Colocation as a Hybrid ICT Sourcing Strategy to Improve Operational Agility

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Abstract

Fast access to communication networks and the availability of high-performance information and communication technology (ICT) infrastructures is indispensable for accelerating business transactions. Yet with increased environmental volatility, companies need to become more agile in identifying and responding to market- and technology-based challenges. Accordingly, a responsive and high-performance ICT infrastructure remains a top priority for firms. Thus, new ICT sourcing strategies may lead to significant competitive advantages, especially in dynamic business environments. This article analyzes a hybrid ICT sourcing strategy called colocation that allows firms to operate their own ICT resources in facilities of specialized data center providers. Grounded in the theory of dynamic capabilities, we theorize and empirically examine how colocation and top management support enable firms to improve their operational agility in the presence of environmental turbulence.

Keywords: ICT Infrastructure Strategy, Colocation Sourcing, Operational Agility, Quantitative Field Study

ACM Categories: H.1.1, H.3.4

Introduction

Within the last decade, the Internet became the backbone for all kinds of business processes, enabling firms to operate in globally connected value chains and integrated markets (Nagurney et al., 2007). It created not only new opportunities for information-based products and services, but also facilitated the deconstruction of value chains, streamlined work processes, and allowed for new inter-organizational relationships (Sambamurthy et al., 2003). A critical driver of these developments has and still is the accessibility to high network bandwidth, processing power, and storage capacity to support information and communication technology (ICT)-based services (Tilson et al., 2010). Accordingly, it is assumed that competitiveness in global markets increasingly demands a reliable high-speed ICT infrastructure and communication networks to accelerate distributed collaboration and digital transactions between geographically dispersed business partners (Weill and Broadbent, 1998). For example, direct access to central Internet exchange hubs that provide extremely low network latencies to stock exchanges worldwide is essential for financial trading platforms to realize competitive advantages (Gsell, 2009).

At the same time, an increase in environmental volatility, resulting from greater uncertainty in international markets and volatile customer demands, requires firms to improve their capability to respond to changes in an efficient and effective manner. This agility imperative also requires a flexible ICT infrastructure to change business operations swiftly if needed (Ciborra et al., 2000, Sambamurthy et al., 2003). Innovations in utility computing, Web services and service-oriented architectures are especially suited to improve the ability of firms to flexibly obtain and integrate digital resources and services (Papazoglou et al., 2007). As a result, firms increasingly purchase ICT resources and services from external providers which themselves benefit from economies of scale and scope (Lacity and Willcocks, 1998). This allows for notable benefits, such as keeping pace with leading-edge technology and specialized expertise, thereby avoiding the risk of technological obsolescence that results from dynamic changes (Grover et al., 1996), and acquiring appropriate ICT resources and capabilities according to business needs to achieve operational agility (Sambamurthy et al., 2003). However, these opportunities and benefits cannot be achieved without making some concessions due to coordination challenges and information asymmetries between the client and ICT service provider (Chiles and McMackin, 1996). As a solution, firms often employ a number of business partners and service providers and combine external services with internal resources to improve their independence by reducing switching costs (Cohen and Young, 2006). As firms grow and their needs change, they need to be sure that they are allocating the appropriate amount of time and resources in the management of their ICT infrastructure. It is not uncommon for firms to expand rapidly and soon realize that the amount of money they are spending on cooling and electricity for their ICT equipment exceeds their budgets. Other technical side effects encountered by rapidly growing firms include insufficient bandwidth capability in their internal data centers or inadequate security measure to protect sensitive information on their servers. Upon realization that they are overextended on internal ICT expenditures, firms may consider outsourcing their data center to a third-party data center provider.

Against this background, a viable alternative is the installation and operation of own ICT systems in external premises, which is known as ICT colocation, ICT hotel, or ICT housing. In such a hybrid sourcing setting, specialized colocation providers offer the basic data center infrastructure and corresponding services, such as space, high bandwidth, reliable power supply, sophisticated cooling systems, fire extinguishing solutions, on-site operation support, and technical assistance, whereas customers can develop, manage, and operate their own ICT systems. Hence, colocation can be regarded as compromise between ICT outsourcing, where the services provider completely manages and operates the ICT infrastructure of the outsourcing firm, and an internally owned and operated data center. In colocation (data) centers, firms can choose which operations they operate in external premises and which ones they want to handle in-house.

The attractiveness of colocation centers mainly comes from the accumulation of Internet service providers (ISPs), network carriers, and other ICT service providers such that a competitive (digital) marketplace emerges for firms searching for redundant, high-speed Internet access for latency-critical business applications (Gerpott and Massengeil, 2001, Malecki, 2002). Such a once established ICT service cluster housed in a colocation center provides valuable infrastructure and services to competitive market prices, as illustrated in Figure 1. Firms that provide basic data center services and operate communication networks, such as data center providers, network carriers, and wide-area network (WAN) providers, represent the “Infrastructure” segment. Application service providers (ASPs) and providers for hosting and managing IT services form the “Services” segment and offer application hosting, administration (e.g., backup, update processes), and user support. This segment also contains ISPs that provide Internet connectivity. Both segments in turn form an ICT service cluster within a colocation center, such that members of the “Services” segment utilize the ICT infrastructure provided by the members of the “Infrastructure” segment. Other industry sectors (Figure 1, outer circle) purchase specialized ICT services from the ICT service cluster. Thus, the ICT service cluster creates unique competitive advantages for firms by providing large-scale hosting infrastructures and services. An illustrative example for a typical customer of the ICT service cluster would be a bank, which, in addition to operating own ICT infrastructure in a colocation center, also uses the services of ASPs for application hosting and specialist data storage providers for financial reference data storage while having access to different WAN providers and ISPs to connect their different branches. Since several providers are present in the ICT service cluster, a bank can benefit from competitive prices since switching costs are comparably low.

Research in the area of ICT colocation is relatively new (Tilson et al., 2010) and thus the importance of combining internal and external ICT resources to achieve higher levels of operational agility has not been investigated so far. In this research, we regard and investigate ICT colocation sourcing capabilities as the capacity of a firm to purposefully extend, create, or modify its ICT infrastructure to achieve tight alignment with the business so as to exploit new business opportunities but also improve operational performance.

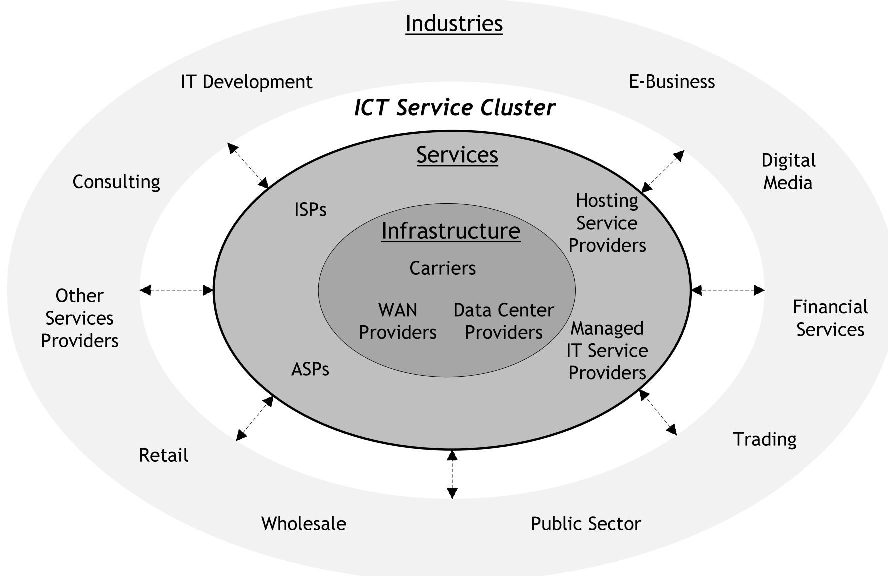

Figure 1. Value creation through service sourcing in an ICT service cluster

While espousing this view, we ground our research on the theory of dynamic capabilities (Helfat et al., 2007, Nelson and Winter, 1982, Teece et al., 1997, Teece, 2007) and analyze how top management support and colocation as ICT sourcing solution improve operational agility in the presence of environmental turbulence. Thereby, we attempt to address the following key research question:

How does ICT sourcing through colocation enhance agility on the operational level as an important dynamic capability and how do turbulent environments moderate this relation?

Driven by this research question, our study seeks to improve the understanding of the interplay between colocation as a sourcing strategy that comprises top management support and the extant of colocation and the creation of business value through fostering operational agility as an important dynamic capability. Noting the practical relevance of ICT infrastructure sourcing for different industry domains and the lack of research on digital infrastructures in general (e.g., Hanseth and Lyytinen, 2010, Tilson et al., 2010), our research focuses on firms that are pursuing a specific sourcing strategy, which we refer to as a "colocation strategy". Specifically, we define a colocation strategy as a top management decision to use colocation centers to leverage the ICT infrastructure that is made available by infrastructure providers (Figure 1, "Infrastructure" segment) and obtain ICT resources and services offered by services providers (Figure 1, "Services" segment). Colocation strategy adoption then refers to the extent to which specific business activities are facilitated by a firm's use of the ICT infrastructure and services provided within a colocation center. As we are dealing with a relatively under-researched topic, we have adopted a multi-method approach including an exploratory and explanatory phase. In the exploratory phase, we conducted site visits, semi-structured interviews, and a Delphi study to understand the characteristics of colocation sourcing and how it can be utilized to enhance agility on the operational level. In the explanatory phase, we subsequently address our research question not only conceptually but also validate the impact of colocation strategy adoption on the organizational level empirically in a quantitative field study.

In the following section, we review relevant research streams and develop the theoretical foundation for our research. Thereby, we consider the theory of dynamic capabilities as appropriate to investigate corporate strategies, business operations, and business value generation in turbulent environments. Moreover, we conceptualize operational agility as a dynamic capability and theorize how colocation as an ICT sourcing strategy drives operational agility. Subsequently, we conceptualize a research model for addressing our research question empirically based on primary data collected from German colocation adopters. Finally, we present our empirical results, conclude with a discussion of our findings and present the implications and contributions of our research.

