THE DEVELOPMENT OF ELECTRONIC DATA INTERCHANGE NETWORKS FROM AN INSTITUTIONAL PERSPECTIVE

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Introduction

This paper focuses on the economic forces that shape the development patterns of computer-based information and communication networks. This, however, requires a shift of perspective. Economic forces are not just limited to the bounds of organizations which interact in a cultural, national or regional environment, but arise from the interaction processes between companies. Thus it is necessary to include these 'network effects' in the theoretical framework which is to be used for analysing and understanding the development of technically based networks. Network effects are located on an institutional level as compared with economic effects on the organizational level. We will discuss these topics by referring to several case studies which deal with the establishment of Electronic Data Interchange (EDI) networks.

The development of EDI networks has opened a new branch in the telecommunication industry which is expected to be expanding in the near future considerably. The EC even expects the telecommunication industry to take over the role as the key industry in Europe. Data communication is considered a major element in this scenario although at the time being it does only cover a small fraction of the total telecommunication market. Thus the development of EDI networks is of major relevance for the future competitive strength of the European industry.

Nevertheless, theoretical understanding of the economic forces behind the development of EDI networks is limited and there is little empirical knowledge so far. Most analyses of related topics, however,

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remain on a descriptive level which does not allow for generalization. It seems as if traditional analytical tools in those disciplines that deal with innovation, diffusion, new technologies etc. cannot be employed in the analysis of EDI networks. This in our view is due to the 'network' aspect of EDI. Whereas traditional analysis could afford to either focus on single organizations or treat economic subjects as atoms which interact in a macrosystem, the analysis of networks must address both aspects, i.e. the micro and macro levels, into account. It is necessary to analyse organizational structures in order to understand the relationships between organizations as well as the organization of the network itself. The startling task is to do two things at the same time: focus on the elements of a network and do not lose analytical grip of the network itself.

If one adopts the social shaping of technology perspective it should be clear that the development of new technologies cannot be understood by deducing their future prospects from the technical characteristics only. Instead it is necessary to look at the social system, in which the new technology is embedded. Having a glance at recent EDI literature it is revealed that the method of deducing future developments from technological characteristics is still dominant. Phrases such as 'EDI will quicken communication flows and thus lead to reduction in stocks' or give rise to other clearly desirable outcomes are still frequent. The future of EDI is still commonly derived from the potential it has in the eyes of its commentators. This perspective often leads to confusion when new technologies do not disperse and unfold their inherent opportunities as expected including all the social changes that have wishfully been linked with the new technology treated here (e.g. videotex and the decentralization of work).

The structure of the paper is as follows. First a short outline of three case studies in the field of consumer goods industries is presented. Second a concise theoretical framework for understanding the development of EDI networks is introduced. Then this is followed by in interpretation of the case studies in the light of this theoretical framework. Finally some conclusions for further theoretical efforts and possible policy implications are drawn.

Case studies

The first case deals with the set-up of a system which eases the exchange of electronic data concerning high value product descriptions. These data are to be used as input in electronic planning systems in the retail of tailored kitchen furniture. The standardisation

of a data format which is at the core of the set-up process was monitored by software companies which supplied retail shops with the planning system. The guiding principle was the idea of a cost-saving potential by centralising input activities for all vendors of the planning systems (which already incorporate the product data of specific kitchen manufacturers). The bargaining took place between software companies and manufacturers. The latter preferred a data format which was able to comprise a great variety of products and hence would be rather voluminous. The former were interested in reducing the size of the data format since they were mainly interested in cutting the costs of data transcription. The process took place in a working group having formed a committee for the purpose of standardisation. The first attempt having failed it took the participants seven years to make their project a success. (see figure 1)

The second case study concerns an information system for the electronic exchange of market data in the footwear industry. The concept for this information system was designed by a consulting company on behalf of an official authority as part of an industrial development project. The main result of this analysis was that German shoe manufacturers were poorly informed about what was happening in the consumer market. Therefore the system was to strengthen the manufacturer's market competence. The article numbering standard resembles the European Article Number (EAN), which inspired the consulting company. The data format which contains all types of data to be exchanged and also describes their respective relationships was very complex and included a lot of options for compiling statistical data about market developments. The finally accepted standard represents only a small fraction of the initially far-reaching goals due to the neglect of the interest of purchasing companies, which consider the comparison of their member's market performance an essential part of their business policy. For two years the system has remained on a pilot-project level. A development, similar to the formerly described project, seems unlikely (see figure 2).

