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Beyond the Electronic Commerce Diffusion Race: Efficiency Prevails

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Abstract

The diffusion race of e-commerce applications and solutions in the German industry seems to be concluded. This applies more or less for large firms, but especially for SMEs in the analyzed industry sectors. Independent of firm size, more than one third of all firms responded that the implementation of e-commerce contributed substantially to improve existing operational processes and to expand markets. E-commerce readiness, and due to its relative efficient usage, is observable not only in large firms. The “digital divide” or “digital gap” between large firms and SMEs has disappeared. Increasingly, SMEs may often benefit more from e-commerce applications than large firms. Although e-commerce technologies may be available theoretically in all industries and firms, efficient usage depends directly on the consistent implementation of more sophisticated solutions, such as on-line procurement

or Internet-based supply chain management. Firms with defined strategic IT-related goals are more often efficient than firms without such goals.

Keywords

Electronic commerce, DEA, SME, diffusion, efficiency

1. Introduction

During the last few years a rapid rate of diffusion and usage of e-commerce solutions was observable not only in the so-called “new economy” sector but also inside traditional industries. In spite of the so-called bubble burst the e-commerce-driven changes and improvements led to efficiency increases in large firms, as well as SMEs.

This paper analyzes the rate of e-commerce diffusion in three German industry sectors. It compares the intensity of usage between large firms and SMEs and identifies efficient e-commerce users by using a Data Envelopment Analysis (DEA) (Charnes et al. 1978). Moreover, the paper analyzes the relation between e-commerce-based strategic goals in contrast to unfocused and non-strategic usage of e-commerce vis-à-vis the derived benefits from either approach.

The impacts of e-commerce diffusion are not only observable within large firms but also among strong and innovation-friendly German SMEs (Mittelstand), which are of high importance for the information and communication technology (ICT) diffusion in Germany. In fact, using ICT and e-commerce enables especially SMEs to profit from the broad potential benefits.

Proposition 1: SMEs are important drivers of e-commerce implementation and usage. The innovation friendly character of SMEs as early adopters of new technologies together with the potential benefits offered by a variety of different solutions will help to close the digital divide between large firms and SMEs.

As an export-oriented nation Germany has to compete in nearly all economic sectors on an international level. Due to this, the need for cost-oriented and efficient production and distribution processes has a long tradition. Nevertheless, some industry sectors have done better and are today relatively famous for their long tradition in computer-based electronic data processing and transmission than other sectors. Inside the manufacturing sector the automotive industry, for instance, developed successful EDI standards and delivery processes resulting in considerable savings of time and money. Data medium exchange, EDI standards such as SWIFT and the payment clearing in computer centers are inventions made in the seventies of the last century in the banking industry. In comparison to these two latter sectors with their high market concentration and mature experiences in electronic-based business processing, the retail and wholesale sectors are much more fragmented and best-practice cases such as in the latter sectors are little known. EDI diffusion in these two sectors, for instance, is not as far developed as in the other two sectors surveyed in this paper.

Proposition 2: The affiliation to a special industry sector has direct impact on the extent of diffusion of e-commerce-related technologies and standards. Industries with a long tradition in mainframe and EDI have better prerequisites to start successful e-commerce solutions.

Gaining the full potential and benefits from e-commerce technologies depends aside from the size and industry affiliation of a firm even more on the consistent integration and

implementation in business processes while these processes must be adjusted at the same time. The efficient and consistent usage is therefore more important than the sheer existence of such technologies.

Proposition 3: A strategic and consistent realization of e-commerce is necessary to develop the full benefit. An efficient implementation improves the strategic position of a firm and increases both, the measurable outputs and the satisfaction with new information technologies.

In order to analyze the stated propositions the authors provide a brief overview of theoretical approaches in the field of innovation theory (section 2.1) and describe the methods used to identify the rate of e-commerce diffusion in section 2.2. Chapter 3 provides information about the underlying survey and the used empirical data to test the validity of formulated propositions, followed by the results of the chosen two different methods to analyze the rate of diffusion and the percentage of efficient users. Chapter 4 concludes the paper.

