analyses.

The funnel plot depicts effect sizes against their standard errors, see Figure AA.8. If the funnel is asymmetrically filled, there is some indication that insignificant effects (with large standard errors but small effect sizes) are not included in the meta-analysis, for example due to non-publication of such findings. In this case, we find some evidence for asymmetry in the plot, meaning publication bias may play a role and the results as previously discussed should be treated with caution.

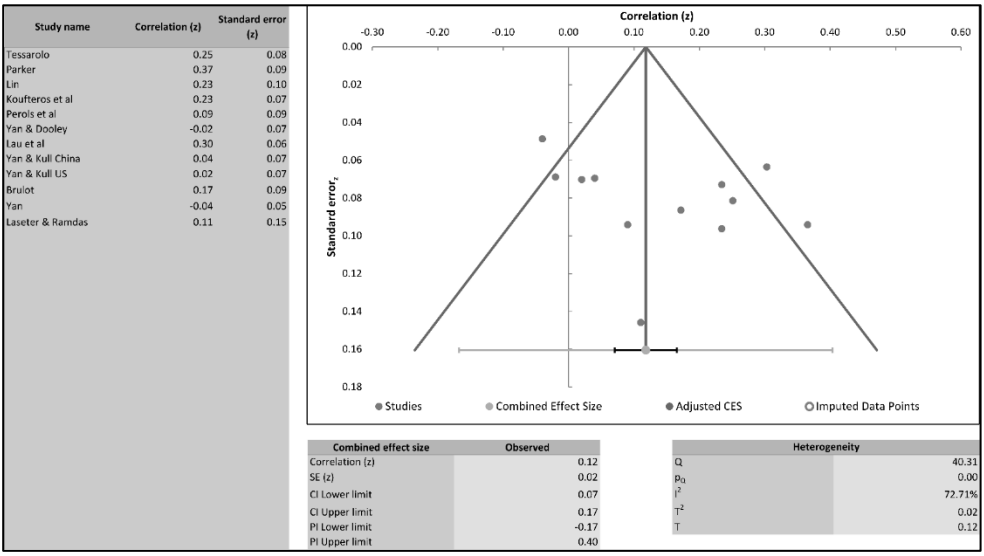


Figure AA.8. Results of a publication bias analysis (funnel plot).

Appendix A-B

Table AB.1. Features of software for meta-analysis

		Meta-Essentials	CMA	Commands for Stata discussed by Palmer and Sterne (2016)	meta and metafor package for R
Basic characteristics	Version	1.1	3.3.070	Versions available from the Statistical Software Components archive on April 20, 2017. E.g., metan 3.04, metareg 2.6.1, and metafunnel 1.0.2. Stata 14.1	meta 4.8-0 metafor 1.9-9. R 3.3.3
	Website	www.meta-essentials.com	www.meta-analysis.com	http://www.stata-press.com/books/meta-analysis-in-stata/	meta: http://meta-analysis-with-r.org metafor: http://www.metafor-project.org/
	Freeware / commercial	Freeware	Commercial	Freeware	Freeware
	Prerequisite software	Microsoft Excel (commercial)	None	Stata (commercial)	R (freeware)
	Operating systems	Windows, Mac OS	Windows	Windows, Mac OS, Linux	Windows, Mac OS, Linux
Supporting material	Documentation	User manual, website, this paper	Borenstein et al. (2009), website, and tutorials	Palmer and Sterne (2016), website, and help function in Stata	meta: Schwarzer et al. (2015), website, and help function metafor: Viechtbauer (2010), website, and help function
Input	Effect size calculation	d and r families	d and r families	d and r families	d and r families
Method settings	User interface	Graphical user interface	Graphical user interface	Syntax	Syntax
	Adaptability	Full	Limited	Full	Full

Output	Between-study variance estimators	DL	DL, (RE)ML	DL, EB, HE, (RE)ML, SJ	meta: DL, PM metafor: DL, EB, HE, HS, PM, (RE)ML, SJ
	Weighting methods	IV, MH, Peto	IV, MH, Peto	IV, MH, Peto	IV, MH, Peto
	Confidence and prediction interval	Both	Confidence interval only	Both available, CI default	Both available, CI default
	Confidence interval distributions	KNHA Student's t	Normal or Student's t (KNHA Student's t in meta-regression)	Normal or KNHA Student's t	Normal or KNHA Student's t
	Automated forest plot	Yes	Yes	Yes	Yes
	Subgroup-analyses	Yes	Yes	Yes	Yes
	Meta-regression	Yes, single covariate	Yes, multiple covariates	Yes, multiple covariates	Yes, multiple covariates
	Funnel plot and trim-and-fill	Yes	Yes	Yes	Yes
	Failsafe-N	Yes	Yes	Yes	meta: No metafor: Yes

