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Explaining the adoption of grid computing: An integrated institutional theory and organizational capability approach

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ABSTRACT

Grid computing can meet computational demands and offers a promising resource utilization approach. However, little research details the drivers of and obstacles to adoption of this technology. Institutional and organizational capability theory suggests an adoption model that accounts for inter- and intra-organizational influences. An empirical study with 233 high-ranking IT executives reveals that adoption results from social contagion, while organizational capabilities such as trust, firm innovativeness, tendency to outsource, and IT department size, influence adoption from an intra-organizational perspective. The findings show that mimetic pressures and trust play major roles in adoption processes, which differentiates grid computing from other inter-organizational systems.

1. Introduction

In the past decade, a networked economy has evolved in which organizations collaborate and create supply chains or value networks. Such networks constitute relationship webs that generate both tangible and intangible value through complex, dynamic exchanges across organizations. The adoption of new technologies in such closely collaborating, networked economies can be consequential. Technologies such as electronic data interchange, voice-over-Internet protocols, and electronic business-to-business marketplaces, constitute a category of such technologies, referred to as inter-organizational systems (IOS) (Eom, 2005). Though the aforementioned have received pertinent research attention, another IOS gaining prominence has not – 'Grid computing'. This study aims to address this gap by analyzing the influences on the adoption of grid computing.

Specifically, grid computing connects various IT resources through a physical network, offering members of the network the capability to share their IT resources (Foster et al., 2001), potentially improving utilization of otherwise idle resources. Grid computing thus can provide significant advantages to its adopters, especially for organizations that comprise subsidiaries in different time zones (where off-peak resources in one zone can be utilized on-peak in another zone). The concept of cloud computing evolved out of grid computing and often uses a grid as its backbone. This evolution reflects a shift in focus, from an infrastructure that delivers storage and computing resources (i.e., grids), to one that is economy-based and aims to deliver more abstract resources and services (i.e. in clouds) (Foster et al., 2008). Grid and cloud computing both can be employed internally by a firm, or can be exposed to others as an IOS. Furthermore, both grid and cloud computing appear poised to induce paradigm shifts, similar to the shift that marked transition from mainframe to client–server architectures in the

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early 1980s (Bhardwaj et al., 2010). Yet we know little about prospective users' intentions to participate in this paradigm shift.

On first consideration, grid computing appears similar to other IOS with regards to factors that influence its adoption. On closer scrutiny however, several important differences become apparent. We will discuss these differences in detail in Section 3 and motivate why a distinct adoption model is appropriate for grid computing. We propose a combined model including institutional pressures and factors that are critical for grid computing, highlighting the differences from other IOS adoption models. In Section 2, we introduce the technology underlying grid computing and its strategic impacts on the firm. We highlight differences between grid computing and other IOS, then offer some examples from business practice before discussing the theoretical background for our proposed adoption model. We describe our conceptual model in Section 5 and subject it to several pretests. Section 6 outlines the status quo of grid adoption in business practice and presents the model results based on data from a large field study involving 233 IT managers who have responsibility for IT budgets. Additionally we compare the results of our adoption model with those obtained for other IOS. Finally, Section 7 concludes with a discussion of the implications of our findings and study limitations and future directions.

2. Grid computing

Grid computing, developed in the early 1990s, connects different computing and data resources from several locations, using a network such as the Internet, to create scalable, high-performance computing capabilities. Foster and Kesselman (1999) coined the term "grid computing" to emphasize their belief that it would revolutionize the world, just as the electric power grid did in the late nineteenth century. Researchers also have offered several alternative definitions: Buyya and Venugopal (2005) define grid computing as "a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed autonomous resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements." In this definition, the grid offers the possibility of sharing computing resources (e.g., servers, desktop PCs, computer clusters), storage resources (e.g., hard disk drives), and specific resources (e.g., astronomical telescopes), making them accessible to all participants in the network. Every participant can simultaneously act as supplier and consumer of IT resources. The performance of grid systems is restricted only by the number of currently connected resources.

A department within a single organization that connects resources through an intra-organizational grid may gain access to the computational power of the entire organization. If the organization is also linked to an inter-organizational grid, all departments can access an even larger pool of resources. The possible benefits of the system thus relate strongly to the degree to which the organization is open to intra- or inter-organizational linkages across departments or with external organizations. Challenges for cultivating grid computing adoption include trust and management issues on the intra-organizational side, as well as cross-organizational commitment on the inter-organizational side (Beck et al., 2008).

Although grid and cloud computing have parallels in terms of their vision, architecture, and technology, they differ in terms of security, programming model, business model, compute model, data model, applications and abstractions (Foster et al., 2008). For the purposes of this study, we therefore define grid computing (this definition also was provided to the study participants) as *a technology that allows sharing (consuming and providing) hardware and software resources by using common network technologies*. Whereas the Internet allows access to information, grid computing allows access to different kinds of IT resources. Instead of physically buying IT resources, grid computing enables members to access necessary resources on demand. The sharing of IT resources in a grid thus provides for a more efficient, flexible usage of existing resources.

3. Differences between grid computing and other IOS

A closer comparison of grid computing and other IOS reveals several distinct differences. First, grid computing provides some utility even when it is implemented exclusively for internal usage. Most other IOS provide utility only when they interconnect two or more institutions (e.g. electronic markets).

Second, the IOS that have been examined offer benefits with respect to the same dimension to all adopting organizations. With electronic data interchange (EDI) for example, both adopters enjoy faster, more automatic data exchanges. Voice-over-Internet protocols (VoIP) simplify communications between adopting organizations and reduce related expenses. Electronic business-to-business (B2B) marketplaces accelerate bargaining and transactions, leading to faster exchanges of goods and payment flows. In contrast, grid computing often provides asymmetric benefits for the adopting organizations. One adopting firm might offer vast computing resources and receive monetary compensation in return; its partner does not benefit in monetary terms but gains additional resources. This asymmetric utility gain across different dimensions makes grid computing comparable to service outsourcing.

Third, grid computing links the IT infrastructure – and thus data and computational power – of two or more grid participants which constitutes nowadays often the centerpiece of the business in many industries. Compared to VoIP or EDI, trust in the technology itself and in other participants in the grid thus must play a key role in the grid adoption decision.

Fourth, EDI, VoIP, and electronic B2B marketplaces aim to support core business relationships among retailers, manufacturers, and suppliers (e.g., data exchange, communication, and trading, respectively). Sharing IT resources via grid computing does not specifically support core business relationships; participants in the grid do not necessarily need to be business partners in their core business areas; for example, an e-commerce firm might use a bank's idle capacities during the Christmas season. Hence, grid computing can open new markets for organizations, where idle IT resources can be traded.

These major differences suggest four important conditions to consider in an adoption model for grid computing:

(1) Institutional pressures to adopt IOS have consequences. Because grid computing does not affect the core business relationship between business partners, coercive and normative pressures should not be as strong as they would be for EDI, VoIP, or electronic B2B marketplaces.
(2) The mimetic pressure that arises from competitors' success should not be underestimated for grid computing adoption. The objectives for adopting grid computing relate primarily to the cultivation of efficiency to gain a competitive advantage (see Section 6.2). We therefore hypothesize that in this adoption process, mimetic pressures exert the most important institutional pressure; studies of EDI, VoIP, and electronic B2B marketplaces instead report weaker mimetic pressures compared with coercive and normative pressures (Basaglia et al., 2009; Son and Benbasat, 2007; Teo et al., 2003).
(3) Grid participants are not necessarily core business partners so that partners who share IT resources through grid computing are easily exchangeable.
(4) Sharing and trading IT resources causes uncertainty about the quality and security of the obtained resources (asymmetric information). Organizations that demand IT resources in the grid may intend to exploit their access; providers of IT resources may intend to damage or spy on demanders' data (moral hazard). Both arguments imply principal-agent problems, which reinforces the claim that trust in the technology and the participants in the grid may be a crucial factor in the adoption decision.

4. Adoption of grid computing

4.1. Business practices

Many examples from scientific organizations (e.g., the Large Hadron Collider Computing Grid, open-source Berkeley Open Infrastructure for Network Computing [BOINC] platform) and members of the World Community Grid, reveal that grid computing is not only technically feasible, but can offer organizational advantages such as cost reduction through improved resource utilization, economies of scale and scope, increased productivity through reduced processing time, greater scalability to meet variable business demands, and reduced time-to-market for new products, all of which can improve competitive positioning in the market (Vykoukal et al., 2009).

Various business cases highlight how grid computing helps generate competitive advantage. The U.S. bank Wachovia first deployed DataSynapse's GridServer in April 2001 to support its production systems. The grid software provided a layer between Wachovia's financial applications and its underlying computing resources, offering a real-time operating environment that enabled the service firm to meet critical service levels (DePompa, 2007). Similarly, The Hartford insurance group adopted grid computing when it confronted a scalability problem. It needed a way to measure risks involved with insurance policies; the director of advanced technologies at Hartford Life asserted that grid computing provided scalability and thus saved the firm millions of dollars compared with alternative technologies (Vance, 2005). In the same year, a management-oriented publication asserted: "You need grid computing. It could save you millions. It could provide competitive advantage to your business" (CIO Magazine, 2005).

