

July 2009

# ADOPTION OF GRID COMPUTING: AN EMPIRICAL VERIFICATION OF AN INTER- AND INTRA-ORGANIZATIONAL APPROACH

Christian M. Messerschmidt

*Author, Germany, messerschmidt@wiwi.uni-frankfurt.de*

Follow this and additional works at: <http://aisel.aisnet.org/pacis2009>

---

## Recommended Citation

Messerschmidt, Christian M., "ADOPTION OF GRID COMPUTING: AN EMPIRICAL VERIFICATION OF AN INTER- AND INTRA-ORGANIZATIONAL APPROACH" (2009). *PACIS 2009 Proceedings*. 3.  
<http://aisel.aisnet.org/pacis2009/3>

This material is brought to you by the Pacific Asia Conference on Information Systems (PACIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in PACIS 2009 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact [elibrary@aisnet.org](mailto:elibrary@aisnet.org).

# ADOPTION OF GRID COMPUTING: AN EMPIRICAL VERIFICATION OF AN INTER- AND INTRA- ORGANIZATIONAL APPROACH

Christian M. Messerschmidt

Research Assistant, Department of Electronic Commerce

Goethe University Frankfurt

Grüneburgplatz 1, 60323 Frankfurt, Germany

messerschmidt@wiwi.uni-frankfurt.de

## Abstract

*Grid computing is a technology that offers the opportunity to share IT-resources between departments in organizations as well as between different organizations. Thereby adopters may obtain significant advantages like cost reduction and efficient IT-resource load balancing. Nevertheless this technology is not established in the industry by now. We developed an adoption model to measure the major factors which are influencing adoption of Grid computing in an organizational environment. As Grid computing is an inter-organizational system providing both inter- and intra-organizational linkages our adoption model accounts for both areas of influence factors. The inter-organizational influence factors were based on a model proposed by Teo et al. (2003) who reverted to the institutional theory. Mimetic-, coercive- and normative pressures exerted by surrounding organizations like suppliers, customers and competitors are representing the inter-organizational influence factors in our adoption model. Following the organizational capability-based theory we included intra-organizational influence factors which consist of IT-related factors, the innovativeness of an organization and the attitude towards outsourcing of IT-resources. Using structural equation modeling our adoption model identified mimetic pressures (emerging from competitors), the innovativeness and the attitude towards outsourcing of IT-resources as factors with significant positive influence on the adoption of Grid computing.*

**Keywords:** Grid Computing, Adoption, IOS, Inter-organizational Linkages, Inter-organizational systems.

# 1 INTRODUCTION

Grid computing as an inter-organizational system (IOS) is a technology that connects different IT-resources via a physical network and offers the possibility to share these IT-resources between all participants who belong to this network (Foster et al. 2001). Implementing Grid computing can thus gain significant advantages for adopters and especially for organizations with subsidiaries in different time zones. During the nighttime in Germany the organization's employees in the Pacific-Asian area can calculate their tasks on the lower utilized German IT-resources and reversely if the IT-resources are shared via Grid computing. Thereby cost reduction and efficient IT-resource load balancing can be achieved by the adopting organizations (Vykoukal et al. 2009). The development of the adoption of Grid computing in Germany is therefore highly relevant for the Pacific-Asian area.

For analyzing the adoption of an IOS like Grid computing in organizations an adequate adoption model is needed. Based on institutional theory *Teo et al. (2003)* focused on inter-organizational influence factors and designed and tested an adoption model that analyzed the *mimetic*-, the *normative*- and the *coercive pressures* which surrounding institutions may cause on the adoption of FEDI (financial electronic data interchange) by organizations. As Grid computing is an IOS which may link different organizations with each other but also several departments within single organizations, we think that inter-organizational as well as intra-organizational influence factors have to be considered equally when analyzing the adoption. Following the model of *Teo et al. (2003)* and the organizational capability-based theory we developed an adoption model for measuring the adoption behavior of Grid computing which covers both sides of influence factors and tested it empirically. To our best knowledge no adequate model to measure the adoption of Grid computing exists, that covers the critical intra-organizational as well as inter-organizational influence factors.

The aim of this study is (1) to include intra-organizational influence factors in the adoption model of *Teo et al. (2003)* and (2) apply that model to the domain of Grid computing to find out the critical influence factors on the adoption.

In section 2 we describe the theoretical background for both our adoption model and our hypotheses, which will be introduced in section 3. The research methodology is displayed in section 4. We will test the hypotheses empirically in section 5 in order to sum up the results in section 6.

## 2 THEORETICAL BACKGROUND

The adoption model we propose in section 3 accounts for influences of inter-organizational and intra-organizational linkages on the adoption behavior of grid computing. The influence factors emerging from inter-organizational linkages are based on the institutional theory. The intra-organizational influence factors that also display the grid-specific structure of an organization can be retrieved from the organizational capability-based theory. The examined technology and both theories will be illustrated in the following three sub-sections.