2. Theoretical Background

2.1 Diffusion of Innovations

The term diffusion is generally defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers 1995, p. 5). The traditional economic analysis of diffusion focuses on describing and forecasting the adoption of products in markets. In particular, the question which factors influence the speed and specific course of diffusion processes is of focal concern (Weiber 1993). Traditional diffusion models are based on similar assumptions. Generally, the number of new adopters in a certain period of time is modeled as the proportion of the group of market participants that have not yet adopted the innovation. Based on this fundamental structure, three different types of diffusion models are most common ((Lilien & Kotler 1983, pp. 706-740) or (Mahajan et al. 1985, pp. 12-26)). The exponential diffusion model (also external influence model or pure innovative model) assumes that the number of new adopters is determined by influences from outside the system, e.g., mass communication.

The logistic diffusion model (also internal influence model or pure imitative model) assumes that the decision to become a new adopter is determined solely by the positive influence of existing adopters (e.g., word of mouth). The semi-logistic diffusion model (also mixed influence model) considers both internal and external influences.

In general, network diffusion models can be divided into relational models and structural models. Relational models analyze how direct contacts between participants in networks influence the decision to adopt or not to adopt an innovation. In contrast, structural models focus on the pattern of all relationships and show how the structural characteristics of a social system determine the diffusion process (Valente 1995, pp. 31-61).

Besides the analytical economic research approaches described above, a set of empirical studies of diffusion processes can be found in various research areas (for an early overview of existing empirical studies refer to (Rogers & Shoemaker 1971, pp. 44-96)). Most of the studies are based on the critical mass approaches which analyze the diffusion rate of innovations, collective behavior, and public opinion (e.g., (Granovetter 1978) or (Marwell et al. 1988)). A long research tradition exists in the area of network models of diffusion of innovations. Subsequently, network analysis in this context is an instrument for analyzing the

pattern of interpersonal communication in a social network (for concepts of sociological network analysis, e.g., (Jansen 1999) or (Wigand 1988 and Wigand & Frankwick 1989)).

This research investigates e-commerce diffusion based on an empirical survey and identifies important drivers of e-commerce diffusion.

2.2 Empirical Survey and used Methods

The underlying questionnaire was designed in co-operation with CRITO, UCI. The survey itself was conducted by IDC during the period February 18, 2002 – April 5, 2002. The survey was conducted in ten countries with altogether 2,100 firms (Brazil, Denmark, China, Germany, France, Japan, Mexico, Singapore, Taiwan, and United States). An establishment is defined as the physical location of a firm. The sampling was a classified random sample. Classified by size (large firms: 250 or more employees, and small firms: between 25 and 249 employees) and by industry (manufacturing, wholesale/retail distribution and banking/insurance). In Germany, 202 firms were investigated, subdivided in 68 from the manufacturing industry, 66 from the wholesale/retail industry and 68 from the banking and insurance industry. 102 interviewed firms belong to the class of small and medium-sized enterprises, 100 to the class of large firms. The survey took only firms into account which used the Internet to buy, sell or support products or services.

In general, two different methods are used to analyze the data at hand. To analyze the relative efficiency of e-commerce users (both SMEs and large firms), a data envelopment analysis (DEA) is used. DEA (Charnes et al. 1978) can be used to compare multi-input with multi-output to analyze the efficient combinations and implementations. The object of interest in a DEA model is the decision making unit (DMU). A DMU is a flexible unit responsible for the in- and output variables. DEA compares each DMU with only the “best” DMUs of the sample. Efficient combinations of input and output relations or efficient DMUs of a sample build the so called “efficient frontier line”. In a three-dimensional room the efficient frontier is equivalent to an imaginary cover on the top of the sample, including the efficient DMUs and all theoretically possible combinations of efficient, virtual DMUs. The DEA model calculates for each DMU based on its set of inputs (in this case the number of used e-commerce technologies (a binary vector of questions Q24A to Q24G (cf., table 1) “Uses of Internet”)) and set of outputs (in this case the gained benefits of e-commerce usage – the “great deal” - by using vectors of questions Q31A to Q31J (cf., table 2) “Impacts of doing business on-line” for each DMU) the relative position. By using a linear programming procedure for the frontier analysis of inputs and outputs, DEA evaluated the “best-practice” users of e-commerce. The basic idea of DEA is the multi-input and multi-output-oriented efficiency evaluation without any further assumptions about the structure (e.g., normal distribution) or side conditions. In contrast to parametric methods DEA can use all kinds of input and output data to analyze the production behavior. The used DEA model was non input or output-oriented because neither an input minimizing (input-oriented) nor an output-maximizing (output-oriented) analysis was necessary to evaluate the current relation identified in the survey. The model assumes furthermore variable returns of scale for each DMU depending on the size and a convex function of decreasing returns. The used software for the data analysis together with a detailed description is available with (Scheel 2000).