Several firms appear to have heeded this advice. RL Polk, an automotive industry market research firm, rolled out grid computing in 2006 to support its data warehouse and provide real-time information. Since then, it has been able to transform its data processing from a batch to a real-time environment, thereby reducing the time for data processing tasks from hours to minutes while increasing the number of transactions processed per second (ComputerWeekly.com, 2006). In the software industry, Synopsys changed from distributed server farms to a grid infrastructure, thus realizing shorter processing times and more stable and significantly greater utilization (above 80%) of its underlying resources (Plaszczak and Wellner, 2006). Finally, Vykoukal et al. (2008) reveal how a grid-based solution allowed a bank to reduce its risk calculation update cycles from twice daily to every 7 min, while also decreasing the time-to-market for new products to one-fourth of the original time. Another large European bank moved its portfolio performance measurement to the grid; the portfolio performance represents a key performance indicator (KPI) and is used as steering tool for the management. Before moving to the grid, the calculation for this KPI for the entire customer base took several weeks and was performed only once a year. A more frequent provision of performance data enabled by grid computing helped to facilitate more sustainable management decisions (Hinz et al., 2007).

4.2. Inter-organizational perspective: institutional theory

Institutional theory focuses on the legitimacy of innovative organizational structures, without consideration of productivity and efficiency (Liu et al., 2008). That is, the institutional environment surrounding an organization has significant impacts on its structure and actions (Burns and Wholey, 1993). Teo et al. (2003) argue that technology adoption in organizations may be driven by the institutional environment and its pressures, rather than just intra-organizational or technological criteria. Success by early adopters in an inter-organizational network might influence other organizations to imitate trendsetters, to (1) replicate their success or (2) be perceived as innovative players themselves in the environment (Markus, 1987).

DiMaggio and Powell (1983) identify three types of isomorphic pressures: *coercive*, *normative,* and *mimetic*. Whereas coercive and normative pressures operate through interconnectedness, mimetic pressures arise from structural equivalence. Mimetic pressures cause the structures and actions of an organization to change over time in response to the structures and actions of other organizations that occupy similar positions in their common environment (e.g., competitors in the same industry). Because they share similar economic goals, manufacture similar products, share similar customers and suppliers, and are committed to similar constraints, the organizations are structurally equivalent (Burt, 1987). By monitoring a competitor, an individual organization discerns its behavior, and may be inclined to imitate its competitors' actions. These mimetic pressures refer to a specific behavior in an organization's market and the perceived success of competing organizations that have already adopted it (Haveman, 1993). Recent studies emphasize that adaptability and the ability to recognize and react quickly to signals in the external environment, such as by adopting similar technologies, should lead to competitive advantages (Reeves and Deimler, 2011). Finally, several studies note a significant influence of mimetic and competitive pressures on the adoption of new technologies through inter-organizational linkages (e.g., Chwelos et al., 2001; Liu et al., 2008; Premkumar et al., 1997; Son and Benbasat, 2007). If organizations observe the adoption of grid computing by competitors in their industry, they might imitate that adoption to obtain competitive advantages; if for example Bank of America can speed up its risk calculations through grid computing, competitors such as Goldman Sachs could observe this development and could feel the pressure to mimic that behavior. Accordingly, we propose:

H1. Higher mimetic pressures lead to stronger intentions to adopt grid computing.

Coercive pressures instead arise when an organization dominates other institutions in its network, such that it can force others to change their organizational structures or execute certain actions (DiMaggio and Powell, 1983). In an organizational environment, dependencies that lead to coercive pressures might include (1) suppliers that control scarce resources or want to enlarge the accessible pool of resources, (2) customers that represent a significant proportion of the organization's turnover, or (3) parent companies that enforce changes to the organizational structure of their subsidiaries. The effects of these coercive pressures on IOS adoption have been analyzed in various contexts, including organizational adoptions of B2B electronic marketplaces (Son and Benbasat, 2007), VoIP (Basaglia et al., 2009), e-business (Ke et al., 2009), and EDI (Chwelos et al., 2001; Grover and Saeed, 2007; Teo et al., 2003). However, as we noted in our previous comparison, grid computing does not primarily support the core business relationships between organizations, so the influence of coercive pressure should not be as strong as for other IOS. Nonetheless, grid computing can reduce costs and the time-to-market for new products (Vykoukal et al., 2009), so potential benefits arise for customers, such as lower product prices and access to innovative products, and can produce increased sales and revenues for the organization. Stakeholders, such as customers or parent companies, thus may have a strong interest in coercing the organization to adopt grid computing. Consequently, though we anticipate coercive pressures for different reasons and perhaps from different sources (i.e. than for other IOS), we hypothesize that

H2. Higher coercive pressures lead to stronger intentions to adopt grid computing.

Finally, normative pressures emerge from the direct or indirect ties of an organization to noncompeting organizations (e.g., firm–customer, firm–supplier) that already have adopted an innovative technology or the norms of the organization's environment. If two organizations engage in frequent contact, they probably think and behave similarly (Burt, 1982). Communicating about the benefits and costs of a new technology persuades a non-adopter to adopt, possibly through the facilitation of communication through a firm–customer channel, firm–supplier channel, or trade, business, or other key institutions (e.g., chambers of commerce) that encourage meetings among representatives of different organizations (Powell, 1991). Previous studies find significant effects of normative pressures on the adoption of IOS such as electronic B2B marketplaces (Son and Benbasat, 2007) and financial EDI (Teo et al., 2003). Son and Benbasat (2007) also argue that critical mass theory (Markus, 1987) creates normative pressures, together with network externality theory (Farrell and Saloner, 1986), because the value of an IOS grows with the number of participants. This theorization easily transfers to the domain of grid computing: With an increasing number of participating organizations, and thus an increasing prevalence of grid computing in the organization's trading environment, the value of the grid for all participants increases together with the number of accessible IT resources. We hypothesize:

H3. Higher normative pressures lead to stronger intentions to adopt grid computing.

Because grid computing rarely affects the core business relationships between organizations, we also posit that the dominance of customers and suppliers (coercive pressures) and the extent of adoption among customers and suppliers (normative pressures) will not be as strong as the pressure exerted by the success and adoption among competitors (mimetic pressures). That is,

H4. Mimetic pressures have a stronger effect on intentions to adopt grid computing than do coercive or normative pressures.

4.3. Intra-organizational perspective: organizational capability theory

Liu et al. (2008) identify IT, innovation, and trust as key capabilities that affect organizational structure. Existing IT capabilities influence whether new technologies can be integrated into an existing IT architecture. In particular, the adoption of an innovative technology depends on the firm's willingness to follow new paths. Thus, the level of innovativeness that prevails in an organization must be important for determining intentions to adopt new technologies (Attewell, 1992; Barczak et al., 2007).

H5. A culture of innovativeness leads to stronger intentions to adopt grid computing.

Moreover, Liu et al. (2008) argue that trust is an important capability; Pavlou (2003) and Gefen et al. (2003) similarly integrate trust and risk into their technology acceptance model. Beck et al. (2008) argue that intra-organizational trust is particularly challenging to the adoption of grid computing by organizations.

Following Zaheer et al. (1998), we define trust as the expectation that an actor can be relied on, will be predictable, and will act fairly. Therefore, in a grid computing context, trust has two dimensions: First, the participant can trust the technology, and second, it can trust other human agents in the system. This differentiation is essential. Person-to-person trust appears in various contexts in information systems research (e.g., e-commerce, Ba and Pavlou, 2002; seller–buyer relationships and e-customer services, Turel et al., 2008), however, few studies examine person-to-technology trust (e.g., Kim and Prabhakar, 2002). We anticipate that both dimensions of trust influence intentions to adopt grid computing.

H6. Increasing trust (person-to-person and person-to-technology) leads to stronger intentions to adopt grid computing.

Inter-organizational linkages via grid computing also enhance the possibility that several IT resources or entire business processes might be outsourced through an IOS. If a firm is very reluctant to outsource processes or IT resources to an external provider in general, this reluctance could hamper the adoption of grid computing. We therefore consider the attitude toward outsourcing as another potentially important influence on the intention to adopt grid computing (Minoli, 2005):

H7. Better attitudes toward outsourcing lead to stronger intentions to adopt grid computing.

However, the growth of IT, with its enhanced capacity for surveillance, communication, computation, storage, and retrieval, as well as the concomitant increased value of information, introduce threats to privacy (Mason, 1986). If privacy is legally mandated (e.g., financial industry) or information is critical to the business (e.g., inventions before patenting), the connectivity between departments within a firm or across the firm's boundaries is particularly sensitive. Many studies have analyzed privacy issues, including the misuse of collected consumer information (e.g., for marketing purposes) or the threat of access by third parties or outsourcing partners if IT processes are outsourced (Hung et al., 2007). In many industries (e.g., automotive, financial services, biotech), new product development also demands large simulation studies, which in turn require powerful computational resources. Knowledge about the intensity and timing of resource usage in the grid then could be valuable information for competitors, which might assess whether another organization is developing new products and estimate the stage of its development. Therefore, need for privacy offers an obstacle to the adoption of grid computing, and we predict:

H8. Increasing needs for privacy reduce intentions to adopt grid computing.

