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ENVIRONMENTAL DYNAMICS AS DRIVER OF ON-DEMAND COMPUTING INFRASTRUCTURES – EMPIRICAL INSIGHTS FROM THE FINANCIAL SERVICES INDUSTRY IN UK

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Abstract

Financial institutions are exposed to a highly dynamic environment that is characterized by an intense competition and short technological hype cycles. Against this background, the assimilation of on-demand computing infrastructures as particularly Grid and Cloud computing can be assumed to be a potential strategic response to address fast changing market and technological demand as well as to comply with arising mimetic pressure between competitors. So far, little empirical research has been conducted to assess the influence of environmental dynamics on the assimilation process of on-demand computing infrastructures. Grounded in the Technology-Organization-Environment framework, this article proposes a holistic perspective emphasizing the environmental determinants of Grid assimilation for the asset management process and analyzes its consequences for IT value generation. The derived hypotheses were tested based on 103 responses from senior IT decision makers of financial services providers that have already adopted Grid technology for their asset management process. The results from partial least squares analyses indicate that in particular environmental dynamics determine the assimilation of Grid-based infrastructures. Our results contribute to IS assimilation theory by integrating environmental dynamics into the Technology-Organization-Environment framework.

Keywords: Diffusion of Innovations, Environmental Turbulence, TOE Framework, Grid Computing.

1 Introduction

In line with most businesses' strategies, enterprises increasingly adopt value chain improving technologies in order to retain a competitive position in a rapidly changing, uncertain, and demanding environment (Sugumaran et al. 2008). Due to its hyper-competitive market, the financial services industry is particularly exposed to a high level of environmental dynamics and resulting uncertainty (Ang & Cummings 1997). Moreover, the financial services industry exhibits a large number of information-intensive business processes, high computational demands, and fast changing customer needs (Hackenbroch & Henneberger 2007). These industry characteristics are reflected by the above-average annual IT investments (~ 8% of the annual revenues) which are almost as twice as high as in other industries (Zhu et al. 2006b). However, traditional IT infrastructures are not able to dynamically adapt to new business demands and constraints due to statically configured servers that were organized as a set of independent "silos", each responsible for a distinct enterprise function or application (Kotsovinos 2011). Consequently, due to the need to provide excess capacity for occasional peak loads, the silos were idle 90% of the time (Foster & Tuecke 2005), which led companies to move from siloed static IT infrastructures to shared on-demand IT infrastructures to reduce capital and operation expenses and to respond more rapidly to changing business demands (Rings et al. 2009). Since shared on-demand IT infrastructures can be realized by the application of Grid technology (or its successor Cloud computing) that supports the efficient and flexible adaptability to rapidly evolving business requirements, the concept of Grid computing is expected to be of crucial importance for the financial services industry (Hackenbroch & Henneberger 2007).

Hence, the assimilation of a flexible Grid-based IT infrastructure (Foster & Kesselman 1999) provides the opportunity to address environmental dynamics and computational challenges since it facilitates the ability to accelerate resource-demanding computations and data mining operations on-demand. Following the threefold definition by Foster (2002), a Grid-based IT infrastructure is a system that (1.) coordinates IT resources that are not subject to centralized control, (2.) uses standards, open protocols and interfaces, and (3.) delivers non-trivial qualities of IT-based services. By these general means and the aforementioned computational and data mining capabilities, the timely assessment of complex financial products and available risk exposure becomes feasible (Hackenbroch & Henneberger 2007), eventually supporting an effective asset management process. Furthermore, the flexibility of on-demand Grid infrastructures enables firms to adaptively change processes and procedures "on the fly". Due to a multi-national study by Quocirca (2006), the adoption rate of so-called compute Grids is estimated to be around 10 to 30 percent, whereas the geographical dissemination significantly varies between the US (high adoption rate), Europe (moderate adoption rate), and Asia (low adoption rate).

An on-demand computing concept that is highly related to Grid computing is its successor Cloud computing. Although both concepts share the same vision to provide on-demand access to large computing and storage capacities and exhibit the same underlying technologies, they differ in some details (Foster et al. 2008). Cloud computing relies on Grid computing as the backbone and infrastructure support and uses a business model in which federated, virtualized IT resources (or Grid resources) are packaged as metered services (Vaquero et al. 2009). These services are offered to customers on a pay-per-use basis, which is typically not the case for Grid computing. However, one can assume that insights with regard to Grid infrastructures are in most parts transferable to Cloud infrastructures, since both concepts can be subsumed as on-demand computing infrastructures.

So far, little empirical research has been conducted to identify and quantify the core determinants of the assimilation of on-demand computing infrastructures as potential strategic IT option in the financial services industry (Hackenbroch & Henneberger 2007). In order to conceptualize the role of environmental dynamics driving the assimilation process in the financial services industry, we draw upon organizational theory and institutional theory to amend the environmental component of the Technology-Organization-Environment (TOE) framework by integrating the concepts of environmental turbulence and mimetic pressure.

The remainder of the article is organized as follows: section 2 briefly introduces the required domain knowledge with regard to the utilization of on-demand Grid infrastructures in the financial services industry. Furthermore, the theoretical background and the appropriateness of the TOE framework and the influence of environmental turbulence and mimetic pressure are depicted. Based on this, the hypotheses and the research model are introduced in the subsequent section. In section 4, the research design and methodology of the conducted quantitative field study are depicted and the main results are discussed. Finally, the article concludes with an overview of the existing limitations and further research opportunities to extend the depicted work.

2 Theoretical Background

The following subsections provide insights about the application and benefits of Grid infrastructures in the financial services industry and introduce the theoretical background of the conducted research.