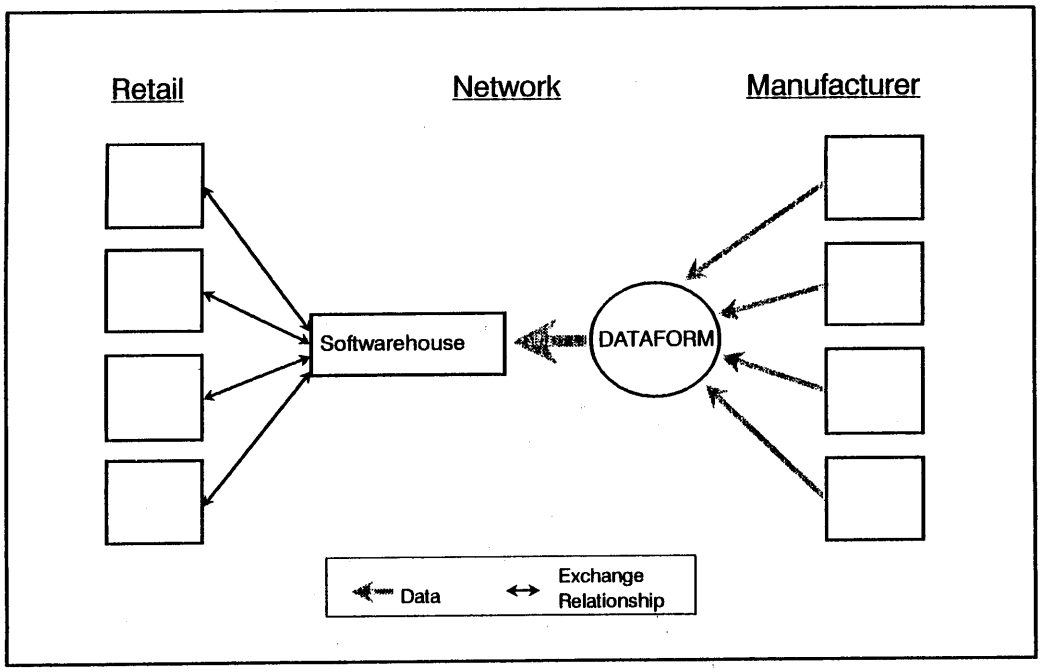

Figure 1: Interchange of Electronic Product Data Descriptions in the Kitchen Industry