In terms of pressures inside the organization, if a current technology does not meet expectations, disaffection with the current technology can arise, so intentions to enhance it or try alternative technologies might increase. For grid computing, a lack of computational power might foster the adoption process, because grid computing promises to increase productivity by reducing processing time and increasing business agility, flexibility, and scalability to meet variable business demands (Hwang and Park, 2007). Therefore,

H9. Greater perceived resource scarcity leads to stronger intentions to adopt grid computing.

4.4. Control variables

DeLone (1981) and Hannan and McDowell (1984) find that firm size and innovation are interdependent. The empirical relationship between the volume of innovative activities and firm size often follows an S-shaped curve, in which small firms appear relatively inactive, activity increases for medium and large firms, but it slows among the largest firms. This pattern reflects indivisibilities and risk, which preclude small firms from innovating; and monopoly power which reduces pressures on the biggest firms to innovate (see Scherer, 1973). Although some U-shaped distribution patterns have been reported as well (Pavitt et al., 1987), typically large firms exhibit more innovation activity. We thus conclude that firm size may influence the adoption of new technologies. Moreover, the size of the IT department likely entails a positive correlation with adoption (e.g., Fichman, 2001). In a meta-analysis, Lee and Xia (2006) even discern that IT department size is a stronger predictor of IT innovation adoption than firm size. Technology adoption also could be driven by financial resources (Waarts et al., 2002); Hong and Zhu (2006) find a significant positive relation between spending and adoption of e-commerce. Adoption intentions may be industry-specific (Lee and Xia, 2006), though it is not obvious whether manufacturing or services should reveal higher adoption intentions toward the demand or supply of IT resources in the grid. To control for heterogeneity in the data set, we simply include the industry sector in our research model. We distinguish between manufacturing and service industry (manufacturing = 0/service industry = 1).

Further because awareness of a new technology drives relative advantage, ease of use, and compatibility for the new technology (i.e., a knowledge-based product configurator), it should be an indirect driver of adoption intentions (Agarwal and Prasad, 1998). Finally, the estimated time – and thus project costs – for the integration process may be important to adoption intentions; we consider the estimated duration of implementation as a control variable in our research model. Thus, we include *firm size*, *size of the IT department*, *IT budget size*, *IT budget development*, *industry*, *grid awareness*, and *estimated duration of implementation* as control variables. Fig. 2 illustrates our conceptual model.

5. Scale development and conceptual validation

5.1. Scale development

When possible, we used established constructs and transferred them to the context of grid computing. We applied existing formative second-order constructs of mimetic, coercive, and normative pressures to measure the influences of inter-organizational linkages on adoption, including the moderating effect of perceived complexity on mimetic pressures (Teo et al., 2003). To address intra-organizational factors, we included five new constructs and seven control variables.

An organizational change prompted by the adoption of an innovative technology might be rejected after a high risk assessment (Tabak and Barr, 1998). If sensitive information about the timing and extent of demand for IT resources is revealed in a grid in which competitors participate, the organization could suffer economic disadvantage. Thus, the risk from insufficient privacy is high. To measure need for privacy, we assess the organization's need for privacy while they process their data in a grid. This should take account of the kind of data being processed in the grid.

The demand for IT resources in an organization, and the corresponding potential demand for IT resources via grid computing, is measured by the construct perceived resource scarcity. The self-developed construct covers whether the participants feel constrained in their work by the available IT resources in their firm.

Outsourced processes take place beyond the organizational boundaries, which means the organization must trust (1) the technology and (2) other participants in the grid. Trust in the technology covers the robustness, reliability, and security that a technology provides; trust in the participants expresses the degree of fear that other participants in the grid will act opportunistically. We therefore operationalize trust as a formative second-order construct, expressed by two reflective subconstructs: trust in grid technology and trust in grid participants (Verhagen et al., 2006), in the context of grid computing.

Innovativeness also is a second-order formative construct, consisting of management-related innovativeness and personnel-related innovativeness (Wang and Ahmed, 2004). Innovative management must be supported by employees who are willing to deploy the new technology; otherwise, managers would need to combat obstacles within the organization to achieve the desired strategic advantage.

The attitude toward outsourcing construct comprises two reflective subconstructs, attitude toward outsourcing IT resources and attitude toward outsourcing business processes. Without any existing constructs in prior literature, we developed new measures.

With special attention to structure and function of the measurement items, we assembled the potential items for each construct according to the two-stage approach described by Burton-Jones and Straub (2006). After that we improved the construct validity via the Q-sorting procedure described by Moore and Benbasat (1991).

Whereas our first-order constructs are all predicated on reflective measurement, all second-order constructs revert to the concept of formative measurement. Though the conceptualization of formative constructs and their validity continues to be debated – more pointed views appeared recently (Edwards, 2011) – this study has taken the stand that formative constructs are valid concepts that continue to play an important role in research. In example, our study has erred in favor of richness and inclusion, resulting in a large and complex model, which nonetheless has been contained and simplified to some extent through the use of formative constructs. We provide full descriptions of the constructs and their indicators in Appendix A.

5.2. Conceptual validation

We verified the content validity of all items through three steps. First, 15 experts in measurement theory and grid computing examined the items. Second, eight marketing researchers and eight doctoral students sorted the items using Moore and Benbasat's (1991) sorting procedure. The procedure achieved Cohen's (1988) kappa values greater than the critical value of .65 for all tested constructs (Moore and Benbasat, 1991). Third, we verified convergent and discriminant validity of the measurement scales with a pretest with 54 participants (see next section).

6. Data analysis

6.1. Survey and analysis strategy

We translated the items into the respondents' native language (German) through the back-translation method (Brislin, 1970) and pre-tested the final questionnaire independently with doctoral students and university employees to identify vague or ambiguous questions. The items finally applied in the questionnaire are displayed in Tables A.6–A.8 in Appendix A. We operationalized our model as a structural equation model and estimated it using partial least squares (PLS; Chin, 1998), implemented in SmartPLS (Ringle et al., 2006). This prediction-oriented method offers optimal prediction accuracy and is appropriate for testing early theories. It is well suitable for exploratory research and shares the modest distributional and sample size requirements of ordinary least squares linear regression (Gefen et al., 2011) and can model both formative and reflective latent constructs (Son and Benbasat, 2007).

We tested our research model in the field with 54 participants representing organizations in German industries. The participants had to fulfill the same conditions as the participants in the main survey. The convergent and discriminant validity for the constructs exceeded all critical values from literature, so that we continued with the main data collection.

6.2. Descriptive statistics

We invited 2538 IT decision makers from German industries to respond to an online survey. All participants had to pass a screening process and fulfill three conditions: (1) They occupied an executive position in their firm, (2) they were responsible for the IT budget for (at least) their department, and (3) their firm included at least 50 employees. Then the survey began with a detailed definition of grid computing, to ensure all participants conceived the term similarly. We provided fully anchored seven-point Likert scales, ranging from "strongly disagree" to "strongly agree," for all the single- and multi-item constructs.

We received 253 completed surveys, yielding a response rate of 10%, which is typical for mailed surveys to senior executives (Hambrick et al., 1993). To verify the validity, we checked the responses and the time each participant took to answer the survey. We excluded 20 questionnaires that were completed in less than 15 min or exhibited a visible pattern of the same responses on all the Likert scales. The final data set of participants from 233 companies yielded the descriptive details listed in Table 1. More than 50% of the responses came from companies with more than 250 employees. In addition, more than 40% of the participants held the position of division manager or department manager, and approximately 13% were CEOs or CIOs in their firms. One-quarter of the companies generated turnover of at least 251 million Euros, another one-quarter earned between 51 and 150 million Euros, and approximately one-third brought in less than 50 million Euros each

Table 1
Firm profiles.

Measure	Frequency	Measure	Frequency
Number of employees		*Respondents' job positions*	
50–99	35 (15.0%)	CEO, CIO	30 (12.9%)
100–199	47 (20.2%)	Division manager	103 (44.2%)
200–249	28 (12.0%)	Department manager	100 (42.9%)
250–499	25 (10.7%)		
>500	98 (42.1%)		
Number of IT employees		*Annual turnover (in mill. EUR)*	
1–9	84 (36.1%)	<10	34 (14.6%)
10–19	36 (15.5%)	11–50	38 (16.3%)
20–49	46 (19.7%)	51–100	37 (15.9%)
50–99	19 (8.2%)	101–250	25 (10.7%)
>100	35 (15.0%)	251–500	17 (7.3%)
n/a	13 (5.6%)	>500	44 (18.9%)
		n/a	38 (16.3%)
IT budget per annum		*Expected development of IT budget*	
<50 k EUR	27 (11.6%)	−26% to −50%	5 (2.1%)
50–100 k EUR	28 (12.0%)	−11% to −26%	5 (2.1%)
100–500 k EUR	45 (19.3%)	−1% to −10%	9 (3.9%)
500–1000 k EUR	23 (9.9%)	+−0%	55 (23.6%)
1000–2000 k EUR	25 (10.7%)	+1% to +10%	54 (23.3%)
>2000 k EUR	36 (15.5%)	+11% to +25%	46 (19.7%)
n/a	49 (21.0%)	+26 to +50%	22 (9.4%)
		>50%	7 (3.5%)
		n/a	30 (12.9%)

year. However, 16.3% chose not to reveal their turnover. Approximately half the companies had an IT department with fewer than 20 employees, and 23.3% had larger IT departments with 50 or more employees.

