INFORMATION AND COMMUNICATION TECHNOLOGY IN HIGH-TECH SMALL AND MEDIUM-SIZED ENTERPRISES. A MANAGEMENT PERSPECTIVE

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Abstract

The adoption and usage of Information and Communication Technology (ICT) is a strongly discussed issue. In particular the interorganizational adoption is recognized as an important issue. While big companies have most of their processes with partners integrated by now, there is still a lot of work to do within the small and medium-sized companies. One of the hypothesis in this context is that high-tech small and medium-sized enterprises (HT-SME) are leading in comparison to average SME concerning their intraorganizational and interorganizational adoption of ICT.

The goals of the study are a description of the state-of-the-art of the (interorganizational) adoption of ICT in high-tech SME. A further goal is the dicsussion of elements of a management framework which allows handling ICT in HT-SME in a more efficient and effective way.

The methodology used for analyzing the interorganizational adoption of ICT in the high-tech small and medium-sized enterprises as well as for developing the above stated framework is case study based.

Interesting intermediate data became visible. It seems that even the small and medium-sized high-tech companies do not use highly sophisticated information and communication technology for interorganizational cooperations. Further interesting results are that hardly any of the companies interviewed develop their employees for using ICT in intra- and interorganizational settings. Another interesting result is that HT-SME hardly evaluate the spending in intra- and interorganizational ICT.

Outline

1.   Introduction/Problem

Electronic Business is nowadays in the business life as well as in the private life nearly om-
nipresent. Looking at the speed of diffusion of internet technology you will realize that no
other medium, maybe even no other technology, was distributed in such a fast manner. Elect-
ronic Business does not only have in practice but also in scientific discussion a high signifi-
cance. Yet the „hype" and the euphoria of the years 1999 and 2000 proceeded to a much mo-
re rational kind of observation.

In the past five to seven years a lot has been written about Electronic Business. The novelty
and especialness of this study is to look at the context of Information and Communication
Technology (ICT) in High-Tech Small and Medium-Sized Enterprises (HT-SME). And there,
more specific, towards the intra- and interorganizational adoption and usage of ICT from di-
verse perspectives which are business administration, information management/information
systems as well as media sciences.

While big companies recognized most chances of the adoption of internet technology, small
and medium-sized enterprises have been long very sceptical towards this adoption (Vincenti
2002). At many places they speak about a very hesitant adoption of internet technology in
SMEs (Wirtz 2000, 27; Hughes/Golden/Powell 2003; Cruickshank/McLeod 2004, 546-548;
Kayser 2005). SME primarily use email applications and simple webpages but with the adop-
tion of complex online applications they are slow. The barrier of „complexity" by the adopti-
on and usage of innovations in general was first identified by Rogers (1995) and confirmed in
the context of SME and E-Business (Kendall et al. 2001).

Broadly it gets argued that through the strategic adoption of internet technology/information
technology organizations (small and big ones) reach their goals more easily, become more
competitive and sustainable management can be assured (Ndubisi 2003, 23). Information as
well as information processing and communication technologies become also more and more
important by developing new business fields (Pietsch 2003, 5). Moreover, Weiber points out
that the adoption of ICT and the usage of electronic applications offer new market opportuni-
ties and thus new potentials to increase revenues (2000, 10). Above all, ICT offers the possi-
bility to generate higher process efficiency and higher output with less employees (Wirtz
2001, 10).

While big companies have most of their processes with partners integrated by now, there is
still a lot to do within the SME. This is important if you consider how many SME there are in
Europe. In average there are 99,8% of all companies SME and 65,7% of all employees work
in SME. One of the hypothesis in this context is that HT-SME are leading in comparison to
„average SME" concerning their intraorganizational and interorganizational adoption of ICT.
Due to their high rate of inventions and innovations, small and medium-sized enterprises in
the high-tech area are an engine for growth of economies and therefore worthwhile to consi-
der.

General conditions HT-SME need to cope with are the following. Nowadays the environment
in which SME and in particular HT-SME need to assert themself is more competitive, faster
and more cost oriented then ever. There is a high number of external influences HT-SME
need to cope with. These influences are the increasing globalization, the boosting deregulati-
on, the enhanced cost pressure, the raised expectations of the customers as well as the reduc-
tion of the product life cycles. But also the continuously increasing digitalization and the

convergence of media are circumstances which lead to a more and more complex management of high-tech SME.