Notes. Between-study variance estimators include: DL: DerSimonian-Laird; (RE)ML: (Restricted) Maximum Likelihood; PM: Paule-Mandel; HE: Hedges; SJ: Sidik-Jonkman; and EB: Empirical Bayes. Models for calculating the weights of individual studies include: IV: inverse variance; MH: Mantel-Haenszel; and Peto. Confidence Intervals can be based on the standard normal distribution, the Student's t distribution, or the Student's t distribution with Knapp-Hartung adjustment (KNHA Student's t); see section A.3.2.5.

Appendix A-B (continued)

		MIX Pro	**OpenMeta[Analyst]**	**RevMan**	**Syntaxes for SPSS by Field and Gillett** (2010) **and Wilson** (2010)
Basic characteristics	Version	2.0.1.5	None indicated	5.3.5	Field and Gillett: Version number not provided. Website last updated September 2010. Wilson: Version number not provided. SPSS Statistics syntax file in .zip-file dates from September 20, 2006. SPSS 23.0.0.0
	Website	http://www.meta-analysis-made-easy.com/	http://www.cebm.brown.edu/openmeta/	http://tech.cochrane.org/revman	Field and Gillett: https://www.discoveringstatistics.com/repository/fieldgillett/how_to_do_a_meta_analysis.html Wilson: http://mason.gmu.edu/~dwilsonb/ma.html
	Freeware / commercial	Commercial	Freeware	Freeware	Freeware
	Prerequisite software	Microsoft Excel (commercial)	None	None	SPSS (commercial)
	Operating systems	Windows	Windows (only 64-bit) and Mac OS	Windows, Mac OS, Linux	Windows, Mac OS, Linux
Supporting material	Documentation	Tips & tricks and Meta-Tutor (embedded)	Wallace et al. (2012) and website	Cochrane Handbook and user guide	Field and Gillet (2010) and website Wilson: Lipsey and Wilson (2001) and website
Input	Effect size calculation	d family	d family	d family	No
Method settings	User interface	Graphical user interface	Graphical user interface and syntax	Graphical user interface	Syntax

	Adaptability	Limited	Full	Limited	Full
	Between-study variance estimators	DL, PM	DL, EB, HE, HS, PM, (RE)ML, SJ	DL	Field and Gillet: DL, HS Wilson: DL, (RE)ML
	Weighting methods	IV, MH	IV, MH, Peto	IV, MH, Peto	IV
Output	Confidence and prediction interval	Confidence interval only	Confidence interval only	Both	Confidence interval only
	Confidence interval distributions	Normal or Student's t	Normal or KNHA Student's t	Normal	Normal
	Automated forest plot	Yes	Yes	Yes	No
	Subgroup-analyses	Yes	Yes	Yes	No
	Meta-regression	Yes, single covariate	Yes, multiple covariates	No	Yes, multiple covariates
	Funnel plot and trim-and-fill	Yes	No	Yes; No trim-and-fill	Field and Gillet: Only funnel plot Wilson: No
	Failsafe-N	Yes	No	No	Field and Gillet: Yes Wilson: No

Appendix A-C: Example of a fictitious data set for validation purposes

Table AC.1: Example of a fictitious data set for validation purposes

#	ID	Correlation	N	Subgroup	Moderator
1	aaaa	0.976	100	AA	15
2	bbbb	0.947	130	AA	16
3	cccc	0.956	80	AA	13
4	dddd	0.967	300	AA	18
5	eeee	0.050	95	BB	20
6	ffff	-0.537	90	BB	14
7	gggg	0.964	120	AA	19
8	hhhh	0.947	130	AA	13
9	iiii	0.380	80	BB	19
10	jjjj	0.970	240	AA	22
11	kkkk	-0.380	90	BB	17
12	llll	-0.462	100	BB	18

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Summary

In this dissertation, I study the integration of supplier knowledge through the lenses of dynamic capabilities and division of responsibilities in the contexts of products and services. I contribute to prior research on this topic by conducting empirical research in three studies. The chapters of this dissertation, respectively, present a meta-analysis on the effects of supplier involvement on New Product Development performance, develop a taxonomy of quality in outsourced business services, and explore the design and operation of service in triadic outsourced arrangements.