Theoretical Background

In years of economic crises, firms have to deal with high dynamism and volatility, which asks for a continuous adaptation to the rapidly changing market conditions, environments, and uncertainties to stay competitive (Dong et al., 2009). Thus, to meet unpredictable business needs resulting from these dynamics, a responsive ICT infrastructure that can be adapted quickly is critical to remain agile on the operational level (Goodhue et al., 2009). In this regard, we first propose a theoretical conceptualization of operational agility before we analyze the extent to which colocation sourcing enables operational agility as an important dynamic capability in turbulent environments. Thereby, we argue that colocation as a hybrid sourcing strategy provides the ability to build, change, and mobilize ICT resources through the establishment of (digital) networks and improved infrastructural facilities.

In so doing, we follow calls to put the ICT infrastructure at the center of investigation (e.g., Hanseth and Lyytinen, 2010, Tilson et al., 2010) and conceptualize the interplay between ICT sourcing capabilities enabled by the adoption of a colocation strategy, dynamics caused by environmental turbulences, and operational agility as an organizational dynamic capability. Sourcing ICT through colocation comprises top management support as well as the extent of colocation. Prior research on IT assimilation has reported top management support to be among the most influential determinants for assimilating innovative IT sourcing solutions and resulting outcomes (Jeyaraj et al. 2006; Thong et al. 1996). Thus, it can be assumed that top management support is driving operational agility directly as well as indirectly through the decision to which extent the firm wants to colocate ICT. Consequently, our research draws on the theory of dynamic capabilities of the firm to integrate agility as a top management ability to adequately react to changes or seize new opportunities by assembling resources, knowledge, and relationships swiftly (Goldman et al., 1995). Our research model is based on a strategic management perspective that regards firms as elements of a dynamic system, which continuously interact with their environments (Pfeffer and Salancik, 1978) thereby creating enhanced performances by managing the critical relationships across external and internal resources and capabilities (Jaworski and Kohli, 1993). Thereby, we deem the operational level as the appropriate level of analysis since ICT resources first affect specific business activities and then eventually improve firm performance on the organizational level (Davamanirajan et al., 2006, Helfat et al., 2007).

Dynamic Capabilities in Turbulent Environments

The theory of dynamic capabilities is an extension of the evolutionary theory of the firm that assumes that firms gain competitive advantages when they are capable to revise routines and resources (Zahra et al. 2006). In general, dynamic capabilities are defined as the "capacity to renew competences so as to achieve congruence with the changing business environment" and the ability to "appropriately adapt, integrate, and reconfigure internal and external organizational skills, resources, and functional competences to match the requirements of a changing environment" (Teece et al., 1997: 515). These capabilities are critical in highly turbulent environments and have a considerable impact on corporate strategy, business operations, and corresponding outcomes (Eisenhardt and Martin, 2000). Specifically, environmental turbulence encompasses uncertainty and unpredictability due to massive and rapid changes in technological developments and market preferences (Atuahene-Gima and Li, 2004). Environmental turbulence demands greater organizational sensemaking and responsiveness and influences the potential outcomes. Firms have to compete by seizing a series of short-term advantages through many competitive actions (D'Aveni, 1994) stimulated by environmental changes and constantly challenged to identify contextually appropriate responses (McGrath, 1979). Accordingly, the dynamic capability theory considers those capabilities that enable a firm to integrate, build, and adjust its internal and external resources, routines, and capabilities (Eisenhardt and Martin, 2000, Teece et al., 1997).

Operational Agility as a Dynamic Capability

So far, existing research has presented several competing definitions of operational agility, mostly grounded in the manufacturing domain (see Ganguly et al., 2009, for an overview). These studies viewed agility as a firm's ability to operate profitably in a rapidly changing and continuously fragmenting market environment by producing high-quality, high-performance, customer-configured goods and services (Sharifi and Zhang, 1999). The concept of agility has received considerable attention in strategic management and IS research as well. There, the concept is described in a more general way and refers to operational agility as an organization's ability to sense and respond to changes by reconfiguring their resources, knowledge, and business processes in an effective, efficient, and timely manner (Dove, 2001, Overby et al., 2006).

However, since different terms have been used in dynamic capability literature referring to similar characteristics, or similar labels refer to different characteristics (Zahra et al., 2006); we conducted a literature review on operational agility to consolidate the various meanings and conceptual elements that are common in literature[1]. As a result, operational agility is best viewed as an organizational dynamic capability as it refers to a firm's ability to purposefully adapt its resources and substantive capabilities so as to achieve congruence with the changing business environment (Teece et al., 1997, Teece et al., 2007, Helfat et al., 2007, Eisenhardt and Martin, 2000). According to this principle, we con-

[1] Details about the review process and the results in terms of the various definitions along their essential characteristics are provided in Appendix A.

clude that the extant literature identifies two primary characteristics of operational agility: the ability to reconfigure existing routines or competencies into new ones that better match the environmental conditions and to do so in a time and cost-efficient manner (e.g., Burgess, 1994, Yusuf et al., 1999).

According to the logic of dynamic capabilities, *reconfigurability* comprises the generation and exploitation of new products, services, processes, and business practices (Pittaway et al., 2004, Pavlou and El Sawy, 2006). In particular, competitive advantages increasingly require the flexible and efficient integration of external activities and resources (Branzei and Vertinsky, 2006) resulting in increased importance of strategic alliances, virtual cooperation, buyer-supplier relations, and technology collaboration. Moreover, with ever-changing customer and market demands, organizations not only have to be innovative but also effectively adapt to changes and business needs as well (Youssef 1994, Dove 1995, Agarwal and Selen, 2009, Raschke, 2010). Thus, the ability to add new or reconfigure existing resources and capabilities helps to improve business operations and is indicative of our first agility characteristic. As reconfiguration is about executing or changing a firm's competencies and implementing an appropriate course of action, it mainly encompasses business process redesign as well as asset-realignment activities (Capron et al., 1998, Teece et al., 1997). These activities rely heavily on flexible and 'lightweight' integration and composition of resources and activities (Galunic and Eisenhardt, 2001).

The second agility characteristic, *responsiveness*, accentuates a time component and the ability to efficiently recover from change (Goldman et al., 1995, Sharifi and Zhang, 2001, van Hoek et al., 2001). More precisely, responsiveness can be defined as "the ability to react purposefully and within an appropriate timescale to significant events, opportunities, or threats to bring about or maintain competitive advantage" (Kritchanchai and MacCarthy, 1999, p. 814). However, although a firm might be able to respond to changes with an appropriate configuration in a timely manner, it may still not be considered as operational agile if the corresponding changes result in high cost. Thus, cost-efficiency – determined by the effort, which is necessary to realize the new business solution as a response to environmental changes – should be taken into account as well. Furthermore, firms should be able to respond to environmental changes in a timely and cost-efficient manner for being able to operate successfully in a dynamic environment (Oosterhout et al., 2006, Saeed et al., 2005, Sherehiy et al., 2007). Consequently, a firm's responsiveness depends on its ability to establish coordination capabilities (Dove 2001). From an internal perspective, coordination capabilities refer to a firm's ability to orchestrate and deploy tasks and resources, as well as synchronizing activities in a structured way (Okhuysen and Eisenhardt 2002; Pavlou and El Sawy 2010). For instance, by increasing the flow of information and reducing potential bottlenecks, well-coordinated operational processes enable the firm to quickly respond to opportunities (Haeckel, 1999).

Further definitions of agility are provided by Yusuf et al. (1999), Ren et al. (2003), and Dove (2001), among others, suggesting additional characteristics that are essential for continuous economic improvement in business operation. Thereby, these studies mainly refer to operational activities and the ability to adapt to changes but simultaneously accomplish performance criteria, such as operational *effectiveness*, *efficiency*, and *quality* (Agarwal and Selen, 2009, Davenport, 2005). Accordingly, and contrary to the traditional view in which such performance objectives were regarded as conflicting to reconfigurability (e.g., Allen and Boynton, 1991), the construct of operational agility inherently postulates the possibility of simultaneously fulfilling these performance objectives. Accordingly, Sambamurthy et al. (2003) define operational agility as the ability of firms' business processes being adaptive to environmental changes and exploiting new opportunities for innovation and competitive action while also accomplishing speed, effectiveness, and efficiency. Based on this principle and according to the results of our literature review, we include effectiveness, quality, and efficiency as further agility characteristics on an operational level (Kohli and Devaraj, 2003, Melville et al., 2004). Hence, effective solutions, aligned with the changing needs of the business, the industry, and the competitive environment are of crucial importance for firms. In this regard, *effectiveness* is defined in terms of aligning the new solution with organizational goals and enhancements in competitiveness because insufficient and misdirected responses can cause undesired side effects or mistakes that require additional resources to fix. Additionally, *quality* is determined by how a new solution meets predefined quality criteria. For example, quality for the order fulfillment process can be assessed by the number of customer complaints, billing and shipping errors, and on-time deliveries that affect the satisfaction of customers. Finally, although a firm might be able to respond to changes in an effective fashion and with an appropriate quality, it may still not be considered as operationally agile if the resulting solution is inefficient.

As a result of our theoretical conceptualization, we define operational *agility as response ability for accurately, rapidly, and efficiently adapting resources and routines to foreseen and unforeseen changes, without compromising the effectiveness, efficiency, and quality of the new or improved business process*. This definition broadly explains how firms can improve their agility in terms of better managing capabilities, resources, and business processes on an operational level. In the following, we conceptually describe how adopting a colocation strategy affects the identified agility characteristics and corresponding microfoundations in a more precise manner.