2.1 Service-oriented Grid infrastructures in the Financial Services Industry

During recent years, enterprises continuously built-up flexible Grid-based infrastructures by transforming their former vertically integrated IT infrastructures (e.g., compute clusters, databases, etc.) to horizontally integrated, on-demand Grid infrastructures built on a set of loosely coupled software services (Foster & Kesselman 1999). In general, Grid-based infrastructures can be characterized by a set of latent properties that extend those of traditional compute clusters. These properties provide a variety of benefits that include (Buyya & Sulistio 2008, Strong 2005):

- Seamless computing power achieved by exploiting under-utilized IT resources to solve compute-intensive problems in a decreased processing time
- A faster access to distributed data
- On-demand provisioning of geographically dispersed, heterogeneous IT resources
- A reliable, resilient, and highly available IT infrastructure with autonomic management capabilities and on-demand aggregation of resources from multiple sites to meet unforeseen demand

Although there are several benefits of Grid infrastructures, significant challenges still have to be resolved in order to facilitate the promotion of Grid infrastructures in the industry domain (Vykoukal et al. 2009). These challenges include further improvements in the stability of Grid infrastructure, the development of holistic approaches to virtualization and service level agreements, as well as improvements in terms of security issues and trust and reputation mechanisms.

The benefits of on-demand Grid infrastructures are especially exploited in the financial services industry for compute-intensive processes, such as the asset management process. Furthermore, this high computational demand can be assumed to be further reinforced by the consequences of the financial crisis which leads to high regulatory and competitive pressure to utilize complex forecasting and analysis tools which can be fostered by a "gridification" of the existing IT infrastructures.

2.2 Technology-Organization-Environment Framework

The TOE framework (Tornatzky & Fleischer 1990) is consistent with the diffusion of innovations theory (Rogers 1995) which emphasizes technological differences as well as internal and external organizational characteristics as main drivers of organizational technology diffusion. Thus, the TOE framework identifies three different contextual aspects of a firm that determine the process of technological assimilation on the firm level of analysis: the technological context, the organizational context, and the environmental context. While the *technological context* relates to the information technologies that are internally or externally available to an organization, the *organizational context* is defined by the characteristics that shape and define an organization. Finally, the *environmental context* captures the setting and environmental conditions in which an organization conducts its business. So far, the TOE framework has been successfully utilized in different prior (post-)adoption studies on IT diffusion on the firm level of analysis, e.g., E-Business (Zhu et al. 2006a) and EDI (Kuan & Chau 2001).

Due to their different purposes, IT innovations can be distinguished based on Swanson's (1994) classification. While type I innovations represent pure technology-driven innovations (e.g., database systems), type II innovations involve the technological support of administrative tasks (e.g., payroll or human resources information systems). Since Grid-based infrastructures eventually foster the on-demand-based access to advanced data processing, data mining, and (inter-)organizational collaboration capabilities, they exhibit the potential to be integrated with the core business model of firms. Due to this potential of generating strategic value, on-demand Grid infrastructures can be classified as type III innovations, which encompass innovations potentially affecting the entire business. Furthermore, Swanson (1994) evaluated the appropriateness of the TOE framework for the different types of innovation, noting that the facilitating technologies, organizational attributes (such as slack resources), and the strategic environment have an impact on type III innovation diffusion. Additionally, type III innovation studies are still rarely covered by prior literature. Thus, we deemed the TOE framework appropriate for our study on Grid assimilation.

2.3 Environmental Dynamics

2.3.1 Environmental Turbulence

The concept of environmental turbulence encompasses environmental conditions of uncertainty and unpredictability due to massive and rapid changes in technological developments and market preferences (Jaworski & Kohli 1993). These can be either caused by market turbulences or technological turbulence (Jap 2001). Market turbulence is caused by unpredictability in market demands, consumer needs, and competitor strategies or a changed rapidity of market demands with regard to the frequency of change in the environment. On the other hand, technological turbulence encompasses the unpredictability of new technological innovations in terms of their unanticipated consequences for an industry and their diffusion rapidity (Jap 2001).

Due to a categorization by Ansoff and Sullivan (1993), environmental turbulence can be further characterized by the complexity of events (in the environment), familiarity of the successive events, rapidity as time span between first occurrence and further evolution, and visibility/unpredictability of the consequences of these events. Based on this characterization, five different hierarchical levels of environmental turbulence can be distinguished (see Table 1). For instance, an environmental turbulence level of 1 reflects a surrounding with slow changes, a limited sphere, high familiarity of occurring events, and gradual long term responses of affected firms. On the other extreme, an environmental turbulence level of 5 is characterized by an environment of discontinuous and unpredictable surprises of global socio-political scope which challenge or overwhelm even well-managed firms, since they fail to respond timely to their initial occurrences.

Turbulence Level	1	2	3	4	5
Complexity	National Economic	+	Regional Technological	+	Global Socio-Political
Familiarity of Events	Familiar	Extrapolable		Discontinuous Familiar	Discontinuous Novel
Rapidity of Change	Slower Than Response	Comparable to Response	Faster Than Response		Much Faster Than Response
Validity of Future	Recurring	Forecastable	Predictable	Partially Predictable	Unpredictable Surprises

Table 1. Levels of environmental turbulence

2.3.2 Mimetic Pressure

In particular, in highly dynamic environments firms tend to imitate the behaviour of a successful competitor to derive their portfolio of IT innovations as fast as possible (Pavlou and El Sawy, 2006; Swanson and Ramiller, 2004). Here, institutional theory is one theoretical lens to account for the rise of mimicry in these environments (Ang and Cummings, 1997; Liang et al., 2007). Institutional theory in general posits that structural and behavioural changes in firms are rather driven by an inherent organizational need and striving for legitimacy than sole considerations of competitive advantages and hidden efficiency potentials (DiMaggio & Powell 1983, Meyer & Rowan 1977). This continuous search for organizational legitimacy eventually facilitates the process of institutionalization and organizational isomorphism especially against the background of an uncertain and turbulent environment. An uncertain environment especially fosters mimicry among firms. Thus, even if the consequences and goals of an IT innovation are poorly understood or are ambiguous, mimetic pressure can foster the assimilation of it, if adopting firms are perceived as successful by the environment.