The second method is oriented on the strategic goals of e-commerce using firms, as defined in (Kraemer et al. 1999). According to the four-quadrant-model developed by Kraemer firms are asked about the impacts and usage of e-commerce in two different ways: The impacts on internal process optimization (Q28D operational focus) and external market penetration

(Q28F market focus). In the original model Kraemer used a seven-point Likert scale where “1” indicates “do not agree” and “7” indicates “agree completely” to measure the impact degree of IT on the focused strategic goal. The used model in this paper is modified and uses a five-point Likert scale. For example, if executives rated two or less on each item, they were assigned to the “unfocused” group since their responses suggested they had no discernible goal for information technology (IT). If executives rated three or above on the operational focus and two or less on the strategic market positioning, they were assigned to the “operations-focus” group. Alternatively, if executives rated two or less on the first item and three or above on the second item, they were assigned to the “market-focus” group. Finally, if executives rated three or above on both items, they were assigned to the “dual-focus” group. Based on executives’ responses to these items, firms were assigned to one of four quadrants (cf., figures 4 to 6).

3. Measuring e-commerce efficiency

The impacts of e-commerce applications on efficiency inside SMEs or large firms in Germany can be calculated by using a Data Envelopment Analysis (DEA). The e-commerce output and therefore the impacts of e-commerce on business processes depend on the intensity and variety of implemented applications. As input variables for the DEA model the results of seven questions are used (cf., table 1), measuring the number of e-commerce technologies in place as a binary variable. The variables are coded as 0 when an establishment uses the asked for e-commerce technology and 1 if it does not use it. The coding is equivalent to more costs of input when e-commerce is not available or the other way round, i.e. firms using e-commerce gain benefits by reducing their processing costs.

	Manufacturing		Wholesale/Retail Distribution		Banking & Insurance		Total	
	GER	Global	GER	Global	GER	Global	GER	Global
Advertising and marketing purposes	75.4%	55.8%	79.3%	57.1%	77.8%	68.3%	78.4%	57.6%
Making sales on-line	29.0%	25.1%	68.1%	31.9%	37.8%	33.0%	57.8%	29.9%
After sales customer service and support	46.1%	48.4%	55.5%	40.7%	58.1%	48.3%	53.8%	43.7%
Making purchases on-line	51.3%	43.4%	65.1%	47.8%	45.3%	52.2%	60.7%	46.8%
Exchanging operational data with suppliers	49.5%	49.9%	65.1%	48.0%	42.8%	41.9%	60.2%	48.1%
Exchanging operational data with customers	57.9%	53.4%	50.4%	49.0%	56.4%	52.5%	52.4%	50.7%
Formally integrating the same business processes with suppliers/partners	23.6%	26.8%	55.5%	37.5%	37.2%	33.5%	47.7%	33.9%

Table 1. Uses of Internet

The ten output variables of the model are measured by a five-point scale (cf., table 2) with 1 (no impact at all) to 5 (a great deal). The DEA model uses a linear program to analyze for each establishment the ratio between low costs of input (using e-commerce) and the resulting satisfaction output. As a result DEA identifies the best practice cases or the most efficient firms of the sample. Firms on this so-called “efficient frontier line” are relatively more efficient users than other firms below the frontier line.