As Table 1 illustrates, the sample also consists of firms with both rather low and high IT budgets, more or less evenly distributed across different ranges. The IT managers expected this budget to stay constant (55 participants) or grow in the next year (129 participants). Only 19 participants stated that the budget will be reduced.

Although the concept of grid computing has been around for some time, it has gained business attention only recently. Thus, prior to our study, the concept was unknown to 87 participants and the diffusion process is still accelerating: 24 participants had been familiar with grid computing for five or more years, 32 participants for 3 or 4 years, 62 participants for 1 or 2 years, and 28 participants heard of this concept only in the past few months. This diffusion also is reflected in adoption rates; namely, 60 adopters and 173 non-adopters of grid computing.

In terms of the main (technological and non-technological) obstacles to adopting grid computing, we found several differences between these adopters and non-adopters. The main technological reasons for non-adoption were unresolved security issues. Non-adopters considered these issues severe, such that 30.1% of them gave it a score of 7 on the seven-point Likert scale (mean 5.1), whereas only 10% of the adopters offered the same drastic assessment although the adopters still had concerns too (mean 4.5). The highest rated (mean) non-technological obstacle that prevented adoption was a lack of trust in other grid participants. The respondents also tried to achieve specific aims by adopting grid computing: 61.8% to speed up their processes, 57.5% to achieve better resource utilization, 54.5% to decrease costs, and 44.2% to attain better sustainability (green computing). These aims are all related closely to obtaining competitive advantages.

The 60 adopters (Table 2) mostly implemented grid computing for intra-organizational usage, though a substantial fraction of 32 adopters connected to external grids. Table 2 shows that firms participate in the grid mainly as resource consumers and often consume resources from external sources. This finding emphasizes the importance of trust in this outsourcing-like relationship. Adopters that solely consume resources have approximately 2 years' experience, whereas resource providers have another year on average, and firms that both consume and provide grid resources have about 4 years' experience. This different might indicate that adopters begin by consuming resources, and then later provide their resources in off-peak times. Alternatively, perhaps firms that consume and provide resources represent first movers. We cannot distinguish these two different adoption paths from our data.

With respect to resource provision and consumption, Fig. 1 illustrates that server capacities and high performance computing resources are mainly shared in grids. There is high demand for storage capacities, which only very few firms are willing to provide and thus offers a business opportunity that services like Dropbox might want to use.

6.3. Common method bias analysis

Self-reported data can create common method biases, such as consistency motifs or social desirability concerns (Podsakoff et al., 2003). The most popular statistical approach to address common method bias in the recent years was developed by Liang et al. (2007). Though this procedure was employed in more than 70 studies, it recently experienced criticism regarding its ability to detect common method bias (see Chin et al., 2012). Due to this criticism we decided to apply two other approaches: the Harman's one-factor test (Podsakoff et al., 2003) and the marker variable approach proposed by Rönkkö and Ylitalo (2011).

We performed the Harman's one-factor test with principal axis factoring and principal component factoring and found that in both cases more than one factor emerged. For principal axis factoring the largest factor explained 32% of the variance. For principal component factoring 33% of the variance where explained by the largest factor. Both results are below the critical value of 50%.

We additionally performed the marker variable approach of Rönkkö and Ylitalo (2011). In step 1 we identified two marker items in our empirical data set, which are not included in the research model and have not an explicit theoretical influence on the items of the constructs in our research model. Additionally these marker items showed only low correlations to the study items. Following Rönkkö and Ylitalo (2011) these low correlations have to be caused by the method. In step 2 we calculated the mean correlation coefficients of both marker variables and found values of .066 and .084. To inspect if the common method bias dilutes our results, we included the marker items as additional latent variable into our model and

Table 2
Interconnection type, consumer/provider ratios, and average experience of adopters.

Do you consume or provide resources in the grid?	How is your grid interconnected?			Total	Average experience
	Intra-organizational only	Inter-organizational only	Intra- and inter-organizational		
Consume	21	10	14	45	1.94 years
Provide	3	1	3	7	3.14 years
Consume and provide	4	1	3	8	4 years
Total	28	12	20	60	

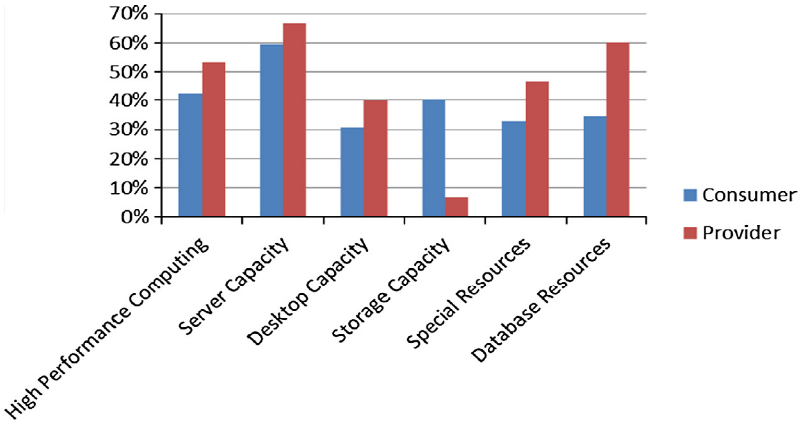

Fig. 1. Consumption and provision per resource type.

analyzed its impact on all endogenous variables like it is proposed by Rönkkö and Ylitalo (2011). Table A.5 in Appendix A shows that the marker variable has no significant effect neither on the dependent variable (intention to adopt) nor on the other endogenous variables (mimetic pressure, coercive pressure, normative pressure, trust, innovativeness, attitude towards outsourcing). Additionally the path coefficients between all constructs and the intention to adopt do not significantly differ between the research model (w/o marker variable) and the CMB test model (with marker variable). These results indicate that a common method bias is unlikely to distort the results of our study.

6.4. Measurement model validation

The adoption model contains 11 reflective multi-item constructs, 12 one-item constructs, and 6 formative second-order constructs. All the reflective constructs meet the criteria required for reflective measurement models (Jarvis et al., 2003). The quality of the reflective measurement model depends on convergent validity and discriminant validity (Bagozzi and Yi, 1988).

To analyze convergent validity, we determined indicator reliability and internal consistency. All the indicator loadings of the reflective multi-item constructs were significant at least at the .01 level. Furthermore, all indicators loaded on the posited underlying factor, higher than the recommended threshold of .707 (Chin, 1998). For the internal consistency assessment, we examined the composite reliability (CR), Cronbach's alpha, and average variance extracted (AVE) (see Table A.1 in Appendix A) (Teo et al., 2003). All of the CR indices, as well as the Cronbach's alpha values, met the threshold of .7 (Nunally and Bernstein, 1978). For AVE, a critical level of .5 is suggested (Fornell and Larcker, 1981), and all reflective multi-item constructs met this criterion. In summary, the constructs satisfied all criteria for indicator reliability and internal consistency, in support of convergent validity.

We also analyzed the discriminant validity of the constructs by examining if the square root of the AVE of the indicators within any construct was higher than the correlations between it and any other construct (Son and Benbasat, 2007). All included constructs met this criterion, in evidence of discriminant validity (see Tables A.2–A.4 in Appendix A). Moreover, none of the correlations between any pair of constructs was higher than the threshold value of .9 (Bagozzi et al., 1991). The loadings of the indicators (Pearson's correlation) on the focal construct were always higher than loadings on other constructs (Bollen and Lennox, 1991). Therefore, we can conclude that the discriminant validity of the reflective constructs is evidenced.

6.5. Structural model validation

The squared multiple correlations ($R^2 = .568$) for the variable intention to adopt grid computing indicate good explanatory power; that is, 56.8% of the variance is explained by the constructs. The analysis of overall effect size (f^2) reveals that all significant constructs in the model have at least weak effects (Chin, 1998). To assess the significance of the path coefficients, we use the bootstrapping procedure implemented in SmartPLS with 1000 re-samples. Because all of our hypotheses are directional, we use one-tailed significance levels. Fig. 2 displays the results, with significant path coefficients marked with continuous lines and dashed lines indicating insignificant paths.