Colocation as Enabler for Operational Agility

Firms increasingly rely on ICT for establishing sophisticated information and knowledge management capabilities, analytical decision support, and enhanced communication and collaboration processes (Sambamurthy et al. 2003, Weill et al. 2002). Reconfigurability as an agility imperative thereby requires a flexible ICT infrastructure for being able to change business operations if needed (Ciborra 2001; Sambamurthy et al. 2003). In this way, Sambamurthy et al. (2003) theorize that ICT should be viewed as a digital options generator since contemporary operational capabilities can continually be innovated or reengineered through the functional capabilities of existing or emerging technologies, which, in turn, support firms to align their ICT infrastructure with changes (Tallon and Pinsonneault, 2011). Innovations in utility computing, Web-based services, and service-oriented architectures are therefore especially suited to facilitate reconfiguration activities by improving a firm's ability to flexibly obtain and integrate digital resources and services (Ciborra 2001, Papazoglou et al. 2007, Sambamurthy et al. 2003). As a result, firms are increasingly able to integrate digital resources and services from external providers that enable them to keep pace with leading-edge technology (Grover et al. 1996) and to acquire appropriate solutions depending on their situational business needs (Ciborra et al., 2000, Sambamurthy et al. 2003, Tilson et al. 2010).

In this regard, an ICT sourcing through colocation strategy can be utilized for improving a firm's capability to purposefully extend, create, or modify its ICT infrastructure to achieve tight alignment with the business to improve a firm's operational reconfigurability. Such a colocation strategy, consisting of top management support as well as the extent of colocation, enhances a firm's ability to explore and exploit opportunities through sourcing and staging service delivery processes, as well as the capability to adapt or extend their networks when they need access to ICT-related assets, competencies, or knowledge (Helfat et al. 2007). In this respect, we assert that the wide range of service providers of the ICT service cluster in colocation centers provide firms with different ICT infrastructure services and cooperation opportunities (Malecki, 2002) to facilitate flexible and scalable capacity adjustments as well as access to crucial ICT resources and capabilities. Firms that pursue a colocation strategy thus can improve their reconfigurability by adapting and changing their sourcing structures and integrating external services. However, a colocation strategy also provides a firm with the opportunity to purposefully create, extend, or modify the firm's ICT resource base by reconfiguring its resources and capabilities based on an internal development process. Thus, firms can individually develop, manage, and operate their own ICT systems but also benefit from scalable data center capacities and high-performance infrastructure facilities, thereby changing their extent of colocation. Furthermore, firms that adopt a colocation strategy can exploit the professional knowledge and skills of the colocation service provider and their business partners in a (digital) value-added network. Thus, colocation can be leveraged as a distributed model of innovation where firms get the opportunity to reach out beyond their own boundaries to access and integrate knowledge, technologies, and services set up by others.

In such an accruing inter-organizational collaboration environment, it is likely that participants share information and exchange resources and services in a value-added network, leading to the formation of digital marketplaces (Bakos, 1998, Cassiman and Veugelers, 2006). Such an ICT cluster constitutes an electronic intermediary that facilitates cooperation and the exchange of information and services, as well as the processing of business activities (Bakos, 1998), providing high-speed and redundant Internet connections to their customers (Gerpott and Massengeil, 2001). Such extended information-processing and transferring capabilities enhance the exchange of information and improve internal as well as external coordination mechanisms between globally distributed business units and other business partners (Dove, 2006, Bharadwaj et al., 2007), which eventually increases a firm's responsiveness.

Colocation service providers can also achieve economies of scale and scope by specializing in off-site data center operations, such that they achieve synergies and cost advantages in the construction of energy-efficient data center space, bulk purchases of electricity, server racks, generators, as well as with respect to the distribution of expenses for qualified personnel, services, and other business resources. Accordingly, colocation as a hybrid sourcing alternative also facilitates improving a firm's reconfigurability, while striving to attain high quality ICT solutions in an effective and cost-efficiency way.

Accordingly, we propose that a colocation strategy enhances a firm's capacity to purposefully and efficiently extend, create, and modify its ICT infrastructure to support the creation and modification of resources and capabilities that heavily depend on ICT to respond to current and future changes in the business environment, thereby capturing current and future business opportunities.

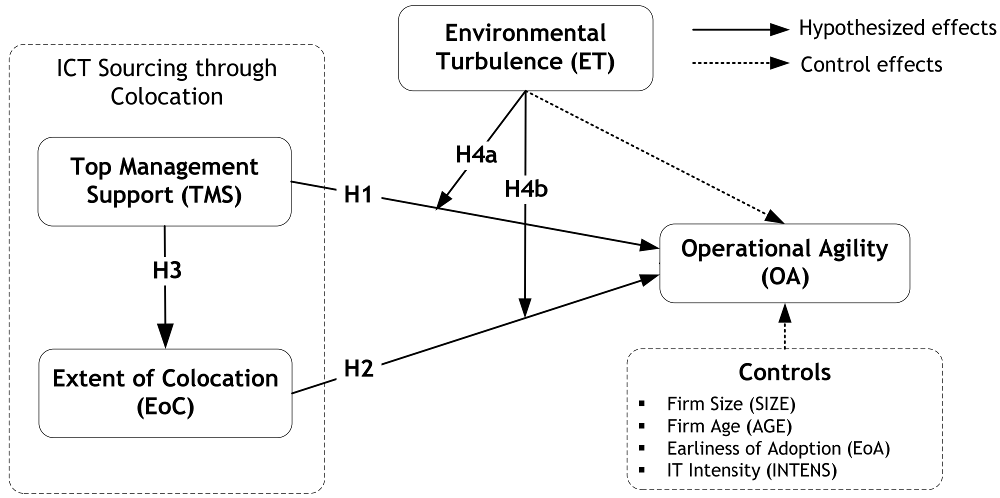

Figure 2. Proposed research model

It appears that, especially in fast-paced environments, firms leverage the high-performance ICT infrastructure and the numerous collaboration opportunities in colocation centers while simultaneously maintaining the autonomy that is needed to establish a firm's operational agility, potentially resulting in competitive advantages.

Hypotheses & Research Model

To address our research question not only conceptually but also to validate the impact of colocation strategy adoption on the organizational level empirically, we developed the research model depicted in Figure 2 conceptualizing the interplay between top management support, the extent of colocation for different business activities, and environmental turbulence as major antecedent of operational agility.

With top management support, we take care of the strategic importance of colocation as an ICT sourcing strategy that is represented by the extent to which top management actively participates in the management of colocation initiatives. In general, a high-level support of top management is important for IS innovations that are resource-intensive and require substantial material and managerial resources (Chatterjee et al., 2002, Rai et al., 2009). Specifically, existing research shows that it is the mindset of top management that determines the success of IT alignment (Preston and Karahanna, 2009). Mindfully acting top management reinforces the effectiveness of operational agility by restructuring and reorganizing processes and organizational routines (Swanson and Ramiller, 2004). Senior management can modify prevailing structures, introduce new and complementary structures to facilitate the integration of new technologies or strategies, and reinforce structures that value the dissemination of those innovations and thus influence operational agility directly. Following Rai et al. (2009), we propose that colocation as an ICT sourcing strategy also relies on top management support in three different organizational activities, which are essential for the assimilation process. By articulating a vision and establishing a sourcing strategy, top management supports the establishment of a context within which operational agility can unfold its potentials. Moreover, top management legitimizes the strategy assimilation by demonstrating its commitment and political support in terms of providing resources and encouraging active participation. Finally, top management plays a key role in setting the agenda by establishing goals and targets for the assimilation of a colocation strategy. Following this theoretical argumentation, the direct and indirect positive impact of top management support on different performance indicators have already been shown in previous IS research studies (e.g., Ragu-Nathan et al., 2004, Sabherwal et al., 2006). Kim and Kankanhalli (2009) further emphasize the role of top management to overcome organizational resistance and to initiate change processes on the operational level. This readiness to change (Armenakis et al., 1993), which is an important organizational capability and prerequisite of operational agility, is only possible if top management recognizes the need for change and is committed to provide full support in dealing with new configurations. Accordingly, a strong and ongoing backing from top management ensures the allocation of valuable resources and the establishment of new colocation initiatives to overcome deficient routines and establish changes, which leads to improved operational responsiveness of a high performance ICT infrastructure. Thus, we propose:

> Hypothesis 1 (H1): A higher level of top management support leads to higher levels of operational agility.

However, extant literature suggests that a technology/strategy must support firms' value-chain activities and business processes prior to gaining significant business value on the operational level (e.g., Santhanam and Hartono, 2003). In this respect, the infusion of an ICT sourcing through colocation strategy constitutes an important aspect of the overall assimilation process (Swanson and Ramiller, 2004). ICT infusion has been defined as the deep and comprehensive embedding of a firm's ICT system on the operational level (Cooper and Zmud, 1990, Fichman, 2000), thereby increasing the flow of information and reducing potential bottlenecks to facilitate a firm's responsiveness (Haeckel 1999). Thus, depending on the extent of colocation, firms can access high-performance ICT infrastructures that enhance inter-organizational interactions and are crucial to realize operational agility (Baraldi and Nadin, 2006). Accordingly, we consider the depth of innovation infusion described by the extent of colocation (i.e., access to external ICT infrastructure, hosting of business applications, data storages, or Internet and e-business portals) and anticipate a positive relationship between the extent of colocation and operational agility.

> Hypothesis 2 (H2): A greater extent of colocation leads to higher levels of operational agility.

Furthermore, top management serves as main human agency for absorbing, conversing, and delegating environmental influences and corresponding strategic decisions to the course of action on the operational level (Liang et al., 2007, Teo and Ang, 2000). In line with this, prior literature on innovation assimilation (e.g., Liang et al., 2007) largely views top management as central agency responsible for changing the norms, values, and culture within a firm that, in turn, enables other organizational members to adapt to technological and organizational changes. The norms, values, and culture engendered by the top management permeate to the operational level in the form of procedures, rules, regulations, and routines (Purvis et al., 2001). Accordingly, if top management understands the benefits and the strategic importance of colocation as a flexible form of ICT sourcing, the chances of a successful alignment on the operational level are higher (Teo and Ang, 2000). With regard to the colocation strategy, top management can legitimize the operational infusion of the colocation strategy by demonstrating its commitment and political support in colocation deployment initiatives. Since the pursuit of a colocation strategy provides firms with a competitive ICT infrastructure, thereby improving operational agility of ICT-intensive business activities, top management is expected to be aware of these benefits. This awareness eventually leads to top management support that is likely to facilitate the internal infusion of the strategy. Thus, we propose:

> Hypothesis 3 (H3): A higher level of top management support leads to a greater extent of colocation.