	Manufacturing	Wholesale/Retail Distribution	Banking & Insurance	Total
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	GER	Global	GER	Global	GER	Global	GER	Global
Internal processes more efficient	41.2%	37.5%	44.2%	32.2%	22.8%	33.8%	41.8%	33.9%
Staff productivity increased	11.4%	25.9%	20.0%	27.6%	23.6%	29.6%	18.6%	27.2%
Sales increased	12.1%	18.8%	20.8%	21.5%	21.4%	19.5%	19.1%	20.5%
Sales area widened	19.7%	33.7%	34.7%	30.3%	31.2%	30.8%	31.5%	31.4%
Customer service improved	22.9%	40.8%	37.2%	31.1%	50.9%	39.7%	35.5%	34.8%
International sales increased	13.7%	24.0%	35.6%	18.5%	1.2%	9.1%	28.0%	19.5%
Procurement costs decreased	1.3%	23.5%	14.8%	15.2%	1.3%	13.8%	11.2%	17.7%
Inventory costs decreased	3.7%	16.0%	7.4%	13.1%	1.5%	12.8%	6.2%	14.0%
Coordination with suppliers improved	32.5%	32.7%	9.0%	28.9%	19.5%	25.2%	14.5%	29.8%
Competitive position improved	21.2%	34.1%	22.2%	27.5%	36.2%	30.9%	23.1%	29.8%

Table 2. Impacts of Doing Business Online (percent indicating impact is a great deal)

For a better explanation of the results the average of “efficient” and “inefficient” establishments were calculated. The seven input variables are aggregated to an Internet usage indicator, while the ten output variables are portrayed resembled as the average e-commerce satisfaction index.

The DEA avails the 202 data sets as decision making units (DMU) of the German sample. Afterwards, the results are divided into “efficient” (e.g., SME+ for SMEs and Large+ for large firms) and “inefficient” (without +).

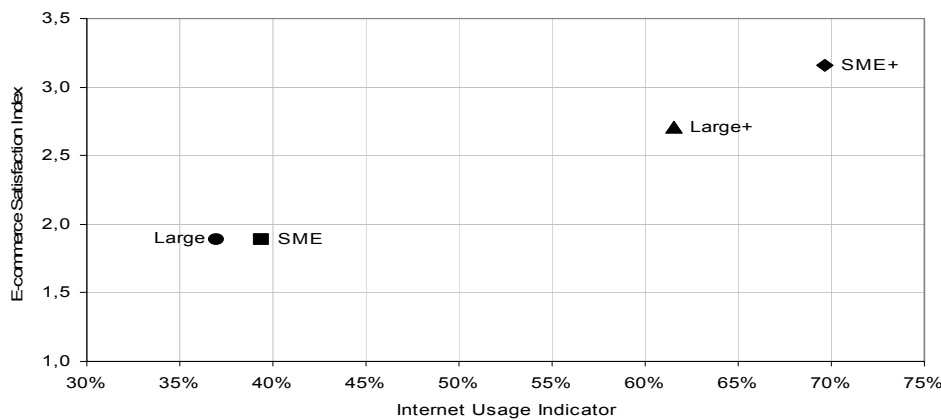


Figure 1. Average usage of Internet technologies and resulting e-commerce satisfaction in the manufacturing industry

In figure 1 the results of DEA for the manufacturing industry are provided. Efficient SMEs (24.2% of all SMEs in this sector) use on average approx. 70% of available Internet possibilities and gain a high benefit from it (Index approx. 3.2). Efficient large firms (37.1% of all large firms in this sector) use in average only 61.5% of all Internet applications and gain only 2.7 on the satisfaction index scale.

Relatively inefficient firms use only 39.4% (SME) and 37.0% (large firms) of available Internet solutions on average but generate the same satisfaction with 1.9 each. If the satisfaction with e-commerce relates positively with the intensity of available Internet

applications, then “inefficient” SMEs should be able to gain more, until now unrealized benefits.

On average, the DEA model identified 30.9% of firms in the manufacturing sample as “efficient”.

In the retail/wholesale industry, SME+ (47.1% of all) use on average 68.8% of Internet applications and gain an average satisfaction of 2.8 in comparison to large+ (40.6% of all) with higher Internet usage (mean = 71.4%) but lower satisfaction (mean = 2.7). SMEs seem to be able to improve and benefit more out of e-commerce even with a slightly lower usage of Internet than large firms.

