

# The Diffusion and Efficient Use of Electronic Commerce among Small and Medium-sized Enterprises: An International Three-Industry Survey

ROMAN BECK, ROLF T. WIGAND AND WOLFGANG KÖNIG



## 1. INTRODUCTION

The diffusion and use of e-commerce applications and technologies have been of research interest from a technological (Angeles *et al.* 2001), as well as an organizational (e.g., Mackay and Rosier 1996; Massetti and Zmud 1996; Rose *et al.* 1999) point of view. While the main attention has focused on the adoption and implementation of e-commerce in large enterprises (e.g., Hausman and Stock 2003; Karahanna and Straub 1999; Saloner and Shepard 1995), e-commerce-driven changes and improvements are also observable at the level of small and medium-sized enterprises (SMEs), such as in the case of EDI adoption (Chau and Hui 2001; Fink 1998; Iacovou *et al.* 1995; Powell and Levy 2000).

This paper analyses the rate of e-commerce diffusion in three industry sectors (manufacturing, retail/wholesale, and banking/insurance) in Denmark, France, Germany and the US. It compares the intensity of e-commerce diffusion and usage by SMEs and identifies efficient users by using a Data Envelopment Analysis (DEA) (Charnes *et al.* 1978) for each industry sector and national market.

The impacts of e-commerce diffusion on process improvements are observable not only within large firms (König *et al.* 2003) but also among strong and innovation-friendly SMEs. In fact, SMEs in particular can benefit from the full potential of automation by adopting and implementing e-commerce carefully (Beck *et al.* 2002). While the size of an enterprise seems to be more and more negligible as a variable, its affiliation to a certain industry has still a positive or negative impact on overall e-commerce readiness. Some industrial sectors have done better in adopting e-commerce with a long tradition in, e.g., computer-based electronic data processing and transmission. For example, the automotive industry has successfully developed EDI-standards and delivery processes resulting in considerable savings of time and money (Hoppen *et al.* 2002; Wigand 1994). In comparison to the manufacturing sector with its sophisticated e-commerce-based business processing, the retail and wholesale sector is much more fragmented and few best-practice cases such as in the former sector are known (Fearon and Philip 1999).

## A b s t r a c t

The diffusion of e-commerce applications and solutions in many countries and industry sectors seems to have reached a level of maturity. This applies not only for large firms, but also for SMEs in three analysed industry sectors, i.e. manufacturing, retail/wholesale and banking/insurance, in Denmark, France, Germany, and the US. With the exception of France, a rather large number of SMEs in these countries responded that the implementation of e-commerce contributed substantially to improve existing operational processes and to expand markets. Although e-commerce technologies may be available hypothetically in all industries and firms, an efficient usage of e-commerce is closely related to a comprehensive implementation of more sophisticated solutions, e.g., online procurement or Internet-based supply chain management. Firms with an all-embracing approach utilizing many e-commerce applications are more often efficient than firms with a lower e-commerce diffusion rate in the sample analysed.

**Keywords:** electronic commerce, DEA, SME, innovation diffusion, efficiency

## A u t h o r s

### Roman Beck

(rbeck@wiwi.uni-frankfurt.de) is a PhD student and graduate research assistant at J. W. Goethe University Frankfurt, Institute of Information Systems, Germany. He publishes on a wide array of topics in the field of IS communication standards with network effects and economics of standardization and their role on creating new business models.

### Rolf T. Wigand

(rtwigand@ualr.edu) is the Maulden-Entergy Chair and Distinguished Professor of Information Science and Management at the University of Arkansas at Little Rock, USA. He researches information management, e-commerce and markets, IS standards and the strategic deployment of information and communication technology.

### Wolfgang König

(wkoenig@wiwi.uni-frankfurt.de) is Professor of Information Systems at the J. W. Goethe University Frankfurt, Germany. He is chairman of the E-Finance Lab, which is analysing, evolving and supporting the structural changes influencing the transformation of the financial service industry today and in the future.

Gaining the full potential and benefits from e-commerce depends on the consistent integration and implementation of all kinds of e-commerce technologies into existing business processes while at the same time adjusting these processes. Thus, there is a strong possibility that a strategy of selective usage of single applications with insufficient interfaces will fail. Therefore, purposeful implementation is especially important for SMEs in strongly export-oriented nations (as a percentage of GDP) such as Denmark or Germany to be competitive on an international level. Due to national differences such as available IT knowledge, ICT infrastructure or business laws, different paths of e-commerce diffusion are observable. Such differences are based on reported variances of e-commerce drivers and inhibitors among the countries investigated. One major methodological problem is certainly the measuring of increased productivity or efficiency improvements directly attributable to e-commerce. A common problem is the lack of data, weak definitions and a lack of methods. If the impact of the increased use of IT has, as yet, not been directly measurable, this impact should at least be visible on the output side. But even measuring these spill-over effects seems to be difficult, although PCs and the Internet have doubtlessly created additional consumer benefit (Gordon 2000).

In order to analyse efficiency improvements based on different degrees of e-commerce diffusions, this paper is organized as follows: In section 2 the research framework is provided together with two propositions to be analysed. A brief overview of the methods used and an introduction into the Data Envelopment Analysis (DEA) model is provided in section 3. Section 4 presents information about the diffusion and usage of e-commerce at the country and industry levels (4.1), the observed drivers and barriers of e-commerce for SMEs (4.2), as well as the resulting efficiency increases or satisfaction levels based on the implementation of e-commerce (4.3). Section 5 provides a discussion and conclusion.

## 2. RESEARCH FRAMEWORK

During the past few years, a primary focus of empirical e-commerce research has been the analysis of its diffusion among SMEs, resulting in contributions about the so-called 'digital gap' or 'digital divide' between large firms and SMEs (Dutta *et al.* 1998; Hawkins *et al.* 1999). Doubtless, e-commerce-driven changes and improvements have the potential to increase overall business efficiency (Cantwell 2001; Wigand 2003a), but until now most of these efficiency increases have been observed and investigated only with large firms, due to increasing economies of scale and scope, especially at the international or global market levels (Jalava and Pohjola 2002; Kiski and Pohjola 2002).

This paper focuses on the analysis of the diffusion of e-commerce on the one hand and the resulting efficiency improvements or perceived satisfaction among SMEs on the other hand. Different sets of e-commerce technologies among countries and industry sectors analysed may be explained as being due to national and sectoral differences (such as available IT knowledge or ICT infrastructure). Consequently, the number of efficient e-commerce-using firms (according to the results of the DEA analysis) may be correlated with the business environments investigated, based on the underlying empirical survey (e-commerce drivers and barriers (see Figures 1 to 6 for the three sectors)).

*Proposition 1:* DEA-efficient firms value drivers of e-commerce significantly more highly (and vice versa obstacles lower) than the rest of the firms investigated.

Although the mere existence of different e-commerce technologies at the firm level might be a good estimator for the diffusion of IT knowledge and use of new technologies, this still only provides limited information about the *de facto* use intensity or the productivity improvements related to the implementation.

Gaining the full potential and benefit from e-commerce depends on its consistent integration and implementation in business processes, while these processes must be adjusted at the same time. Obviously, efficient and consistent use is therefore more important than the sheer existence of such technologies.

*Proposition 2:* The efficient use of e-commerce is positively related to the number of e-commerce solutions deployed.

The number of deployed e-commerce-based applications (Table 2) together with the perceived impacts of e-commerce (Table 3) are used to identify the relation between the total number of e-commerce solutions and efficiency per sector.

## 3. DATA SAMPLE AND METHODOLOGICAL BACKGROUND

The underlying questionnaire was designed by the participants in an international joint research project (The Globalization and E-Commerce Project of the Center for Research on Information Technology and Organizations (CRITO) at the University of California, Irvine). The questionnaire comprised 50 questions on different topics such as globalization of enterprises, implementation of e-commerce technologies, as well as the use of these technologies, drivers and inhibitors of e-commerce implementation and use, impacts on business processes and efficiency and e-commerce implementation strategies. The survey itself was conducted by IDC in Spring 2002 on behalf of the research project and was

administered in the four countries with altogether 458 SMEs responding from Denmark, Germany, France and the United States.