Seven of the nine directional hypotheses received support at least at a $p < .1$ significance level (Sellin and Keeves, 1994). Among the inter-organizational factors, mimetic pressures (.194, $p < .05$) and coercive pressures (.129, $p < .05$) exhibit high, significant, positive effects on the intention to adopt grid computing, followed by normative pressures (.107, $p < .1$). Adoption intentions increase when many competitors already have adopted grid computing and achieved success with it, in support of H1. Mimetic pressures consist primarily of perceptions of the success of competitors that have adopted grid computing

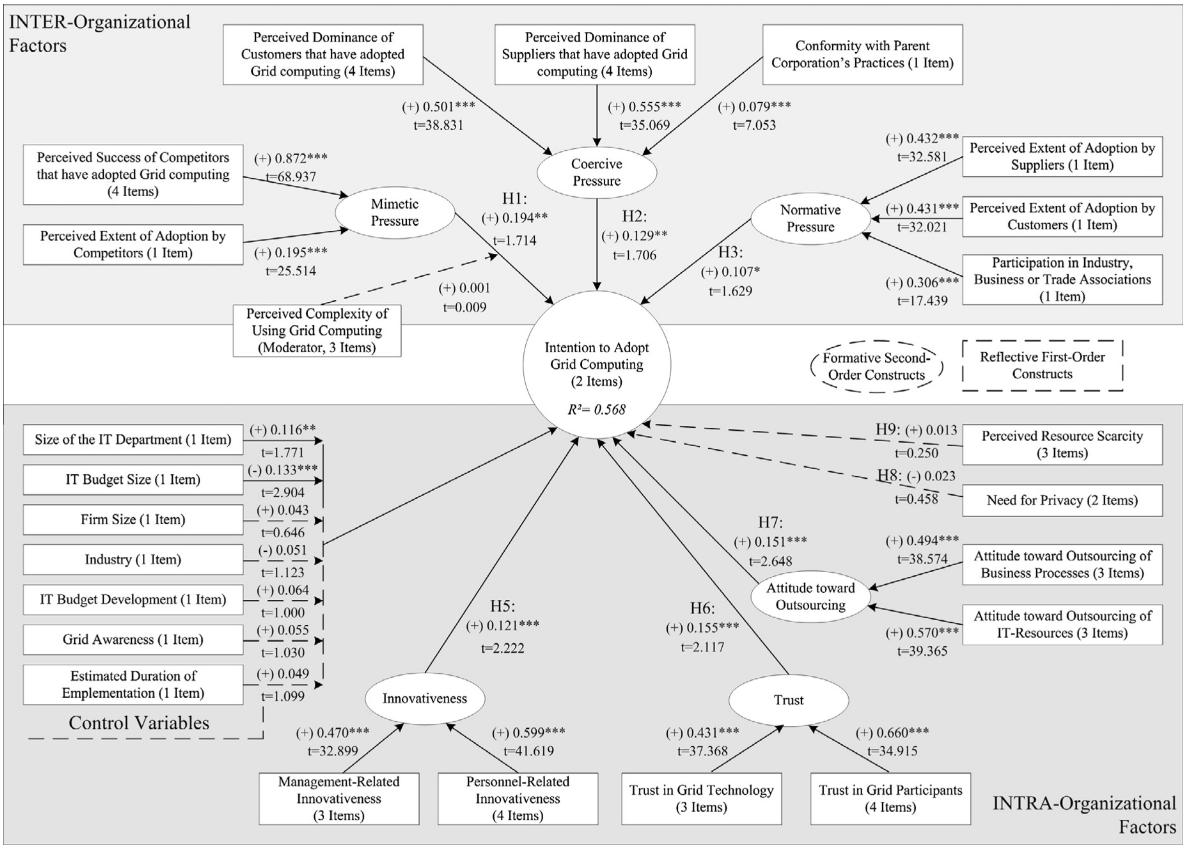

Fig. 2. Path model with results (***$p < .01$; **$p < .05$; *$p < .1$).

(.872, $p < .01$), whereas the extent of adoption is a highly significant but less important factor (.195, $p < .01$). We did not find a moderating effect of perceived complexity on the influence of mimetic pressures on adoption intentions as suggested by Teo et al. (2003). Coercive pressures reflect dominance by suppliers (.555, $p < .01$) and customers (.501, $p < .01$), which reveal similar levels of influence on this higher-order construct. In contrast, conformity with the parent corporation's practices has only a low effect (.079, $p < .01$) on coercive pressures. These results strongly support H2.

Normative pressures also have a significant positive effect (.107, $p < .1$) on adoption intentions, in support of H3. This second-order construct consists mainly of the perceived extent of adoption among suppliers (.432, $p < .01$) and customers (.431, $p < .01$), together with a lower but still significant effect (.306, $p < .01$) of participation in industry, business, or trade associations. Thus, monitoring and recognizing the extent of adoption in the organizational environment seem to be more important for an organization than recommendations for new technologies expressed in inter-organizational associations.

Among the inter-organizational pressures, mimetic ones have the strongest effect on adoption intentions. Following Eckhardt et al. (2009), we generate 1000 ß-coefficients for mimetic, coercive, and normative pressures using PLS bootstrapping and perform a t-test for mean equality to examine whether the differences between the path coefficients are significant. Significant differences arise between mimetic pressures and both coercive pressures ($p < .001$) and normative pressures ($p < .001$), which strongly supports H4. This outcome supports the uniqueness of grid computing compared with other IOS, which we discuss later.

Among the intra-organizational factors, trust, attitude toward outsourcing, innovativeness, and size of the IT department have highly significant positive effects ($p < .01$) on adoption intentions. The highly significant positive path coefficient of innovativeness (.121, $p < .01$) also reveals that increasing innovativeness in an organization makes the adoption of grid computing more likely, in support of H5. Innovativeness comprises management-related (.470, $p < .01$) and personnel-related (.599, $p < .01$) innovativeness and the path coefficients show that innovative personnel are slightly more influential than an innovative management.

Both trust in grid technology and trust in grid participants show significant and large influences on overall trust. In our sample the organization's trust in other participants is relatively more influential than trust in the technology. The highly significant positive effect (.155, $p < .01$) of trust on adoption intentions suggests that with increasing trust in the technology and other participants, intentions to adopt grid computing increase, in support of H6.

The attitude toward outsourcing has the third largest effect on adoption intentions (.151, $p < .01$). A more positive attitude toward outsourcing correlates highly with an increasing intention to adopt grid computing, as exemplified by the attitude toward outsourcing IT resources (.570, $p < .01$) and attitude toward outsourcing business processes (.494, $p < .01$).

With respect to the IT capabilities of the firm, only the size of the IT department significantly influences adoption intentions (.116, $p < .01$). Firm size has no effect on adoption and hence might not be an adequate proxy for the deployment of IT resources in an organization in our sample and thus supports findings by Lee and Xia (2006).

We do not find a significant influence of perceived resource scarcity, which may theoretically represent the prospective demand for IT resources through grid computing, on adoption intentions. This finding needs to be supported in other studies since we cannot rule out the possibility that our self-developed construct lacks conceptual rigor. The same holds for the need for privacy which has no significant effect on adoption intentions. Because privacy and security concerns are two key obstacles to the implementation of inter-organizational systems (Butt et al., 2003), this outcome seems surprising and might be due to an inappropriate multi-item construct. Alternatively, the adopting organizations might have implemented grid computing largely for intra-organizational resource sharing and thus do not need to fear that competitors will monitor their activity; or prospective grid participants might simply trust the technology's capability to solve privacy issues satisfactorily.

Among the control variables, only IT budget size has a significant negative effect on the intention to adopt. This interesting result may indicate that firms with small IT budgets cannot invest in additional IT resources when they are needed, unlike firms with higher IT budgets. In such cases these firms can satisfy their need for IT resources from the grid on demand. The remaining control variables have no significant effects on intentions to adopt grid computing and follow-up studies need to confirm this finding.

To compare the effect of the inter-organizational vs. the intra-organizational influence factors on the adoption intention, we compute two additional models to run a pseudo *F*-Test. By integrating intra-organizational influence factors, 56.8% of the variance in the dependent variable (R^2) can be explained, whereas a model without those factors explains 44.8%. A model that includes only intra-organizational influence factors can explain 50.9% of the variance in the dependent variable. Following Mathieson et al. (2001), a pseudo *F*-test is executed to determine whether the changes in the explained variances between the models are significant (see Table 3).

Comparison 1 in Table 3 demonstrates that adding intra-organizational influence factors to the model leads to a significant increase in the explained variance of the adoption intention. Cohen (1988) suggests f^2-values of 0.02, 0.15 and 0.35 as operational definitions of small, medium and large effect sizes, respectively. Thus, the f^2-value of 0.278, $p < .01$ in comparison 1 illustrates a medium effect by adding intra-organizational factors. Comparison 2 shows that adding inter-organizational factors also leads to a significant increase in the explained variance. In contrast to the first comparison, the size of the effect now reaches an f^2-value of 0.137, $p < .01$, which is slightly below the critical value for verifying a medium effect. This finding leads to the result that the intra-organizational influence factors in this study have a stronger effect on the adoption intention than the inter-organizational influence factors, leading us to recommend paying special attention to the intra-organizational factors when analyzing the adoption of inter-organizational systems.