Among the group of “inefficient” firms again SMEs use more Internet applications (average 50.0%) and gain a higher satisfaction (average index = 2.0) in comparison to large ones (mean Internet usage = 41.4%, mean index = 1.8). In total, 42.1% of firms in the retail/wholesale sector may be regarded as “efficient” in terms of DEA.

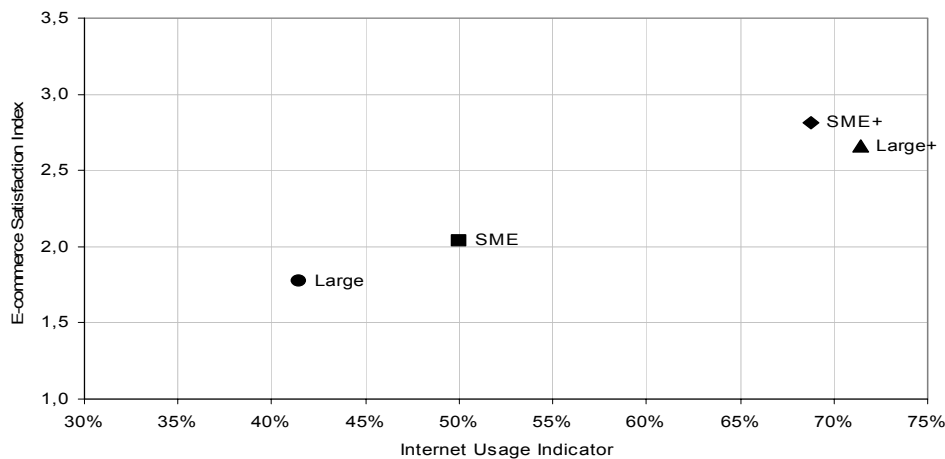


Figure 2. Average usage of Internet technologies and resulting e-commerce satisfaction in the retail/wholesale industry

In contrast to the latter industries the banking & insurance sector use less often all possible Internet applications on average (cf., figure 3). Relative efficient SMEs (31.4% of all) use 61.1% of Internet applications on average but regard with a satisfaction index of 3.0 e-commerce more often as a great deal in comparison to efficient large firms (only 24.1% of all). Those use more Internet solutions (mean = 64.3%) but are in average less satisfied than SMEs (mean = 2.9).

The same holds true when looking at relatively inefficient firms. Large firms use more Internet solutions on average (mean = 49.1%) in comparison to SMEs (mean = 41.7%) but are just as satisfied (mean index = 2.0). While e-commerce seems to be “a great deal” for SMEs to improve their processes and to play an active part in supply chains for the first time, large firms do not benefit in the same way due to existing solutions for EDI and internal process management from the pre-e-commerce area.

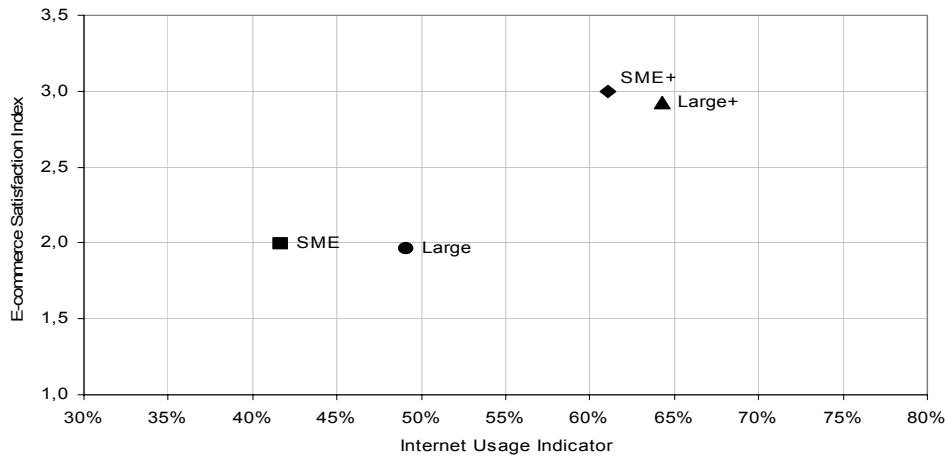


Figure 3. Average usage of Internet technologies and resulting e-commerce satisfaction in the banking/insurance industry