2.4 Assimilation

Assimilation is defined as the extent to which a firm has progressed through stages of innovation deployment (initiation, adoption, and routinisation) (Fichman 2001). In this context, initiation accounts for a firm's identification and match of existing business requirements with potential (IT-based) solutions (Kohli & Grover 2008, Rogers 1995). In this stage, its fit to the business requirements and the potential business value resulting in cost reduction and market expansion induced by IT-based innovation among value chains is evaluated (Dong et al. 2009). This evaluation influences the final adoption decision (Dong et al. 2009). While technology initiation or infusion serves as a starting point, the adoption stage encompasses the active decision to acquire the intended technology and to allocate the required physical resources. Termed in assimilation theory as so-called "assimilation gaps", there is often a mismatch between the decision to adopt a technology and its subsequent usage behaviour (routinisation stage) (Fichman & Kemerer 1999). This gap also occurs with respect to the time span between its initial introduction and the lagged point of routinised usage. Finally, the routinisation stage reflects the scenario when the innovation has become a stable and regular part of organizational procedures and behaviour (Fichman 2001). A business process level perspective was chosen as unit of analysis for measuring the assimilation progress and business value generation due to the fact that IT investments are supposed to affect the performance of specific business processes first (Davamanirajan et al. 2006). In general, a firm encompasses approximately 18 key processes being vital for the overall firm performance (Davenport 1993). In order to identify the key business process that is primarily influenced by Grid assimilation in the financial services industry, several expert interviews with IS executives of financial services providers and IT vendors were conducted. The interviews revealed that the asset management process is especially crucial for the financial services industry in this context. For instance, in 2008, the asset management process of the Bank of America accounted for 10 percent of the revenue but concurrently contributed with 35 percent to the net income (SEC 2008) with projected growing potential for the future.

3 Research Model and Hypotheses

In the following, the research model and the derived hypotheses, as well as the measures used to validate the model, are introduced.

3.1 Research Hypotheses

Based on the TOE framework and deductively drawing upon extant literature, the determinants shaping Grid assimilation on the firm level of analysis were conceptualized in a parsimonious model as depicted in Figure 1.

The technological context is represented by Grid infrastructure capability and Grid technology integration (adapted from Zhu et al. (2006b)). Grid infrastructure capability captures the firm's technical capability resulting from having extensive access to distributed computing power and purpose-specific technologies (e.g., a high-capacity, low latency network) within the organization. In the first place, these technologies enable a firm to adopt and implement an on-demand-based Grid (Foster & Kesselman 1999). Thus, we hypothesize:

H1: Firms with greater Grid infrastructure capability are more likely to be in a more mature stage of Grid assimilation

Grid technology integration (adapted from Zhu et al. (2006b)) is defined as the degree of inter-connectivity among applications and the inter- and intra-organizational backend systems or architectures. This is expressed by the access of applications to standardized enterprise infrastructures, virtualized environments as execution environment, or the integration of external IT resources. In this case, a "gridification" and migration of existing legacy systems becomes easier. Since technological integration leverages the potential advantages of Grid-based infrastructures to existing applications, Grid technology integration is vital for a successful assimilation of Grid technology. Hence, we hypothesize:

H2: Firms with greater Grid technology integration are more likely to be in a more mature stage of Grid assimilation

The organizational context encompasses Grid technology competence (adapted from Zhu et al. (2005)) and Grid implementation management capability (adapted from Dong et al. (2009) and Pavlou and El Sawy (2006)).

Grid technology competence (adapted from Zhu et al. (2005)) reflects explicit knowledge and skills (e.g., distributed systems programming skills, knowledge of virtualized environments) of the firm's IT staff that are needed to successfully implement Grid infrastructures. Thus, Grid technology competence complements the physical capabilities by human-related factors (Mata et al. 1995), both contributing to the organizational readiness to assimilate Grid infrastructures. Due to this, we hypothesize:

H3: Firms with greater Grid technology competence are more likely to be in a more mature stage of Grid assimilation

Since the organizational readiness to successfully assimilate a technology is neither solely defined by technological nor human factors but additionally decisively relies on their combination (Melville et al. 2004), this inherent complementarity and interdependence is conceptualized in a twofold way. First, consistent with the resource-based view of the firm, the research model distinguishes between two different kinds of IT resources that complement each other (Melville et al. 2004): technological IT resources (i.e., Grid infrastructure capability and Grid technology integration) and human IT resources (i.e., Grid technology competence). Second, the interdependence between these complementarities is reflected by the Grid implementation management capability since operational middle management leads the overall Grid assimilation process from both a technological and business-driven perspective. This "conversion capability" of the involved IS department reflects the degree of managerial competence to successfully monitor and guide through the process of Grid assimilation. Thus, we hypothesize:

H4: Firms with greater Grid technology implementation capability are more likely to be in a more mature stage of Grid assimilation