6.6. Actual adopters vs. non-adopters

Beside the information on adoption intentions, we also collected information on the actual adoption behavior up to the point of the survey. This variable is dichotomous with 1 for the adoption of grid computing up to the point of the survey and 0 otherwise. It is important to emphasize that firms that adopt the day after the survey and firms that will never adopt are treated equally as non-adopters. Since the date of the survey is arbitrary the results have to be interpreted carefully. When going back to a dichotomous dependent variable we also lose some variance which may make it more difficult to find nuanced results.

We exactly use the same set of explanatory variables as depicted in Fig. 2 and apply PLS estimations based on the "folk theorem" that linear regression is about as good as logit for estimating average marginal effects. For a detailed discussion of this theorem, see e.g. Beck (2011). We emphasize these issues clearly and that especially the *t*-values have to be interpreted carefully as they may suffer from heteroskedasticity. This additional analysis can serve however as a robustness test because a CMB is rather unlikely for the dichotomous outcome variable.

Table 3
Results of the pseudo *F*-test.

Comparison	R^2 Model 1	R^2 Model 2	R^2 Model 3	f^2-Value	Pseudo *F*-statistic	*Df*
1: Full model vs. inter-organizational only	0.568	0.448		0.278	41.11***	(1,229)
2: Full model vs. intra-organizational only	0.568		0.509	0.137	31.28***	(1,220)

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$ (two-tailed).

Table 4
Results for grid computing compared with other IOS.

Construct	Grid computing	Financial EDI	B2B-Markets Pot./Cur. Adopters	VoIP	eSCMS
Inter-organizational factors					
Mimetic	0.194**	0.083**	0.180**/−0.030	n.s.	0.110
Coercive	0.129**	0.156***	0.130/−0.040	0.110**	0.298**
Normative	0.107*	0.479***	0.160*/0.180	0.200***	0.219**
Different covariates (omitted here)					

Notes: Grid computing (this study), financial EDI (Teo et al., 2003), B2B-markets (Son and Benbasat, 2007), VoIP (Basaglia et al., 2009), eSCMS (Ke et al., 2009). n.s. = not significant.
* $p < .1$.
** $p < .05$.
*** $p < .01$.

The squared multiple correlations ($R^2 = .490$) for the variable grid computing adoption indicate good explanatory power. We find that for a fast adoption especially normative pressures are important ($p < .01$). Communication about the benefits and costs of a new technology, possibly through the facilitation of communication through a firm–customer channel, firm–supplier channel, or trade, business, or other key institutions (e.g., chambers of commerce) seems to be especially important for early phases of the diffusion. This is underlined by the significance of awareness about the technology for the actual grid adoption ($p < .01$) that we find in this analysis. This additional analysis also confirms that trust is a driver for adoption ($p < .05$) and that firms with small IT budget ($p < .01$) but relatively large IT departments ($p < .01$) start to implement grid computing rather early. The results also highlight that manufacturing firms implemented grid computing first ($p < .1$). All together, we find the same direction for all estimates (which should be unbiased) except for firm size, resource scarcity and IT budget development which are however anyway insignificant in both models. Overall, the analysis shows that our adoption model is suitable for this context and that the findings are quite robust.

6.7. Grid computing in contrast with other IOS

To highlight the uniqueness of grid computing compared with other IOS, we contrast our empirical results with outcomes from those IOS adoption studies that also employ the framework of Teo et al. (2003) to analyze IOS'. Based on literature research we selected studies on B2B marketplaces (Son and Benbasat, 2007), VoIP (Basaglia et al., 2009), electronic supply chain management systems (eSCMS) (Ke et al., 2009) and, of course, the origin study on financial EDI (Teo et al., 2003). Table 4 offers an overview of the path coefficients and significance levels of all selected studies.

For grid computing the outcomes for H4 already have shown that among inter-organizational factors, mimetic pressures affect adoption intentions significantly more than either coercive or normative pressures. Studies on financial EDI and VoIP indicate different magnitudes of influence, with normative pressures exerting the strongest effect, followed by coercive pressures (Basaglia et al., 2009; Teo et al., 2003). Mimetic pressures only had minor influence (financial EDI) or no significant effect (VoIP) on adoption intentions. Another study of eSCMS even reports no significant effects of mimetic pressures on adoption intention, strongly significant coercive pressures, and significant normative pressures (Ke et al., 2009). Only an analysis of the adoption of electronic B2B marketplaces indicates some similarities to our grid computing investigation: Among potential adopters, mimetic pressures have the strongest effect, followed by normative and then coercive pressures (Son and Benbasat, 2007).

These differences align with our arguments from Section 3. Grid computing offers a greater basic utility than other IOS, so it is more likely that organizations want to imitate grid adopters to gain similar competitive advantages (i.e., better load balancing, reduced costs, faster time-to-market). Furthermore, grid computing is not well established, such that the imitation of a few competitors that have gained benefits through their grid adoption likely offers strong competitive advantages over the bulk of non-adopting competitors. Both arguments help explain why mimetic pressures should be more important for the adoption of grid computing than the adoption of financial EDI or VoIP for example.

Furthermore, EDI, VoIP, and eSCMS support core business relationships between organizations and directly connect them for data exchange or communication purposes. Organizations thus may coerce each other to adopt, so they can realize the advantages of IOS. These stronger coercive pressures do not apply to grid computing, which is not part of core business relationships.

7. Discussion and implications

Our study has revealed that the properties of organizations and their capabilities have strong influences on their intentions to adopt new technologies. Capabilities can be a source of competitive advantage, but they also define constraints on the degree of structural change possible. We find multiple intra-organizational capabilities with significant influences on intentions to adopt grid computing technology. For the non-significant paths we however acknowledge that these could be a result of the self-developed constructs and follow-up studies should retest them.

We find that the size of the IT department has a significant positive impact on the adoption of grid computing which implies that larger IT departments may have more human capabilities and expertise to accomplish the implementation of this technology in an existing IT structure. Yet the tendency to adopt grid computing also increases when the IT budget is rather small and IT management must find new, innovative ways to cut costs. Perceived resource scarcity does not indicate a significant effect on adoption intentions. This result could be caused by an inappropriate construct or the organizations in our sample are simply equipped with sufficient IT resources, such that they do not need access to the IT resources of other organizations, as suggested by the high fraction of idle resources in industry. Their main interest may be the efficient balancing of existing IT resources or cost-effective reductions of overcapacity. We find no significant effect of the need for privacy on the intention to adopt which needs to be confirmed in further studies.

The strongest effect among the intra-organizational influence factors is trust; if firms lack trust in the technology or other participants, they are unlikely to adopt grid computing. Further diffusion of grid technology thus depends on how reliable and secure this technology can become in the market. Closely related to this finding are the results pertaining to attitudes toward outsourcing. If firms have a positive attitude toward outsourcing, they are more likely to adopt grid computing. Therefore, grid computing clearly differs from other IOS but shares some interesting commonalities with outsourced services and processes.

We also find that organizational innovativeness, measured as management-related and personnel-related innovativeness, enhances adoption intentions. For strategic decisions such as the paradigm shift to grid computing, a project needs backing from management, but personnel-related innovativeness appears even more important. If employees are innovative, they are willing to adopt new technologies; employees who are very conservative and risk-averse with respect to innovations prefer familiar work processes and tools and may refuse to use the new technology. If an organization is open-minded about new practices and supports its employees in their attempt to work with or think about new technologies, it develops a stronger intention to adopt new technologies. We therefore predict that grid computing is more likely to be deployed in younger, open-minded organizations with high levels of confidence in IT, rather than in established, conservative organizations. The commitment of firms such as Amazon and Google to cloud computing supports this prediction.

Overall, we find that intra-organizational factors are important predictors of technology adoption processes. Both individuals and organizations begin by sensing uncertainty about new technologies as they become available, though this uncertainty decreases with additional information (Chatterjee and Eliasberg, 1990; Hinz and Spann, 2008). Such information is certainly not exogenous; it diffuses through the firm's environment and can be gathered through communication with suppliers and customers, recommendations from business or trade associations, or observations of competitors. These different sources of relevant information all constitute inter-organizational factors though. In particular, mimetic pressures strongly influence the adoption of grid computing. If the competitors of an organization have already adopted grid computing and succeeded (e.g., cost reductions, higher scalability, reduced time-to-market), the organization must follow to benefit from similar advantages and avoid competitive disadvantages. In contrast, for other IOS, mimetic pressures play a smaller role than coercive or normative pressures. We thus conclude that mimetic pressures are more important when a particular new technology (1) can be used to gain a competitive advantage and (2) is not configured to support core business relationships between organizations. In this case the competitor follows the innovators due to mimetic pressures and tries to mitigate the advantage. In addition, the positive influence of coercive pressure that we find implies that dominating suppliers, customers, or parent companies can exert pressure on organizations to adopt. Especially during crises, cost savings arguments often require companies to use their resources more carefully. Normative pressures also exist, though they are weaker in the case of grid computing than are mimetic and coercive pressures.

In line with these findings, we recommend that vendors of grid computing solutions start with a penetration pricing strategy and highlight the technologies' ability to create competitive advantages. Vendors and providers also should target attractive new customers with prices even below costs. Social contagion and bandwagon effects will trigger a faster diffusion, after initial uncertainty about the new technology diminishes. Because mimetic pressure has the strongest effect, different seeding points (Hinz et al., 2011) across industries should serve to ignite diffusion.