Since a higher level of top management support needs to be achieved and the norms and values have to be implemented on the operational level in the form of procedures, rules, regulations, and routines to finally facilitate operational agility, we propose that the effect of top management support on the operational agility is mediated by the extent of colocation. Thus, in addition to the direct effects (hypotheses 1 and 3), we also evaluate whether the operational implementation of a colocation strategy mediates the relationship between top management support for colocation and operational agility.

Environmental Turbulence as a Moderator

The effect of the sourcing capabilities on operational agility is moderated by the level of environmental turbulence, which is defined as the frequency and amplitude of changes in the environment and general conditions of uncertainty (Duncan, 1972). These environmental dynamics spawn new opportunities (Sull, 2009), thus creating incentives to employ sourcing capabilities to reconfigure existing and allocate new resources and capabilities to pursue emerging opportunities. Because turbulent environments create a discrepancy between existing and ideal resources and capabilities, the need for reconfiguration enhances the value of dynamic capabilities. Teece et al. (1997) argue that there is great value in the ability of top management to reconfigure resources in turbulent environments. In line with this, Rindova and Kotha (2001) reason that turbulent environments make it more likely to reconfigure operational capabilities, which require a mindful top management. In other words, top management support to build up operational agility is more effective in times of high environmental turbulence due to lower organizational resistance to improve effectiveness and lower costs. On the other hand, in times of low environmental turbulence, it will be more difficult to facilitate organizational change and thus positively influence operational agility with the same level of top management support since the need to be agile is not perceived as equally important. Therefore, we propose:

> Hypothesis 4a (4a): Environmental turbulence moderates the positive relationship between top management support and operational agility.

A similar moderating influence can be found for environmental turbulence on the relation between the extent of colocation and operational agility. In times of high environmental turbulence, more firms will search for ways to lower their ICT budget while maintaining or even increasing the level of ICT effectiveness simultaneously. Thus, with more customers there will be more providers in ICT colocation clusters as well which will — due to network effects — lower costs even more. On the contrary, in absence of high environmental turbulence, the need to colocate in order to generate operational agility is lower. This in turn reduces the offerings in ICT colocation clusters, which subsequently make them more expensive. Therefore, we propose:

> Hypothesis 4b (H4b): Environmental turbulence moderates the positive relationship between extent of colocation and operational agility.

Control Effects

In addition to the moderating effect of environmental turbulences, we assume a direct impact of turbulences (Sambamurthy et al., 2003) on the level of operational agility (i.e., organizations operating in stable industries with predictable changes require, in general, a lower level of agility compared to those who operate in fast changing environments) (Tallon, 2008). Therefore, we use the extent of environmental turbulences to control how a colocation strategy can be utilized to achieve operational agility. Accordingly, we expect that organizations operating in fast changing environments are more likely to achieve higher levels of operational agility compared to those operating in relatively stable environments.

Moreover, to account for differences among the investigated firms, we also included different control variables, such as firm size (Zhu et al., 2006), firm age (Jayanthi et al., 2009), earliness of adoption (Fichman, 2001), and IT intensity (Bharadwaj et. al., 1999). Rogers (1995) suggests that *firm size* (SIZE) relates positively to value creation because large companies have more slack resources, though they also may be hampered by structural inertia. Moreover, one could expect older, more established businesses to have greater experience and sufficient resources to host their ICT infrastructures in their own data center facilities (internal hosting). Therefore, we included *firm age* (AGE), measured as the number of years that a firm had been in business, as a second control factor. *Earliness of adoption* (TIME), which we measure as the years elapsed since the first colocation activity, reflects that firms, which initiated their colocation strategy implementation activities earlier, have had more time to reach the later stages of adoption, so they might have attained different magnitudes of operational agility as well. In addition, the potential of colocation as an ICT sourcing strategy may also vary depending on the *IT intensity* (INTENS) within the industry. For example, for financial services providers, IT not only facilitates supportive or administrative procedures but also implements productive and processing activities (Teubner, 2007). Consistent with previous literature, we define IT intensity as the ratio of IT expenditures to total revenue (Bharadwaj et al., 1999). The industry-level information about IT intensity was obtained from the Gartner IT Key Metrics Database which provides total IT investment metrics and performance metrics to derive market trends in IT spending, staffing, cost-efficiency, and productivity. Based on this information, we generated dummy variables for firms with a high, medium, and low IT intensity and included them as further control factors in our research model.

Design of the Empirical Study

To operationalize and empirically validate our research model, we employed a multi-method research design based on research cycles proposed by McGrath (1979). As noted above, the design featured two main phases: an exploratory phase to develop the measurement model and an explanatory phase to test it using cross-sectional data.

In the exploratory phase, we followed the approach suggested by Burton-Jones and Straub (2006) to operationalize the constructs and identify the measures. We pursued this integrated research approach to account for the specific research context thereby ensuring model completeness, appropriate and complete choices of measures and dimensions, and practical relevance. We aimed to identify and validate specific operationalizations of relevant value-added business activities that benefit the most from the use of a colocation strategy. Therefore, we first conducted several interviews with experts to identify the dimensions and measures of the conceptual model. These dimensions and measures then provided the basis for a questionnaire issued during a Delphi study to obtain the detailed operationalization and specification of the constructs. The widely used Delphi method is a structured, multi-pass group decision process that can address research problems where there is no absolute answer (e.g., Keil et al., 2002). For our study, we selected a panel of 30 high-level IT managers of companies that have adopted colocation as an ICT strategy from a list of the largest customers of a leading colocation provider in Germany. Each panelist considered the list of factors we had developed, and we aggregated their individual responses. Each panelist also ranked the factors identified by the group in terms of their significance. We collated these rankings to compile an overall ranking, and then showed this ranking to each expert, along with their original ranking, to allow them to review their ranking in view of the aggregated group response.

Subsequently, we analyzed our proposed research model in the explanatory phase using partial least squares (PLS), a components-based structural equation modeling (SEM) technique, that concurrently tests the psychometric properties of measurement scales (through tests of the measurement model) and assesses the strength and direction of the hypothesized relationships (through tests of the structural model). This method is appropriate for several reasons. First, PLS handles measurement errors in exogenous variables better than other methods, such as multiple regressions (Chin, 1998). Second, components-based SEM approaches require fewer distributional assumptions about the data (Cassel et al., 1999). Especially in areas of newly applied research and early stages of measurement instrument development, little is known about the distributional characteristics of observed variables. Third, PLS can accommodate both exploratory and explanatory analyses, which is particularly suitable for our research context. Although PLS is often used for theory testing, it can also suggest where relationships might exist and propositions for subsequent testing (Chin et al., 2003). Therefore, the PLS approach is prediction oriented (Chin, 1998) and estimates latent variables as exact linear combinations of the observed measures (Wold, 1982), which offers an advantage because theory construction is as important as theory verification. Fourth, PLS is able to accommodate smaller samples and latent constructs in conditions of non-normality for small to medium-sized samples (Chin, 1998).

Ensuring Content Validity of the New Measures

Whenever possible, we adapted existing measures from previous empirical studies to our research context. For "top management support" (TMS), we applied the operationalization of Ragu-Nathan et al. (2004) while we built upon Pavlou and El Sawy (2006) and Jaworski and Kohli (1993) for the "environmental turbulence" (ET) construct.

To ensure the content validity for the two new constructs "extent of colocation" as well as "operational agility", we performed additional validity checks, e.g., by conducting expert interviews as well as using a panel of practitioners and academics to review the survey instrument and suggest refinements to the wording of the indicators (measurement items). Each construct is represented by a set of indicators, as listed in Table A2 in the Appendix.

The scale development for the "extent of colocation" (EoC) construct is based on a review of existing literature in the field of innovation assimilation. In particular, we used the operationalization identified by Massetti and Zmud (1996) and adapted by Liang et al. (2007), as a guide to develop our EoC scale. However, since we refer to another technological context, not all items provided by Massetti and Zmud (1996) could be replicated. Moreover, in the interest of maintaining the conciseness of the questionnaire, we decided to focus on business activities that are likely to benefit most from colocation sourcing. Thus, the Delphi study conducted as part of the exploratory phase revealed that four business activities benefit the most from a colocation strategy: (1) access to external ICT infrastructures (point-of-presence); (2) hosting of business applications; (3) hosting of storage or storage-area networks; and (4) hosting of Web pages, Internet portals, e-business infrastructures. The respondents were asked to indicate the percentage to which these key business activities are facilitated by a colocation strategy. In particular, we operationalized EoC as a formative construct setting an indicator for a specific business activity to zero if the business activity was not colocated. Otherwise, we utilized five-point Likert scales, as defined in Table A2 in the Appendix, to measure the extent of colocation in the identified business activities. As a result, our operationalization considers diversity and depth as the essential dimensions of an assimilation construct simultaneously. Thus, with regard to diversity, the EoC score is determined by the number of the identified business activities that are facilitated by a colocation strategy. In addition, the vertical impact of the colocation strategy on the identified business activities (depth) also determines the EoC measure.

Turning to the dependent variable, we analyzed the added business value in terms of operational agility, which can be realized by using colocation as an ICT sourcing strategy. In line with previous research and the theoretical development, we operationalized operational agility by identifying different characteristics of an agile business activity. According to the theoretical conceptualization and the results of our comprehensive literature review depicted in Table A1, we operationalized the operational agility (OA) construct as a dependent variable that captures the agility creation momentum of colocation strategy adoption, attributed mainly to the operational level. Since agile business processes are characterized by the (not mutually interchangeable) presence of these six dimensions (Adler et al., 1999), we assume that they covary to a high extent. Accordingly, OA was operationalized as reflective model and a two-stage approach was utilized (Yi and Davis, 2003) to include this construct as a dependent variable in the structural model. In particular, the latent variable scores were extracted in an initial analysis for each of the four identified business activities that benefit from operational agility. Subsequently, to measure the OA construct in the overall research model, we averaged the latent variable scores for each business activity that is facilitated by utilizing a colocation strategy.

Data Collection & Sample Profile

To validate the research model and the associated hypotheses, we finally conducted a questionnaire-based survey, featuring strategic decision-makers from different German firms and industry sectors (see Figure 1, outer circle) that have adopted a colocation strategy for at least one of the four selected business activities. From an empirical perspective, our focus on a single country enabled us to control for extraneous country-specific factors that could confound the analysis, which enhances internal validity (Zhu and Kraemer, 2005).