In this context it is questionable whether HT-SME are able to be competitive without the interorganizational adoption of ICT. Is it the pure adoption that brings competitive advantages or are there further circumstances which have to be taken into account like for example the efficient and effective adoption of them. In other words, is it just the use of technology or does it depend on how one uses them? Therefore one needs to take into account considerations from the strategic management and other functions from business administration. Furthermore there might be a possibility that the „average SME" learn from the HT-SME and their experiences of intra- and interorganizational ICT adoption.

2.   Goals and Motivation

One goal of the study is a description of the state-of-the-art of the (interorganizational) adoption of ICT in high-tech SME. Who uses intra- and interorganizational ICT, who doesn't? If they use or don't use ICT interorganizationally and why do they behave in a certain way? Are there any differences between enterprises in the US and in Germany? How will the intra- and interorganizational usage of ICT develop in the future? A further goal is to discuss elements of a management framework which allows handling ICT in HT-SME in a more efficient and effective way.

The motivation for this study is based on several reasons: First, there exist several confirmations that adequate research in the context of ICT and high-tech industries hardly exist (e.g. Trettin 2005; Wareham/Zheng/Straub 2005). One of the very few articles is: ‚The Strategic Impact of Internet Technology in Biotechnology and Pharmaceutical Firms' (Salazar/Hackney/Howells 2003). Second, the State Ministry of Economic Affairs and Employment in Germany in cooperation with the European Institute of International Cooperations (EIIW) and the „Fraunhoferinstitut" support in their study „Internetwirtschaft 2010" the estimation that there exists a lack of internet oriented research concerning SME's (Welfens 2005). Exactly   the   same   was   also   identified   on   some   other   place   (Dixon/Thompson/McAllister 2002). Third, management of interorganizational processes remain on top of the research agenda (see for example meta-analysis from Wareham/Zheng/Straub 2005). McAfee also suggests that the construction of electronic partnerships becomes one of the most important IT-based competitive battlegrounds in the coming years (2005). Furthermore there is evidence that until now the usage of ICT by formulating electronic based cooperations is hardly analysed (Rothgang/Trettin 2005). Fourth, as already stated in the introduction, due to the inventions and innovations, the high-tech industry is an engine for growth of economies. There is a tendency visible that the huge overall impact of high-tech will increase in the next years. Fifth, there hardly exists any study in this context concerning comparisons between different areas or countries.

3.   Classification in the Context of Scientific Research

Influenced by the interdisciplinary character of the present topic there are several scientific disciplines which have to be taken into account. From a business administration point of view strategic management, innovation and technology management, human resources, organization and controlling are areas of central importance. From a more technical point of view com-

puter sciences, information systems and information management have to be considered. Moreover media sciences are also very important for explaining these patterns, which is often neglected in the traditional literature about Electronic Business.

At the end of the nineties first interdisciplinary studies were conducted in the area of information management and organization research (Picot/Reichwald/Wigand 2003; Reichwald et al. 2000). Nevertheless there is still a lot to do on the interface between business administration and computer sciences, information systems and information management respectively. Partially the latter ignore findings made in the area of business administration and models business software, which gets obtruded to companies without any adaptation. Hence an integrated model with all the relevant aspects of this context is necessary.

4.   Methodology

The methodology used for analyzing the intra- and interorganizational adoption of ICT in the high-tech small and medium-sized enterprises as well as for developing the above stated framework is case study based (see Eisenhardt 1989; Gassmann 1999; Meyer 2003; Yin 2003). In 2005 and 2006 several interviews with CEO's, CIO's and people from business development in high-tech companies in Germany and in the US were conducted. The interviews were semi-structured and partially done by phone, partially done personally and took about one hour in average. The focus thereby is on the following four industries. The biotechnology, nanotechnology, software industry as well as the medical device sector. In Germany companies which are a member of www.nano-map.de were contacted. This is an initative from the Federal Ministry of Ecucation and Research. In the US, or rather in Boston and the region around, companies were contacted over several councils and directories [Massachusetts High Technology Council (MHTC), Massachusetts Software Council, Massachusetts Biotech Industry Directory, Massachusetts Medical Device Industry Council (MassMEDIC)]. Until now half of the planned interviews are completed. Meaning there are still more to come to stabilize the first results.