In highly dynamic environments organizations have to identify market or technological changes close to their emergence and need to develop contextually tailored (IT) strategies. Strategic IT responses (Ang & Cummings 1997), such as the assimilation of an on-demand-based Grid infrastructure, are one means to address environmental turbulence. Especially the asset management process in financial institutions is affected by an increasing customer demand for highly customized and complex financial products for varying lifetime contingencies. The evaluation, optimization, and monitoring of portfolios of these complex products require substantial computational power. In addition to this, customers stipulate access to real-time performance data on their assets under management. Grid infrastructures, which allow the on-demand access to computing power, are one viable approach to satisfy theses customer needs from a technological perspective. Thus, we hypothesize:

H5: Firms that are exposed to a higher level of environmental turbulence are more likely to be in a more mature stage of Grid assimilation

Even if the consequences and benefits of an IT innovation are poorly understood or are ambiguous, in highly volatile and uncertain environments mimetic pressure can foster the assimilation of a technology if adopting firms are perceived as successful by the environment. In our case, mimicry is of special importance and even more enforced since financial services providers are particularly exposed to an uncertain and hyper-competitive environment (Ang & Cummings 1997). Consequently, the information on the number and type of first adopters might outweigh the importance of the rational evaluation of the innovation characteristics itself (Meyer & Rowan 1977). In particular, under high-ambiguity conditions, the mimetic pressure is likely to be higher (Rosenkopf & Abrahamson 1999).

H6: Firms that are exposed to a higher level of mimetic pressure are more likely to be in a more mature stage of Grid assimilation

According to the resource-based view of the firm theory, business processes provide a context within which business value can be examined (Markus et al. 2002). The rationale behind this perspective is the argument that first-order effects of IT investments manifest first at the operational level (Barua et al. 2004) in terms of changes in operational process efficiency, effectiveness, and flexibility (Karimi et al. 2007b). As proposed by Karimi et al. (2007a) in the domain of ERP systems assimilation, process efficiency, process effectiveness, and process flexibility reflect the overall business process outcomes construct. While process efficiency is defined by the extent to which the use of IT implementation reduces the operational costs and decreases the input/output conversion ratio, process effectiveness reflects the extent to which IT implementation provides an improved functionality and enhances the quality of the users' work. The extent to which IT implementation provides firms with more flexibility in response to changing business environments defines the process flexibility of the business process outcomes construct. In our study, business process performance as perceptual measure of business value was operationalised as dependent variable for the asset management process of financial services providers in order to capture the business value generation momentum of Grid assimilation. In sum, we hypothesize:

H7: Firms that are in a more mature stage of Grid assimilation are more likely to realize higher business process outcomes

3.2 Measures

Reflective measures were used for all of the constructs except for the formative Grid assimilation and firm size construct. All constructs of the depicted research model were deductively derived from well-established IS journals and adapted to the Grid context where necessary. As shown in Table A1 in the Appendix, fully anchored 7-point Likert scales (from 1 ('strongly disagree') to 7 ('strongly agree')) were used for all reflective constructs, except for Grid infrastructure capability and Grid technology integration. These were measured on a 5-point Likert scale (from 1 ('0%') to 5 ('100%')) since they captured the relative extent of access to specific infrastructure capabilities. For firm size, a 4-point ordinal scale for different categories of size (1,000-5,000; 5,001-10,000; 10,001-50,000; >50,000) was employed. Drawing upon Fichman (2001), we conceptualized the Grid assimilation construct as the degree of assimilation regarding the extent to which a firm has progressed through stages of innovation deployment (initiation, adoption, routinisation). Since a technology-focused assimilation study on firm level was conducted, an aggregated measure for the assimilation stages was employed. In order to identify the key business process being primarily influenced by Grid assimilation in the financial services industry, several expert interviews with IS executives were conducted. Additionally, a review of the current banking services landscapes provided by Oracle and the "Banking Industry Architecture Network" (BIAN) was utilized to further ground the set of identified business processes. The finally utilized measure aggregates over the entire assimilation lifecycle of a single technology (i.e., Grid technology) for the asset management process of financial services providers. Therefore, a 7-point Guttmann scale (from 1 ('awareness') to 7 ('general deployment')) (adapted from Rai et al. (2009)) was utilized for the asset management process.

Overall, the presented operationalisation implies several benefits, e.g., greater robustness and generalisability, at the cost of a possible loss of context specificity and reduced clarity of the theoretical interpretation (adapted from Fichman (2001)). Since it is expected that the drivers and inhibitors of Grid assimilation influence all assimilation stages in the same direction, this bias can be assumed to be of less importance in comparison to its potential benefits.

4 Research Design and Methodology

This section depicts the utilized research methodology and the data collection process and discusses the results of the model validation and hypotheses testing.

4.1 Data Collection and Sample Profile

In order to validate the research model presented in Figure 1 and the associated hypotheses proposed in section 3.1, we conducted a quantitative, survey-based field study. The study aimed at senior IT decision makers that work for a financial services provider in the United Kingdom with more than 1,000 employees. Since the study focused on determinants of Grid assimilation which also covers the post-adoption stage, only financial institutions already implemented Grid infrastructures were considered. Since the IT budget in the financial services industry is approximately twice as high as in other industries, the adoption rate of on-demand Grid infrastructures is likely to be higher than in other industries. These facts make the financial services industry a valuable testing field for our research model. From an empirical perspective, focusing on a single industry also allows to control for extraneous industry factors that could otherwise confound the analysis, thereby enhancing internal validity.