### 2.1 Grid computing in organizations

The idea of connecting different computational- and data-resources from several locations via a network like the internet, to create scalable high-performance-computing capabilities, was developed in the beginning of the 1990. In analogy to the electric power grid, *Foster and Kesselman (1999)* coined the term "Grid computing" because of their belief that this technology will revolutionize the world such as the electric power grid did in the late 19<sup>th</sup> century. In the last decade several definitions have been published. *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" which corresponds best to the scenario we revert to in this study. Due to this definition a grid offers the possibility to share computational

resources (e.g. servers, desktop pcs or computer clusters), storage resources (e.g. hard disc drives) and specific resources (e.g. astronomical telescopes) and make them accessible to all participants in the network. Every participant can simultaneously act as supplier and inquirer of IT-resources. The performance of such grid systems is only restricted by the number of currently connected resources. The following benefits in contrast to traditional computing systems can be achieved (Buyya and Sulistio 2008; Strong 2005):

- On-demand supply of geographically dispersed, heterogeneous resources
- Exploiting under-utilized or unused resources providing seamless computing power to solve compute-intensive problems
- Resource allocation and load balancing based on Service Level Agreements (SLAs) to meet Quality of Service (QoS) requirements
- Reduced administration effort with integration of resources as compared to managing multiple standalone systems
- More reliable, resilient, and highly available infrastructures with autonomic management capabilities and on-demand aggregation of resources from multiple sites to meet unexpected demand

These technical benefits convinced a lot of institutions in the scientific field to adopt Grid computing (e.g. SETI@home, Search for Extraterrestrial Intelligence) for sharing their resources with other institutions and getting access to large computing power on-demand. Based on the technical benefits mentioned above several economic benefits can be specified, that support the decision to adopt Grid computing in organizations (Hwang and Park 2007; Vykoukal et al. 2009):

- Increased productivity due to reduced processing time
- Cost reduction due to higher resource utilization, lower IT operating costs, and economies of scale and scope
- Increased business agility, flexibility, and scalability to meet variable business demands
- Increased competitiveness in the market because of reduced time-to-market of new products
- Increased inter-operability between different applications

Despite these promising benefits, the German industrial sector is still reserved towards the adoption of Grid computing. This outcome may be related with the fact that the yielding of the benefits depends on the extent of adoption in the organizations themselves. A department within an organization that connects its resources via a mere intra-organizational grid, may access the maximum computational power of the whole organization. If the organization is linked to an inter-organizational grid, the departments can revert to an even larger pool of resources. Hence, exhausting the benefits is strongly related to the degree an organization opens up to intra- or inter-organizational linkages with other departments and institutions. The challenges in accelerating the adoption of Grid computing within organizations are drawn by issues like trust and management on the intra-organizational side and cross-organizational commitment on the inter-organizational side (Beck et al. 2008). For a better understanding of the adoption behavior concerning grid computing, the intra- and inter-organizational factors which influence this process have to be examined.

## 2.2 Institutional Theory

The institutional theory focuses on legitimacy of innovative organizational structures and consciously neglects productivity and efficiency (Liu et al. 2008). This approach argues that the institutional environment, an organization is situated in, bears significant impacts on its' structure and actions (Burns and Wholey 1993). Organizations are exposed to the pressure to be isomorphic with their environment, which implies interconnectedness and structural equivalence (Burt 1987). Interconnectedness is characterized by inter-organizational relations, tying them among each other, (e.g. transactions taking place between different organizations or IT-resources that are shared by different organizations via Grid computing). If several organizations are not compulsory interconnected like above, but capture similar positions like other organizations in an inter-organizational network, structural equivalence is given. Connecting IT-resources with IOSs like Grid computing provides IT-based inter-organizational linkages which induce uncertainty because of

network effects and reciprocal interdependence. The observed success of early adopters in an inter-organizational network can affect other organizations to imitate the early adopters to (1) replicate the success or (2) being perceived as innovative player in their environment (Markus 1987). *Teo et al. (2003)* argue that the adoption of such technologies in organizations may rather be driven by the institutional environment and pressures caused by this environment than mere intra-organizational and technological criteria.

Focusing on institutional pressures and influences that may have an impact on the adoption on IOSs, *Teo et al. (2003)* developed an adoption model that is based on the three types of isomorphic pressures proposed by *DiMaggio and Powell (1983)*: *coercive*-, *normative*- and *mimetic pressures*. *Coercive*- and *normative pressures* operate through interconnectedness; *mimetic pressures* appear with structural equivalence.

*Mimetic pressures* cause that the structures and actions of an organization change over time and adjust to the structures and actions of other organizations, which are at a similar position in the common environment. Thus they show structural equivalence to each other. These pressures consist of the prevalence of a special behavior in the considered organization's market and the perceived success of the organizations that have already adopted this behavior (Haveman 1993).

*Coercive pressures* occur when an organization has dominant other institutions in its network which it depends on. The dependence enables the dominant institutions to *exert coercive pressures* on the dominated organization and force them to change the organizations structure or execute actions (DiMaggio and Powell 1983). Dominant institutions are in our case suppliers which control scarce resources, customers who yield a huge part of the organizations turnover or parent companies that have the power to enforce changes in their subsidiaries organization structure.