Table 1. Sample characteristics (n = 137)

Industry sector		
Application service, hosting service, Internet service, content delivery network	44	(32%)
Digital media, online retail, e-business	30	(21%)
Financial services	16	(12%)
Consulting, IT development, systems integrator	19	(14%)
Manufacturing, wholesale and retail, logistics services	13	(10%)
Public sector	6	(4%)
Other services provider	9	(7%)

Firm size (#employees)		Firm age	
≤ 250	55 (40%)	<5 years	14 (10%)
251 - 1,000	17 (12%)	5-10 years	27 (20%)
1,001 - 5,000	17 (12%)	10-20 years	54 (39%)
5,001 - 10,000	23 (17%)	20-50 years	18 (13%)
> 10,000	25 (18%)	>50 years	24 (18%)

Year of first colocation adoption	
< 2000	30 (22%)
2000-2003	31 (23%)
2003-2006	26 (19%)
2006-2009	50 (36%)

Respondent's position		
C- level management (e.g., CTO, CIO)	44	(32%)
Directors (ICT & Operation)	45	(33%)
ICT project manager	28	(20%)
Other ICT decision-maker	20	(15%)

Respondent's tenure	
≤ 2	9 (7%)
2 - 5	18 (13%)
5 - 10	30 (22%)
10 -15	40 (29%)
> 15	40 (29%)

Moreover, we followed a key informant approach (Bagozzi and Phillips, 1991) to collect data on firms and their actual colocation-related business activities. In IS research, this approach is often used to extract information on organizational factors, especially in the context of the business value of IS (e.g., Tanriverdi, 2005). Therefore, in October 2009, we extracted a list of 1,012 potential participants from a contact database of a large colocation provider in Germany and invited them to participate in the survey by completing an online questionnaire. The reported positions of the informants (Table 1) suggested that the sample was an accurate representation of the population of interest. Since the respondents were senior executives responsible for (parts of) the ICT infrastructures in their respective firm, it can be assumed that they are familiar with different sourcing strategies in general and have significant knowledge about colocation activities of their firm. In other words, their response can be assumed to represent the organizational perspective.

Since the study aimed at colocation strategy adopters, the study participants were asked to indicate whether they had already adopted a colocation strategy or not. In total, 142 responses (137 questionnaires with no missing values) were returned (response rate = 14.0%), 82 of which had adopted a colocation strategy for application hosting, 68 for storage hosting, 92 for Web hosting, and 86 for the access to external ICT infrastructures. The key characteristics of the sample are shown in Table 1. The descriptives of our sample demonstrate that the participating firms belong to a variety of industry sectors, with the majority of service providers heavily relying on a powerful and reconfigurable ICT infrastructure, such as the digital media, financial services, or online retail and e-business industry (Overby et al., 2006). Accordingly, we suppose that especially those firms can leverage sourcing capabilities to enable operational agility. The figures show that the firms are pursuing a colocation strategy for more than five years on average. Moreover, the firm sizes indicate that the data sample is a representative subset of the German corporate landscape where small and medium-sized enterprises generate a large amount of the total economic output. As discussed below, some of these organizational factors were also included as control variables in our data analysis.

As the data were obtained from one key respondent of each organization, we conducted a Harman's one-factor test (Podsakoff and Organ, 1986) to control for single respondent bias. To ensure the internal validity of our analysis even further, we minimized influences that may stem from common method bias by using different measurement scales to weaken systematic bias of the measurement scale (King et al., 2007). Moreover, we followed Podsakoff et al. (2003) and Liang et al. (2007) to test the PLS model with a single, latent method factor in the measurement model. However, the results indicate that one factor cannot adequately account for the variance and that the constructs of our research model explain considerably more variance in the data set than the common method factor.

Data Analysis & Results

As a SEM technique, PLS analyzes a measurement model and a structural model simultaneously and combines the advantages of regression analysis and multivariate measurement approaches. The results for the PLS estimation were obtained from SmartPLS (Version 2.0 M3). Because PLS does not directly provide significance tests, we applied non-parametric bootstrap resampling to determine the confidence intervals for all parameter estimates and provide a basis for our statistical inference. Specifically, the performance of an estimator of interest depends on its parameter and standard error bias, relative to repeated random samples drawn with replacement from the original observed sample data (Marcoulides and Saunders, 2006).

Moreover, we checked the required sample size with regard to the presented research model. Therefore, we conducted a statistical power analysis based on the portion of the sub-model with the largest number of predictors (Chin and Newsted, 1999). With regard to our theoretical development and the proposed hypotheses, the largest number of endogenous constructs as predictors (including main effects, interaction effects, and controls) is 10. Assuming a medium effect size as defined by Cohen (1988), the power tables of Green (1991, p. 503) point to a minimum sample size of 117 that is needed to obtain a power of 0.80 (alpha = 0.05). In addition, Reinartz et al. (2009) recently suggest a minimum of 100 observations to achieve acceptable levels of statistical power given a certain quality of the measurement model. Consequently, our sample with 137 observations meets the sample size requirements for testing the derived research model using PLS.

Validation of the Measurement Model

In order to validate the measurement model, the psychometric properties of all scales were assessed within the context of the structural model through examination of the individual item reliability, construct reliability, convergent validity, and discriminant validity (Chin, 2010, Hair et al., 2011, Roldán and Sánchez-Franco, 2012).

According to the individual item reliability, Loch et al. (2003) claim that the existence of significant inter-indicator and indicator-to-construct correlations evidences convergent validity. Our results in Table 3 clearly show that almost all loadings of the reflective constructs are greater than the recommended threshold of 0.707 (Chin, 1998), such that there exists more shared variance between the construct and its indicators than error variance, and the measurement items used are adequate for measuring each construct. Although the loadings for a few items do not exceed the threshold, the cross-loadings shown in Table 2 reveal that they load significantly higher on their own construct than on any other construct.

Construct reliability refers to the internal consistency of the measurement model (Straub et al., 2004), or the degree to which items are free from random error and yield consistent results.

Composite reliability (CR) is an aggregate measure of the degree of inter-correlation or internal consistency among measurement items of the same construct and indicates how reliably the construct is represented by its indicators (Chin, 1998). Table 3 shows that the CR score of each construct is greater than the recommended threshold of 0.7 (Hair et al., 1998), which is evidence of sufficient reliability. The Cronbach's alpha is a traditional, alternative measure for estimating internal consistency; it assumes equal weights of all items of a construct and depends on the number of items. As we show in Table 3, all Cronbach's alpha values exceed the critical value of 0.7 (Nunnally, 1978), in further support of the internal consistency among the measurement items.

Construct validity instead refers to the wider validation of measures (Straub et al., 2004). It reveals whether indicators of the construct measure what they intend to, from the perspective of the relationships between constructs and between the constructs and their indicators. This validity can be assessed in terms of convergent validity and discriminant validity (Campbell and Fiske, 1959). The test for convergent validity determines if the indicators of latent constructs that theoretically should be related are observed to be related in actuality. In this context the average variance extracted (AVE) measures the amount of variance that a construct captures from its indicators, relative to the amount due to measurement error.

As we indicate in Table 3 in the Appendix, the AVE values of all constructs are equal or above the recommended threshold of 0.5 (Fornell, 1992), so at least 50% of measurement variance is captured by a construct. Because the constructs have satisfactory AVE, CR, and Cronbach's alpha scores, the measurement model exhibits convergent validity.

Table 2. Item loadings and cross-loadings

	TMS	EOC[1]	ET	OA	EoA[2]	SIZE[2]	AGE[2]	INTENS[2]
TMS1	**0.78**	0.37	0.32	0.51	0.13	-0.07	-0.22	0.26
TMS2	**0.85**	0.20	0.27	0.25	0.12	-0.06	-0.19	0.28
TMS3	**0.89**	0.33	0.28	0.40	0.23	-0.05	-0.05	0.22
TMS4	**0.83**	0.21	0.30	0.26	0.04	-0.12	-0.21	0.25
TMS5	**0.82**	0.27	0.23	0.22	0.17	-0.05	-0.05	0.22
TMS6	**0.81**	0.18	0.26	0.26	0.18	-0.07	-0.14	0.22
$EoC_{Infrastructure}$[1]	0.23	**0.67***	0.21	0.44	0.35	0.00	-0.05	0.37
EoC_{App}[1]	0.31	**0.27***	0.01	0.32	0.22	0.02	-0.07	0.22
$EoC_{Storage}$[1]	0.18	**0.10**	0.07	0.30	0.19	0.11	0.00	0.14
EoC_{Web}[1]	0.23	**0.51***	0.03	0.39	0.08	-0.15	-0.01	0.01
ET1	0.23	0.10	**0.75**	0.21	0.19	0.02	-0.19	0.30
ET2	0.24	0.14	**0.75**	0.21	0.11	0.04	-0.10	0.15
ET3	0.30	0.07	**0.76**	0.17	0.18	0.09	-0.18	0.27
ET4	0.31	0.20	**0.75**	0.27	0.27	0.04	-0.18	0.30
ET5	0.19	0.02	**0.74**	0.13	0.18	0.05	-0.16	0.16
ET6	0.22	0.13	**0.69**	0.24	0.09	0.03	-0.12	0.17
ET7	0.21	0.06	**0.75**	0.20	0.19	-0.01	-0.11	0.24
ET8	0.19	0.11	**0.72**	0.17	0.17	-0.02	-0.20	0.30
OA[2]	0.42	0.56	0.30	**1.00**	0.31	0.03	-0.08	0.30
EoA[3]	0.18	0.32	0.25	0.31	**1.00**	0.09	0.18	0.34
SIZE[3]	-0.08	-0.08	0.04	0.03	0.09	**1.00**	0.60	-0.06
AGE[3]	-0.18	-0.06	-0.22	-0.08	0.18	0.60	**1.00**	-0.21
INTENS[3]	0.29	0.31	0.34	0.30	0.34	-0.06	-0.21	**1.00**