During August and September 2009, 788 British participants of a business-to-business panel were invited by a large international market research company to respond to the survey. In a first wave, the market research company sent out electronic invitations to the panellists. After one week, an email reminder was sent out to non-respondents. The date of invitation, the date of participation, and the user ID were logged to ensure that each panellist only completed the online survey once. In order to ensure that all of the participants had a common understanding of on-demand Grid infrastructures, a brief definition with examples was provided to them as part of the online survey. Finally, 279 responses from the survey were gathered, leading to a response rate of 35.4 percent. The comparatively high response rate might be grounded in the fact that all participants completing the questionnaire received additional airline and hotel discount vouchers as incentive for their participation. Finally, we verified that all the participants of the panel satisfied our requirements (financial services industry, >1,000 employees, IT decision maker), excluding 135 responses from non-Grid adopters and 41 questionnaires that exhibited missing values. Consequently, the final sample contained 103 complete responses.

4.2 Measurement Model Validation

To ensure content validity, all measures were informed by the extant literature and adapted to the specific context. Additionally, due to feedback from a panel of domain experts, some minor adjustments were made to the length of survey instruments and the wording of the items. To further validate the reflectively measured constructs, (1) the construct reliability, (2) the convergent validity, and (3) the discriminant validity were assessed. Construct reliability was tested by computing the average variance extracted (AVE) and the composite reliability (CR) scores (see Table 2). All estimated values exceed the proposed threshold of 0.5 for AVE and 0.7 for CR. Second, convergent validity was assessed by analyzing the loadings, which were all highly significant at least at the 0.001 level and all above the proposed value of 0.707 (Chin 1998).

	Mean	SD	AVE	CR
GIC	3.25	0.90	0.68	0.81
GTI	3.12	0.78	0.69	0.82
GTC	5.76	1.16	0.74	0.93
GIMC	4.82	1.47	0.82	0.96
ET	5.75	1.08	0.62	0.91
MIM	4.72	1.13	0.85	0.94
ASSM	3.45	2.48	n/a	n/a
BPO	2.79	2.90	0.96	0.99

Table 2. Means, standard deviations, AVEs, and CRs

Finally, discriminant validity was tested by computing the inter-correlations between the latent variables. Consistent with the Fornell and Larcker criterion, the square root of the AVE of each construct is higher than the correlations between the construct and the other constructs in the model (see Table 3). Furthermore, the cross-loadings of the different items emphasize that the loadings on the referring construct are higher than on all other constructs. As far as the formative ASSM construct is concerned, the weight is above 0.2 and significant (Chin 1998). Finally, the reflective second-order construct (BPO) was validated in a twofold manner: first, the aforementioned psychometric properties of the first-order model were assessed. In a second step, the second-order measurement model was validated in the context of the other constructs (see Table 2). In essence, the results suggest a good reliability as well as good convergent validity and discriminant validity of our measurement model.

Since all self-reported data can potentially be affected by common method bias arising from different sources, such as social desirability and consistency motif, we conducted an additional common method bias analysis (Podsakoff et al. 2003). First, we computed a Harman's one-factor test, revealing that the most variance explained by one theoretical factor is 31.53 percent. Thus, the presence of common method bias is not likely in our study. Despite this, we included a common method factor in our PLS model whose indicators included all the principal constructs' indicators and calculated each indicator's variances substantively explained by the principal construct and by the method. The results show that the average substantively explained variance of the indicators is 0.595, while the average method variance is 0.011 resulting in a ratio of about 54:1. In addition, most method factor loadings are not significant. Based on both of these results, we concluded that there is unlikely to be a serious concern of common method bias for this study.

	GIC	GTI	GTC	GIMC	MIM	ET	ASSM	BPO
GIC	**0.82**							
GTI	*0.50*	**0.83**						
GTC	*0.22*	0.18	**0.86**					
GIMC	*0.29*	0.12	*0.63*	**0.91**				
MIM	*0.02*	0.06	0.14	0.17	**0.92**			
ET	0.13	0.17	0.04	0.14	0.06	**0.79**		
ASSM	*0.24*	*0.25*	0.14	*0.33*	*0.29*	*0.20*	**n/a**	
BPO	0.14	0.15	0.13	*0.20*	*0.36*	0.12	*0.65*	**0.98**

Table 3. Cross-correlations, square roots of AVEs (diagonal elements); italic correlations significant at $p < 0.05$

4.3 Hypotheses Testing and Discussion

The research model was operationalized as a structural equation model (SEM) and analyzed using the Partial Least Squares (PLS) approach with a 500 sample bootstrapping technique for model assessment (Chin 1998) with the software implementation SmartPLS (Version 2.0 M3). All statistical tests were assessed with one-tailed t-tests because of the unidirectional nature of our hypotheses. Due to the explanatory approach, the measurement model of both formative and reflective constructs with mixed scales (Chin 1998) and the data set of 103 responses, we deemed a component-based approach instead of covariance-based approach appropriate for the complexity and design of our research model.

Figure 1 depicts the estimates obtained from our PLS analysis. The R^2 value of .254 indicates that the model explains a moderate amount of variance for Grid assimilation (Chin 1998). The results provide first evidence that four (GTI, GIMC, ET, MIM) of the six TOE factors have a significant positive impact on Grid assimilation. Only the paths associated with GIC and GTC are insignificant ($p > 0.05$). In essence, five (H2, H4, H5, H6, H7) out of seven hypotheses are supported. In sum, our results indicate that in the asset management process, the assimilation of an on-demand Grid-based infrastructure leads to the generation of business value at the process level (support for H7, $p < 0.05$).