Denmark, France and Germany differ in the intensity of demand drivers (industry structure, information infrastructure, financial and human resources, and social and cultural factors) but are experiencing the same increasing productivity gap (Farrell *et al.* 2003) based on a time-lag in e-commerce readiness and diffusion (Kraemer *et al.* 2000; Kraemer and Dedrick 2000) in comparison to the US (Gordon 2000). Due to these national and industrial path dependencies in the diffusion of e-commerce, a comparison among e-commerce-leading countries such as Denmark and the US with the two largest economies in continental Europe, i.e. France and Germany, seems to be a promising way to identify differences in the ways e-commerce is used, as well as finding 'best practice' cases or 'leading' sectors or countries.

The sampling was a clustered random sample. An SME was classified as a firm with 25 to 249 employees. Smaller firms with employees from 1 to 24 were not considered because it was assumed that the e-commerce and Internet literacy in this firm-size category is too heterogeneous to derive any useful and significant data. The goal of this survey was to analyse e-commerce-using SMEs, and therefore the results are limited to the group of SMEs with any kind of e-commerce experience. SMEs without online activities such as online sales or procurement were not taken into account. 152 SMEs in the manufacturing sector from Denmark (35), Germany (33), France (34) and the United States (50) were surveyed. In the retail/wholesale sector the survey was conducted among 151 SMEs from Denmark (33), Germany (34), France (31), and the United States (53). In the banking and insurance sector the survey was conducted among 155 SMEs from Denmark (32), Germany (36), France (35) and the United States (52).

For analysing the relative efficiency of e-commerce-deploying SMEs, a Data Envelopment Analysis (DEA) was used (Charnes *et al.* 1978). Since most SMEs cannot determine the benefits they derive from implementing innovative technologies in monetary units, the survey asked for the set of e-commerce technologies adopted on the one hand and the individually perceived efficiency or satisfaction on the other hand.

The used BCC model (Banker, Charnes and Cooper) of the DEA analysis offers a differentiation between technical efficiency and scale-efficiency (Golany and Roll 1989: 249) and evaluates solutions for non-increasing, decreasing and variable returns of scale. The object of interest in a DEA model is the decision-making unit (DMU), which is similar to a firm. A DMU is a flexible unit responsible for the in- and output variables. DEA only compares each DMU with the 'most efficient' DMUs in the sample (Bala and Cook 2003). Efficient

combinations of input and output relations or efficient DMUs of a sample form the so-called 'efficient frontier line'. In an n-dimensional room the efficient frontier is equivalent to an imaginary umbrella over the sample, covering the efficient DMUs and all theoretically possible combinations of efficient, virtual DMUs. The DEA model calculates the relative position inside the data sample for each DMU, based on its set of inputs and set of outputs (Parsons 1992). Using a linear programming procedure for the frontier analysis of inputs and outputs, DEA accordingly evaluates the 'best practice' users of e-commerce. The basic idea of DEA is multi-input and multi-output-oriented efficiency evaluation without any further assumptions about the structure (e.g., normal distribution) or side conditions. Unlike parametric methods, DEA can use all kinds of input and output data to analyse the production behaviour. The DEA model used 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 observed, actual input/output relation identified in the survey. Moreover, the model assumes returns of scale for each DMU depending on the size and a concave function of decreasing returns. The software used for the data analysis together with a detailed description is available from Scheel (2000).

DEA was chosen due to the unique alternative way of analysing a set of data in comparison to the best performing data sets. A regression analysis, for example, only describes the deviation of best fitting and performing data sets from the average. Unlike parametric approaches, DEA optimizes on each individual observation independent of any distribution assumptions (Charnes *et al.* 1994: 5; Cooper *et al.* 2003: 13). Different kinds of DEA models have been used in a large number of ways to measure the impacts of IT: e.g. in the banking industry (Barr *et al.* 2002) or in the retail and wholesale industry (Beck *et al.* 2003a).

Here, the DEA model was adapted and used as follows: the input variables – aggregated to an Internet usage indicator – are the results of seven questions concerning online advertising, online sales and procurement, online customer services, exchange of operational data with customers and suppliers, as well as formal integration of similar business processes along the supply chain, which are actively used by the respondents. Variables are coded as 0 when an establishment uses the asked-for e-commerce application and 1 if it does not use it. The coding is equivalent to 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.

*Input variables (Internet usage indicator) = u (online advertising, online sales, online procurement, ..., same formal business processes along supply chain)*

$$s.t. u_j \in (0; 1)$$

The ten output variables – aggregated to an e-commerce satisfaction index – of the model are measured on a five-point scale with 1 ('no impact at all') to 5 ('a great deal') and comprise the results of the following questions: internal processes more efficient, staff productivity increased, sales and national/international sales area increased, customer service improvement, procurement and inventory costs decreased, coordination with suppliers improved and competitive position improved.

*Output variables (E-commerce satisfaction index)=v (internal process more efficient, staff productivity increased, ..., competitive position improved)*

$$s.t. v_j \in \{1; 2; 3; 4; 5\}$$

The basic formula of the chosen model is similar to the CCR model (Charnes, Cooper, Rhodes):

$$\max \theta = \frac{\sum_{j=1}^s v_j y_j}{\sum_{i=1}^t u_i x_i}$$

The previous formulation cannot be solved by linear programming tools and therefore has to be transformed in the following equation, which is an output-oriented maximization example:

$$\max = \sum_{j=1}^s v_j y_j \text{ with constant input } \sum_{i=1}^t u_i x_i = 1$$

$$\sum_{i=1}^t u_i x_i \leq \sum_{j=1}^s v_j y_j$$

$$s.t. u_i \geq 0, v_j \geq 0$$

Efficiency in this context is the benefit gained, based on the e-commerce application used improving efficiency or productivity. SMEs with a high satisfaction index based on the installed e-commerce infrastructure may be defined as efficient in comparison to other SMEs of the sample.

#### 4. THE DIFFUSION OF E-COMMERCE IN THREE INDUSTRY SECTORS

The diffusion of e-commerce technologies has received broad attention, especially in the business-to-business area and interorganizational cooperation together with the integration of heterogeneous partners such as SMEs (Ketler *et al.* 1997; Kiiski and Pohjola 2002). One of the most challenging problems, not only inside industry sectors but also on a macroeconomic level, is the often

insufficient electronic supply chain integration of SMEs, reflecting the physical stream of goods. SMEs have to cope with a variety of problems normally impeding a successful integration of e-commerce technologies, such as inadequate ERP systems, lack of IT know-how or not totally automated internal business processes, as a prerequisite to gain benefits in exchanging business messages electronically (Beck *et al.* 2003b). In the pre-e-commerce era, SMEs were forced to integrate technologies such as EDI by large business partners – often not necessarily for economic reasons (Tucker 1997; Wigand 1994). Nevertheless, in comparison to large enterprises, SMEs have more difficulties in attracting IT specialists for their business and cannot usually benefit from economies of scale, nor do they have sophisticated distribution systems (König *et al.* 2003).

Therefore, fast adoption of innovative techniques and technologies is a critical factor for all SMEs if they want to be successful and competitive. Through the internationalization of markets, manufacturers and their suppliers are increasingly forced to intensify and improve their business relations in order to avoid losing competitive advantage. Consequently, a higher level of integration or cooperation is needed (Oliver and Webber 1992). The Internet and e-commerce-based supply chain integration into SMEs business processes implies more than just the exchange of business documents. Moreover, the planning, execution and control of supply chain activities requires the efficient use of e-commerce technologies, as well as the organizational willingness to cooperate (Swaminathan *et al.* 1998). This involves the sharing of information and knowledge that used to be considered proprietary or even strategic. The sharing of business-critical information or Internet-based supply chain management is therefore inefficient as long as SMEs within value chains are not totally integrated (Lee 1998). As a result, a preliminary step towards a soundly functioning supply chain is the availability of rudimentary e-commerce technologies among SMEs.