Notes. Top management support (TMS), Extent of Colocation (EoC), environmental turbulence (ET), operational agility (OA), earliness of adoption (EoA), firm size (SIZE), firm age (AGE), IT intensity (INTENS).
[1] formative measure with weights and significance levels, * $p < 0.05$ (two-tailed); [2] one-item measures

Table 3. Descriptive statistics as well as validity and reliability criteria

	Mean	SD	AVE	CR	Alpha	TMS	EoC[1]	ET	OA	EoA[2]	SIZE[2]	AGE[2]	INTENS[2]
TMS	5.01	1.30	0.69	0.93	0.91	**0.83**							
EoC[1]	1.92	1.53	n/a	n/a	n/a	0.34	**n/a**						
ET	5.26	0.97	0.51	0.89	0.86	0.34	0.16	**0.72**					
OA	3.13	2.11	n/a	n/a	n/a	0.42	0.56	0.30	**n/a**				
EoA[2]	5.96	5.11	n/a	n/a	n/a	0.18	0.32	0.25	0.31	**n/a**			
SIZE[2]	4853	1089	n/a	n/a	n/a	-0.08	-0.08	0.04	0.03	0.09	**n/a**		
AGE[2]	32.9	46.1	n/a	n/a	n/a	-0.18	-0.06	-0.22	-0.08	0.18	0.60	**n/a**	
INTENS[2]	3.07	0.81	n/a	n/a	n/a	0.29	0.31	0.34	0.30	0.34	-0.06	-0.21	**n/a**

Notes.[1] formative measure; [2] one-item measures
Top management support (TMS), Extent of Colocation (EoC), environmental turbulence (ET), operational agility (OA), earliness of adoption (EoA), firm size (SIZE), firm age (AGE), IT intensity (INTENS)
Mean value (Mean), standard deviation (SD), average variance extracted (AVE), construct reliability (CR), Cronbach's alpha, correlations among constructs (off-diagonal), and square roots of average variance extracted (diagonal).
All correlations with absolute values of $|r| > .16$ are significant at $p < .05$; all correlations with absolute values of $|r| > .21$ are significant at $p < .01$.

For discriminant validity, we tested whether indicators of latent constructs that theoretically should not be related are actually observed as unrelated. MacKenzie et al. (2005) propose an approach appropriate for evaluating the discriminant validity of both formative and reflective measures, which analyzes if the inter-construct correlations are relatively low. The discriminant validity for the reflective constructs also can be assessed by analyzing the cross-loadings and the Fornell-Larcker criterion. The cross-loadings reveal that each indicator loading is much higher on its assigned construct than on the other constructs, in support of sufficient discriminant validity on the indicator level (Henseler et al., 2009). The Fornell-Larcker criterion (Fornell and Larcker, 1981) postulates that a construct must share more variance with its assigned indicators than with any other construct, as assessed by the relationships between the inter-construct correlations and the square roots of the AVE scores. In statistical terms, the square root of the AVE for each construct should exceed the inter-construct correlations involving the construct (Fornell and Larcker, 1981). As presented in Table 3, the calculated square root of each AVE score is greater than the correlations between the construct and any other construct, which indicates satisfactory discriminant validity.

For the formative construct EoC, we additionally assessed the potential threat of collinearity by analyzing the bivariate correlations among the indicators and with their construct as well as by calculating variance inflation factors (VIF). The results show bivariate correlations among the four indicators ranging from 0.19 to 0.67, thus suggesting the (relatively limited) possibility of collinearity. In addition, the VIF scores – ranging from 1.05 to 2.94 – show lower values than the proposed threshold of 3.3 (Petter et al., 2007). Moreover, from a conceptual point of view the operationalization of the EoC construct suggests no major overlap of its indicators. Thus, where collinearity has been ruled out as a cause of destabilization of the construct, we could interpret the indicator weights and corresponding significance with t-values and p-values. The results (see Table 2) show positive and significant weights for all formative indicators with the exception of the indicator $EoC_{Storage}$.

Validation of the Structural Model

Because all constructs exhibit convergent and discriminant validity and almost all indicators satisfy various reliability and validity criteria, we feel confident using them to test the structural model and the proposed hypotheses.

The empirical results for the theoretically derived structural model are depicted in Table 4. Checking for robustness, we compared nested models for the dependent variable OA (1. baseline model with control factors only; 2. additionally including all main effects; 3. full models with all main effects, the interaction effects, and all control factors). In addition, we followed the suggestions of Cohen et al. (2003) by conducting two additional estimations considering only one interaction term per model to reduce multicollinearity issues.

Since the resulting models are fully nested, the difference in the explanatory power enables a valid model comparison in terms of effect sizes. The explanatory power of the structural model is measured by the squared multiple correlations (R^2) of the dependent variable. According to Cohen's (1988) approach, we additionally considered the relative impact of a particular exogenous latent variable on the endogenous latent variable by means of changes in the R^2 values, based on the effect size f^2. Moreover, we refer to sample reuse techniques proposed by Stone (1974) and Geisser (1974) to assess the model's predictive validity by means of the cross-validated redundancy measure Q^2. The Q^2 values were obtained by using a blindfolding procedure that omits every fifth data point and uses the resulting estimates to predict the omitted data point. Q^2 values greater than 0 imply that the model has predictive relevance, whereas Q^2 values less than 0 suggest that the model lacks predictive relevance.

Comparing control model (including the control factors only) with the model that additionally comprises all main effects, the path coefficients and corresponding significance levels clearly indicate that the main effects decrease explanatory power of the control factors. A separate estimation showing positive and significant coefficients of EoA and INTENSITY on EoC demonstrates that these control factors significantly influence the operational embeddedness of a colocation strategy. However, as the results show, we find support for H1 and H2 in our survey data, indicating the positive effect of top management support for the colocation strategy and its implementation on the operational level on operational agility. For testing the indirect effect of TMS on OA mediated by EoC (H3), we followed the three-step approach proposed by Baron and Kenny (1986). Accordingly, we tested the significance of the direct effect of TMS on OA and then considered the effect of TMS on the mediator EoC. Finally, we tested the direct effect of TMS on OA and the indirect effect through the mediator EoC simultaneously. In so doing, we followed researchers who recommended using the bootstrapping procedure instead of the Sobel test to assess indirect effects of mediation models (Shrout and Bolger, 2002, Preacher and Hayes, 2008, Williams and MacKinnon, 2008). The bootstrapping procedure does not impose normality of the sampling distribution and has a higher statistical power while maintaining adequate control over Type I errors.

Table 4. Empirical results of the hierarchical SEM analysis

Explanatory Variables (on operational agility)	**Nested Research Models** (n = 137)				
	Controls	+ Main Effects	+ Interaction ET×TMS	+ Interaction ET×EoC	f^2
Environmental Turbulence (ET)	0.15* (0.04)	0.10 (0.08)	0.09 (0.11)	0.09 (0.11)	0.02
Firm Size (SIZE)	0.07 (0.34)	0.12 (0.11)	0.16* (0.03)	0.18* (0.03)	0.02
Earliness of Adoption (EoA)	0. 23** (< 0.01)	0.10 (0.11)	0.08 (0.21)	0.08 (0.21)	0.02
Firm Age (AGE)	-0.10 (0.23)	-0.08 (0.15)	-0.08 (0.07)	-0.14 (0.07)	0.01
IT Intensity (INTENS)	0.16 (0.07)	0.04 (0.30)	0.05 (0.31)	0.07 (0.31)	0.01
H1: Top Management Support (TMS)	–	0.20** (< 0.01)	0.19* (0.02)	0.20** (< 0.01)	0.06
H2: Extent of Colocation (EoC)	–	0.44** (< 0.01)	0.45** (< 0.01)	0.41** (< 0.01)	0.25
H3: TMS → EoC (indirect effect)	–	0.34** (< 0.01)	0.34** (< 0.01)	0.34** (< 0.01)	–
H4a: ET×TMS (moderating effect)	–	–	0.33** (< 0.01)	–	0.18
H4b: ET×EoC (moderating effect)	–	–	–	0.20* (0.02)	0.10
R^2 (ΔR^2)	0.17	0.41 (+ 0.24)	0.50 (+ 0.09)	0.46 (+ 0.05)	–
F test (ΔR^2)	–	17.36***	11.34***	5.83***	–
Q^2	0.15	0.42	0.48	0.45	–

Notes.
p-values are in parentheses below standardized path coefficients.
** p < 0.01, * p < 0.05 (two-tailed)

In this regard, an indirect effect is considered to be significant if its 95% bootstrap confidence interval of 5,000 bootstrap iterations does not include the value 'zero' (Preacher and Hayes, 2008). The results show that the direct effect of TMS, without the mediator EoC, on OA is significant ($\beta_{TMS\text{->}OA}$ = 0.33, p < 0.01). Moreover, after controlling for the mediator EoC, the direct effect of TMS still shows a positive and significant effect ($\beta_{TMS\text{->}OA}$ = 0.22, p < 0.01). The indirect effect of TMS through the mediator EoC is significant and estimated to be 0.15 with a 95% bootstrap confidence interval of 0.09 to 0.23. However, the direct effect of TMS on OA stays positive and significant ($\beta_{TMS\text{->}OA}$ = 0.20, p = 0.02). This means that TMS not only positively affects operational agility directly but also indirectly through the realization of the colocation strategy on an operational level, indicating a partial mediation effect of EoC (Shrout and Bolger, 2002).