These findings may also hold for the related concept of cloud computing. We expect to observe similar effects with respect to the examined inter- and intra-organizational factors. However, cloud computing also includes other factors, such as business models, applications, and different abstraction concepts, so a more complex adoption model may be needed. We recommend caution before generalizing our findings.

The here presented model for the adoption of grid computing is quite complex and the study and its presentation is subject to a number of limitations: First, in order to accommodate the breadth (i.e. model complexity and completeness) of the model, we were not able to carry out all analyses in depth. We therefore emphasize that especially the self-developed constructs need a more careful and rigorous development in future work to assure their generalizability to other contexts. Some of the control variables and intra-organizational constructs are tailor-made for this study and facing the trade-off between addressing the complexity of organizational adoption processes and developing a parsimonious model we were not able to take all findings from previous research into account.

Second, given the size of our sample we were not able to analyze the differences between adopters and non-adopters of grid computing. This analysis would certainly be interesting because adoption research emphasizes significant differences between these groups in other contexts (Eckhardt et al., 2009).

Third, further research should assess any influence of cultural differences, beyond organizations from one country. Again, we call for caution in generalizing our results, because cultural affinities may have significant impacts on system adoption behaviors.

Acknowledgements

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Appendix A

See Tables A.1–A.8.

Table A.1
Convergent validity of the reflective multi-item constructs (first-order constructs).

Construct	Number of Items	CR	Cronbach's Alpha	AVE
Perceived Success of Competitors that have adopted Grid computing (CO-SUC)	4	0.977	0.969	0.914
Perceived Dominance of Suppliers that have adopted Grid computing (DOM-SU)	4	0.962	0.947	0.863
Perceived Dominance of Customers that have adopted Grid computing (DOM-CU)	4	0.946	0.924	0.816
Perceived Complexity of Using Grid computing (P-CPLX)	3	0.984	0.986	0.829
Intention to Adopt Grid computing (INTENT)	2	0.951	0.896	0.906
Perceived Resource Scarcity (PRS)	3	0.867	0.769	0.685
Management-Related Innovativeness (MRI)s	3	0.918	0.867	0.789
Personnel-Related Innovativeness (PRI)	4	0.931	0.901	0.772
Trust in Grid Technology (T-TRUST)	3	0.945	0.912	0.851
Trust in Grid-Participants (P-TRUST)	4	0.974	0.964	0.904
Need for Privacy (PRIV)	2	0.983	0.967	0.967
Attitude towards Outsourcing of Business Processes (OUT-BP)	3	0.939	0.903	0.837
Attitude towards Outsourcing of IT-Resources (OUT-IT)	3	0.969	0.951	0.911

Table A.2
Discriminant validity of the reflective multi-item constructs: construct correlations and square root of AVE (diagonal elements); Part I.

Construct	PAR-ADP	INDUSTRY	INTENT	IT-BD	IT-BS	GA	DI	MRI	OUT-BP	OUT-IT
PAR-ADP	1.000									
INDUSTRY	−0.036	1.000								
INTENT	0.428	−0.087	0.952							
IT-BD	0.234	−0.030	0.275	1.000						
IT-BS	−0.024	0.013	−0.082	0.159	1.000					
GA	0.240	0.024	0.231	0.298	0.062	1.000				
DI	0.081	−0.093	0.238	0.069	0.088	0.121	1.000			
MRI	0.220	−0.169	0.458	0.165	−0.127	0.110	0.164	0.888		
OUT-BP	0.204	−0.122	0.427	0.168	0.188	0.120	0.150	0.307	0.915	
OUT-IT	0.234	−0.089	0.524	0.217	0.146	0.183	0.147	0.324	0.766	0.954
MEMBER	0.371	−0.019	0.321	0.179	0.027	0.204	0.091	0.242	0.256	0.287
P-CPLX	0.072	−0.082	0.111	−0.004	0.042	−0.061	0.040	0.146	0.277	0.239
CO-ADP	0.401	0.020	0.617	0.144	−0.056	0.160	0.164	0.403	0.316	0.394
CU-ADP	0.296	−0.088	0.509	0.234	−0.009	0.133	0.116	0.380	0.369	0.406
SU-ADP	0.414	0.022	0.537	0.187	−0.058	0.117	0.137	0.393	0.286	0.369
DOM-CU	0.265	−0.056	0.461	0.090	0.079	0.061	0.232	0.379	0.461	0.474
DOM-SU	0.274	0.012	0.526	0.159	0.059	0.125	0.219	0.280	0.408	0.493
CO-SUC	0.326	0.005	0.556	0.108	0.042	0.099	0.229	0.264	0.369	0.450
PRI	0.229	−0.088	0.343	0.120	−0.124	0.083	0.145	0.744	0.221	0.203
PRIV	0.189	−0.006	0.110	0.091	0.167	0.034	0.093	0.247	0.161	0.161
PRS	0.204	−0.044	0.411	0.107	0.112	0.052	0.211	0.355	0.435	0.494
IT-SIZE	0.344	0.002	0.375	0.472	0.138	0.240	0.148	0.233	0.244	0.306
T-TRUST	0.228	−0.005	0.492	0.099	−0.050	0.142	0.155	0.264	0.438	0.537
P-TRUST	0.264	0.038	0.522	0.099	−0.010	0.169	0.181	0.259	0.425	0.488
FIRM-SIZE	0.129	−0.002	0.173	0.496	0.127	0.200	0.133	0.042	0.033	0.084

Table A.3
Discriminant validity of the reflective multi-item constructs: construct correlations and square root of AVE (diagonal elements); Part II.

Construct	*MEMBER*	*P-CPLX*	*CO-ADP*	*CU-ADP*	*SU-ADP*	*DOM-CU*	*DOM-SU*	*CO-SUC*	*PRI*	*PRIV*
PAR-ADP										
INDUSTRY										
INTENT										
IT-BD										
IT-BS										
GA										
DI										
MRI										
OUT-BP										
OUT-IT										
MEMBER	1.000									
P-CPLX	0.074	0.910								
CO-ADP	0.403	0.128	1.000							
CU-ADP	0.452	0.190	0.651	1.000						
SU-ADP	0.408	0.109	0.713	0.823	1.000					
DOM-CU	0.269	0.331	0.460	0.423	0.458	0.903				
DOM-SU	0.247	0.299	0.488	0.463	0.482	0.703	0.929			
CO-SUC	0.284	0.126	0.590	0.506	0.579	0.534	0.624	0.956		
PRI	0.171	0.173	0.305	0.248	0.324	0.293	0.246	0.266	0.879	
PRIV	0.052	0.248	0.071	0.078	0.138	0.239	0.150	0.092	0.318	0.983
PRS	0.216	0.279	0.337	0.318	0.315	0.508	0.504	0.407	0.278	0.097
IT-SIZE	0.268	−0.062	0.268	0.337	0.275	0.255	0.194	0.215	0.155	0.155
T-TRUST	0.168	0.257	0.395	0.367	0.391	0.383	0.475	0.613	0.286	0.199
P-TRUST	0.333	0.197	0.481	0.400	0.435	0.417	0.528	0.602	0.262	0.069
FIRM-SIZE	0.015	−0.054	0.037	0.069	0.030	−0.011	0.013	0.026	0.053	−0.073

Table A.4
Discriminant validity of the reflective multi-item constructs: construct correlations and square root of AVE (diagonal elements); Part III.

Construct	PRS	IT-SIZE	T-TRUST	P-TRUST	FIRM-SIZE
PAR-ADP					
INDUSTRY					
INTENT					
IT-BD					
IT-BS					
GA					
DI					
MRI					
OUT-BP					
OUT-IT					
MEMBER					
P-CPLX					
CO-ADP					
CU-ADP					
SU-ADP					
DOM-CU					
DOM-SU					
CO-SUC					
PRI					
PRIV					
PRS	0.828				
IT-SIZE	0.194	1.000			
T-TRUST	0.409	0.093	0.922		
P-TRUST	0.492	0.087	0.669	0.915	
FIRM-SIZE	0.110	0.504	0.023	0.029	1.000

Table A.5
Common method bias assessment.