Although Eisenhardt develops her framework for generating theories it will be used in this context rather to test and check existing hypotheses and theories (Eisenhardt 1989; for Eisenhardts framework see Chart 1). The advantages with inductive case study research are the ones given below. Case study research is very useful by looking at highly complex and less structured objects. Moreover different data collection methods for gathering and understanding the interrelationships can be integrated, it gives answers to „how"- and „why"-questions, the explorative gathering of findings gets supported and influencing factors can be considered.

A further reason supporting qualitative research is the following. Lee recognizes scientific research as a social constructed reality and therefore scientific knowledge as human creation like every other form of knowledge as well (2001, 240). Consequently social systems, organizations, customers and social practices are a social constructed reality. Here the connection to the qualitative methods becomes clear: the generation of information is a social process and qualitative methods are more appropriate than quantitative methods to approach social processes and their complexity (Trauth 2001, 275). Besides there are also some disadvantages of case study research like the problem that statistical representativeness can't be obtained or the existence of implicit hypotheses due to the influence of previous knowledge or insularity. After the presentation and analysis of the individual case studies it is necessary to conduct a

cross-case analysis. This is important to find similarities and differences of the cases on the basis of several dimensions. With this procedure the probability increases to find all the results which are in the data.

Step	Activity	Reason
1. Getting Started	Definition of research question Possibly a priori constructs Neither theory nor hypotheses	Focuses efforts Provides better grounding of construct measures Retains theoretical flexibility
2. Selecting Cases	Specified population Theoretical, not random, sampling	Constrains extraneous variation and sharpens external validity Focuses efforts on theoretically useful cases - i.e. those that replicate or extend theory by filling conceptual categories
3. Crafting Instruments and Protocols	Multiple data collection methods Multiple investigators	Strengthens grounding of theory by triangulation of evidence Synergistic view of evidence Fosters divergent perspectives and strengthens grounding
4. Entering the Field	Overlap data collection and analysis, including field notes Flexible and opportunistic data collection methods	Speeds analyses and reveals helpful adjustments to data collection Allows investigators to take advantage of emergent themes and unique case features
5. Analysing Data	Within-case analysis Cross-case pattern search using divergent techniques	Gains familiarity with data and preliminary theory generation Forces investigators to look beyond initial impressions and see evidence thru multiple lenses
6. Shaping Hypotheses	Iterative tabulation of evidence for each construct Replication, not sampling, logic across cases Search evidence for „why" behind relationships	Sharpens construct definition validity and measurability Confirms, extends, and sharpens theory Builds internal validity
7. Enfolding Literature	Comparison with conflicting literature Comparison with similar literature	Builds internal validity, raises theoretical level and sharpens construct definitions Sharpens generalizability, improves construct definition, and raises theoretical level
8. Reaching Closure	Theoretical saturation when possible	Ends process when marginal improvement becomes small

Chart 1: Process of case study research (Eisenhardt 1989, 533)

5.   ICT and High-Tech

In the area of ICT there exist quite a few different terms and definitions depending on the research discipline as well as on the time of publication. Here ICT is considered as media ranging from telephone to Internet as well as the systems behind it. For the support of information- and communicationsystems technical devices like telephone, fax or computer as well as non-technical devices like paper or files can be used (Gabriel et al. 2002, 104). Although the main focus here lies on devices and possiblities based on the internet technology. The technological possibilities/means of interorganizational cooperations also increase steadily. But due to the diffusion in nearly all areas of companies the complexity increases as well. While EDI – a form of interoganizational system – has been around for about 30 years, it has failed to gain acceptance in general and in particular among SME. The Internet – a newer form of IOS – has been in just two years adopted faster than EDI in the previous 20 years (Hughes/Golden/Powell 2003, 277). A lot is based on EDI but important developments in this area are Web Services, Groupwaresystems and Computer Mediated Communication (CMC).