*Normative pressures* emerge from direct or indirect ties of an organization to other organizations that have already adopted an innovative technology. If two organizations have frequent conversation with each other, it is not unlikely that they think and behave similar (Burt 1982). Communicating about the benefits and costs that arise with the technology may a non-adopter get persuaded to adopt as well. The communication can be enabled through the firm-customer-channel, the firm-supplier-channel as well as through trade, business and other key institutions where representatives of different organization may meet (Powell 1991). Additionally key institutions or industry associations may conclude norms and standards, which have to be respected for continuing participation (King et al. 1994).

### 2.3 Organizational Capability-based Theory

The modification of an organization's structure via implementing an IOS like Grid computing may also be influenced by intra-organizational factors that are represented by the capabilities that exist in this organization. The capabilities can be a source of competitive advantage but they also define the constraints of the degree of a structural change (Liu et al. 2008).

Beside trust and risk assessment, *Liu et al. (2008)* identified IT and innovation as major capabilities impacting an organizational structure. The attitude towards outsourcing can be considered additionally as an important influence factor on structural changes in an organization due to the adoption of Grid computing (Minoli 2005). The existing IT-capabilities affect whether new technologies are needed and whether new technologies can be integrated into the present IT-structure. Associated with inter-organizational linkages the present intra-organizational IT-capabilities are crucial for implementing Grid computing. Basically the adoption of an innovative technology depends on the willingness to strike new paths. Thus, innovativeness that prevails in an organization has to be an important influence factor on the intention to adopt. Organizations have to combine two types of innovativeness. An innovative management that is not supported by employees with the willingness to deploy a new technology will have to combat obstacles within their organization that should not be underestimated until the desired strategic advantage is achieved. Vice versa potential innovative employees will not be stimulated to think about new performance enhancing structures and technologies if they work for a conservative management. These arguments show that if innovativeness is included, it is necessary

to consider both management-related- and personnel-related innovativeness in the adoption model. Inter-organizational linkages enhance the possibility that several (prior intra-organizational) IT-resources will be outsourced via the IOS. For that reason it is obvious that the adoption of Grid computing may be strongly related to the attitude towards outsourcing of IT-resources and the experience an organization gained with this in the past.

### 3 CONCEPTUAL MODEL AND HYPOTHESES

Merging institutional theory and organizational capability-based theory we developed an adoption model (see Figure 1) which measures the influence of both the inter- and intra-organizational influence factors on the adoption of Grid computing.

#### 3.1 Inter-organizational Influence Factors

Following *Teo et al. (2003)* we adapted their framework which includes the formative second-order constructs *mimetic*-, *coercive*- and *normative pressures* for measuring the influences of inter-organizational linkages on adoption.

*Mimetic pressures* are consisting of the constructs *extent of adoption among competitors* and *perceived success of competitor adopters*. Both have a positive effect on mimetic pressures. Competitors that adopt Grid computing may have the advantages of, among others, high scalable computing power and lower costs (see section 2.1) which can result in cost leadership and more attractive prices for the customers in the branch. With rising extent of competitors adopting Grid computing and the more they succeed due to this adoption, the pressure on an organization to mimic the behavior will increase:

*H1: Higher mimetic pressures will lead to a higher intention to adopt Grid computing.*

*Coercive pressures* are assembled by the constructs *perceived dominance of supplier adopters*, *perceived dominance of customer adopters* and *conformity with parent corporation's practices*. All three factors have a positive effect on *coercive pressures*. While customers can force the organization to adopt Grid computing to lower the costs and set lower prices for the organization's products, dominant suppliers may be interested in using the IT-resources of the organization via Grid computing. A parent corporation which already adopted Grid computing and which is aware of its advantages may force its subsidiary companies to do the same:

*H2: Higher coercive pressures will lead to a higher intention to adopt Grid computing.*

*Normative pressures* are composed by the constructs *extent of adoption among suppliers*, *extent of adoption among customers* and *participation in industry, business and trade associations*. A frequent communication to other organizations, such as suppliers and customers which already adopted Grid-computing may offer the possibility to hear about the technologies advantages at first hand. A higher extent of adoption in the organizations environment cause that it can revert to many firsthand experiences of adopters to get persuaded to adopt. Additionally the higher extent of an IOS such as Grid computing may create positive externalities and increase the technical value of this technology (Farrell and Saloner 1986). Industry, business and trade associations provide a platform where organizations of one branch may communicate about their experiences with deploying Grid computing. Participating in such key institutions may persuade an organization to adopt. Furthermore the participation can be linked to specific conditions, such as considering the institutions standards or justify the behavior to specific norms. Such norms may be being always up-to-date with new technologies. These three factors are positively related to *normative pressures* and may support the adoption:

*H3: Higher normative pressures will lead to a higher intention to adopt Grid computing.*

*Teo et al. (2003)* found out that the perceived complexity of using a technology significantly moderates the effect of *mimetic pressures* on the *intention to adopt*. Many industrial organizations

have a limited knowledge concerning Grid computing (Messerschmidt 2009) and may see this technology as very complex. So the *mimetic pressures* have to be high, that they are willing to adopt. We consider the construct *perceived complexity of using Grid computing* to moderate positively the effect of *mimetic pressures* on the *intention to adopt*:

H4: *With rising perceived complexity, mimetic pressures will have a more significant effect on the intention to adopt Grid computing.*

### 3.2 Intra-organizational Influence Factors

The intra-organizational influence factors of our model consist of the constructs *company size*, *size of the IT-department*, *resource scarcity*, *innovativeness* and *attitude towards outsourcing*. Liu et al. (2008) identified IT and innovation as major capabilities impacting on change of an organizational structure.