The impact of e-commerce on accepted and traditional business processes and methods has especially influenced the retail/wholesale industry. No other industry has to cope as much with the changes in customer preferences to shop online instead of making sales at traditional brick-and-mortar shops. Internet customers are better informed and more price-sensitive than off-line customers (Brynjolfsson and Smith 2000). The ability to compare prices directly on the Internet increases competition and provides greater transparency (e.g., Wigand 2003b). On the other hand, SMEs are predicted to be flexible and innovative in using the new form of conducting business more flexibly than large retailers. In contrast, SMEs are often not able to compete with large competitors due to the high setup costs of web-enabled materials management systems or web-based shopping systems.

In the banking/insurance sector, the products offered are mainly information goods, which may easily be provided, in digital form over the Internet. The underlying ICT-driven processes are subject to steady changes, due not least to new distribution channels such as online banking. Changing customer preferences together with decreasing loyalty are a new challenge banks have to cope with. PC and Internet usage have doubtlessly created consumer surpluses, especially with regard to online banking and brokerage services (Gordon 2000). But the multi-channel distribution strategy holds no additional utility for banks if they cannot benefit from economies of scale by reducing the number of physical branches at the same time.

#### 4.1. E-commerce readiness and usage among SMEs

The overall diffusion and adoption of e-commerce applications has reached a high level in all the countries studied. As Table 1 indicates, Danish SMEs are at the forefront in the field of Internet-based services in comparison to most of the other countries and sectors investigated. With 100% availability of e-mail and 91.4 to 100% diffusion of public websites, as well as in the deployment of Intranet (starting with 74.3% in the manufacturing industry to 96.9% in the banking/insurance industry) Danish SMEs are the overall leaders in being equipped to use e-commerce. But German SMEs are not far behind, i.e. they provide their own websites less often (90.9%) and they are nearly equal to Danish firms in the areas of Intranet usage (69.7%). German SMEs are leading in the use of electronic funds transfer (EFT) (90.9%) ahead of all other countries in the sample. Aside from German and Danish SMEs in the manufacturing sector, French (with the exception of EDI) and US SMEs (with exception of call centre use) use one of these technologies less often.

Based on the large installed base of established e-commerce technologies, e-commerce is used to improve many kinds of internal and external business processes (see Table 2). While in Table 1 on average Danish firms reported the highest availability of e-commerce technologies, in the area of e-commerce use US and German SMEs on average are leading, especially in the area of more sophisticated and complex applications such as EDI with customers or Internet-based supply chain management. While German SMEs use, at a level of 75.8%, online advertising more often than any other manufacturing sector, only 32.4% of French SMEs used this application at the same time. On average, SMEs in the US reported the highest usage rates of e-commerce applications in the manufacturing sector in the areas of after sales customer service (60%), online procurement (76%), EDI with customers (64%) and Internet based supply chain management (34%).

In the retail/wholesale industry, German SMEs are at the forefront, deploying e-commerce applications such as on-line sales (55.9%), on-line procurement (73.5%), EDI with suppliers (67.6%), EDI with customers (52.9%) or Internet-based supply chain management (44.1%) more often. In the banking/insurance sector, Danish SMEs use on average any of the asked for e-commerce technologies more often than SMEs in other countries. They are leading in the area of online sales (56.3%), EDI with suppliers (56.3%) and Internet-based supply chain management (37.5%). French SMEs do not dominate either in a single industry sector or in the use of a specific e-commerce application. German and US SMEs seem to use more sophisticated solutions such as EDI with customers or Internet-based supply chain management more often. As Proposition 2 suggests, the implementation and use of more complex technologies should be positively related with the satisfaction with the positive impact e-commerce technologies have on the efficiency of SMEs (see section 4.3).

Table 1. SMEs' e-commerce readiness per country and sector (%)

	Denmark			France			Germany			USA		
	M	R	B	M	R	B	M	R	B	M	R	B
E-mail	100.0	100.0	100.0	94.1	96.8	97.2	100.0	100.0	100.0	98.0	100.0	100.0
Public Website	91.4	97.0	100.0	61.8	51.6	61.1	90.9	91.2	97.1	84.0	73.6	86.5
Intranet	74.3	78.8	96.9	67.6	71.0	61.1	69.7	82.4	91.4	44.0	58.5	55.8
Extranet	40.0	39.4	46.9	38.2	9.7	27.8	36.4	26.5	40.0	26.0	28.3	26.9
EDI	48.6	66.7	75.0	64.7	41.9	41.7	51.5	76.5	60.0	54.0	37.7	34.6
EFT	82.9	57.6	75.0	23.5	29.0	30.6	90.9	85.3	85.7	50.0	56.6	80.8
Call Centre	31.4	33.3	37.5	20.6	25.8	16.7	21.2	41.2	54.3	50.0	35.8	48.1

M: Manufacturing, R: Retail/Wholesale, B: Banking/Insurance, SMEs: 25 to 249 employees

Source: Own survey, conducted by IDC

Table 2. SMEs' e-commerce usage per country and sector (in %)

		Online advertising	Online Sales	After sales customer services	On-line procurement	EDI with suppliers	EDI with customers	Internet based supply chain management
Denmark	M	65.7	31.4	45.7	74.3	54.3	54.3	25.7
	R	93.9	45.5	48.5	72.7	45.5	27.3	39.4
	B	90.6	56.3	62.5	71.9	56.3	46.9	37.5
France	M	32.4	8.8	17.6	20.6	44.1	52.9	23.5
	R	25.8	9.7	12.9	22.6	29.0	29.0	16.1
	B	47.2	16.7	27.8	27.8	41.7	38.9	33.3
Germany	M	75.8	27.3	42.4	51.5	51.5	57.6	21.2
	R	82.4	55.9	41.2	73.5	67.6	52.9	44.1
	B	85.7	45.7	65.7	42.9	28.6	40.0	25.7
USA	M	72.0	26.0	60.0	76.0	44.0	64.0	34.0
	R	54.7	49.1	52.8	69.8	41.5	43.4	35.8
	B	80.8	30.8	50.0	76.9	38.5	63.5	32.7

M: Manufacturing, R: Retail/Wholesale, B: Banking/Insurance, SMEs: 25 to 249 employees  
 Source: Own survey, conducted by IDC

4.2. E-commerce drivers and barriers for SMEs

While section 4.1 provides a brief overview on the diffusion of e-commerce technologies and the differences in each country as well as sectors, this section provides some possible reasons for the diffusion pattern reported, based on different drivers and barriers supporting or hindering the diffusion in each sector and/or country. Figure 1 depicts e-commerce drivers yielded, using a five-point scale, where 1 corresponds to 'not a driving factor at all' and 5 to 'a very significant factor'.

Important drivers for SMEs to adopt e-commerce technologies are deployed in all countries to improve coordination with customers and suppliers. The most important drivers in Denmark, Germany and the US are the potential to reduce costs by implementing e-commerce solutions, the expansion of markets together with the ability to improve coordination with customers and suppliers. The latter reason is also of importance in France while on average the overall lowest rated drivers were reported there as well, resulting in a low diffusion of e-commerce technologies in the manufacturing sector in France (see section 4.1). Government contributions

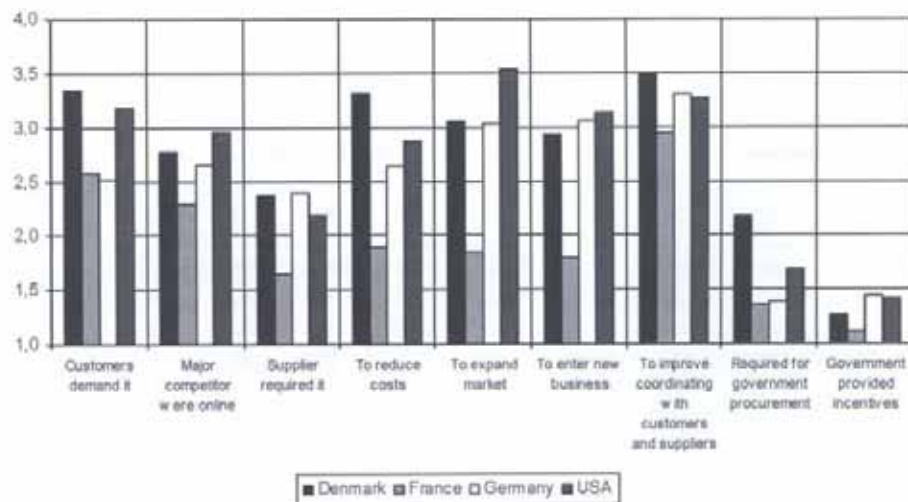


Figure 1. E-commerce drivers for SMEs in the manufacturing sector Source: Own survey, conducted by IDC