To define small and medium-sized enterprises (SME) you will find about 200 different definitions. They are mostly divided in a quantitative (e.g. employees, turnover) and a qualitative (e.g. unity of property and responsibility or limited access to capital) section. The problem with the definition of SME is, that a lot of economic, social and even psychological characteristics have to be taken into account. In 2003 the European Commission (EC) developed a new definition and uses it since January 2005 (European Commission 2003). The EC considers number of employees and financial thresholds like turnover and total assests. Moreover

there exist different possibilities to distinguish high-tech small and medium-sized enterprises. On the one hand they have to fulfill the above stated criteria on the other hand the below stated aspects in regard to high-tech. Partly this is based on Jassawalla/Sashittal (1998):

First one can analyze to what extent technology and what kind of it will be needed in the production process. Second there is the possibility to look at the product. Concerning the product you would look towards the features and the technology integrated in the product. One can also look at the high rates of product obsolescence as an indicator for a high-tech company. Third one can look at the industries. Most people would consider microelectronics, computer industry, biotechnology, nanotechnology, rocket industry and others of the technology fusion fields (concerning the technology fusion fields see Sannemann 2000, 148; v. Waldkirch & Koruna 1998) as high-tech. The fourth indicator of high-tech industries might be their R&D-expenditures. The German Ministry for Education and Research for example suggests that a company would be high-tech if it spent 3,5-8,5% of turnover in R&D. And they would call a company spending more than 8,5% on turnover into R&D „Spitzentechnologie". This is something like „advanced technology" or „leading edge technology". The problem with these figures, primarily in the context of small and medium-sized enterprises is, that many of these small and medium-sized companies just were founded. Therefore they won't generate any turnover. And a life-cycle bias is imaginable as well. Because it is possible that the companies spend early at the life-cycle more into R&D than later. So these figures are only partially senseful due to this and due to the fact that expenses and profits get mixed up. Which leads us directly to another, the fifth possibility to define high-tech small and medium-sized companies. One could use the R&D-expenditures in relation to the total cost. If these expenditures are at least 10% then one could say they are high-tech companies (Klocke 2004, 7). The sixth possibility might be how many people in relation to the overall employment do they have in the R&D area or R&D department (see chart 2).
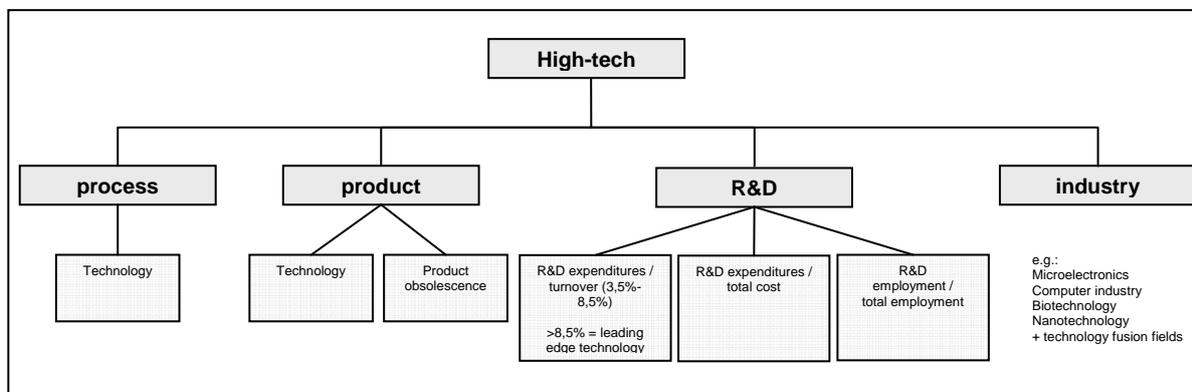

Chart 2: Possibilities to define high-tech enterprises

6.   Strategic Aspects and Management Aspects of the Study

The presumption of the strategic management, irrespective of the approach (resource-based/market-based), is that companies acting strategic are more successful than companies who don't. Strategic management is therefore occupied with the planning and implementation of corporate strategies (Welge/Al-Laham 2003, 3). Small and medium-sized companies get quite often organized and managed centrally. Problematic in this context is that business managers or owners hardly do have any time to think about strategic issues due to a high burden of operational tasks (Haake 2002, 234; Vincenti 2002, 34). For this reason these kind of considerations will be undertaken for E-Business and the interorganizational adoption of ICT, which is becoming more and more important in the overall strategic context. Due to specific

conditions and a specific environment this is not always possible thus there one will find at least in an abstract way some typologies and guidelines for decision making.