The IT is represented by three constructs: *company size* gives a proxy for the deployment of IT-resources in an organization. On average only 20% of the capacity of the IT-resources in organizations are utilized (The Economist 2004). The more IT-resources exist, the more unutilized capacities are available. Grid computing can help to balance the IT-resources more efficiently. *Size of the IT-department* constrains the possibilities to implement a new technology. IT-departments with big size have more human resources to accelerate the adoption of Grid computing than smaller IT-departments. The demand for IT-resources and linked to this the potential demand for IT-resources via Grid computing may be displayed by the construct *perceived resource scarcity* in an organization. Due to these arguments we hypothesize:

H5: *A larger company size will lead to a higher intention to adopt Grid computing.*

H6: *A larger size of the IT-department will lead to a higher intention to adopt Grid computing.*

H7: *An increasing perceived resource scarcity will lead to a higher intention to adopt Grid computing.*

*Innovativeness* is assembled by the constructs *management-related innovativeness* and *personnel-related innovativeness*. A management that supports innovative approaches in their organization will also support the adoption of an innovative technology like Grid computing (*management-related innovativeness*). The management additionally has to motivate the organization's personnel to think and work innovative. The adoption of a new technology will not succeed, if the employees only prefer work processes and tools they are familiar with and refuse to use the new technology (*personnel-related innovativeness*):

H8: *A distinct innovativeness will lead to a higher intention to adopt Grid computing.*

Besides the proposed influence factors of the organizational capability-based theory, we consider the *attitude towards outsourcing of IT-resources* as a critical factor influencing the intention to adopt Grid computing. In a computational Grid, IT-resources are shared with other parties, such as other departments in an internal Grid or other organizations in a Grid that includes also external IT-resources. Tasks that are executed in a Grid may be computed on IT-resources which are located in other departments or even external in other organizations. If IT-resources are outsourced, a quite similar situation will result. Therefore we think that organizations, which already have made experiences with the outsourcing of IT-resources, may also be open-minded to the adoption of Grid computing:

H9: *An increasing attitude towards outsourcing of IT-resources will lead to a higher intention to adopt Grid computing.*

## 4 RESEARCH METHODOLOGY

Whenever possible we used established constructs and transferred them into the context of Grid computing. All reflective and 1-item constructs (first-order constructs) are described in Table 1. The

formative second-order-constructs and the reflective constructs these constructs consist of are displayed in Table 2. As measurement scale, we employed a fully anchored 7-point Likert-scale, ranging from “strongly disagree” to “strongly agree” in all multiple items constructs. The constructs no. 1 – 11 and no. 17 – 19 were adopted from *Teo et al. (2003)*. Constructs no. 12 – 14 and 20 were self-developed based on *Wang and Ahmed (2004)*. Construct no. 15 and 16 were fully self-developed.

No.	Construct	Number of Items	Origin
1	Perceived Extent of Adoption by Competitors	1	(Teo et al. 2003), transferred to the context of Grid computing
2	Perceived Success of Competitors that have adopted Grid computing	4	
3	Perceived Dominance of Suppliers that have adopted Grid computing	4	
4	Perceived Dominance of Customers that have adopted Grid computing	4	
5	Conformity with Parent Corporation's Practices	1	
6	Perceived Extent of Adoption by Suppliers	1	
7	Perceived Extent of Adoption by Customers	1	
8	Participation in Industry, Business or Trade associations	1	
9	Perceived Complexity of Using Grid computing	3	
10	Intention to Adopt Grid computing	2	
11	Size of IT-Department	1	self-developed
12	Perceived Resource Scarcity	3	
13	Management-Related Innovativeness	3	
14	Personnel-Related Innovativeness	4	
15	Company Size	1	
16	Attitude towards Outsourcing of IT-resources	3	self-developed

Table 1. Reflective and 1-item constructs (first-order constructs).

No.	Construct	Related Reflective First Order Constructs
17	Mimetic Pressures (Second Order Construct)	No. 1 and 2
18	Coercive Pressures (Second Order Construct)	No. 3, 4 and 5
19	Normative Pressures (Second Order Construct)	No. 6, 7 and 8
20	Innovativeness (Second Order Construct)	No. 13 and 14

Table 2. Formative second-order constructs and their composition.

The content validity of all included self-developed and established items was carefully verified in two steps. In the first step six research assistants with expertise in measurement theory and Grid computing examined the items. Based on these experts' suggestions, marginal changes were made to avoid ambiguous items. In the second step the items were sorted using *Moore and Benbasat (1991)*'s sorting procedure with eight marketing-scholars and eight doctoral students as judges. A strong inter-judge reliability was found. Calculating Cohen's Kappa all constructs satisfied the *Moore and Benbasat*'s criterion of 0.65. The constructs were used in the survey in a respondents' native-language version (German) using the back-translation method (Brislin 1970). The final questionnaire was again pre-tested independently with doctoral students und university employees.