In *Chapter 2*, we study supplier involvement in New Product Development (NPD). Prior research paints a blurred and inconclusive picture of the state-of-the-art, with the use of a wide variety in terminology and mixed empirical findings. We aim to reconcile these issues by reconceptualizing supplier involvement and the various forms it can take as well as study its impact on different types of performance outcomes, including NPD efficiency (e.g., time-to-market) and NPD effectiveness (e.g., product quality). We conduct a systematic review and meta-analysis of the empirical literature with 11,420 observations to understand to what extent and when suppliers should be involved to achieve better NPD performance. Our findings provide general support for a positive effect of supplier involvement on NPD performance but also provide a critical reflection on the literature on 'Early Supplier Involvement'. Building on the perspectives on knowledge integration emanating from a capabilities view, we explain these effects in terms of organization's absorptive and connective capacities. Further subgroup meta-

analysis and meta-regression are provided to unravel this relationship further, for specific dimensions of supplier involvement and NPD performance as well as other study characteristics such as industrial and cultural context.

In *Chapter 3*, we develop a taxonomy of the impact of relational and non-relational factors on the quality of outsourced business services. Buying business services is complex due to high levels of uncertainty and changing requirements, along with a gap in sourcing capabilities for services more generally. While some prior research has conceptualized or demonstrated the effect of individual factors for achieving high quality service performance, no systematic analysis of how such conditions in combination shape service quality has been presented so far. Therefore, we conduct qualitative comparative analyses, complemented by necessary condition analyses and regression analyses, of 48 facility services, such as cleaning, from The Netherlands. We show that different organizations reach high levels of service performance through a limited set of asymmetrically contributing relational, structural, and service-specific conditions. In particular, our results imply different knowledge-integration recommendations for (purchasing) managers of large and public organizations than for small and medium sized enterprises. Our research in this chapter promotes a holistic understanding of the interplay of various factors for the sourcing of high quality business services.

In *Chapter 4*, we study two operational processes related to innovating the service supply network: the design and provision of service in triadic outsourcing arrangements. We adopt the perspective of a service triad as an operating entity—not just a configurational or relational structure—in which a service buyer arranges with and delegates responsibility to a service provider to directly interact on behalf of the service buyer with its service end users. The existence of two service customers from the provider's standpoint and two service suppliers from the end user's perspective gives rise to increased operational complexity in this specific type of outsourced servicing arrangement. To improve understanding of this operational

complexity, we study member-to-member exchanges underlying the formation and functioning of service triads using four illustrative innovations undertaken at several Dutch universities. Leveraging insights related to service operations management, we find that the formation and functioning of the innovated service triads entail a complex set of members' roles and responsibilities as well as require distinctive service capabilities. Based upon a novel approach to quantifying and visualizing members' exchanges, the reported descriptive investigation of the evolving nature of these four innovated triadic outsourcing arrangements and their management allows us to advance an initial theorization on service triad design and provision. Our study contributes to the literature by examining the process of developing a new servicing delivery system as well as new services in the context of a triadic buyer-provider-customer service arrangement.

Overall, this research provides important theoretical advances on the capabilities and responsibilities to manage the integration of supplier knowledge with the buyer's product or service development and/or sourcing processes. In an era of increasingly networked organizations, the findings provide distinct practical recommendations for buying organizations that pursue supplier knowledge. By means of the studies included in this dissertation, I have provided an overview of the mechanisms and effects of the absorption and retention of knowledge in inter-organizational (buyer-supplier) relationships. Our research also provides one of the first extensions on this topic in the area of business services, in which research is scant and (purchasing) management's attention lacking.

Samenvatting

In deze dissertatie onderzoek ik de integratie van kennis van leveranciers, door middel van het uitnutten van kunde en verdelen van verantwoordelijkheden, in de context van producten en diensten. Ik draag bij aan voorgaand onderzoek op dit gebied door middel van empirisch onderzoek in drie studies. De hoofdstukken van deze dissertatie, respectievelijk, presenteren een meta-analyse van het effect van leveranciersbetrokkenheid op product-ontwikkelings-uitkomsten, ontwikkelen een taxonomie van kwaliteit in uitbestede zakelijke dienstverlening, en verkennen het ontwerpen en uitvoeren van diensten in triadische uitbestedingsverbanden.