The benefits of ICT for gaining competitive advantages you will find in general in two different aspects (Weiber 2000, 16). First, the adoption of ICT leads to a direct improvement of the corporate value-added process. Second, nowadays information is the steering force in competition. Already in 1952 Hayek pointed out that competition has to be interpreted as a process of information processing. Later it has been also observed, that the foundation for competitive advantages lies in information advantages (Kirzner 1978). Out of this the meaning of a strategic, that means methodic, procedure for Electronic Business can be derived. The accelerated processing of intra- and interorganizational processes and information can potentially lead to competitive advantages.

Why will the strategic aspect of Electronic Business in high-tech small and medium-sized enterprises be discussed in this study? There are several reasons for doing so. The two most important are the following. First, in general a strategy represents a corridor of activities which under normal circumstances a company tries to follow. This is also true in the field of ICT and can be adopted to it. Second, Gartner Group (1999) found out that the following reasons are the main causes for the failure of E-Business projects. On the one hand companies try to convert premature business models into reality. On the other hand there exist immense problems by implementing and realising planned e-business projects. Moreover, mistakes in the strategy are a further cause of failure. A high level of attention will be dedicated in the study to this last point.

Due to the increased cooperation and collaboration of companies, issues like network management and Supply Chain Management became and are still becoming more and more important. A characteristic for networks is the high complexity which results out of a large number of connected entities. Even the customers (in this study primarily on a b-to-b level) are becoming in the development phase more and more integrated (virtual customer integration). Advantages due to ICT lie in the high interactivity over distance and time. Moreover nowadays it is possible to visualize physical product- and service components close to reality (Dahan/Hauser 2002, 333; Gassman/von Zedtwitz 2003, 244).

All of this leads to an increased necessity of an effective and efficient management of interorganizational ICT. In this context theories like for example game theory, transaction cost theory, resource-oriented approach or interaction oriented network theory play an important role. It is also important to mention that cooperations of companies can happen on different levels which affects directly the adoption of ICT. One can distinguish the level of the company, of single departments and of course of individuals. The direction of the cooperation can be horizontal, vertical (that would equal the Supply Chain Management) and diagonal. But there are many more possibilities to characterize cooperations and in particular networks.

Like stated above it is possible due to ICT to gain competitive advantages. Nowadays the problem in doing so is that ICT is to a high extent commoditized. That means that literally every company can buy itself all kind of ICT. Meaning if a company is generating competitive advantages due to the adoption of ICT this advantage normally won't last long. Exactly that long until another enterprise copies the adoption of ICT in that specific way. According to several scientists (Clemons/Row 1987; Mata/Fuerst/Barney 1995; Dehning/Stratopoulus 2003) ICT itself offers no possibilities to gain sustained competitve advantages. Due to the fact that the technology is not heterogeneously distributed across competing enterprises or not