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 Million EUR):	
1 – 9	84 (36.1%)	<10	34 (14.6%)
10 – 19	36 (15.5%)	11 to 50	38 (16.3%)
20 – 49	46 (19.7%)	51 to 100	37 (15.9%)
50 – 99	19 (8.2%)	101 to 250	25 (10.7%)
> 100	35 (15.0%)	251 to 500	17 (7.3%)
n/a	13 (5.6%)	> 500	44 (18.9%)
		n/a	38 (16.3%)

Table 3. Company-profiles of the participating respondents.



In June 2008 2,538 potential participants of an online panel, consisting of IT-decision-makers in German industries, were invited to respond to the survey. The participants had to occupy an executive position in the company their work with, they had to be responsible for IT-budget for at least their department and the company had to consist of at least 50 employees. 253 completed surveys were submitted, leading to a response rate of 17.7%. After checking validity further 30 datasets were excluded because of inconsistent responses (see Table 3 for the respondents' companies' profiles). The resulting dataset contained 60 adopters and 173 non-adopters of Grid computing. The adoption model was operationalized as a structural equation model and estimated using the Partial Least Squares (PLS) approach (Chin 1998) with the software implementation SmartPLS (Ringle et al. 2006). PLS was preferred because this method is prediction-oriented, giving optimal prediction accuracy and appropriate for testing theories that are in an early stage of their development.

## 5 EMPIRICAL STUDY

### 5.1 Measurement Model validation

The adoption model contains nine reflective constructs, seven 1-item constructs and four formative second-order constructs. All constructs measured in reflective mode meet the criteria postulated for reflective measurement models (Jarvis et al. 2003). The quality of the reflective measurement model is determined by (1) convergent validity and (2) discriminant validity (Bagozzi and Youjae 1988). Convergent validity is analyzed by indicator reliability and construct reliability. In the model tested, all loadings are significant at least at the 0.01 level and above the recommended 0.707 parameter (Chin, 1998). Construct reliability was tested using the composite reliability (CR). All estimated indices were above the recommended threshold of 0.6 (Bagozzi and Youjae 1988). Additionally all constructs showed Cronbach's alphas above the critical value of 0.7. Discriminant validity of the construct items was analyzed by examination of the cross-loading. The loadings of the indicators resp. Pearson's correlation of the specific construct are always higher with this construct than with others (Bollen and Lennox 1991). Furthermore, the Average Variance Extracted (AVE) is always higher than the recommended threshold of 0.5 (Fornell and Larcker 1981). Thus, all reflective constructs showed convergent validity, construct reliability and discriminant validity. The strength of the constructs with formative measurement model can be verified by the significance of the item weights and t-statistics of the included indicators. All weights of the constructs' indicators are significant at the 0.01 level. The tests showed evidence of acceptable measurement quality for all constructs.

### 5.2 Structural model

In addition to the review of the measurement model, the explanatory power of the structural model was evaluated. The squared multiple correlations ( $R^2$ ) for the variable *intention to adopt Grid computing* of 0.532 indicates explanatory power. 53.2% of the variance is explained by the included constructs. The Stone-Geisser test ( $Q^2$ ), measuring the quality of each structural equation by the communal validity redundancy (cv-redundancy index), is positive and therefore the model has predictive relevance. The analysis of overall effect size ( $f^2$ ) reveals that all significant constructs in the model have least weak effects (Chin 1998). The significance of the path coefficients was assessed using the bootstrapping procedure implemented in SmartPLS with 1,000 re-samples. Since all of our hypotheses are directional, we use one-tail significance levels. Figure 1 displays the results. All significant path coefficients are marked by continuous lines whereas the not significant paths have dashed lines.

Six of nine hypothesis are supported at least at significance levels that meet the criterion of  $p < 0.1$  (Sellin and Keeves 1994). *Mimetic pressures*, *coercive pressures* and *normative pressures* show a high significant ( $p < 0.05$ ) positive effect to the *intention to adopt Grid computing*. Hence, H1, H2 and H3 are strongly supported. The *company size* (H5) and the *size of the IT-department* (H6) also have positive effects on the dependent variable, both with significances on the 10%-level. *Innovativeness* and *attitude towards outsourcing of IT-resources* are positively related to the dependent variable with

significance levels of 1%, strongly supporting our hypotheses H8 and H9. Only the moderating effect of *perceived complexity of using Grid computing* to *mimetic pressures* on the dependent variable and *perceived resource scarcity* were insignificant. Thus, H4 and H7 have to be rejected. The coefficients of the significant paths range from 0.084 to 0.203 with *mimetic pressures*, *innovativeness* and *attitude towards outsourcing of IT-resources* showing the strongest effects on the *intention to adopt Grid computing*.