In *Hoofdstuk 2* bestuderen we leveranciersbetrokkenheid bij productontwikkeling (New Product Development of NPD). Voorgaand onderzoek laat een wazig en onbeslist beeld achter door het gebruik van veel verschillende termen en een mix van empirische uitkomsten. Wij willen deze problemen aanpakken door leveranciersbetrokkenheid en de verschillende vormen die het aanneemt opnieuw te conceptualiseren en bovendien onderzoeken hoe het leidt tot verschillende typen prestatie-uitkomsten, specifiek NPD efficiëntie (bv. doorlooptijd) en NPD effectiviteit (bv. product kwaliteit). We voeren een systematisch onderzoek en meta-analyse van de empirische literatuur uit met 11.420 observaties om te begrijpen in welke mate en wanneer leveranciers moeten worden betrokken bij product innovatie. Onze bevindingen geven in het algemeen ondersteuning voor een positief effect van leveranciersbetrokkenheid op NPD prestaties, maar ook een kritische reflectie op de literatuur over *vroegtijdige leveranciersbetrokkenheid*. Bouwend op theoretische perspectieven over het integreren van kennis die voortkomen uit een ‘capabilities view’, leggen we deze

effecten uit in termen van absorberende en verbindende capaciteiten van organisaties. Verdere subgroep-meta-analyses en meta-regressie worden verschaft om de relatie verder te ontrafelen, voor verschillende dimensies van leveranciersbetrokkenheid en NPD prestaties, en overige studie-karakteristieken zoals industriële of culturele context.

In *Hoofdstuk 3* ontwikkelen we een taxonomie van de invloed van relationele en niet-relationele factoren op de kwaliteit van uitbestede zakelijke dienstverlening. Het inkopen van zakelijke diensten is complex vanwege een hoge mate van onzekerheid en steeds veranderende specificaties, in samenhang met een gebrek aan expertise over de inkoop van diensten in het algemeen. Voorgaand onderzoek heeft wel de invloed van individuele factoren benoemd of aangetoond, maar er is geen systematisch onderzoek over hoe de combinaties van factoren kwaliteit gestalte geven. Daarom voeren wij kwalitatieve comparatieve analyse uit, aangevuld met analyses van noodzakelijke voorwaarden en regressie, op basis van 48 facilitaire diensten zoals schoonmaak uit Nederland. We laten zien dat verschillende organisaties een hoog niveau van dienstverlenings-prestaties behalen volgens een gelimiteerde set van asymmetrisch bijdragende relationele, structurele, en dienst-specifieke condities. Meer toegepast bevat ons onderzoek verschillende aanbevelingen voor (inkoop) managers van grote of publieke instellingen dan voor middelgrote en kleine bedrijven (MKB). Ons onderzoek ontwikkelt daarmee een holistisch perspectief op het samenspel van factoren op de kwaliteit van uitbestede zakelijke dienstverlening.

In *Hoofdstuk 4* bestuderen we twee operationele processen gerelateerd aan innovatie in een toeleveringsnetwerk van diensten: het ontwerpen en verlenen van diensten in een triadisch uitbestedingsverband. We nemen daarbij het perspectief van een dienstentriade als een werkmaatschappij—en niet slechts een structurele of relationele configuratie—waarin de inkoper de dienst afstemt en verantwoordelijkheid delegeert aan een aanbieder om, namens de inkoper, direct

met de eindgebruikers te interacteren. De aanwezigheid van twee klanten vanuit het perspectief van de aanbieder en van twee leveranciers vanuit het perspectief van de eindgebruiker leidt tot een toegenomen operationele complexiteit in dit type uitbestedingsverband. Om deze complexiteit beter te begrijpen bestuderen wij uitwisselingen tussen de leden van de triade gedurende het formeren en het uitvoeren van de dienstverlening door middel van vier illustratieve innovaties op meerdere Nederlandse universiteiten. Door gebruik te maken van inzichten uit operationeel dienstenbeheer (service operations management) ontdekken we dat de formatie en uitvoering van geïnnoveerde dienstentriades een complexe set aan rollen en verantwoordelijkheden van leden vereist alsmede specifieke dienstenexpertise. Op basis van een nieuwe aanpak voor het visualiseren en kwantificeren van uitwisselingen tussen leden, staat het gerapporteerde beschrijvende onderzoek over het ontwikkelende karakter en management van deze vier geïnnoveerde triadische uitbestedingsverbanden ons toe om een eerste theoretisering te ontwikkelen over het ontwerpen en verlenen van diensten in een triade. Onze studie draagt daarmee bij aan de literatuur door het proces te belichten waarmee nieuwe dienstverleningsverbanden en nieuwe diensten zelf worden ontwikkeld.