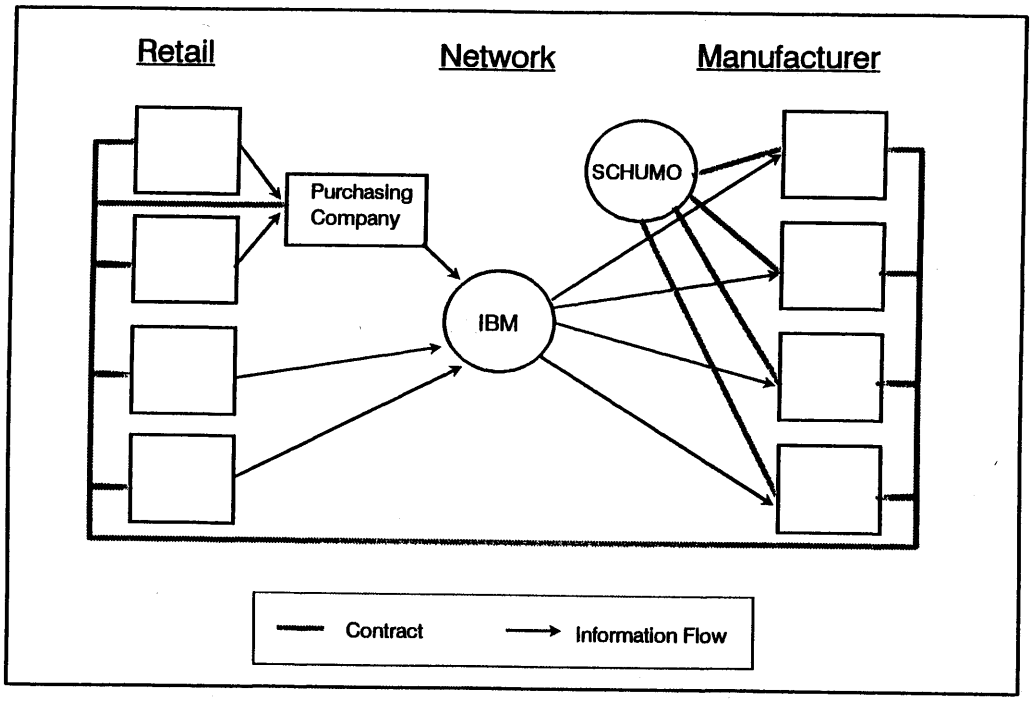

Figure 2: Electronic Interchange of Market Data in the Footware Industry

A network service for the electronic exchange of business data in the clothing industry is subject of the third case study. The basic idea behind the development of this network service was the concept of 'Quick-Response' in the fashion market, aiming at the ability to react towards changes in consumer preferences within a very short time. The main activities in establishing the VAN were carried out by a textile retailer. Other important players were a software company which promised to provide access to about 2000 users of a stock-management system and a textile manufacturer who developed a CIM-system. These three actors formed a pressure group which tried to put through a proposal for a data format as an EDIFACT-subset in order to increase the incentives for participation in the planned VAN. These activities collided with the attempt of the European Article Numbering Association to develop an EDIFACT-Subset on the basis of the European Article Number (EAN). Hence potential users got mixed up about the future situation and preferred to wait until a clear winner appeared (see figure 3).

Theoretical framework

The set up of an EDI-network concerns the way companies exchange information. Thus the question arises whether the process of information exchange is just transferred to a new a technical medium or will instead be altered by the use of EDI. If only the former is true, some improvements in the way information is exchanged can be expected, i.e. faster and/or cheaper delivery of data. In this case, organisational and institutional change might be induced on the level of carriers, e.g. National Telecom Services might be substituted by private VANs. We will not deal with these forms of changes further on.

Nevertheless, the common thesis is that EDI will change the structure of the information exchange process. Thus organisational change is assumed a necessity in the course of introduction of EDI. Although we do not want to question this thesis we contend that organisational factors do not sufficiently explain development patterns of EDI and claim that institutional factors must be taken into account. That in the first place means that there are at least two institutionally distinct actors who have to co-ordinate their actions (if we leave EDI-links between companies and subsidiaries etc. aside). It is this aspect of co-ordination that requires special attention since the development of EDI might be hindered by merely institutional factors, which would otherwise have become an EDI success.

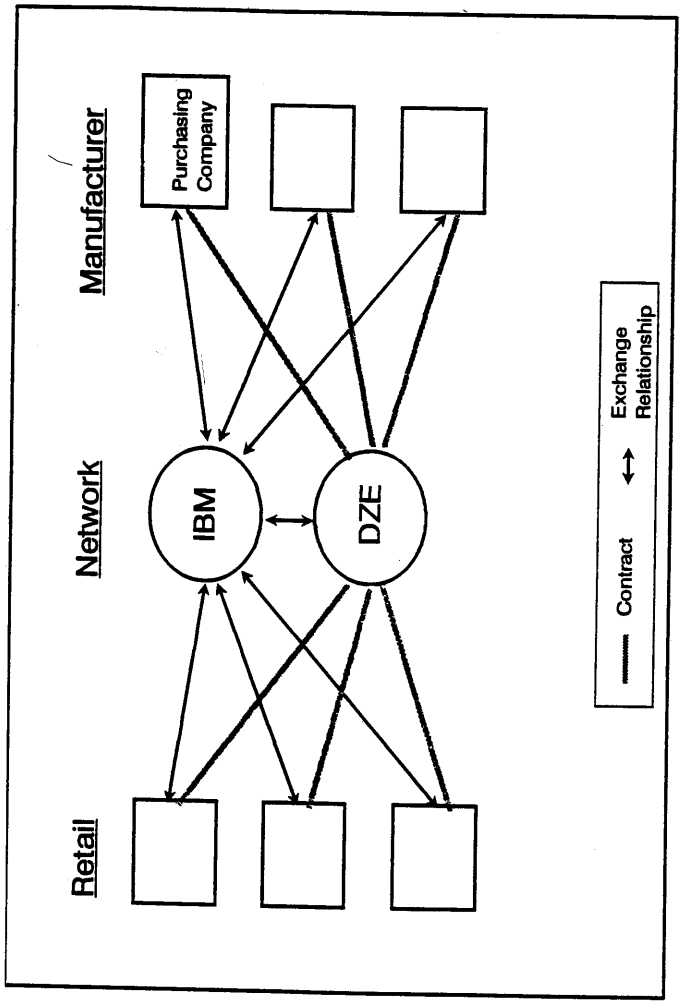

Figure 3: Electronic Data Interchange in the Clothing Industry

In order to come to grips with organisational and institutional factors that are shaping the development of EDI we propose to first analyse both aspects separately. Thus costs and benefits of EDI must be evaluated on an individual and on a collective level respectively. The individual level concerns the internal EDI impact for an organisation. At the same time EDI has by definition external effects that also influence cost/benefits of actors within the EDI network. These external effects will shape the collective action that might or might not result in the set up of an EDI network. Thus collective action will change the institutional framework for individual action, thus linking micro and macro level.