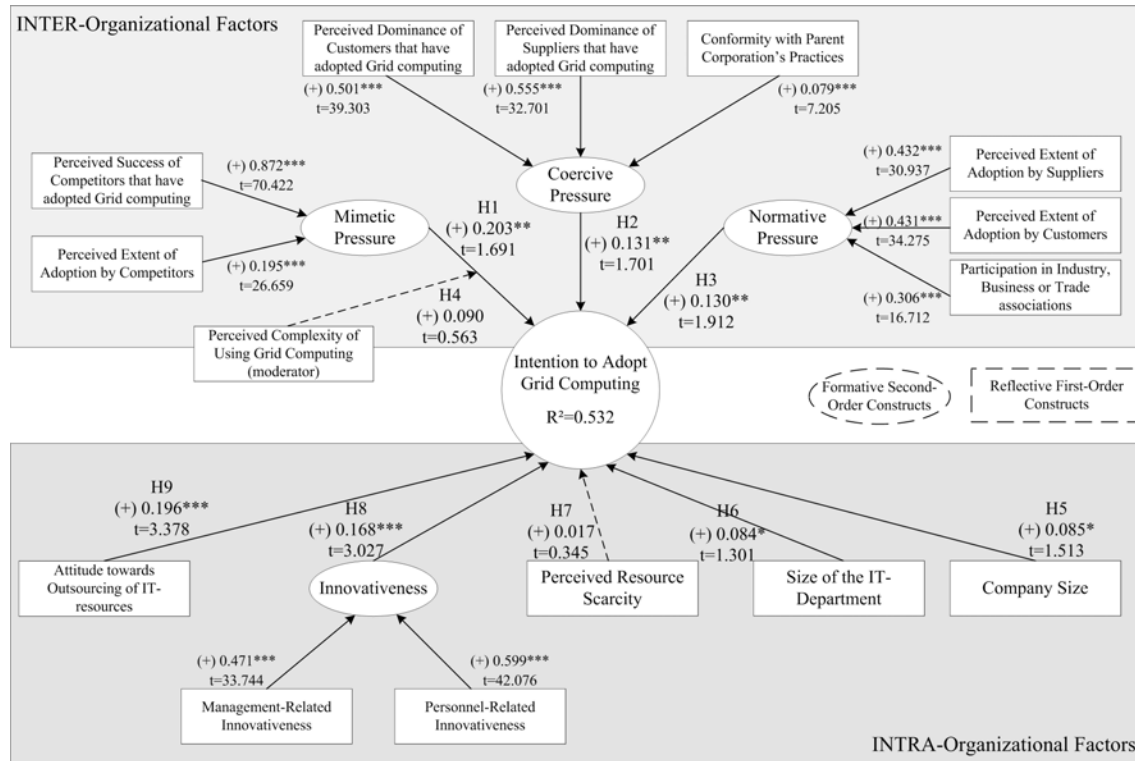


Figure 1. Path model with results (\*\*\*)  $p < 0.01$  (\*\*)  $p < 0.05$  (\*)  $p < 0.1$

### 5.3 Results and Interpretation

Within the inter-organizational influence factors the *mimetic pressures* show the strongest effect (0.203) on the adoption of Grid computing. If the competitors of an organization have already adopted and succeeded with the adoption, the observed organizations are enforced to follow for benefitting from the advantages Grid computing is giving, to avoid competitive disadvantages. The *perceived complexity of using Grid computing* does not significantly moderate the effect of *mimetic pressures* on the adoption intention. Even when the complexity is perceived as high, the effect of mimetic pressures will not be stronger. The objective to benefit of the same advantages as the competitors is not influenced by the complexity of the technology. *Coercive pressures* (0.131) display a quite similar effect as *normative pressures* (0.130) on the adoption intention. The pressures which appear from dominant suppliers, dominant customers and the parent corporations on the organization are as strong as the extent of the adoption the organizations perceives at their suppliers and customers. Hence, organizations are enforced to adopt because their suppliers, customers and parent corporations coerce them to do so. In almost the same manner organizations, which may not be directly coerced to adopt, feel an indirect *normative pressure* through observing the spread of adoption within their business environment. In this case they want to avoid losing important suppliers and customers because of being regarded as technologically antiquated.

On the intra-organizational side concerning the IT-related factors, we found the *company size* to have a weak significant positive effect on the adoption of Grid computing. Companies of bigger sizes have

more IT-resources to share and to balance efficiently, so they are more interested in adopting Grid computing than smaller companies. The adoption intention is also positively related with the *size of the IT-department*. A larger IT-department has more human capabilities and expertise to accomplish the implementation of this technology into the existing IT-structure. *Perceived resource scarcity* does not show a significant effect on the adoption intention. The observed organization seem to be equipped with sufficient IT-resources so that they do not need to access to the IT-resources of other organizations. As shown before, their main interest may be the efficient balancing of existent IT-resources. The strongest positive effects within the intra-organizational influence factors are carried out by the *attitude towards the outsourcing of IT-resources* (0.196) followed by *innovativeness* (0.168). Organizations that already made good experiences with the outsourcing of IT-resources may thereby have obtained benefits of reduced costs and increased performance. Thus, they are more likely to adopt Grid computing and share IT-resources with other organizations. If an organization is open-minded to new practices and supports its employees to work with or think about new technologies, it has a stronger intention to adopt Grid computing. The strong significant positive effect of *innovativeness* on the adoption intention corroborates this argumentation. At first glance this outcome might be regarded as trivial, but it shows that although the idea of Grid computing is more than 10 years old and the advantages are obvious (see section 2.1), Grid computing is still regarded as innovative- and not as established technology by the respondents of our survey.