All users of a variety of e-commerce-enabling technologies do not collect information about the intensity of usage, the impacts on traditional working processes or even the resulting efficiency. To analyze the character of e-commerce readiness a purely descriptive comparison is not useful. Due to this a DEA model described in the method section is used to analyze the relative efficiency of firms among the survey sample. An aggregated result of the DEA model is provided in table 3, where the relative efficient firms are categorized by their appropriate industry and firm size. While one third of all firms can be regarded as “relatively efficient”, a detailed analysis revealed SMEs as relatively more efficient in the retail/wholesale and banking/insurance sectors in comparison to large firms in this sector. Even more interesting, the retail sector gains more efficiency out of the e-commerce usage than the manufacturing or the banking sector.

	Manufacturing	Retail/Wholesale	Banking/Insurance	Total
SME	24.2%	47.1%	31.4%	34.3%
Large	37.1%	40.6%	24.2%	33.0%
Total	30.9%	42.4%	27.9%	33.7%

Table 3. Percentage of relative efficient e-commerce users by size and industry

Looking at the differences between “relatively efficient” and “inefficient” firms per sector reveals that “efficient” firms have not only answered an equivalent or higher percentage of easy-to-implement e-commerce solutions such as on-line advertising or on-line sales but also a significant higher percentage of more complex solutions such as EDI or Internet-based supply chain management.

In table 4 to 6 the relative efficient firms are marked by a +.

	On-line advertising	On-line Sales	After sales customer services	On-line procurement	EDI with suppliers	EDI with customers	Internet-based supply chain management
SME+ (n=8)	100.0%	50.0%	75.0%	75.0%	75.0%	75.0%	37.5%
SME (n=25)	68.0%	20.0%	32.0%	44.0%	44.0%	52.0%	16.0%
Large+ (n=13)	76.9%	46.2%	69.2%	69.2%	61.5%	61.5%	46.2%
Large (n=22)	68.2%	13.6%	31.8%	45.5%	40.9%	36.4%	22.7%

Table 4. Manufacturing: E-commerce usage depending on relative efficiency and firm size

	On-line advertising	On-line Sales	After sales customer services	On-line procurement	EDI with suppliers	EDI with customers	Internet-based supply chain management
SME+ (n=16)	75.0%	75.0%	50.0%	81.3%	87.5%	62.5%	50.0%
SME (n=18)	88.9%	38.9%	33.3%	66.7%	44.4%	38.9%	38.9%
Large+ (n=12)	91.7%	75.0%	58.3%	66.7%	91.7%	58.3%	58.3%
Large (n=20)	75.0%	20.0%	40.0%	25.0%	45.0%	45.0%	40.0%

Table 5. Retail/Wholesale: E-commerce usage depending on relative efficiency and firm size

	On-line advertising	On-line Sales	After sales customer services	On-line procurement	EDI with suppliers	EDI with customers	Internet-based supply chain management
SME+ (n=11)	90.9%	54.5%	81.8%	63.6%	36.4%	63.6%	36.4%
SME (n=24)	83.3%	41.7%	58.3%	33.3%	25.0%	29.2%	20.8%
Large+ (n=8)	100.0%	75.0%	87.5%	37.5%	50.0%	50.0%	50.0%
Large (n=25)	100.0%	44.0%	60.0%	40.0%	28.0%	48.0%	24.0%

Table 6. Banking/Insurance: E-commerce usage depending on relative efficiency and firm size

Besides the impacts on relative efficiency of firms inside the sample, e-commerce has also impacts on strategic goals. According to a model developed by Kraemer (Kraemer et al. 1999) firms are asked about the impacts and usage of e-commerce in two different ways: The impacts on internal process optimization (Q28D operational focus) and external market penetration (Q28F market focus). In the original model Kraemer used a seven-point-scale to measure the degree of impact of IT on the focused strategic goal. The used model in this paper is modified and uses a five-point scale. The results for all German firms are provided in figure 4.