On the level of an individual organisation the exchange of data via EDI might change the informational relationship between the organisation and its business partners. To understand this it is useful to distinguish between general and special information. Both types of information induce some kind of transaction, e.g. the delivery of goods or the transfer of payment. Special information has to be transmitted each time a distinct transaction should be started. General information in contrast only requires part of the information to be transmitted whereas the other part is stored locally. The locally stored part of the information is activated as a function of the transmitted part. The splitting of information is achieved by comprising those parts that are constant in each instance of transaction. It is then only necessary to transmit that part of information which is unique for a specific transaction. The splitting of information in a constant and a unique part is called a transformation (Kosiol, 1972). Standardisation of data formats often imply such a transformation on the level of an individual organisation.

This is the case if the relationship between the constant and the unique part is changed by the standardisation of data formats. Such a kind of change could be expected if the level of generality is shifted by standardisation. E.g. it might be relatively easy to define a data format for a given set of users that communicate on the basis of procedures which are already standardised. The definition of the data format then just requires the transcription of these procedures. If the level of generality is raised by standardisation the relationship between the constant and the unique part of transactional information units will be altered, otherwise the amount of special information must be increased. This can be illustrated by reference to EDIFACT experiences. Recent disputes about the further development of EDIFACT have focused on the question, whether the number of segments should be extended (New Principles) or rather the number of segments restricted to the existing set, whereby new flexibility

demands would be handled with by extending the number of codes and qualifiers (Quality Control Policy) (Foray 1991). The former would increase the amount of special information necessary for each transaction, the latter the amount of locally stored information.

The transformation of special into general information allows for the rationalisation of internal procedures. E.g. payment or delivery procedures could become routine through the use of general information and would be automated via EDI. These rationalisation effects are the higher the more data are to be processed for each instance of transaction, i.e. the higher the volume of data to be exchanged with one business partner. Since the volume of data are normally not equally distributed among business partners it is assumed that there are few business partners with whom the co-ordinated transition towards common EDI procedures promises high rationalisation effects and a bulk of others which offer rather small rationalisation effects when joining the EDI network.

On the other hand the increase of business partners normally require additional equipment and competence. E.g. the number of codes for article number etc. will increase with the number of EDI partners, if there has been no prior standardisation effort. Also converters which cope with different data formats, transmitting protocols etc. are becoming increasingly complex. Sometimes it will be necessary to add hardware components in order to electronically communicate with additional business partners. Thus the rationalisation effects might be counterbalanced, rendering the EDI participation economically objectionable. In figure 4 the curve NI represents the net internal benefits of EDI in relation to the number of participants, which is composed of internal rationalisation effects on the one hand and additional requirements through new participants. We propose that the values of the NI curve could become negative as the number of participants increases.

Nevertheless, it is possible to mitigate these effects by collective action, e.g. standardisation or joint VAN operation. Otherwise we would expect serious limits to the development of EDI which are illustrated by the intersection of the NI curve with the horizontal axis in figure 4. Thus we have to ask, which economic factors shape the collective action that aims at changing the institutional setting of the network. These external effects consist of positive network effects and of opportunity costs. Positive network effects stem from the saving of transaction costs, that would exist if an EDI system is to be established by a set of bilateral contracts between business partners. The transaction cost savings are thus the larger the more business partners participate in a multilateral contract system. Examples of such kind of systems are closed user groups like EDIFICE,

EANCOM, CEFIC etc. as well as the world wide potential user group for EDIFACT.

The participation in a new EDI network system also has opportunity costs. Opportunity costs can occur either when there are established patterns of communication, or other EDI systems exist which have to be disposed of i.e. whose benefits could not be used effectively, e.g., a firm might have developed effective routines for delivery procedures with a huge body of local knowledge which will be made useless by the transition to EDI procedures. Similarily there might already exist EDI networks which already confer considerably benefits to their users. A change to a wider network results at least in a partial loss of some of the former network's benefits. The combination of positive network effects and opportunity costs is indicated by the curve NE in figure 4. Opportunity costs of participation in a new network may offset its positive network effects if only a small number of business partners participate. The values of the external effects gradually become positive as the number of participants grows.