In het geheel genomen ontwikkelt dit onderzoek belangrijke theoretische bijdragen over de kunde en verantwoordelijkheid voor de integratie van kennis van leveranciers in de processen om nieuwe producten en diensten te ontwikkelen en/of in te kopen. In een tijdperk van genetwerkte organisaties geeft dit onderzoek praktische aanbevelingen voor inkopers op jacht naar de kennis van leveranciers. Door middel van de studies in deze dissertatie heb ik een overzicht gepresenteerd van de mechanismen en effecten van het absorberen en behouden van kennis in interorganisationele (inkoper-leverancier) relaties. Ons onderzoek bevat mede een van de eerste extensies van dit onderwerp naar het domein van (zakelijke)

dienstverlening, waar wetenschappelijk onderzoek nog schaarser is en de aandacht van leidinggevenden nog minder op is gevestigd.

About the Author

Robert Suurmond was born on 9 July 1989 in Gouda, The Netherlands. He holds a bachelor's degree in Business Administration and a master's degree in Supply Chain Management from Rotterdam School of Management, Erasmus University. After graduation in December 2013, Robert joined the PSM@RSM team in the Department of Technology and Operations Management to pursue his PhD.

His main research interests lie at the intersection of purchasing/supply management and innovation to elaborate insights about (supplier) knowledge integration in the development of products and services. Robert presented parts of his research at international conferences including at Academy of Management, EurOMA, and IPSERA. At IPSERA 2018, his paper on supplier involvement in NPD was selected as the runner-up for the best conference paper award. In Fall 2017, he was a visiting scholar at Ivey Business School in London, Ontario, where he worked with dr. Larry Menor. In addition to research, Robert teaches in Purchasing and Supply (Chain) Management, Strategic Sourcing, Meta-Analysis and Research Methods, and has supervised many master thesis projects. Currently, Robert holds a position as Assistant Professor in the department of Marketing and Supply Chain Management at the School of Business and Economics, Maastricht University.

Portfolio

Publications

Suurmond, R., H.J. Van Rhee, and T. Hak (2017). Introduction, comparison, and validation of Meta-Essentials: A free and simple tool for meta-analysis. *Research Synthesis Methods*, Vol. 8, Iss. 4, pp 537-553. DOI: 10.1002/jrsm.1260.

Working papers (under review/development)

Supplier Involvement in New Product Development: A meta-analysis (Chapter 2). With Finn Wynstra and Jan Dul. 2nd round revise and resubmit.

A Taxonomy of Sourcing Business Services: A qualitative comparative analysis (Chapter 3).With Finn Wynstra. Under development.

Design and Operation of Service Triads: A multiple-case study (Chapter 4). With Larry Menor and Finn Wynstra. Under journal review.

Purchasing and Supply Management as a Multi-disciplinary Research Field: E Pluribus Unum? Revise and resubmit. With Finn Wynstra (1st author) and Fabian Nullmeier (3rd).

Conference Proceedings

Suurmond, R., J.Y.F. Wynstra, and J. Dul (2018). The sense and non-sense of (Early) Supplier Involvement: a meta-analysis. In: *Proceedings of the 27th Annual Meeting of the International Purchasing and Supply Education and Research Association* in Athens, Greece. – Runner-up Best Conference Paper award.

Suurmond, R. and J.Y.F. Wynstra (2018). Buyer-Supplier co-development of business service specifications in the sourcing process. In: *Proceedings of the 27th Annual Meeting of the International Purchasing and Supply Education and Research Association* in Athens, Greece.

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Chen, C., R. Suurmond, E.M. van Raaij, and J. Bäckstrand (2017). Purchasing process models: tools for teaching Purchasing and Supply Management. In: *Proceedings of the 26th Annual Meeting of the International Purchasing and Supply Education and Research Association* in Budapest, Hungary.

Suurmond, R. and J.Y.F. Wynstra (2017). Outsourcing in service triads. Presented at the *9th Service Operations Management Forum* in Copenhagen, Denmark.