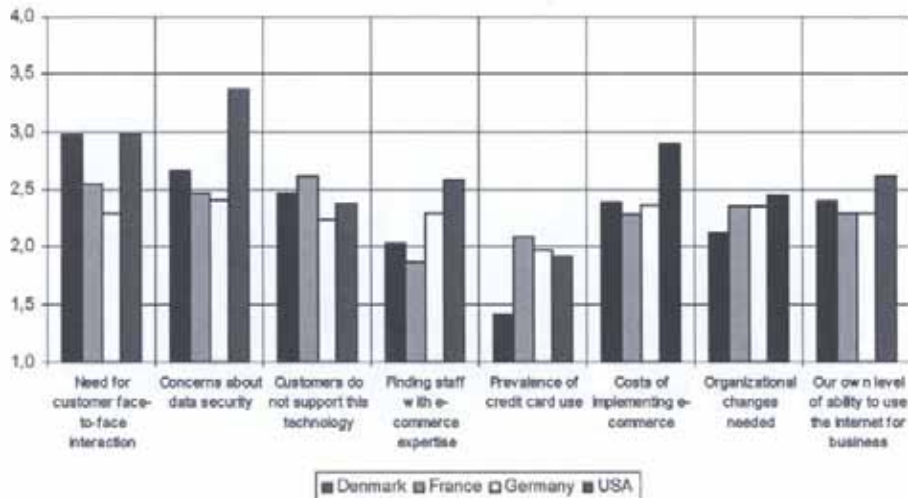


Figure 2. Factors impeding e-commerce for SMEs in the manufacturing sector Source: Own survey, conducted by IDC

to the diffusion of e-commerce seem to be rather unimportant in all countries surveyed. With the exception of Denmark, where online business with government seems to require e-commerce standards, SMEs in the manufacturing sector do not see the impact of the government as a driving factor.

As well as e-commerce drivers, the most important factors impeding doing business online in the manufacturing sector are also investigated (see Figure 2). Analogous to Figure 1, a five-point scale was used; where 1 corresponds to 'not an obstacle' and 5 to 'a very significant obstacle'.

Interestingly, SMEs in the US reported the highest obstacles scores on average. While the need for customer face-to-face interaction is not as important in Germany or France, American or Danish SMEs rate this obstacle as an important hindering factor. US SMEs, followed by Danish and French ones, regard security factors as important obstacles. While the obstacles in the field of technology support on the customer side or the bottleneck of e-commerce-skilled staff is more of a problem in France or the US, the prevalence of credit cards for online shopping is not seen as an important impeding factor in all countries, especially not in Denmark. An often-mentioned barrier for SMEs is the costliness of integrating e-commerce solutions into an existing in-house IT infrastructure. US SMEs regard this as an important barrier. Mandatory organizational changes can be reported for US SMEs, followed by German and French ones, as the highest hindering factors. The level of ability to use the Internet for their own business is seen as critical in the US, followed by Danish SMEs. In general, US SMEs regard themselves to be confronted with more impeding factors than their European counterparts.

In the retail/wholesale sector, one of the least important drivers of e-commerce – for economic reasons

– is the necessity to integrate e-commerce due to pressure from suppliers requiring e-commerce-ready business partners (see Figure 3). Government contributions to the diffusion of e-commerce seem to be unimportant with the exception of France and Denmark, where online business with the government seems to require e-commerce applications to a certain degree. Overall, SMEs in the retail/wholesale sector do not regard the impact of the government as a driving factor to implement or use e-commerce.

In comparison to other countries, on average, US SMEs produce the highest level of obstacles in the retail/wholesale sector (Figure 4). While the need for customer face-to-face interaction is not as important in Germany or Denmark, US or French SMEs rate this obstacle as an important hindering factor. US SMEs, followed by French and German ones, regard security factors as important obstacles. While the obstacles in the field of technology support on the customer side or the bottleneck of e-commerce-skilled staff is more a problem in the US, the prevalence of credit cards for online shopping is not seen as an important impeding factor in all countries, especially not in Denmark. In general, it seems that US SMEs believe themselves to be confronted with more impeding factors than European ones.

The reasons for implementing e-commerce technologies also vary in the banking/insurance sector among the surveyed countries. While customer demand may be identified as an important driver in most countries, especially Denmark, the use of online banking seems not to be as widespread yet on the customer side in France (Figure 5).

The same seems to be true of online competition with major competitors. While especially in the US the adoption of e-commerce is strongly driven by competition, in Denmark and again in France this factor seems to be less important in the banking sector.

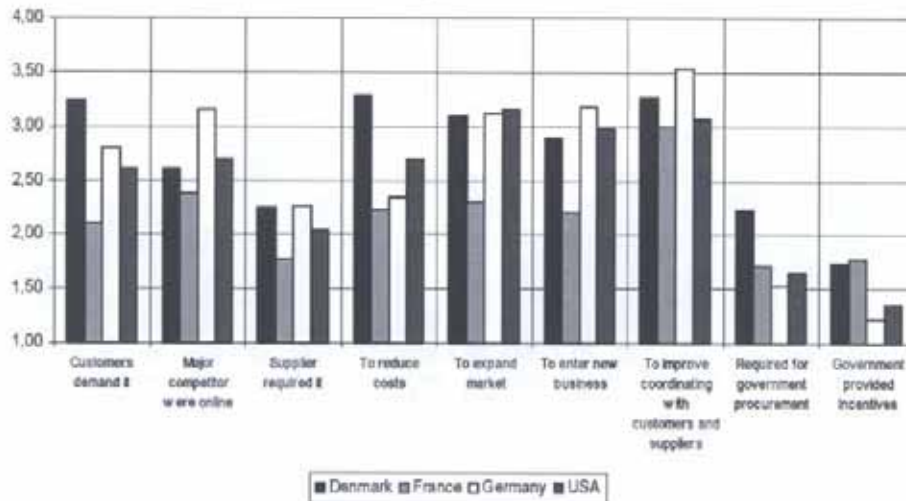


Figure 3. E-commerce drivers for SMEs in the retail/wholesale sector *Source: Own survey, conducted by IDC*

Due to the low degree of vertical fragmentation – in general, banks develop, create and distribute their products themselves – needs of integrating suppliers are not as important as, for example, in the manufacturing industry. In Denmark, the US and even Germany, SMEs assess the benefits of e-commerce in the field of automation and increasing efficiency by exploiting economy of scale effects as an important driver of e-commerce investments. E-commerce as an enabler to expand markets, to enter new business areas or to improve coordination with suppliers and customers are also seen as important drivers, especially for Danish and US SMEs. Government's contribution to the diffusion of e-commerce seems to be rather unimportant in all countries surveyed. With the exception of France, where online bank and insurance transactions with the government seem to require e-commerce standards, SMEs do

not regard the impact of the government as a driving factor.

Again, the highest obstacles impeding the use of e-commerce are reported from SMEs in the US (Figure 6).