While 34% regard e-commerce as a “great deal” for both foci, 25% used e-commerce technologies more or less without specific focus. The potential of e-commerce is seen more

often in the field of market penetration (31%) than in the operational field (10%). An average of only 34% regard e-commerce solutions as important to support strategic goals over all industry sectors and they cannot answer the question if the strategic use of e-commerce has impacts on the efficiency of firms.

To answer this question and to test the results of the DEA analysis provided above a closer look at the strategic goals of “efficient” and “inefficient” is provided in figure 5 and 6.

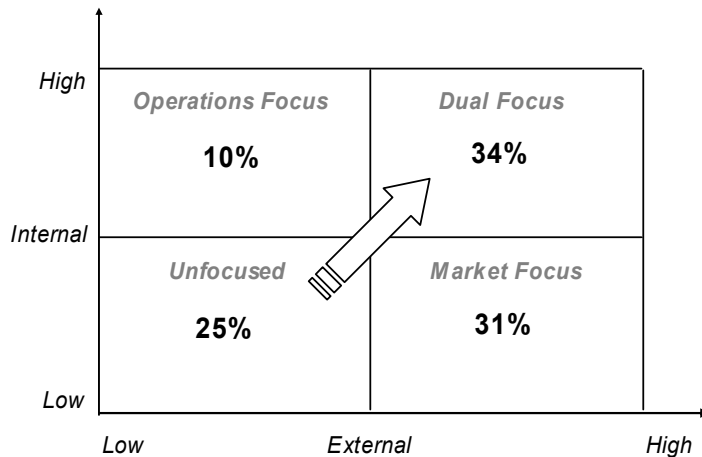


Figure 4. Strategic goals of IT usage as an average of all firms and sectors

Significant differences are observable between “efficient” and “inefficient” firms. DEA efficient firms responded more often that e-commerce is a great deal for their strategic goals than inefficient ones. 46% of “efficient” firms have a dual focused strategy while “inefficient” firms responded only in 28% of all cases a dual strategy. Vice versa, only 10% of efficient firms are unfocused users of e-commerce seeing no further impacts on their strategic goals while after all 33% of DEA inefficient firms reported an unfocused usage.

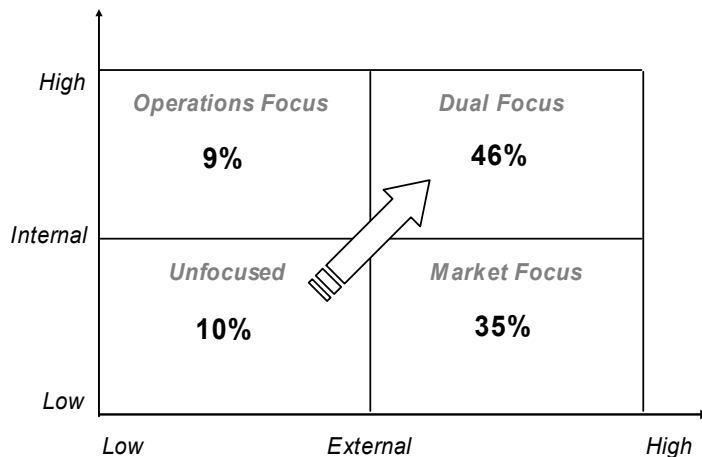


Figure 5. Strategic goals of IT usage as an average of “relatively efficient” firms

Figure 5 and 6 indicate that the results of the DEA model are not random. The differences between “efficient” and “inefficient” users of e-commerce are measurable in the DEA, as well as in the Kraemer-model. Based on different questions significant differences occur.