Suurmond, R. and J.Y.F. Wynstra (2016). Value co-creation in service triads. In: *Proceedings of Frontiers in Services* in Bergen, Norway.

Suurmond, R. (2015). Supplier involvement in new product and service development. Doctoral research proposal presented at the *Joint Doctoral and Junior Faculty consortium in Operations Management, Academy of Management Annual Meeting* in Vancouver, BC. – received travel grant.

Suurmond, R., F.M.E. Nullmeier, and J.Y.F. Wynstra (2015). Purchasing and Supply Management: an examination of fifteen years of research. In: *Proceedings of the 24th Annual Meeting of the International Purchasing and Supply Education and Research Association* in Amsterdam, The Netherlands.

Research Visit

09/2017-11/2017	Research Visit to Ivey Business School, Western University (London, Ontario). Visited dr. Larry Menor for joint research.

Teaching

Strategic Sourcing - Master Elective
Lecturer on Managing Supplier Innovation (2016-18).
Academic Coach for team projects on diverse subjects (2016-17).

Research Training and Bachelor Thesis
Lecturer on Meta-Analysis (2014-18).
Course Coordinator (2015).

Master Thesis Coach/co-reader. (2015-18). Supervision of practice-oriented (intership) and theory-oriented projects.

Training

Qualitative Comparative Analysis
Global School in Empirical Research Methods, St. Gallen Instructor: prof. dr. Charles Ragin. 2016.
Qualitative Methods
ERIM course. Instructor: prof. dr. Pursey Heugens. 2016.
Statistical Methods
ERIM course. Instructor: prof. dr. Patrick Groenen. 2015.
Necessary Condition Analysis
ERIM Summer School. Instructor: prof. dr. Jan Dul. 2016.

Philosophy of Science
Management Foundations
Social Networks
Innovation Management
Scientific Integrity
Publication Strategy

Skills and Languages

Empirical Research Methods
Project Management
Teaching

Dutch (native)
English (CPE C2)

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Dissertations in the last four years

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Bliek, R. de, *Empirical Studies on the Economic Impact of Trust*,
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Bouman, P., *Passengers, Crowding and Complexity: Models for Passenger Oriented Public Transport*, Prof. L.G. Kroon, Prof. A. Schöbel & Prof. P.H.M. Vervest,
EPS-2017-420-LIS, https://repub.eur.nl/

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Lenoir, A.S. *Are You Talking to Me? Addressing Consumers in a Globalised World*, Promotors: Prof. S. Puntoni & Prof. S.M.J. van Osselaer, EPS-2015-363-MKT, http://repub.eur.nl/pub/79036

Li, D., *Supply Chain Contracting for After-sales Service and Product Support*, Promotor: Prof. M.B.M. de Koster, EPS-2015-347-LIS, http://repub.eur.nl/pub/78526

Liu, N., *Behavioral Biases in Interpersonal Contexts*, Supervisors: Prof. A. Baillon & Prof. H. Bleichrodt, EPS-2017-408-MKT, https://repub.eur.nl/pub/95487

Ma, Y., *The Use of Advanced Transportation Monitoring Data for Official Statistics*, Promotors: Prof. L.G. Kroon & Dr J. van Dalen, EPS-2016-391-LIS, http://repub.eur.nl/pub/80174

Maira, E., *Consumers and Producers*, Promotors: Prof. S. Puntoni & Prof. C. Fuchs, EPS-2018-439-MKT, https://repub.eur.nl/pub/104387

Mell, J.N., *Connecting Minds: On The Role of Metaknowledge in Knowledge Coordination*, Promotor: Prof. D.L. van Knippenberg, EPS-2015-359-ORG, http://hdl.handle.net/1765/78951

Meulen,van der, D., *The Distance Dilemma: the effect of flexible working practices on performance in the digital workplace*, Promotors: Prof. H.W.G.M. van Heck & Prof. P.J. van Baalen, EPS-2016-403-LIS, http://repub.eur.nl/pub/94033

Micheli, M.R., *Business Model Innovation: A Journey across Managers' Attention and Inter-Organizational Networks*, Promotor: Prof. J.J.P. Jansen, EPS-2015-344-S&E, http://repub.eur.nl/pub/78241

Moniz, A, *Textual Analysis of Intangible Information*, Promotors: Prof. C.B.M. van Riel, Prof. F.M.G de Jong & Dr G.A.J.M. Berens, EPS-2016-393-ORG, http://repub.eur.nl/pub/93001

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