#### 4.3. The efficient usage of e-commerce

E-commerce output and, therefore, the impact of e-commerce on business processes or e-commerce satisfaction depend directly on the intensity and variety of applications implemented. To test this proposition, a DEA analysis was used as described in section 3. The chosen DEA model avails itself of the data sets from each industry sector, starting with 152 sets in the manufacturing industry. Afterwards, the results may be used to

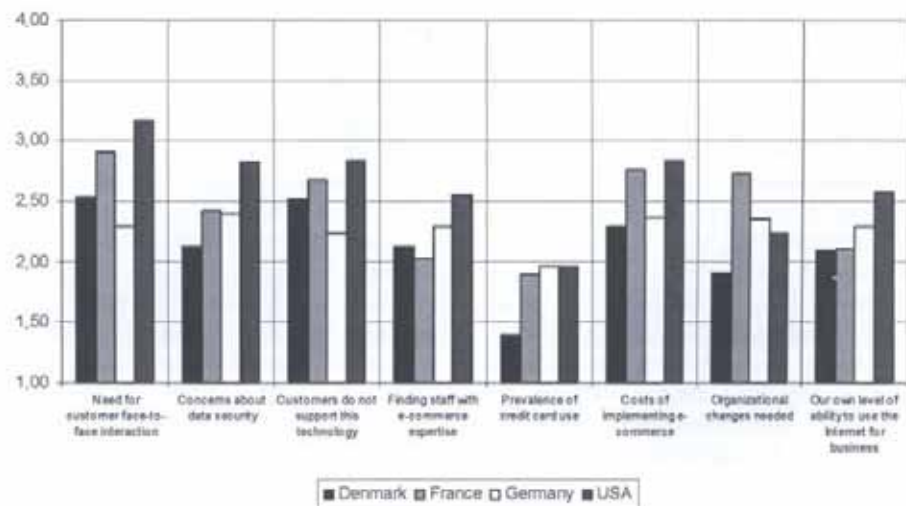


Figure 4. Factors impeding e-commerce for SMEs in the retail/wholesale sector *Source: Own survey, conducted by IDC*

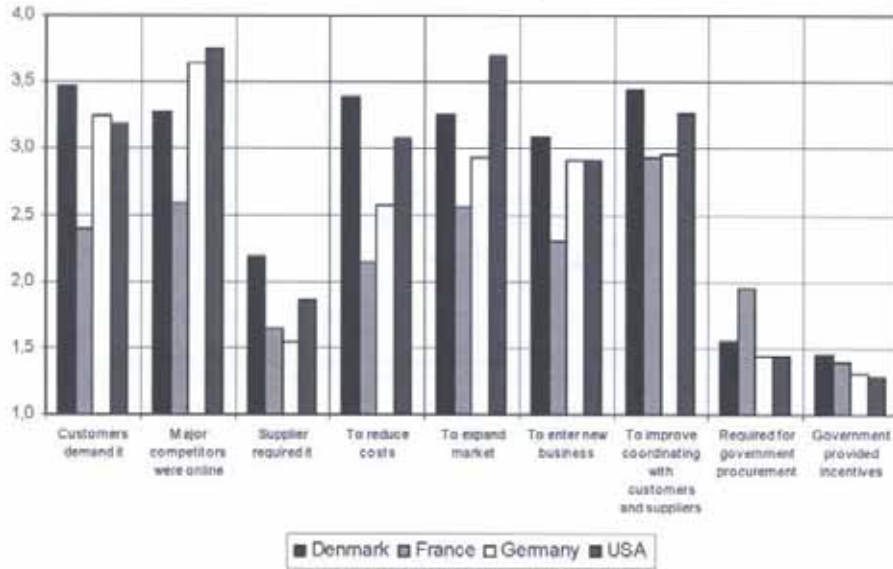


Figure 5. E-commerce drivers for SMEs in the banking/insurance sector Source: Own survey, conducted by IDC

select the efficient (marked by \*) from the inefficient ones. The results of the DEA for the manufacturing sector are provided in Figure 7.

On average, efficient SMEs in the US use 67.5%, in Denmark 81.8%, in France 46.4% and in Germany 64.3% respectively of the seven e-commerce technologies asked for (i.e. use of: online advertising, online sales, after-sale customer service, online procurement, EDI with suppliers, EDI with customers, Internet-based supply chain management). The impact on business improvement is measured by the satisfaction index for Germany with an index of 3.0, France with 3.1, and 3.2 each for Denmark and the US.

Interestingly, efficient French SMEs in the manufacturing sector derive a higher level of satisfaction from e-commerce than German ones with only 46.4% of all available e-commerce technologies. One possible explanation might be the innovative character of e-commerce, which is embraced more enthusiastically in France. Another explanation might be the larger efficiency potentials of even fewer e-commerce technologies in France than in Germany.

In the retail/wholesale industry, altogether 151 data sets are used to calculate the relative efficiency of SMEs in the four countries by using DEA. The results are provided in Figure 8, where the relatively efficient

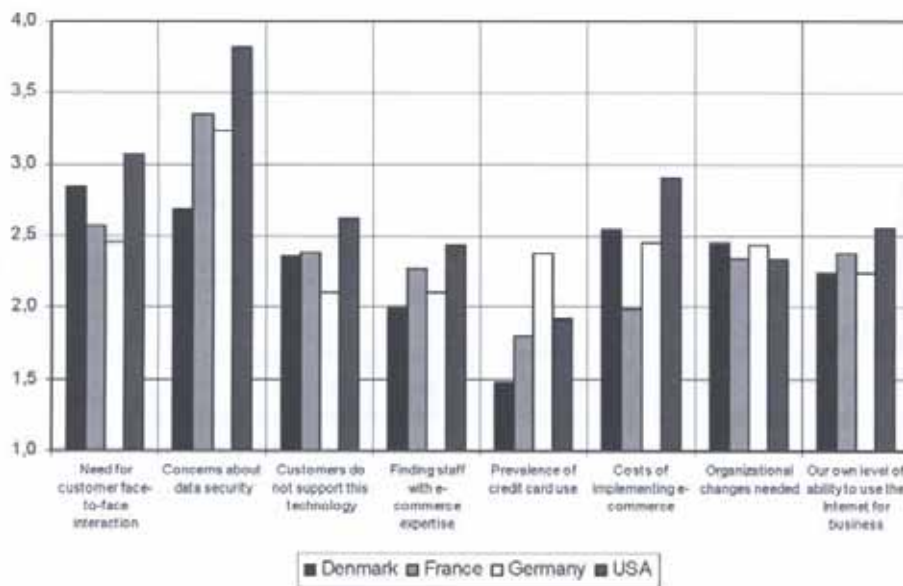


Figure 6. Factors impeding e-commerce for SMEs in the banking/insurance sector Source: Own survey, conducted by IDC

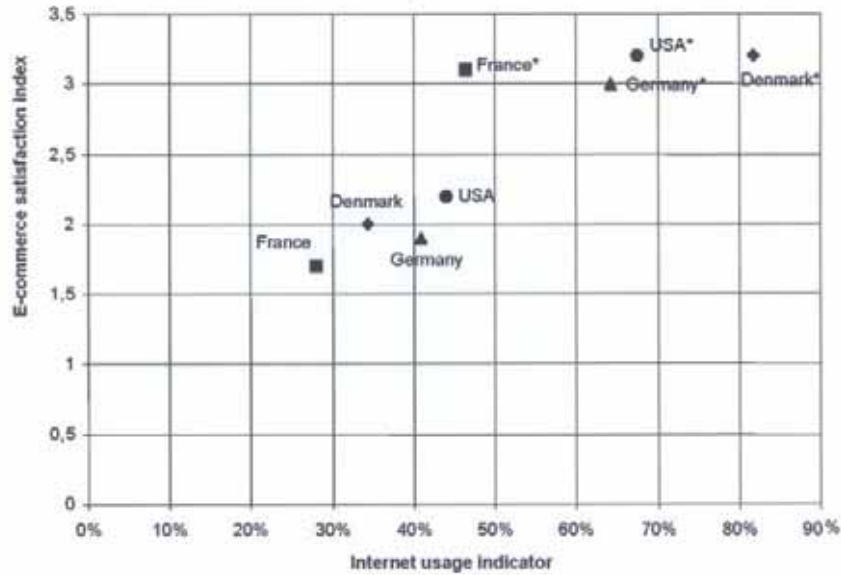


Figure 7. Results of the DEA analysis in the manufacturing sector DEA-efficient firms per countries are marked by \* Source: Own survey, conducted by IDC

SMEs are marked by \*. On average, efficient SMEs in the US use 63.5%, in Denmark 42.9% and in Germany 64.3% of the seven e-commerce technologies asked for and therefore significantly more than inefficient ones compared with both their national as well as international efficient competitors. The impact on business improvement (measured as the satisfaction index) is therefore also significantly higher among efficient SMEs compared to their relatively inefficient counterparts.