Path coefficients	Research model (w/o marker variable)	CMB test model (with marker variable)
Inter-organizational factors		
Mimetic Pressure → Intention to Adopt	(+) 0.194**	(+) 0.197**
Coercive Pressure → Intention to Adopt	(+) 0.129**	(+) 0.124*
Normative Pressure → Intention to Adopt	(+) 0.107*	(+) 0.101*
Intra-organizational factors		
Innovativeness → Intention to Adopt	(+) 0.121***	(+) 0.120***
Trust → Intention to Adopt	(+) 0.155***	(+)0.152***
Attitude Towards Outsourcing → Intention to Adopt	(+) 0.151***	(+)0.156***
Need for Privacy → Intention to Adopt	(−) 0.023 n.s.	(−) 0.024 n.s.
Perceived Resource Scarcity → Intention to Adopt	(+) 0.013 n.s.	(+) 0.011 n.s.
Control variables		
Size of the IT Department → Intention to Adopt	(+) 0.116**	(+) 0.118**
IT Budget Size → Intention to Adopt	(−) 0.133***	(−) 0.137***
Firm Size → Intention to Adopt	(+) 0.043 n.s.	(+) 0.047 n.s.
Industry → Intention to Adopt	(−) 0.051 n.s.	(−) 0.048 n.s.
IT Budget Development → Intention to Adopt	(+) 0.064 n.s.	(+) 0.057 n.s.
Grid Awareness → Intention to Adopt	(+) 0.055 n.s.	(+) 0.062 n.s.
Est. Duration of Implementation → Intention to Adopt	(+) 0.049 n.s.	(+) 0.047 n.s.
Marker variable		
Marker Variable → Intention to Adopt	–	(+) 0.041 n.s.
Marker Variable → Mimetic Pressure	–	0.000 n.s.
Marker Variable → Coercive Pressure	–	0.000 n.s.
Marker Variable → Normative Pressure	–	0.000 n.s.
Marker Variable → Innovativeness	–	0.001 n.s.
Marker Variable → Trust	–	0.000 n.s.
Marker Variable → Attitude Towards Outsourcing	–	0.000 n.s.

n.s. = Not significant.
* $p < .1$.
** $p < .05$.
*** $p < .01$.

Table A.6
Constructs and items deployed in the survey I.

Construct and indicators	Origin
Perceived Extent of Adoption by Competitors (CO-ADP): What is the extent of adoption of grid computing by your firm's competitors currently? (CO-ADP) 1-None has adopted; 7-All have adopted	Teo et al. (2003)
Perceived Success of Competitors that have adopted Grid computing (CO-SUC): Our main competitors that have adopted Grid Computing... ...have benefited greatly (CO-SUC1) ...are perceived favorably by others in the same industry (CO-SUC2) ...are perceived favorably by suppliers (CO-SUC3) ...are perceived favorably by customers (CO-SUC4) 1-Strongly Disagree; 7-Strongly Agree	Teo et al. (2003)
Perceived Dominance of Suppliers that have adopted Grid computing (DOM-SU): With regard to our main suppliers that have adopted Grid computing... ...our firm's well-being depends on their resources (DOM-SU1) ...our firm cannot easily switch away from them (DOM-SU2) ...our firm MUST maintain good relationships with them (DOM-SU3) ... they are the core suppliers in a concentrated industry (DOM-SU4) 1-Strongly Disagree; 7-Strongly Agree	Teo et al. (2003)
Perceived Dominance of Customers that have adopted Grid computing (DOM-CU): With regard to our main customers that have adopted Grid computing... ...our firm's well-being depends on their purchases (DOM-CU1) ...our firm cannot introduce switching costs to them (DOM-CU2) ...our firm MUST maintain good relationships with them (DOM-CU3) ...they are the largest customers in the industry (DOM-CU4) 1-Strongly Disagree; 7-Strongly Agree	Teo et al. (2003)
Conformity with Parent Corporation's Practices (PAR-ADP): Has your parent company adopted Grid computing?(PAR-ADP) Yes; No	Teo et al. (2003)

Table A.6 (*continued*)

Construct and indicators	Origin
Perceived Extent of Adoption by Suppliers (SU-ADP): What is the extent of adoption of Grid computing by your firm's suppliers currently? (SU-ADP) 1-None has adopted; 7-All have adopted	Teo et al. (2003)
Perceived Extent of Adoption by Customers (CU-ADP): What is the extent of adoption of Grid computing by your firm's customers currently? (CU-ADP) 1-None has adopted; 7-All have adopted	Teo et al. (2003)
Participation in Industry. Business or Trade associations (MEMBER): Do you participate in any industry. trade or professional bodies where you have been exposed to Grid computing promotion and information? (MEMBER) Yes; No	Teo et al. (2003)
Perceived Complexity of Using Grid computing (P-CPLX): Grid computing is conceptually difficult to understand from a business perspective (P-CPLX1) Grid computing is conceptually difficult to understand from a technical perspective (P-CPLX2) Using Grid computing is difficult (P-CPLX3) 1-Strongly Disagree; 7-Strongly Agree	Teo et al. (2003)
Intention to Adopt Grid computing (INTENT): Our firm is contemplating to adopt Grid computing in the next 1–2 years (INTENT1) Our Firm is likely to adopt Grid computing in the next 1–2 years (INTENT2) 1-Strongly Disagree; 7-Strongly Agree	Teo et al. (2003)
Size of IS-department (IT-SIZE): What is the current number of IT professionals in your firm? (IT-SIZE) 1–5; 6–10; 11–15; 16–20; 21–30; 31–40; 41–50; above 50	Teo et al. (2003)

Table A.7
Constructs and items deployed in the survey II.

Construct and indicators	Origin
Perceived Resource Scarcity (PRS): Our firm's IT-resources are not adequate to handle the development need of new products and services (PRS1) The work done in my department could be done more efficiently, if we could access to more powerful IT-resources (PRS2) The employees in my department often completely utilize the available IT-resources (PRS3) 1-Strongly Disagree; 7-Strongly Agree	Self-developed
Management-Related Innovativeness (MRI): Key executives of the firm are willing to take risks to seize and explore "chancy" growth (MRI1) Senior executives constantly seek unusual and novel solutions to problems (MRI2) When our firm sees new ways of doing things. it quickly adopts them (MRI3) 1-Strongly Disagree; 7-Strongly Agree	Self-developed (based on Wang and Ahmed (2004))
Personnel-Related Innovativeness (PRI): We get a lot of support from managers if we want to try new ways of doing things (PRI1) In our company. we tolerate individuals who do things in a different way (PRI2) We are willing to try new ways of doing things and seek unusual. novel solutions (PRI3) We encourage people to think and behave in original and novel ways (PRI4) 1-Strongly Disagree; 7-Strongly Agree	Self-developed (based on Wang and Ahmed (2004))
Firm Size (FIRM-SIZE): What is the current number of employees in your Firm? (FIRM-SIZE) 1–9; 10–19; 20–49; 50–99; 100–199; 200–249; 250–499; above 500	Son and Benbasat (2007)
Trust in Grid Technology (T-TRUST): Grid computing is… …dependable (T-TRUST1) …process data securely (T-TRUST2) …robust (T-TRUST3) 1-Strongly Disagree; 7-Strongly Agree	Self-developed (based on Verhagen et al. (2006))
Trust in Grid-Participants (P-TRUST): Suppliers and enquirers of Grid-resources are in general… …dependable (P-TRUST1) …reliable (P-TRUST2) …honest (P-TRUST3) … trustworthy (P-TRUST4)	Verhagen et al. (2006)

(*continued on next page*)

Table A.7 (*continued*)

Construct and indicators	Origin
1-Strongly Disagree; 7-Strongly Agree	
Need for Privacy (PRIV): It is important. that other firms in the Grid cannot discover at which time our firm is using resources in the Grid (PRIV1) It is important. that other firms the Grid cannot discover how intensely our firm is using resources in the Grid (PRIV2) 1-Strongly Disagree; 7-Strongly Agree	Self-developed
Attitude towards the Outsourcing of Business Processes (OUT-BP): Our firm is outsourcing many business processes to external service providers (OUT-BP1) Our firm has made good experiences with the outsourcing of business processes (OUT-BP2) Our firm will continue with the outsourcing of business processes in the future (OUT-BP3) 1-Strongly Disagree; 7-Strongly Agree	Self-developed
Attitude towards the Outsourcing of IT-Resources (OUT-IT): Our firm is outsourcing IT-resources to external service providers (OUT-IT1) Our firm has made good experiences with the outsourcing of IT-resources (OUT-IT2) Our firm will continue with the outsourcing of IT-resources in the future (OUT-IT3) 1-Strongly Disagree; 7-Strongly Agree	Self-developed

Table A.8
Constructs and items deployed in the survey III.

Construct and indicators	Origin
IT-Budget-Development (IT-BD): How will your IT-budget develop in the next 2 years? (IT-BD) −76 to −100%; −51 to −75%; −26 to −50%; −11 to −25%; −1 to −10%; +/−0%; +1 to +10%; +11 to +25%; +26 to +50%; +51 to +75%; +76 to +100%; +100% and above; n/a	Self-developed
IT-Budget-Size (IT-BS): Which is the size of your current IT-budget p.a.? (IT-BS) Less than €50.000; €50.000–€99.999; €100.000–€499.999; €500.000–€999.999; €1.000.000–€1.999.999; €2.000.000 and above; n/a	Self-developed
Grid Awareness (GA): How long are you aware of the technology grid computing? (GA) Since that questionnaire; half a year; 1 year; 2 years; 3 years; 4 years; 5 years; 6 years; 7 years; 8 years; 9 years and above	Self-developed
Perceived Duration of Implementation (PDI): How long will it take to implement grid computing the IT-infrastructure of your firm? (PDI) Unpredictable; 1–6 months. 7–12 months; 1–2 years; 3–5 years; more than 5 years	Self-developed
Industry (INDUSTRY): Manufacturer; Service Provider	Self-developed

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