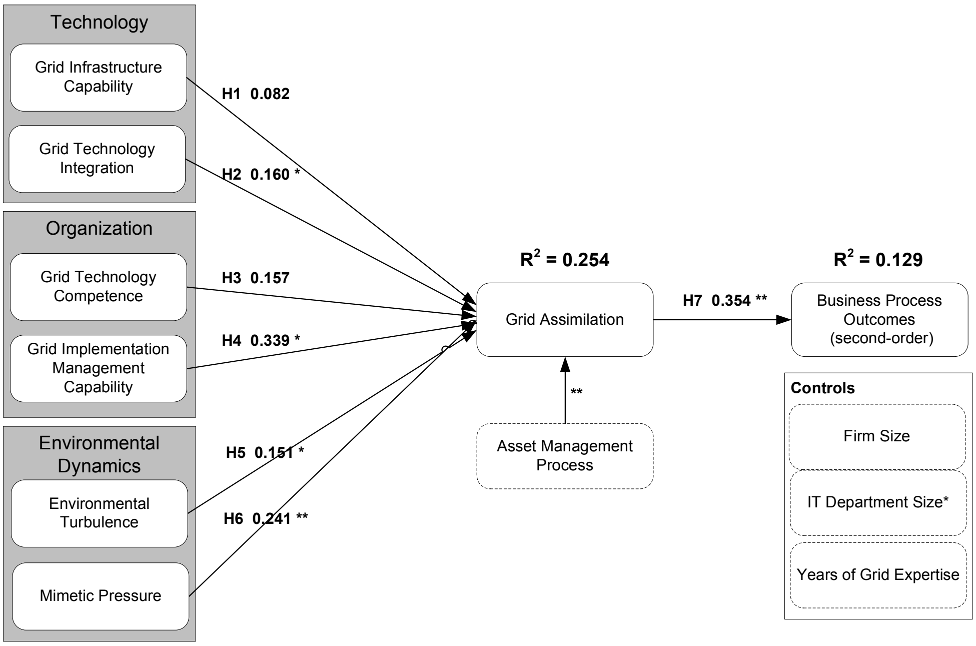

*Figure 1. Empirical results; ** p < 0.01, * p < 0.05 (one-tailed)*

In essence, our results indicate that environmental dynamics (i.e., environmetal turbulence (H5) and mimetic pressure (H6)) are among the core drivers of on-demand-based Grid infrastructures. In particular, the assimilation of Grid-based infrastructures can be assumed to be both (1.) a strategic response towards arising environmental turbulence and (2.) a means to be part of the hype cycle or industry consensus in the realm of on-demand computing infrastructures. As far as the *strategic dimension* is concerned, on-demand-based Grid infrastructures enable financial services providers to immediately adapt their asset management process to changing requirements in terms of technology and market demand, such as changing customer preferences. By means of "gridification" of the asset management process, the increasing customer and IT ressource demand arising from more sophisticated financial products, investment strategies, and the assessment of associated risk can be met. Therefore, the required data mining and data processing capabilities can be provided by Grid-based infrastructures. Concurrently, there seems to be an *industry-wide consensus* that on-demand computing infrastructures, such as Cloud and Grid computing, will be the "next big thing" with regard to technological evolution. This consensus manifests in the high extent of mimetic pressure to assimilate on-demand-based infrastructures early. Surprisingly, we could not identify a significant relationship between GIC and GTC to Grid assimilation, which is counter-intuitive. This might be grounded in the fact that on-demand Grid infrastructures are perceived as a rather smooth evolution of established concepts, such as cluster computing and service-oriented architectures by IT decision-makers. Consequently, they do not necessarily associate idiosyncratic technical competences with the assimilation of on-demand computing infrastructures.

Interestingly, our results only partly support that the complementarity of IT resources that reflects the organizational IT innovation readiness decisively drives the Grid assimilation process. Among the four IT-related constructs (GIC, GTI, GTC, GIMC), only two (GIMC, GTI) are found to significantly drive Grid assimilation. However, the results indicate that operational GIMC, which integrates both technical and business capabilities, exhibits the strongest impact towards Grid assimilation, which is consistent with the extant literature (Melville et al. 2004). With regard to the control variables, only IT department size, operationalized as employees in the IT department, exhibits a significant negative path towards Grid assimilation, indicating that especially financial services providers with smaller IT departments (but still with more than 1,000 employees) are able to realize benefits from Grid assimilation. Due to the reduced organizational complexity, it might be easier for the IT department to implement highly customized Grid infrastructures for the asset management process that eventually lead to positive gains on the business process level.

In sum, our results suggest that on-demand-based Grid infrastructures are successfully utilized in the asset management process so far. In this context, our analyses indicate that financial services providers that are already in a more mature stage of Grid assimilation gain substantial benefits from "gridification" at the business process level with regard to the effectiveness, efficiency, and flexibility of the digitized process. The identified strong influence of environmental dynamics especially demands for organizational sensemaking patterns in order to safeguard organizational outcome performance in these highly dynamic environments (McGill et al. 1993). However, if firms act as sensemaking units stimulated by environmental dynamics and constantly identify contextually appropriate strategic responses (Neill et al. 2007) IT-based value can be realized by the means of on-demand-based computing infrastructures.