The moderating effects of environmental turbulence (ET) were calculated following two different procedures. The effect with ET as moderator and top management support (TMS) as predictor was estimated according to the product indicator approach proposed by Chin et al. (2003). This approach was our first choice since, based on the findings of Henseler and Chin (2010), the product indicator procedure provides a significantly and substantially more accurate prediction than other approaches (e.g., the product sums approach) especially if the sample size or the number of indicators per construct is medium to large, as was the case in our study. However, since the extent of colocation was operationalized as a formative construct, the effect of ET as moderator and EoC as predictor was conceptualized following the two-stage approach proposed by Henseler and Chin (2010) as well as Henseler and Fassott (2010). Accordingly, we first reduced multicollinearity by standardizing all indicators reflecting the predictor and moderator constructs to a mean of 0 and variance of 1. This also enables an easier interpretation of the resulting regression beta for the predictor variable. The path coefficient represents the effect expected at the mean value of the moderator variable, which is 0. However, considering the potential high intercorrelations among the main effects (TMS, EoC, ET) and interaction terms (TMS×ET, EoC×ET), we also assessed the potential threat of multicollinearity by analyzing the variance inflation factor (VIF). The VIF scores of the exogenous variables show lower values than the recommended level of 3.3, which indicates the absence of multicollinearity (Petter et al., 2007). The estimation results thus demonstrate that the effect of TMS on OA is positively moderated by the turbulences of the environment (as a driver for operational changes), thus supporting the hypothesis H4a for the analyzed business activities ($\beta_{ETxTMS\text{->}OA} = 0.33$, $p < 0.01$). Moreover, the results support the hypothesized positive moderation of ET on the relationship between EoC and OA (H4b) in our research context ($\beta_{ETxEoC\text{->}OA} = 0.20$, $p = 0.02$).

With regard to the control variables, we note that firm size (SIZE) positively influences the realized operational agility with regard to the investigated business activities, while AGE seems to be negatively related to OA (even it is not statistical significant at the 0.05 level). The results in Table 4 clearly indicate the robustness of our estimations when controlling for other influence factors (ET, SIZE, TIME, AGE, INTENS). Accordingly, the hypothesized main and moderating effects contribute substantially to the explanatory power of our research model. According to Chin (1998), an R^2 value of 0.41 indicates a moderate amount of variance of the dependent variable explained by our main research model. In particular, the explained variance increases about 24 percent for the full model compared to the baseline model, which only includes the control factors. In detail, both changes in the R^2 values from the control model as well as the full model with interaction terms are highly significant at the 0.01 level. In addition, the increasing and positive Q^2 values for OA exhibit the predictive relevance of the hypothesized explanatory variables and moderator effects.

The analysis of the effect sizes (Cohen, 1992) further confirms the explanatory power of the main effects and ET as a moderator. Thereby, the effect sizes f^2 of 0.18 (ETxTMS; H4a) and 0.10 (ETxEoC; H4b) indicate that the corresponding influences are not only statistically but also economically significant (Cohen, 1988). This exhibits the extent of the theoretical relationships found in our analysis and thereby provides a solid estimation of the degree to which environmental turbulence influences the adoption decision process and the business value creation momentum in our data sample.

As a robustness check, we additionally estimated an alternative research model that includes dummy variables for different industry sectors (instead of the firm-specific control variables) to control for cross-sectional, industry-specific factors (e.g., ICT dependency, market development, economic situation) (Chatterjee et al., 2002, Zhu et al., 2006). The estimation results show nearly equivalent coefficient estimates for the proposed relationships. However, the alternative models show an equal or even lower amount of the explained variance of EoC and OA. Hence, the results provide support for our initial models and we are reasonably confident in the robustness of our results.

Discussion

Key Findings

Leveraging ICT sourcing strategies to respond to environmental dynamics in the form of operational agility continues to be of high interest for managers and researchers (Hanseth and Lyytinen, 2010, Tilson et al., 2010). The objective of this article is to extend our understanding of the interplay between colocation as sourcing strategy and the value generation in turbulent as well as in stable markets. We do this by embedding top management support and the extent of colocation in a nomological network that both affect operational agility. Thereby, we regard ICT sourcing capabilities as the capacity of a firm to purposefully extend, create, or modify its ICT infrastructure to achieve tight alignment with the business to enable a firm to capture new business opportunities. While espousing this view, we ground our research in the theory of dynamic capabilities (Helfat et al., 2007, Teece, 2007, Teece et al., 1997) and expose a conceptualization of colocation sourcing as an enabler of important microfoundations of operational agility. To validate the impact of colocation on operational agility also empirically, we developed a research model conceptualizing the interplay between top management support, the extent of colocation for different business activities, and environmental turbulence as major antecedent of operational agility.

The results of our empirical analysis indicate a positive influence of top management support on the realization of operational agility for all investigated business activities (H1). Accordingly, the empirical investigation confirms the beneficial role of top management to overcome organizational resistance and to initiate changes as an important responding capability. Top managers are more apt to notice market opportunities and threats as well as technological developments. Hence, top management support improves sensing and responding capabilities that are important prerequisites of operational agility (Overby et al., 2006). In addition to the direct effect of top management support on operational agility, the results clearly indicate that the operational implementation of a colocation strategy mediates the link between top management support and operational agility. Thus, the results suggest that fostering the implementation of the colocation strategy in different business activities facilitates the realization of operational agility as an important dynamic capability (H2). Accordingly, our results show that implementing a colocation strategy improves a firm's responsiveness while also being able to realize effective and efficient application, storage, and Web hosting, as well as access to external ICT infrastructures. Because of the formative measurement specification of the EoC construct, we were able to interpret each formative indicator based on the weights, which provide information about the relative importance of each indicator for the EoC construct (Chin, 1998). In addition, due to the formative measurement model that is based on principles of multiple regressions, the weights provide information about the predictive power of each indicator in relation to the dependent variable associated with the construct. According to the empirical results depicted in Table 3, we can conclude that the access to external ICT infrastructures (point-of-presence) ($\gamma_{EoC\_Infrastructure} = 0.67$, $p < 0.01$), as well as hosting of Web pages, Internet portals, and e-business applications are the main drivers for assimilating a colocation strategy ($\gamma_{EoC\_Web} = 0.51$, $p < 0.01$). Thus, it seems that these investigated business activities benefit most from colocation activities with respect to operational agility improvements. Accordingly, flexible and scalable capacity adjustments, as well as efficient and situational access to computing resources and a reliable ICT infrastructure, are of central importance for different kinds of distributed (Web-based) applications for mailing, messaging, and collaboration that must be readily accessible anywhere and anytime. This finding is also helpful to explain that a greater extent of colocation activities with regard to the access to external ICT infrastructures leads to significant improvements in operational agility, which is a result of efficient connectivity opportunities (i.e., direct access to different carriers, WAN providers, and ISPs). In contrast, the relatively low weight for storage hosting indicates that colocation plays a minor role with respect to storage hosting activities. An explanation might be that outsourcing business-critical data increases strategic risk (e.g., industrial espionage) and operational risk (e.g., intensified attacks on an emerging "single point of failure") which may lead to increased administration and security overhead and thus to lower operational agility of storage hosting. This goes along with the negative effect of IT intensity on operational agility for the business activity of storage hosting, indicating that especially the financial services industry is concerned about data security issues.

When looking at the impact of environmental turbulence, the results indicate that a higher level of volatility accompany with a higher level of operational agility for the investigated business activities. In other words, top management support to build up operational agility is more effective in times of high environmental turbulence due to lower organizational resistance to improve effectiveness and lower costs. In line with these findings, our results confirm the reinforcing moderating effect of environmental turbulence on both the relation between top management support and operational agility (H4a) as well as the relation between the extent of colocation and operational agility (H4b). This means that firms operating in highly dynamic environments can gain a higher benefit from a colocation strategy since more firms will search for ways to lower their ICT budget while maintaining or even increasing the level of ICT effectiveness simultaneously. Thereby, our results confirm prior findings, which suggest that high levels of dynamics could also spawn new opportunities (Sull, 2009) and create incentives to employ sourcing capabilities to reconfigure existing and allocate new resources and capabilities to pursue these emerging opportunities. This finding empirically supports the theoretical argumentation of Sambamurthy et al. (2003) with respect to the role of digital options in creating operational agility. While the moderating effects as stated in H4a and H4b could be confirmed, we could not find a significant direct effect of environmental turbulence on operational agility.

Implications for Research & Practice

This study provides the following three main contributions. First, we propose a research model that analyzes the strategic value of sourcing ICT through colocation based on the theory of dynamic capabilities, which already has been applied in prior IS literature but has not been used in the context of ICT sourcing so far. Second, we conceptualized, operationalized, and validated the construct of operational agility as an important dynamic capability in turbulent environments. The construct is a prerequisite of organizational performance and a valuable measure for future investigations in the field of IS value research. Third, we identified the moderating role of environmental turbulence, with high environmental turbulence being a facilitator of operational agility. These key contributions are described in more detail in the following.

Business value of colocation as an ICT sourcing strategy: The findings of our investigation go beyond prior prescriptive recommendations for firms to expedite ICT sourcing activities to decrease their fixed costs and increase firm performance. Our results do not contradict to this advice but provide a more nuanced view, treating fast access to communication networks and the availability of a high-performance ICT infrastructure as indispensable for accelerating digital transactions between geographically dispersed firms. In the light of this paradigm, we show how the value of a flexible ICT sourcing strategy can be investigated as a function of whether it increases the agility of firms on an operational level. Thereby, we argue that colocation as a sourcing strategy provides the ability to build, change, or mobilize ICT resources and capabilities through the establishment of (digital) networks and improved infrastructural facilities.

Operational agility as an important dynamic capability and valuable measure for future investigations in the field of IS value research: A central theme in IS research is the understanding of the value impact of ICT on firm performance. However, the value contribution of an ICT innovation is difficult to measure on the firm level and has led to inconsistent results in previous research (see, e.g., Melville et al. (2004) for a review). One of the reasons for these contradictory findings is the use of various general ICT-related constructs (e.g., ICT investments, ICT spending) that may have inhibited the creation of a common understanding of the strategic role of ICT infrastructures. Although the generalized concept of dynamic capabilities captures all reconfiguration capabilities, it remains on an abstract level (Winter, 2003). Hence, the identification of different kinds of agility, such as operational agility or customer agility (Roberts and Grover, 2012), as potential mediators of the link between ICT capabilities and firm performance in turbulent environments is an important result.

Moreover, the impact of an ICT innovation is best determined on the level at which business value is created directly, such as on the business activity and business process level (Melville et al., 2004, Raschke, 2010, Ray et al., 2004). Accordingly, our research examines the impact of ICT sourcing on the business activity level by examining ICT as a platform for agility on which business value is created (Sambamurthy et al., 2003). The relationship between new ICT sourcing alternatives (such as colocation sourcing) and operational agility is of specific interest for practitioners since firms need to expand their ICT infrastructures to better anticipate environmental changes and opportunities in future developments.