imperfectly mobile, ICT may only lead to competitive parity or temporary competitive advantages. Moreover they argue that the sustained competitive advantages are lying rather in the management of ICT. This is the reason why in this study the management of ICT will be analysed in detail. For the coherences of the above stated aspects see chart 3.
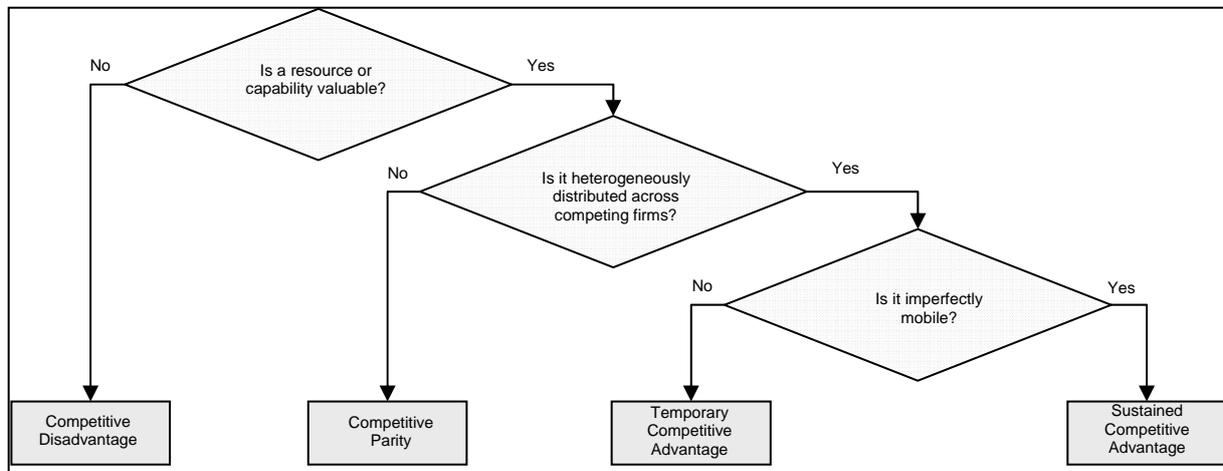

Chart 3: Resource-based model of competitive advantages (Mata/Fuerst/Barney 1995)

A further reason for analyzing the management of ICT is the result of a meta-study of 72 studies concerning the interrelationship of ICT and economic success (Pfeifer 2003). In 81 % of the studies there is a positive relationship between ICT and economic success. In the studies without the positive relationship, critical factors are organizational change and HR change (Pfeifer 2003). Also others identified the importance of the organizational and HR perspective (Fischer 2002; Dedrick/Gurbaxani/Kraemer 2003; McAfee 2005). The organizational and HR perspective are two out of five variables of the above stated management framework. The third variable is the strategic aspect of ICT. For successful adoption of ICT there has to be a strategic direction as well as management support (Dixon/Thompson/McAllister 2002; Ross/Weill 2004). The fourth variable is the assessment of ICT spending and adoption. IT-Investment appraisal is an important part in the decision-making process (Irani/Love 2002). Last but not least the environment has to be taken into account and needs to be analyzed.

7.   Intermediate Data and First Results

Through the case studies intermediate data and first results, interesting for practitioners and scientists, became visible. In the following some of the results of a first cross-case analysis will be listed in an eclectic manner:

At first there will be a short overview of ICT related matters of HT-SME. Many of the enterprises interviewed do have an IT-department. But the department only consists of 1 person and sometimes this person has to accomplish other tasks (non-IT related tasks) as well. From the resource-side it is difficult to select, implement and most important run a highly complex intra- and interorganizational ICT solution. No question there is also the possiblity of outsourcing. But this is a question of financial resources and in the context of these high-tech companies even more important of privacy and of business secrets. Often the „one-person-IT-department" is totally overloaded and tasks of the IT department get outsourced. Due to the above stated reasons this are mostly easy and not very strategic tasks like for example the design and maintenance of websites.

In the companies itself employees are mostly connected via an intranet. Furthermore many of HT-SME do have a virtual private network (VPN). In a truly private network the company owns all the wires and nobody else can use them. In the VPN also public networks get used. With the VPN employees are able to access the companies information from external sites.

Cooperations happen in the context of HT-SME primarily on the research and development side as well as on the marketing side. Here small and medium-sized companies try for example to do research with large enterprises or want to use their established distribution channels. In general one can use several theoretical explanations to argue why organizations act together. There you will find justifications from exchange theory, contingency theory and organizational ecology as well as transaction cost theory (Alexander 1995, 7-14).

Concerning the first goal, meaning the adoption of interorganizational ICT, it seems that small and medium-sized high-tech companies use unsophisticated applications for supporting interorganizational cooperations. Sophisticated information and communication technology they hardly use for interorganizational cooperations. For many companies, which were interviewed in this study until today, the most complex tools they use are applications for web conferencing, video conferencing and online meeting services (e.g. „WebEx", „GoToMeeting"). The utilization of these tools offers a lot of possibilities in the context of interorganizational settings. Features like slide presentations, application sharing, web co-browsing, text messaging and files sharing can improve and optimize interorganizational cooperations. However these applications are far from a real integrated interorganizational system.