5 Conclusion and Limitations

The theoretical contribution of the article is twofold: First, it contributes to the diffusion of innovations theory by validating the role of environmental dynamics impacting on IT assimilation in the context of the TOE framework. In detail, the results of our field study suggest that especially environmental dynamics, i.e. environmental turbulence and mimetic pressure, significantly drive financial services providers to progress in the process of Grid assimilation as one appropriate on-demand computing infrastructure. Second, especially the integration (i.e., Grid implementation management capability) of business- and technology-related determinants is identified as important driver of the Grid assimilation process in the financial services industry. For practitioners, the research indicates that there is a rational component (environmental turbulence and associated volatility in resource demand) as well as an industry consensus or hype that drives firms to assimilate on-demand-based computing infrastructures and will do so in the future with regard to Cloud computing. In essence, a "gridification" of the asset management process leads to increased business process outcomes with regard to its process effectiveness, efficiency, and flexibility. Our results indicate that especially scalable computing infrastructures, such as Grid infrastructures, are perceived as strategic response to a highly volatile market as prevailing in the financial services industry. Still, the depicted work is limited with regard to the specific country, technology, industry, business process, and the cross-sectional approach, thus restricting the generalizability of the supported hypotheses. Moreover, it would be interesting to take a closer look on organizational capabilities (e.g., organizational mindfulness) that mitigate the impact of environmental pressures towards Grid assimilation, potentially contributing to an increased generation of business value. This could be especially valuable in a highly turbulent and uncertain environment caused by the current financial crisis.

References

Ang, S. and Cummings, L. L. (1997). Strategic Response to Institutional Influences on Information Systems Outsourcing. Organization Science, 8(3), 235-256.

Ansoff, H. I. and Sullivan, P. A. (1993). Optimizing Profitability in Turbulent Environments: A Formula for Strategic Success. Long Range Planning, 26(5), 11-23.

Barua, A., Konana, P., Whinston, A. B. and Fang, Y. (2004). An Empirical Investigation Of Net-Enabled Business Value. MIS Quarterly, 28(4), 585-620.

Buyya, R. and Sulistio, A. (2008). Service and Utility Oriented Distributed Computing Systems: Challenges and Opportunities for Modeling and Simulation Communities. Proceedings of the 41th Annual Simulation Symposium, Ottawa, Canada.

Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. Lawrence Erlbaum Associates, Hillsdale, NJ.

Davamanirajan, P., Kauffman, R. J., Kriebel, C. H. and Mukhopadhyay, T. (2006). Systems Design, Process Performance, and Economic Outcomes in International Banking. Journal of Management Information Systems, 23(2), 65-90.

Davenport, T. (1993). Process Innovation: Reengineering Work Through IT. Harvard Business School Press, Boston.

DiMaggio, P. W. and Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. American Sociological Review, 48(2), 147-160.
Dong, S., Xu, S. X. and Zhu, K. X. (2009). Information Technology in Supply Chains: The Value of IT-enabled Resources under Competition. Information Systems Research, 20(1), 18-32.
Fichman, R. G. (2001). The Role of Aggregation in the Measurement of IT-related Organizational Innovation. MIS Quarterly, 25(4), 427-455.
Fichman, R. G. and Kemerer, C. (1999). The Illusory Diffusion of Innovation: An Examination of Assimilation Gaps. Information Systems Research, 10(3), 255-275.
Foster, I. (2002). What is the Grid? A Three Point Checklist. GRIDtoday, 1(6).
Foster, I. and Kesselman, C. (1999). The Grid: Blueprint for a New Computing Infrastructure. Morgan Kaufmann, San Francisco, USA.
Foster, I. and Tuecke, S. (2005). Describing the Elephant: The Different Faces of IT as Service. ACM Queue, 3(6), 26-34.
Foster, I., Zhao, Y., Raicu, I. and Lu, S. (2008). Cloud Computing and Grid Computing 360-Degree Compared. Proceedings of the IEEE Grid Computing Environments Workshop, Austin, USA.
Hackenbroch, W. and Henneberger, M. (2007). Grid Computing Infrastructures and their Value for Risk Management. Proceedings of the 40th Annual Hawaii International Conference on System Sciences (HICSS'07), Waikoloa, Hawaii.
Jap, S. D. (2001). Perspectives on Joint Competitive Advantages in Buyer - Supplier Relationships. International Journal of Research in Marketing, 18(1-2), 19-35.
Karimi, J., Somers, T. M. and Bhattacherjee, A. (2007a). The Impact of ERP Implementation on Business Process Outcomes: A Factor-Based Study. Journal of Management Information Systems, 24(1), 101-134.
Karimi, J., Somers, T. M. and Bhattacherjee, A. (2007b). The Role of Information Systems Resources in ERP Capability Building and Business Process Outcomes. Journal of Management Information Systems, 24(2), 221-260.
Kohli, R. and Grover, V. (2008). Business Value of IT: An Essay on Expanding Research Directions to Keep up the Times. Journal of the Association for Information Systems, 9(1), 23-39.
Kotsovinos, E. (2011). Virtualization: Blessing or Curse? Communications of the ACM, 54(1), 61-65.
Kuan, K. K. J. and Chau, P. Y. K. (2001). A Perception-based Model for EDI Adoption in Small Businesses using a Technology-Organization-Environment framework. Information & Management, 38(8), 507-521.
Liang, H., Nilesh, S., Hu, Q. and Xue, Y. (2007). Assimilation of Enterprise Systems: The Effect of Institutional Pressures and the Mediating Role of Top Management. MIS Quarterly, 31(1), 59-87.
Markus, M. L., Majchrzak, A. and Gasser, L. (2002). A Design Theory for Systems That Support Emergent Knowledge Processes. Management Information Systems Quarterly, 26(3), 179–212.
Mata, F. J., Fuerst, W. L. and Barney, J. B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-based Analysis. MIS Quarterly, 19(4), 487-505.
McGill, A. R., Johnson, M. D. and Bantel, K. A. (1993). Cognitive Complexity and Conformity: The Effects on Performance in a Turbulent Environment. Academy of Management Proceedings, 379-383.
Melville, N., Kraemer, K. and Gurbaxani, V. (2004). Information Technology and Organizational Performance: An Integrative Model of IT Business Value. MIS Quarterly, 28(2), 283-322.
Meyer, J. and Rowan, B. (1977). Institutional Organizations: Formal Structure as Myth and Ceremony. The American Journal of Sociology, 83(2), 340-363.
Neill, S., McKee, D. and Rose, G. M. (2007). Developing the Organization's Sensemaking Capability: Precursor to an Adaptive Marketing Response. Industrial Marketing Management, 2007(36), 731-744.
Pavlou, P. A. and El Sawy, O. A. (2006). From IT Leveraging Competence to Competitive Advantage in Turbulent Environments: The Case of New Product Development. Information Systems Research, 17(3), 198-227.
Podsakoff, P. M., MacKenzie, S. B., Jeong-Yeon, L. and Podsakoff, N. P. (2003). Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. Journal of Applied Psychology, 88(5), 879-903.
Quocirca (2006). Grid Computing Update - Cycle IV. http://www.quocirca.com/pages/analysis/reports/view/store250/item2991/?link_683=2991. (2011-04-28).
Rai, A., Brown, P. and Tang, X. (2009). Organizational Assimilation of Electronic Procurement Innovations. Journal of Management Information Systems, 26(1), 257-296.
Rings, T., Caryer, G., Gallop, J. R., Grabowski, J., Kovacikova, T., Schulz, S. and Stokes-Rees, I. (2009). Grid and Cloud Computing: Opportunities for Integration with the Next Generation Network. Journal of Grid Computing, 7(3), 375-393.
Rogers, E. M. (1995). Diffusion of Innovations. 4th Edition. The Free Press, New York, NY.
Rosenkopf, L. and Abrahamson, E. (1999). Modeling Reputational and Informational Influences in Threshold Models of Bandwagon Innovation Diffusion. Computational and Mathematical Organization Theory, 5(1), 361-384.