While inefficient German SMEs in the retail/wholesale sector deploy only 9.2% fewer e-commerce applications than efficient SMEs, the differences in

Denmark, with 24.1%, or France, with 22.3%, are quite large. In Germany, the percentage of efficient firms is higher and the gap between efficient and inefficient SMEs is not as large. This might be an indicator for a broader diffusion of advanced e-commerce solutions among the majority of the German retail/wholesale industry.

In the last industry sector investigated, the banking/insurance sector, the DEA uses 155 data sets as decision-making units (DMU) (Figure 9). On average, efficient small and medium sized banks in the US use 74%, in Denmark 78% and in Germany 68%, respectively, of the

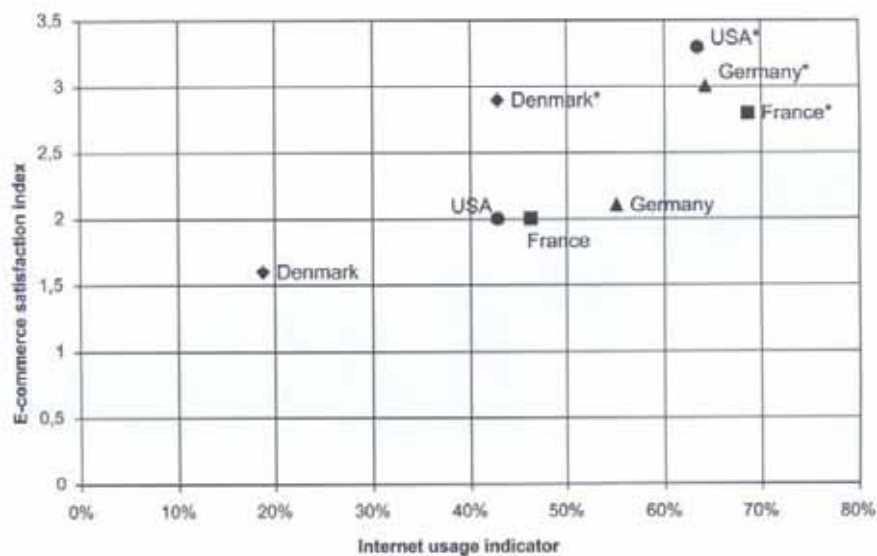


Figure 8. Results of the DEA analysis in the retail/wholesale sector DEA-efficient firms per countries are marked by \* Source: Own survey, conducted by IDC

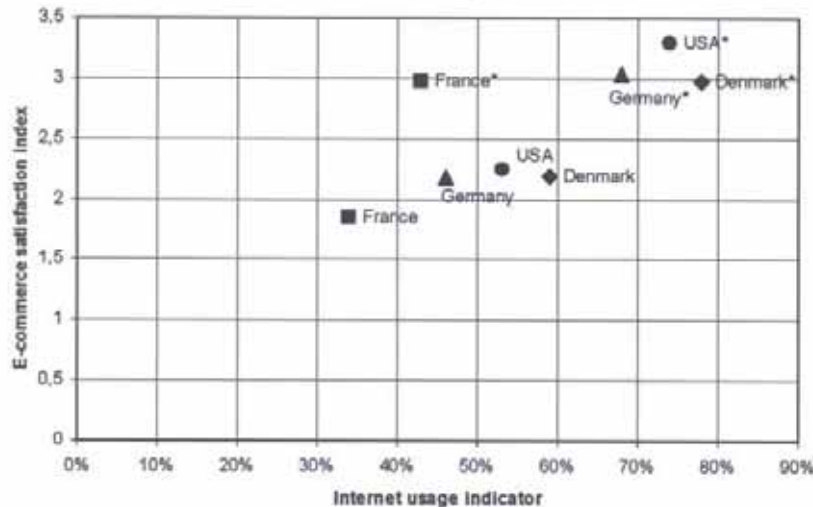


Figure 9. Results of the DEA analysis in the banking and insurance sector DEA-efficient firms per countries are marked by \* Source: Own survey, conducted by IDC

seven e-commerce technologies asked for. The impact on business improvement is measured as the satisfaction index for Denmark with 2.97, 3.03 for Germany and 3.29 for the US. Although efficient finance institutes in France are only using 43% of all available e-commerce solutions, the resulting satisfaction index, at 2.97, is as high as in Denmark. As expected, relatively inefficient banks in the sample used fewer e-commerce solutions, resulting in a lower satisfaction rate.

Based on the broad diffusion of e-commerce technologies, Danish and US SMEs reported the highest business improvements provided by employing all kinds of e-commerce applications (see Table 3).

While Danish SMEs in the manufacturing sector reported the largest positive impacts on their business processes on average, US SMEs in the banking/insurance sector were able to gain higher benefits by deploying e-commerce in nearly every area asked for. While in France only SMEs in the retail/wholesale sector are at the forefront in gaining the highest benefit of internal business improvements in the data sample, German SMEs in the manufacturing sector (internal business improvement 36.4%) or in the retail/wholesale sector (international sales increased 14.7% and procurement costs decreased 20.6%) are at the forefront.

As Proposition 1 suggested, e-commerce drivers have a significant positive impact on firms at the country level. Figure 10 provides the significant symmetric difference between DEA-efficient firms and the rest of the data sample on average. Efficient firms always perceive higher impacts by drivers of e-commerce than DEA-inefficient firms. Government-related drivers, as provided earlier, are not taken into account because they are insignificant for all countries analysed. On the other hand, there are no significant differences between DEA-efficient and

inefficient firms in relation to the asked for obstacles (with exception of recruiting employees with IT know-how and the prevalence of credit cards). Drivers seem to accelerate efficient firms significantly better than inefficient ones, especially in France where the average gap between both types of firms is highest in most cases.

A positive business environment seems, therefore, to have a significantly higher positive impact on firms applying e-commerce efficiently, whereas the obstacles tested are insignificant in terms of impeding efficient and inefficient firms.

According to the claim posited in Proposition 2, the correlations between the number of e-commerce applications deployed (e-commerce deployment) and the positive impact or efficient use on the industry level (impact of doing business online) are provided in Table 4, based on a Spearman significance test. Therefore, the correlations between the number of e-commerce applications used per firm in an industry in the rows (sum of used applications, see Table 2) and the efficiency increase, represented as positive impacts in the columns (see Table 3), are calculated.

As Proposition 2 indicates, there is a significant but weak correlation between the number of e-commerce applications deployed for SMEs (N) per industry and the perceived efficiency increases. The use of the rank order correlation coefficient reveals a monotonic relation among ordinally scaled data. While the results are very significant in the manufacturing and banking and insurance industry, in the retail and wholesale industry they are insignificant in terms of internal processes and staff being more efficient, as well as international sales being increased. Nevertheless, the efficient use of e-commerce applications seems to be positively correlated with the number of technologies deployed as has already been revealed by the DEA analysis.

Table 3. Impact of doing business online, i.e. percentage indicating impact is a great deal (4 or 5 on a five-point scale)

	Denmark			France			Germany			USA		
	M	R	B	M	R	B	M	R	B	M	R	B
Internal processes more efficient	31.4	38.7	31.3	26.5	27.3	22.2	36.4	29.4	28.6	32.0	24.5	36.5
Staff productivity increased	28.6	29.0	15.6	11.8	9.1	13.9	12.1	11.8	17.1	24.0	30.2	38.5
Sales increased	22.9	9.7	31.3	2.9	9.1	2.8	12.1	20.6	22.9	22.0	24.5	15.4
Sales area widened	20.0	16.1	25.0	8.8	12.1	16.7	18.2	26.5	22.9	40.0	35.8	30.8
Customer service improved	48.6	19.4	50.0	20.6	27.3	22.2	18.2	23.5	51.4	34.0	35.8	42.3
International sales increased	17.1	9.7	3.1	5.9	6.1	5.6	12.1	14.7	2.9	14.0	9.4	5.8
Procurement costs decreased	20.0	3.2	12.5	11.8	18.2	2.8	0.0	20.6	2.9	18.0	11.3	15.4
Inventory costs decreased	11.4	0.0	3.1	8.8	15.2	2.8	3.0	5.9	5.7	4.0	11.3	17.3
Suppliers coordination improved	28.6	16.1	18.8	23.5	30.2	19.4	27.3	17.6	14.3	28.0	28.3	28.8
Competitive position improved	28.6	12.9	31.3	2.9	21.2	8.3	18.2	23.5	37.1	34.0	32.1	28.8

M: Manufacturing, R: Retail/Wholesale, B: Banking/Insurance, SMEs: 25 to 249 employees

Source: Own survey, conducted by IDC

## 5. DISCUSSION AND CONCLUSIONS

Within the four countries studied (Denmark, France, Germany, US), the implementation of e-commerce has shown operational process improvements resulting in efficiency gains and to expand markets, as well as to thereby help to decrease costs. Firms with an all-embracing approach utilizing e-commerce applications are more often efficient than firms with a lower e-commerce diffusion rate. Although the nature of e-commerce applications is more or less the same, each country is following its own diffusion pattern or path, based on national differences recognizable in competition, existing and emerging IT infrastructure, business concentration, governmental regulations or even national mentality.