The five most important barriers with the intercompany employment of ICT, here in particular of web services, are insufficient standardization, complex integration in IT infrastructure, small spreading at customers, complex integration in existing processes and other security problems (Prokein/Faupel 2006, 5-6). In the context of high-tech small and medium-sized enterprises there were statements like from a business (business model) point of view it is not necessary to be connected. It is only necessary to integrate with other companies when it is suitable. This is an important aspect before discussing about the adoption of interorganizational ICT. Is it really necessary to use any sophisticated, complex and modern technology? Or is it totally sufficient to handle the intercompany cooperation with telephone and email? A very important and big issue is in this context the topic of security and privacy. Companies experienced for example problems with intercompany systems due to too restrictive firewalls. Furthermore if you take into account the data handeld by pharmaceutical companies it is understandable how important the security aspect in these companies is. But also reasons like complex integration, inadequate quality of the interorganizational systems as well as the argument that costs exceed utility.

Further interesting results concerning the second goal, the management framework, are the following. Here a diverse picture became obvious. Some of the interviewee mentioned that a management framework for managing intra- and interorganizational adoption of ICT would be helpful. In contrast others argued it is not necessary at all. And some said they think it would be very helpful in companies with more than 100 employees and for people not very experienced with these issues. Also interviewees mentioned that in the area of security it would make sense to have certain policies.

In the following some management issues will be presented. Questionable is if these results would be similar with having the above stated management framework. Very interesting is

that hardly any of the companies interviewed do develop their employees for using ICT in-house and in interorganizational settings. A lot of potential might be unexploited due to the lack of education in ICT related fields. Most HT-SME in the study argue that their employees don't need any special training concerning ICT because they have adequate knowledge about ICT. Only employees in one of the interviewed hight-tech small and medium-sized enterprises receive educational training in the context of ICT via telephone as well as online.

Interesting as well are the actions companies take or don't take to narrow down the misuse of ICT. Here all interviewees emphasise the importance of trust between the management and the employees. Trust as a prerequisite between parties in interorganizational virtual collaborations has been already identified (Hossain/Wigand 2004). It seems that in the context of ICT the intraorganizational trust plays also a key role. But here differences become explicit. While some companies emphasise the self-policing aspect others restrict the access to websites which are not relevant for working purposes. In some of the interviewed HT-SME employees are allowed to download for example music; in others employees were fired due to that kind of behavior.

A further first result in regard to the management framework is that companies do hardly evaluate or assess the spending of intra- and interorganizational ICT. Except one company all HT-SME in the study categorical excluded doing an assessment of ICT-Investments although this provides management with a lot of relevant information. ICT-Investment appraisal helps companies in the decision-making process and companies are able to gain higher profits. The only company in the study assessing ICT-Investments is doing so by trying to calculate the ROI of these investments. The reason for not doing an assessment is in the opinion of the interviewees in most companies a lack of human resources as well as a low level of ICT spendings. Asked about the next steps concerning ICT many HT-SME plan further developments. This ranges from further employments to the implementation of an ERP-system.

8.   Conclusion

Due to space restrictions a lot of problems couldn't be discussed in this paper but are part of the present study. For example the integration of ICT in the interorganizational business processes of HT-SME, the appliance of media-richness-theory in the context of complex products and services and the differences between German and US HT-SME in the interorganizational adoption of ICT.

In this stage of the study a lot of fundamentals have been discussed like ICT and high-tech in general. Furthermore it has been pointed out that the efficient and effective management of ICT leads to sustained competitive advantages. Also it became obvious that HT-SME exploit only in certain circumstances sophisticated ICT. A management framework for managing ICT should consider elements like strategy, organization, HR, controlling as well as the environment.

Some first insights and empirical evidence has been put forward to highlight the adoption of ICT from a management perspective. But we need further evidence and analysis of the adoption and usage of intra- and interorganizational ICT in high-tech small and medium-sized enterprises.

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