## 6 CONCLUSION, LIMITATIONS AND FURTHER RESEARCH

The adoption of Grid computing can yield significant advantages in terms of cost reduction, efficient IT-resource load balancing and increasing inter-operability between different applications to adopting organizations. Globally we see two scenarios where even organizations in the pacific area can benefit from Grid adoption in Germany due to different time zones: (1) Organizations that have subsidiaries in both time zones may balance their IT-resources more efficiently. In the nighttime in Germany the employees in the Pacific-Asian area can calculate their tasks on the lower utilized German IT-resources if they are shared via Grid computing. During the nighttime in the Pacific-Asian area this can be deployed reversely. Thus IT-resources can be reduced in these organizations and costs can be decreased. (2) Organizations that are acting locally can access to IT-resources of other organizations via a marketplace on-demand and reduce their fixed costs by decreasing own IT-resources. Due to these facts the outcomes of our study and the development of the adoption of Grid computing in Germany is particularly highly relevant for organizations in the Pacific-Asian area.

In this study we described which influence factors support the adoption of Grid computing in Germany. As Grid computing is an IOS providing both inter-organizational linkages and intra-organizational linkages, we have to consider both sides of influence factors for describing the adoption intention. By including inter- and intra-organizational influence factors we explained 53.2% of the variance in the adoption intention which is higher compared to the model of *Teo et al. (2003)* who accounted only for inter-organizational factors and reached a  $R^2$ -level of 36.6%. Other prior studies with comparable models reported  $R^2$ -levels ranging from 16% to 39.5% (*Jai-Yeol and Benbasat 2007; Ke et al. 2009*). This outcome indicates that intra-organizational influence factors should not be disregarded when describing the intention to adopt an IOS like Grid computing.

Our adoption model identifies *mimetic pressures*, *attitude towards outsourcing of IT-resources* and *innovativeness* as main driving factors on the adoption of Grid computing. Within the inter-organizational factors we found *mimetic pressures*, *coercive pressures* and *normative pressures* to have significant positive effects on adoption intention. This indicates that the environment of an organization (consisting of competitors, suppliers, customers and parent corporations) may have a distinct interest to access the IT-resources of the observed organization via Grid computing and exhaust the advantages this technology can provide. As *mimetic pressures* shows the strongest effect, the observed organizations are rather influenced by the competitors' extent of adoption and their success with it in order to avoid competitive disadvantages than being directly pressured by dominant suppliers and customers or indirectly by the extent of adoption by suppliers and customers. *Attitude towards outsourcing of IT-resources* and *innovativeness* display the strongest effects among the intra-

organizational factors. The chance for an adoption of Grid computing significantly increases if the organization has already made good experiences with the outsourcing of IT-resources. The more organizations are willing to outsource the more may consider using Grid Computing in the future. Organizations which see themselves as innovative are more likely to adopt. Hence, we think that Grid computing will rather be deployed in younger open-minded organizations than in established conservative organizations.

Our study is limited so far, that trust, which is seen as an important issue to accelerate the adoption of Grid computing (Beck et al. 2008), is not included in our adoption model. To find out the importance of trust in relation to the technology and additionally in relation to the participants in a Grid, we are currently running further empirical studies. Furthermore it is limited, as it includes only organizations in one country at present. The results cannot be generalized, as cultural affinities were shown to have a high impact on system adoption behavior (Phillips and Calantone 1994). Eckhardt et al. (2009) identified significant differences in the impact of single influence factors between adopters and non-adopters on the adoption of innovative technologies. Since adopters of Grid computing no longer have to struggle with their environment forcing them to adopt, we think that for these organizations the intra-organizational influence factors will have a significant higher effect on the usage of the technology than for non-adopters. For further research we therefore propose to analyze and identify the differences between adopters and non-adopters of Grid computing in our adoption model.

## References

- Bagozzi, Richard P. and Youjae, Yi (1988), "On the Evaluation of Structural Equation Models," *Journal of the Academy of Marketing Science*, 16 (1), 74-94.
- Beck, Roman; Schwind, Michael; Hinz, Oliver (2008), "Grid Economics in Departmentalized Enterprises," *Journal of Grid Computing*, 6 (3), 277-90.
- Bollen, Kenneth and Lennox, Richard (1991), "Conventional Wisdom on Measurement: A Structural Equation Perspective," *Psychological Bulletin*, 110 (2), 305-14.
- Brislin, Richard W. (1970), "Back-Translation for Cross-Cultural Research," *Journal of Cross-Cultural Psychology*, 1 (3), 185-216.
- Burns, Lawton R. and Wholey, Douglas R. (1993), "Adoption and Abandonment of Matrix Management Programs: Effects of Organizational Characteristics and Interorganizational Networks," *The Academy of Management Journal*, 36 (1), 106-38.
- Burt, Ronald S. (1982), *Toward a Structural Theory of Action: Network Models of Social Structure, Perception, and Action*, New York [u.a.]: Academic Press.
- Burt, Ronald S. (1987), "Social Contagion and Innovation: Cohesion Versus Structural Equivalence," *The American Journal of Sociology*, 92 (6), 1287-335.
- Buyya, R. and Sulistio, A. (2008), "Service and Utility Oriented Distributed Computing Systems: Challenges and Opportunities for Modeling and Simulation Communities," in *Proceedings of the 41th Annual Simulation Symposium*, Ottawa, Ont., 68-81.
- Chin, Wynne W. (1998), "The Partial Least Square Approach to Structural Equation Modeling," in *Modern Methods for Business Research*, ed. George A. Marcoulides, Mahwah, NJ, USA: Lawrence Erlbaum Associates, 295-336.
- DiMaggio, Paul J. and Powell, Walter W. (1983), "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," *American Sociological Review*, 48 (2), 147-60.
- Eckhardt, Andreas; Laumer, Sven; Weitzel, Tim (2009), "Who Influences Whom? Analyzing Workplace Referents' Social Influence on It Adoption and Non-Adoption," *J Inf technol.*
- Farrell, Joseph and Saloner, Garth (1986), "Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation," *The American Economic Review*, 76 (5), 940-55.
- Fornell, Claes and Larcker, David F. (1981), "Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics," *Journal of Marketing Research*, 18 (3), 382-88.