SMEs constitute the backbone of the economy in the countries studied. The vast majority of all firms are SMEs and they also employ the vast majority of people when compared to large firms. SMEs also create more jobs than large firms and SMEs exhibit considerable creativity and innovativeness. These small and medium-sized firms have solidly embraced e-commerce. One explanation may be that their leadership role in the economy coupled with their high degree of innovativeness triggered their innovator and early-adopter behaviour with regard to e-commerce diffusion. Conversely, one may argue that firms to which these SMEs are suppliers, especially when these firms are large firms, require SMEs to be e-commerce-ready. This creates for SMEs a particularly stringent imposition with regard to strategic positioning in the market in that larger firms are

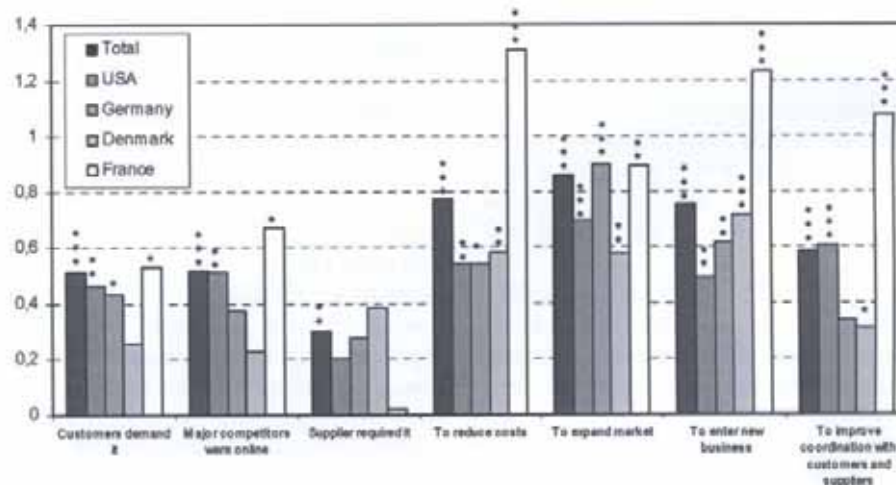


Figure 10. Significant differences among perceived drivers between DEA-efficient firms and the rest of the data sample \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$

Table 4. Number of e-commerce solutions deployed correlated with positive impacts and efficiency gains

	<i>E-commerce deployment Manufacturing (N= 152)</i>	<i>E-commerce deployment Retail/Wholesale (N= 151)</i>	<i>E-commerce deployment Banking/Insurance (N= 155)</i>
Internal processes more efficient	.299**	.114	.273**
Staff productivity increased	.371**	.091	.319**
Sales increased	.263**	.397**	.486**
Sales area widened	.474**	.357**	.390**
Customer service improved	.378**	.251**	.321**
International sales increased	.381**	.095	.303**
Procurement costs decreased	.432**	.207*	.366**
Inventory costs decreased	.389**	.233**	.241**
Suppliers coordination improved	.424**	.300**	.414**
Competitive position improved	.469**	.211*	.449**

\*\*  $p < .01$ , \*  $p < .05$

very likely not even interested in doing business with SMEs unless they are indeed already e-commerce-ready (Wigand 2003a).

According to Proposition 1 the efficient usage of e-commerce is indeed significantly related to positive national business environments. French firms have to cope with above average obstacles, resulting in low efficiency rates as the DEA analysis has shown. On the other hand, US firms seem to be confronted with high drivers and high inhibitors at the same time, enjoying a relatively large efficiency position.

SMEs in the three industries studied within the four countries utilize more or less the same high level of e-commerce applications. Although the *de facto* e-commerce readiness is clearly visible, in-depth statements about current usage-behaviour and intensity *per se* cannot be made, based on the design and questions asked in the underlying survey. The overall diffusion of e-commerce technologies may be described as high, but France, especially, is still lagging behind leading countries and sectors in terms of e-commerce technology diffusion.

While all industry sectors are more or less similarly well equipped, industry-related differences remain. At the industry level, the e-commerce-based improvement of internal processes are highest in Germany, while the overall impact of e-commerce together with the installed set of e-commerce technologies is highest in Denmark and the US.

SMEs inside the retail/wholesale sector benefit especially from Internet-based possibilities of online sales and procurement. In this area, German SMEs are leading in terms of e-commerce readiness with more e-commerce technologies in place than anywhere else. Although US retailers reported a lower diffusion rate in comparison to German or French SMEs, the impact on

efficiency was the highest, especially in the ability to widen sales or to improve customer services.

A similar situation may be observed in the banking and insurance sector, where again Danish SMEs are leading in terms of e-commerce technology diffusion, but US SMEs benefit most in reporting the highest impact of e-commerce in nearly all areas investigated.

The results of the two propositions tested, i.e. (1) DEA-efficient firms value drivers of e-commerce significantly more highly than other firms and (2) the efficient use of e-commerce is positively related to the number of e-commerce solutions deployed, have shown that much more research is needed in this under-researched area of diffusion and efficient use of e-commerce by SMEs. Comparable data about SMEs and their e-commerce activities are still in short supply. Therefore, this contribution can only be seen as a first step towards further empirical research about SMEs, impacted by fast e-commerce technology developments and global competition. Although the same e-commerce technologies may be available in every country or industry for SMEs, academic knowledge about the different modes of diffusion, usage and integration and, furthermore, the resulting benefits are still very limited. Several cross-country differences in responses may potentially have resulted from country-specific culturally biased response preferences.

#### ACKNOWLEDGEMENTS

We want to thank the anonymous reviewers, who contributed substantially to improving this paper. This research is a part of the Globalization and E-Commerce Project of the Center for Research on Information Technology and Organizations (CRITO) at the

University of California, Irvine. The present material is based upon work supported by the National Science Foundation under Grant No.0085852. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. This research is also supported by a grant from the German National Science Foundation ('IT-Standards and Network effects,' Grant No.220352). We gratefully acknowledge both organizations' financial support.