The mediating role of top management support on the extent of colocation: Top managers have a direct impact on operational agility, as they are responsible for setting the organizational rules, norms, and corporate culture. However, they also indirectly influence operational agility via their investment decision and support for ICT sourcing from a colocation center where they can improve different business processes while enjoying having access to competitive services at the same time. In so doing, they gain access to more digital options, which in turn increase operational agility. In this regard, academia as well as industry need to have a closer look into sourcing benefits when it comes to ICT services sourcing from colocation centers. The findings from this research illustrate that different business activities benefit in different ways from colocation, which is the reason why the decision to which extent a firm should use colocation requires a profound upfront analysis.

The moderating role of environmental turbulence: Our results also indicate that colocation as an ICT sourcing alternative is moderated by volatile environments, thereby highlighting the options value of a colocation strategy in times of high environmental turbulence. More specifically, our results show that environmental turbulence reinforces the impact of ICT sourcing opportunities on operational agility, stressing the notion that the role of ICT infrastructure sourcing competence becomes more pronounced when the environment is more turbulent. In addition, we were able to show that the strategic impact (reflected by a higher level of top management support) of ICT sourcing capabilities is more likely to be evident in higher levels of environmental turbulence.

Limitations & Future Research

Despite the rich findings, our study has some limitations that suggest avenues for future research. In this study, we investigated colocation strategy as an enabler of ICT sourcing capabilities leading to enhanced operational agility. Thereby, we expanded the conceptualization of enterprise ICT sourcing capabilities by reinterpreting it according to the dynamic capabilities theory in the light of environmental turbulences accruing from technological and market changes. However, to better understand how to achieve dynamic capabilities through flexible and high-performance ICT infrastructures, we further need to differentiate between types of turbulences that result in forces of changes (e.g., Overby et al., 2006) and identify more differentiated classifications of ICT (sourcing) capabilities, which enable the establishment of microfoundations of dynamic capabilities. Thereby, as a starting point, further research could consider the differentiation between external and internal changes. An external change may come from market changes (i.e., changing customer needs) or from regulations, whereas internal changes come from within the firm, e.g., due to a change in the business strategy. Further research should proceed to elaborate on the identification and classification of different types of ICT capabilities, such as ICT sourcing and ICT infrastructure capabilities that are needed to address these different types of environmental turbulence. Accordingly, sourcing capabilities should be combined with the firm's ICT architecture competence (e.g., Ross, 2003), which we consider as essential to achieve the improvements in operational agility.

Moreover, our results indicate that the relationship between ICT (sourcing) capabilities and operational agility can be regarded as an important intermediary step in better understanding the connection between ICT investments, business process support and ultimately firm performance. Thus, the concept of operational agility can be thought of as a building block for research on agility as an important dynamic capability of the firm. However, a more comprehensive investigation of the general concept of business agility might extend our theoretical and practical implications regarding different dimensions of business agility, such as market, network, and operational agility (Sambamurthy et al., 2003) and also to consider different sources of turbulences and uncertainties.

Implicitly, we assumed that ICT sourcing from a colocation provider is a viable means to scale-up business activities and to achieve higher levels of operational agility. However, dynamic capabilities are also important in economic situations where firms need to scale-down their operations while keeping the same level of operational agility. This needs to be addressed in future research, e.g., to understand how business process performance can be maintained or even improved by up- or downscaling of ICT infrastructure in a colocation center.

From a methodological perspective, future research can benefit from more comprehensive data sets. Since we included different industries, additional research should focus on multi-group analyses to determine industry-specific differences. These findings may provide more insights into industrial heterogeneity with regard to different business activities and facets of agility. Furthermore, considering the cross-sectional nature of our research design, we have focused on synchronous effects. To complement these findings, additional research might take a longitudinal approach and demonstrate the relations over time, thus accounting for diachronic effects. Moreover, the cross-sectional nature of the available data limits our ability to observe how firms react to different forms of change. Previous research (e.g., Rindfleisch et al., 2008) already illustrated the benefits of using longitudinal data that can be utilized to investigate how the development of ICT capabilities enables agility over time and how the success or failure of agility contributes to future adoption decisions. Finally, current research (e.g., Chin et al., 2012) demonstrated that the unmeasured latent method construct approach of Liang et al. (2007) has its limitations in detecting and controlling for common method bias. Moreover, although the calculated Harman test is very often used, its applicability is questioned and better statistical remedies should be used (Podsakoff et al., 2003). Consequently, future research should address possible common method biases by applying approaches that are more appropriate.

Conclusion

In response to calls for more research in the area of digital infrastructures and their importance for industry (e.g., Tilson et al., 2010), we analyzed the potential of ICT infrastructure sourcing (i.e., colocation sourcing) to enhance operational agility. Considering the early stage of ICT infrastructure strategy research that pertains to digital infrastructures in general, and colocation in particular, we were able to provide one of the first insights into that area.

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Appendix A1

Table A1. Characteristics of operational agility

Source	Characteristics of Operational Agility				
	Reconfigurability/ Flexibility	*Responsiveness/ Time-efficiency*	*Responsiveness Cost –Efficiency*	*Effectiveness*	*Quality*
Agarwal and Selen (2008)	X	X			X
Burgess (1994)	X	X	X		X
Cho et al. (1996)		X		X	
Dove (2001)	X	X	X	X	X
Fliedner and Vokurka (1997)		X	X	X	X
Ganguly et al. (2009)		X	X		
Goldman et al. (1995)	X	X		X	
Goranson (1999)	X	X		X	
Jain et al. (2008)	X	X	X		X
Jie et al. (2009)		X			
Kumar and Motwani (1995)		X		X	
Lin et al. (2006)	X	X	X	X	
Menor et al. (2001)	X	X	X		X
Overby et al. (2006)		X	X	X	
Raschke and David (2005)	X	X		X	
Ren et al. (2003)	X	X	X	X	X
Sambamurthy et al. (2003)	X	X	X	X	
Sethi and Sethi (1990)	X				
Sieger et al. (2000)		X	X	X	
Sharifi and Zhang (1999)	X	X			
Tallon (2008)	X	X	X	X	X
Tallon and Pinsonneault (2011)	X	X	X	X	X
Tsourveloudis and Valavanis (2002)		X	X	X	X
van Hoek et al. (2001)	X	X		X	
Vázquez-Bustelo et al. (2007)	X	X	X		X
Yang and Li (2002)	X	X	X	X	
Yusuf et al. (1999)	X	X	X	X	X
Total = 27	**19**	**26**	**17**	**18**	**12**

To identify the different definitions of operational agility, we conducted a systematic literature review following the approach of Webster and Watson (2002) to analyze, synthesize, and integrate the results of extant studies on agility. First, we created a list of literature relevant for our review. Since operational agility - with our focus on ICT sourcing strategies - has most often been addressed in IS research as well as operations research and management science (Overby et al., 2005, Ganguly et al., 2009), we started selecting top journals from each of these streams of literature. In this regard, we considered Saunders' (2007) MIS journal ranking. Since we could not find a similar ranking for operations research and management science, we followed the recommendations of Xu et al. (2011) to select the most influential scientific sources. Subsequently, we chose papers related to business agility. This resulted in more than 200 articles that have been published since 1990, whereby the term "agility" is commonly used in many different contexts not specifically related to the operational level (e.g., operational agility, operation-level agility, process agility, manufacturing agility). Finally, we reviewed these articles and discussed the definitions and specifications to discover the major components that characterize the concept of operational agility.

Appendix A2

Table A2. Measurement items

Top Management Support (TMS) *(reflective measures)*		7-point Likert (1 = strongly disagree; 7 = strongly agree) Ragu-Nathan et al. (2004)	
TMS1	Top management defined colocation as corporate data centre strategy	TMS4	Top management keeps the pressure on operating units to deal with the colocation strategy
TMS2	Top management understands the importance of our colocation strategy	TMS5	Top management understands the benefits of our colocation strategy
TMS3	Top management supports our colocation strategy	TMS6	Top management is interested in colocation
Extent of Colocation (EoC) *(formative measures)*		5-point Likert (1 = < 20%; 5 = 80–100%) Liang et al. (2007), expert interviews, Delphi study	
Please rate the extent of your colocation-based activities in the following areas:			
EoC1	Access to external ICT infrastructure (Point-of-Presence, PoP)	EoC3	Hosting of Storage-Area-Networks
EoC2	Hosting of business applications	EoC4	Hosting of Web pages, Internet portals, e-business infrastructures
Environmental Turbulence (ET) *(reflective measures)*		7-point Likert (1 = strongly disagree; 7 = strongly agree) Pavlou and El Sawy (2006), Jaworski and Kohli (1993)	
ET1	The environment in our industry is continuously changing.	ET5	In our kind of business, customers' product preferences change a lot over time.
ET2	Environmental changes in our industry are very difficult to forecast.	ET6	Marketing practices in our product area are constantly changing.
ET3	The technology in our industry is changing rapidly.	ET7	New product introductions are very frequent in our market.
ET4	Technological breakthroughs provide big opportunities in our industry.	ET8	There are many competitors in our market.
Operational Agility (OA) *(reflective measures)* Exemplarily for application hosting		7-point Likert (1 = strongly disagree; 7 = strongly agree) Literature review, expert interviews, Delphi study	
The colocation strategy has…			
OA1	… improved the flexibility of our business application hosting. (*reconfigurability*)	OA4	… improved the effectiveness of our business application hosting. (*effectiveness*)
OA2	… decreased the time-to market/ deployment time of our business application services. (*responsiveness; time-efficiency*)	OA5	… improved the latency of our business application hosting. (*efficiency*)
OA3	… lowered our costs for changes in business application hosting. (*responsiveness; cost-efficiency*)	OA6	… improved the quality of our business application hosting. (*quality*)
Controls *(1-item measures)*		Open survey questions and secondary data e.g., Rogers (1995), Fichman (2001), Zhu et al. (2006)	
TIME	Years elapsed since first colocation activity	SIZE	Number of employees (worldwide)
AGE	Firm age in number of years	INTENS	Ratio of IT expenditure to total revenue (%)