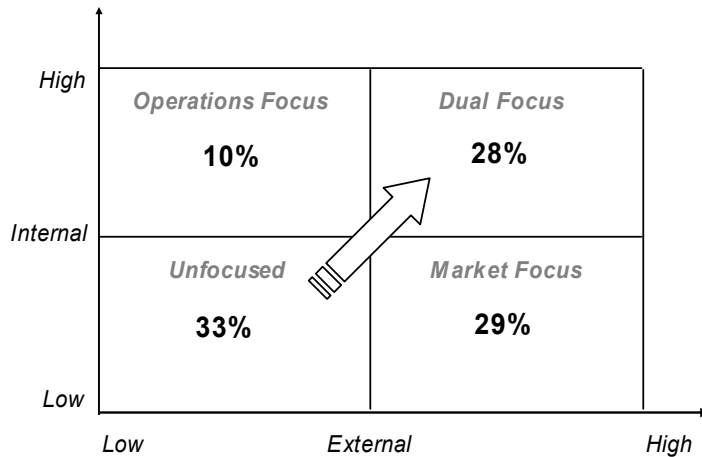


Figure 6. Strategic goals of IT usage as an average of “relatively inefficient” firms

The results provided in figure 6 and 7 are tested by using Pearson’s chi-square significance tests. A strong deviation between the observed and the expected number of valuations is an indicator for a close relation between the tested attributes “efficiency” and “IT usage” in the cross-classified table. For question 28D (operational focus) the hypothesis that there is no significant correlation between the efficient usage of IT and the strategic orientation to improve their internal processes can be denied with an error probability of 0.004%. For question 28F (market focus) the hypothesis that there is no significant correlation between the efficient usage of IT and the strategic orientation to widen the market or open new ones can be denied with an error probability of 0.001%. Thus, efficient establishments reported more often that IT has a high importance for their strategic goals than inefficient ones.

4. Conclusions

The diffusion of e-commerce applications and solutions in the German industry seems to have peaked, leveled off and seems to be concluded. Large firms as well as SMEs in the studied industries utilize more or less the same high level of e-commerce applications. Although the de facto e-commerce readiness is observable, advanced statements about the actual usage behavior and intensity cannot be made based on the underlying survey.

Starting from a low level of ICT investment at the end of the last century, Germany was able to increase these investments substantially over the last five years. The e-business forum e-readiness ranking, created by economists and including 60 countries, counts Germany on the eighth position in 2002 after being twelfth in 2001 and thirteenth in 2000, respectively.

In contrast to the global survey, German firms regard e-commerce less often as an enabler to increase markets on the international level. Given the existing global market orientation, German firms were competitive on international markets even in the pre-e-commerce era.

On the industry level, the e-commerce-based increase of productivity in the manufacturing industry was not as high as in the global sample due to existing competitive supply chain managing systems.

After e-commerce solutions have proven successful SMEs are at the forefront implementing e-commerce applications and be therefore important drivers of innovation diffusion in Germany. Although all industry sectors are well equipped, industry related differences remain. The manufacturing industry started from a high level of existing technologies such as

EDI or joint supply chain management systems, i.e. in the automotive industry, where moreover most firms are large ones.

The retail/wholesale industry with its large number of SMEs realizes large profits from formerly impossible Internet-based EDI connections. SMEs in this sector were able to improve their business processes more often than SMEs in other sectors where industry-related EDI standards or ERP systems were still in place. Especially this sector benefits from the Internet based possibilities of on-line sales and procurement. Besides the access on new markets e-commerce using firms in this sector were able to create more efficient internal process at the same time.

The banking and insurance sector invested heavily in on-line business models. While most benefits of on-line banking and brokerage appeared on the customer side, the improvement of internal bank processes could not benefit in the same way. As long as banks are not able to decrease their costs, e.g., by reducing the number of branches, the multi-channel distribution strategy holds few benefits.

The relative efficient usage of e-commerce seems to depend directly on the strategic focus of firms. While unfocused firms might be still experimenting with e-commerce others gain yet profit.

SMEs as backbone of German industry are not only able to reach the same stage of diffusion as large firms but also able to achieve commercial benefit. Especially in the retail/wholesale industry SMEs can participate for the first time from decreasing costs resulting from supply chain improvements and electronic transactions.

Recapitulating, German industry adopted fast e-commerce solutions after a certain time lag. Many of those firms implementing e-commerce in a consistent way benefit from process improvements and increasing efficiencies. The e-commerce diffusion race has reached a maturity stage which seems to be an excellent base for further developments such as mobile commerce in the near future.

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