## References

- Angeles, R., Corritore, C. L., Basu, S. C. and Nath, R. (2001) 'Success Factors for Domestic and International Electronic Data Interchange (EDI) Implementation for US Firms', *International Journal of Information Management* 21(5): 329-47.
- Bala, K. and Cook, W. D. (2003) 'Performance Measurement with Classification Information: An Enhanced Additive DEA Model', *Omega - The International Journal of Management Science* 31(6): 439-50.
- Barr, R. S., Killgo, K. A., Siems, T. F. and Zimmel, S. (2002) 'Evaluating the Productive Efficiency and Performance of US Commercial Banks', *Managerial Finance* 28(8): 3-25.
- Beck, R., Weitzel, T. and König, W. (2002) 'Promises and Pitfalls of SME Integration', *Proceedings of the 15th Bled Electronic Commerce Conference: e-Reality: Constructing the e-Economy*, Bled, Slovenia.
- Beck, R., König, W. and Wigand, R. T. (2003a) 'Creating Value in E-Banking: Efficient Usage of E-Commerce Applications and Technologies', *Proceedings of the 7th Pacific-Asia Conference on Information Systems (PACIS)*, Australia, Adelaide.
- Beck, R., Weitzel, T. and König, W. (2003b) 'The Myth of WebEDP', in J. Monteiro, P. M. C. Swatman and L. Valadares Tavares (eds) *Towards the Knowledge Society, eCommerce, eBusiness and eGovernment*, Norwell, MA: Kluwer Academic Publishers, 585-99.
- Brynjolfsson, E. and Smith, M. (2000) 'Frictionless Commerce? A Comparison of Internet and Conventional Retailers', *Management Science* 46(4): 563-85.
- Cantwell, J. A. (2001) 'Innovation, Profits and Growth: Schumpeter and Penrose', Working paper no. 427, Reading, England: University of Reading, Department of Economics.
- Charnes, A. W., Cooper, W. and Rhodes, E. (1978) 'Measuring the Efficiency of Decision Making Units', *European Journal of Operational Research* 2(6): 429-44.
- Charnes, A. W., Cooper, W., Lewin, A. Y. and Seiford, L. M. (1994) *Data Envelopment Analysis: Theory, Methodology, and Application*, Amsterdam, Boston: Kluwer Academic Publisher.
- Chau, P. Y. K. and Hui, K.-L. (2001) 'Determinants of Small Business EDI Adoption: An Empirical Investigation', *Journal of Organizational Computing and Electronic Commerce* 11(4): 229-52.
- Cooper, W., Seiford, L. M. and Tone, K. (2003) *Data Envelopment Analysis - A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, Amsterdam, Boston: Kluwer Academic Publisher.
- Dutta, S., Segev, A. and Kwan, S. (1998) 'Business Transformation in Electronic Commerce: A Study of Sectoral and Regional Trends', *European Management Journal* 16(5): 540-51.
- Fearon, C. and Philip, G. (1999) 'An Empirical Study of the Use of EDI in Supermarket Chains Using a New Conceptual Framework', *Journal of Information Technology* 14(1): 3-21.
- Farrell, D., Fassbender, H., Kneip, T., Kriesel, S. and Labaye, E. (2003) 'Reviving French and German productivity', *The McKinsey Quarterly*, Number 1.
- Fink, D. (1998) 'Guidelines for the Successful Adoption of Information Technology in Small and Medium Enterprises', *International Journal of Information Management* 18(4): 243-53.
- Golany, B. and Roll, Y. (1989) 'An Application Procedure for DEA', *OMEGA International Journal of Management Science* 17(3): 237-50.
- Gordon, R. J. (2000) 'Does the New Economy Measure Up to the Great Inventions of the Past?', *Journal of Economic Perspectives* 14(4): 49-74.
- Hausman, A. and Stock, J. R. (2003) 'Adoption and Implementation of Technological Innovations Within Long-term Relationships', *Journal of Business Research* 56(8): 681-6.
- Hawkins, R., Mansell, R. and Swan, P. (1999) *The Economic and Social Impact of Electronic Commerce: Preliminary Findings and Research Agenda*, Paris: OECD Publications.
- Hoppen, N., Fricke, M., König, W. and Pfitzer, D. (2002) 'The Role of Bilateral B2B e-Procurement in the European Automotive Industry - Results from an Empirical Survey', *Proceedings of Americas Conference on Information Systems (AMCIS)*, Dallas, USA.
- Iacovou, C. L., Benbasat, I. and Dexter, A. S. (1995) 'Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology', *MIS Quarterly* 19(4): 465-85.
- Jalava, J. and Pohjola, M. (2002) 'Economic Growth in the New Economy: Evidence from Advanced Economies', *Information Economics and Policy* 14: 189-210.
- Karahanna, E. and Straub, D. W. (1999) 'Information Technology Adoption Across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs', *MIS Quarterly* 23(2): 183-213.
- Ketler, K., Willems, J. R. and Hampton, V. (1997) 'The EDI Implementation Decision: A Small Business Perspective', *Proceedings of the Association for Computing Machinery*, 70-6.
- Kiiski, S. and Pohjola, M. (2002) 'Cross-country Diffusion of the Internet', *Information Economics and Policy* 14: 297-310.

- König, W., Wigand, R. T. and Beck, R. (2003) 'Globalization and E-Commerce: Environment and Policy in Germany', *Communications of the AIS* 10: 33-72.
- Kraemer, K. L. and Dedrick, J. (2000) *European EC report*, Center for Research on Information Technology and Organizations. University of California, Irvine, online at: <http://www.crito.uci.edu/git/publications/pdf/european-EC-report2.pdf> [accessed 1 May 2003].
- Kraemer, K. L., Dedrick, J. and Dunkle, D. (2000) *EC in the United States: Leader or One of the Pack?*, Center for Research on Information Technology and Organizations. University of California, Irvine, online at: <http://www.crito.uci.edu/publications/pdf/GIT/GEC/USsnapshot.pdf> [accessed 1 May 2003].
- Lee, H. L. (1998) 'Postponement of Mass Customization', in J. Gattorna (ed.) *Strategic Supply Chain Alignment. Best Practice in Supply Chain Management*, Aldershot, Hampshire, UK: Gower Publishing Limited, 77-91.
- Mackay, D. and Rosier, M. (1996) 'Measuring Organizational Benefits of EDI Diffusion: A Case of the Australian Automotive Industry', *International Journal of Physical Distribution and Logistics Management* 26(10): 60-78.
- Masseti, B. and Zmud, R. W. (1996) 'Measuring the Extent of EDI Usage in Complex Organizations: Strategies and Illustrative Examples', *MIS Quarterly* 20(3): 331-45.
- Oliver, R. K. and Webber, M. D. (1992) 'Supply Chain Management: Logistics Catches Up With Strategy', in M. Christopher (ed.) *Logistics - the Strategic Issue*, London: Chapman and Hall, 63-75.
- Parsons, L. J. (1992) 'Productivity Versus Relative Efficiency In Marketing: Past And Future?', in G. Lilien, G. Laurent and B. Pras (eds) *Research Traditions in Marketing (Recent Economic Thought)*, Amsterdam: Kluwer Academic Publisher, 169-96.
- Powell, P. and Levy, M. (2000) 'Information Systems Strategy for Small and Medium Sized Enterprises: An Organisational Perspective', *Journal of Strategic Information Systems* 9(1): 63-84.
- Rose, G., Khoo, H. and Straub, D. W. (1999) 'Current Technological Impediments to Business-to-Consumer Electronic Commerce', *Communications of the AIS* 1(16): 1-74.
- Saloner, G. and Shepard, A. (1995) 'Adoption of Technologies with Network Effects: An Empirical Examination of the Adoption of Automated Teller Machines', *The RAND Journal of Economics* 26(3): 479-501.
- Scheel, H. (2000) 'EMS: Efficiency Measurement System' online at: <http://www.wiso.uni-dortmund.de/lsfg/or/scheel/ems/>, [accessed 9 November 2002].
- Swaminathan, J. M., Smith, S. F. and Sadeh, N. M. (1998) 'Modelling Supply Chain Dynamics: A Multiagent Approach', *Decision Sciences* 29(3): 607-32.
- Tucker, M. (1997) 'EDI and the Net: A profitable partnering' Online at <http://www.datamation.com/PlugIN/issues/1997/april/o4ecom.html> [accessed 11 November 2002].
- Wigand, R. T. (2003a) Electronic Commerce, *Encyclopedia of International Media and Communications (Vol. 1)*, San Diego, CA: Academic Press/Elsevier Science, 489-503.
- Wigand, R. T. (1994) 'Electronic Data Interchange in the United States of America: Selected Issues and Trends', in W. Kilian et al. (eds) *Electronic Data Interchange aus ökonomischer und juristischer Sicht: Forschungsbericht zu dem von der Volkswagenstiftung geförderten Forschungsprojekt ELTRADO (Elektronische Transaktionen von Dokumenten zwischen Organisationen)*, Baden-Baden, Germany: Nomos Verlagsgesellschaft, 369-91.
- Wigand, R. T. (2003b) 'Emerging Electronic Markets at eBusiness Crossroads: Competitive and Regulatory Issues in the Electricity Industry', *Prometheus: The Journal of Issues in Technological Change, Innovation, Information Economics, Communications and Science Policy* (20th Anniversary Special Issue, invited article) 21(4): 415-28.