SEC (2008). Bank of America Corporation Form 10-K. http://www.sec.gov/archives/edgar/data/70858/000119312509041126/D10K.htm. (2011-04-28).
Strong, P. (2005). Enterprise Grid Computing. ACM Queue, 3(6), 50-59.
Sugumaran, V., Tanniru, M. and Storey, V. C. (2008). A Knowledge-based Framework for Extracting Components in Agile Systems Development. Information Technology and Management, 9(1), 37-53.
Swanson, E. B. (1994). Information Systems Innovation among Organizations. Management Science, 40(9), 1069-1092.
Tornatzky, L. G. and Fleischer, M. (1990). The Deployment of Technology: The Processes of Technological Innovation. Lexington Books, Massachusetts, Toronto.
Vaquero, L. M., Rodero-Merino, L., Caceres, J. and Lindner, M. (2009). A Break in the Clouds: Towards a Cloud Definition. ACM SIGCOMM Computer Communication Review, 39(1), 50-55.
Vykoukal, J., Wolf, M. and Beck, R. (2009). Services Grids in Industry – On-Demand Provisioning and Allocation of Grid-Based Business Services. Business & Information Systems Engineering, 1(2), 177-184.
Zhu, K., Dong, S., Xu, S. X. and Kraemer, K. L. (2006a). Innovation Diffusion in Global Contexts: Determinants of Post-adoption Digital Transformation of European Companies. European Journal of Information Systems, 15(6), 601-616.
Zhu, K., Kraemer, K. L. and Xu, S. (2006b). The Process of Innovation Assimilation by Firms in Different Countries: A Technology Diffusion Perspective on E-Business. Management Science, 52(10), 1557-1576.

Appendix

Country: United Kingdom	103 (100.0%)	*Number of employees:* 1,001 - 5,000 5,001 - 10,000 10,001 - 50,000 50,000+	8 (7.8%) 11 (10.7%) 19 (18.4%) 65 (63.1%)
Respondent's position: CTO COO CIO Chief Systems Architect Other Senior IT decision maker	1 (1.0%) 5 (4.9%) 5 (4.9%) 3 (2.9%) 89 (86.4%)	*Year of first Grid adoption:* < 2000 2000 - 2001 2002 - 2003 2004 - 2005 2006 - 2007 2008 - 2009	6 (5.8%) 12 (11.7%) 9 (8.7%) 15 (14.6%) 31 (30.0%) 30 (29.1%)

Table A1. Sample Descriptives

Construct	Abbreviation	Number of Items	Scale	Source
Grid Infrastructure Capability (reflective)	GIC	2	5-point Likert	Zhu et al.(2006a) Zhu et al. (2006b)
Grid Technology Integration (reflective)	GTI	2	5-point Likert	Zhu et al. (2006b) Two items were added based on expert interviews
Grid Technology Competence (reflective)	GTC	5	7-point Likert	Zhu et al. (2006a) Zhu et al. (2006b)
Grid Implementation Management Capability (reflective)	GIMC	6	7-point Likert	Dong et al. (2009) Pavlou et al. (2006)
Environmental Turbulence (reflective)	ET	6	7-point Likert	Jaworski and Kohli (1993) Dong et al. (2009)
Mimetic Pressure (reflective)	MIM	3	7-point Likert	Liang et al. (2007)
Grid Assimilation (ASS) (formative)	ASS	7	7-level Guttman	Fichman (2001) Rai et al. (2009)
Business Process Outcomes (second-order reflective)	BPO	3/3/4	7-point Likert	Karimi et al. (2007a)

Table A2. Measurement Items