- Foster, Ian and Kesselman, Carl (1999), *The Grid: Blueprint for a New Computing Infrastructure*, San Francisco, Calif.: Kaufmann.
- Foster, Ian; Kesselman, Carl; Tuecke, Steven (2001), "The Anatomy of the Grid: Enabling Scalable Virtual Organizations," *International Journal of High Performance Computing Applications*, 15 (3), 200-22.
- Haveman, Heather A. (1993), "Follow the Leader: Mimetic Isomorphism and Entry into New Markets," *Administrative Science Quarterly*, 38 (4), 593-627.
- Hwang, Junseok and Park, Jihyou (2007), "Decision Factors of Enterprises for Adopting Grid Computing," in *Grid Economics and Business Models*, 16-28.
- Jai-Yeol, S. O. N. and Benbasat, Izak (2007), "Organizational Buyers' Adoption and Use of B2b Electronic Marketplaces: Efficiency- and Legitimacy-Oriented Perspectives," *Journal of Management Information Systems*, 24 (1), 55-99.
- Jarvis, Cheryl Burke; Mackenzie, Scott B.; Podsakoff, Philip M. (2003), "A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research," *Journal of Consumer Research*, 30 (2), 199-218.
- Ke, Weiling; Liu, Hefu; Wei, Kwok Kee; Gu, Jibao; Chen, Huaping (2009), "How Do Mediated and Non-Mediated Power Affect Electronic Supply Chain Management System Adoption? The Mediating Effects of Trust and Institutional Pressures," *Decision Support Systems*, 46 (4), 839-51.
- King, John Leslie; Gurbaxani, Vijay; Kraemer, Kenneth L.; McFarlan, F. Warren; Raman, K. S.; Yap, C. S. (1994), "Institutional Factors in Information Technology Innovation," *INFORMATION SYSTEMS RESEARCH*, 5 (2), 139-69.
- Liu, Chunhui; Sia, Choon-Ling; Wei, Kwok-Kee (2008), "Adopting Organizational Virtualization in B2b Firms: An Empirical Study in Singapore," *Information & management*, 45 (7), 429-37.
- Markus, M. Lynne (1987), "Toward A "Critical Mass" Theory of Interactive Media: Universal Access, Interdependence and Diffusion," *Communication Research*, 14 (5), 491-511.
- Messerschmidt, Christian M. (2009), "Grid-Technologie in Deutschen Unternehmen – Eine Empirische Studie," in *Grid Computing in der Finanzindustrie*, ed. Hinz et al., Norderstedt: Books on Demand, 30-68.
- Minoli, Daniel (2005), *A Networking Approach to Grid Computing*, Hoboken, NJ: Wiley-Interscience.
- Moore, Gary C. and Benbasat, Izak (1991), "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation," *INFORMATION SYSTEMS RESEARCH*, 2 (3), 192-222.
- Phillips, Lisa A. and Calantone, Roger (1994), "International Technology Adoption: Behavior Structure, Demand Certainty and Culture," *Journal of Business & Industrial Marketing*, 9 (2), 16-28.
- Powell, Walter W. (1991), *The New Institutionalism in Organizational Analysis*, Chicago [u.a.]: Chicago Univ. Press.
- Ringle, Christian M.; Wende, Sven; Will, Alexander (2006), "Smartpls," University of Hamburg.
- Sellin, Norbert and Keeses, J.P. (1994), *Path Analysis with Latent Variables*, London: Elsevier Publishers.
- Strong, Paul (2005), "Enterprise Grid Computing," *Queue*, 3 (6), 50-59.
- Teo, H. H.; Wei, K. K.; Benbasat, I. (2003), "Predicting Intention to Adopt Interorganizational Linkages: An Institutional Perspective," *Management information systems*, 27 (1), 19-50.
- The Economist (2004), "From Grid to Great? Grid Computing's Corporate Prospects," in *Economist Intelligence Unit*.
- Vykoukal, Jens; Wolf, Martin; Beck, Roman (2009), "Services Grids in Industry – on-Demand Provisioning and Allocation of Grid-Based Business Services," *Business & Information Systems Engineering*, 2, 1-8.
- Wang, Catherine L. and Ahmed, Pervaiz K. (2004), "The Development and Validation of the Organisational Innovativeness Construct Using Confirmatory Factor Analysis," *European journal of innovation management* (4), 303-13.