Finally only internal and external effects together reveal the true potential of EDI for each organization. It is thus necessary to understand how the NI and the NE curve are related. Of course, collective action aims at improving the results of internal rationalization which means an anti-clockwise rotation of the NI curve in point A. The success of the collective action, however, is not guaranteed, since standardisation efforts could be counter-balanced by additional requirements through the storage of local information or the extension of data formats as demonstrated for the EDIFACT example (see above). The collective efforts result in a changed position of the NI curve indicated by the NI* curve. Thus the aggregate of the NE and NI* curves indicates the break-even of participation in the collective action aimed at the establishment of a multilateral EDI network system. Beyond this point (CM for critical mass) participation in the network is self enforcing. Up to this point the development of a multilateral network system will not take off unless some other incentives are provided; instead a network system based on bilateral contracts will evolve whose growth is limited to the point MN (maximum number of participants).

The existence of a critical mass for a collective action clearly shows that the development of EDI networks cannot be fully understood from the point of view of a single organization. There is an 'institutional gap' which cannot be overcome by collective efforts unless some institutional arrangements are offered. Otherwise economic behavior will result in a bilateral approach which seriously limits the development of the EDI network. Different institutional

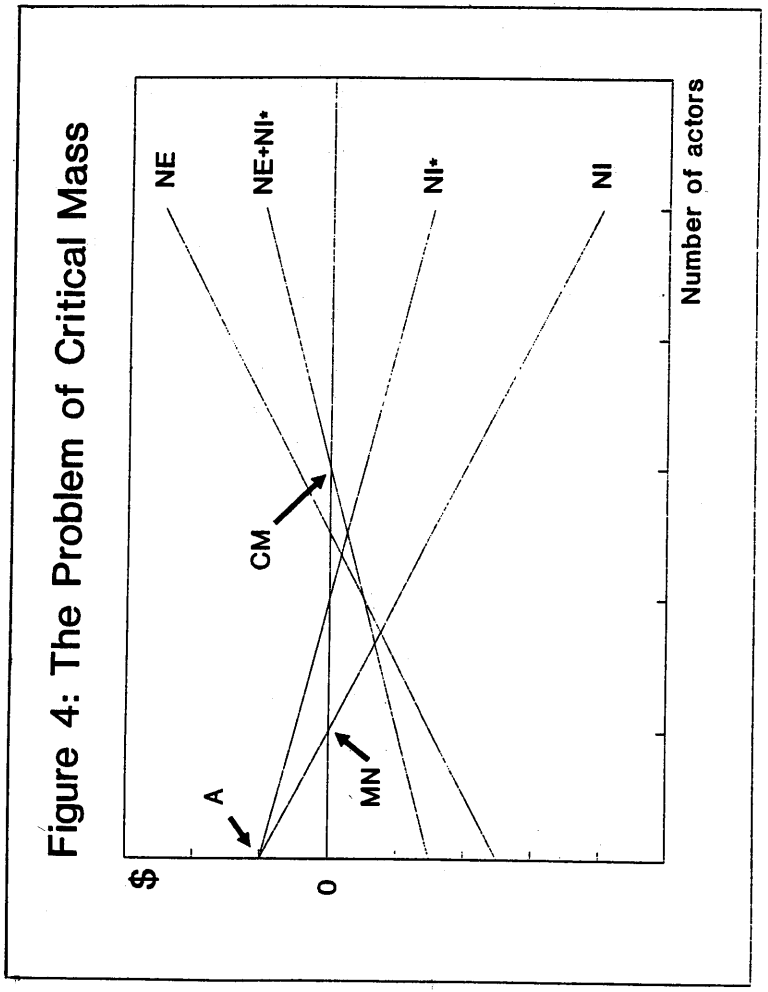

Figure 4: The Problem of Critical Mass

solutions are possible which will be demonstrated by a discussion of the three case studies in the next section.

Interpretation of case studies

In order to understand the differences between the three case studies two aspects should be distinguished. First it is necessary to analyse the costs and benefits of those actors who take a rather passive part in the developing process, i.e. who decide on the basis of the current state of development whether to participate or not. These actors are only interested in an effective use of the system. Second the problem of critical mass has to be examined. According to the analysis presented above, it is clear that network development processes do not start right away, but display a considerable inertia in the initial phase due to negative values of the aggregate of internal and external effects. Therefore there must be actors who are interested in the set up of a network since otherwise multilateral network systems would not develop. These actors are of an entrepreneurial type, since they can look forward to considerable profits from the set up of a new network.

To analyse the passive type of actors using the theory outlined above the internal and external effects must be examined and their combined effects evaluated. With respect to the problem of critical mass three distinct possibilities of overcoming the initial inertia in the development of networks will be illustrated.

The data format for the kitchen industry had to be accepted mainly by the manufacturers. A first attempt failed because the manufacturers were reluctant to participate in the system. This raises the question of the kind of costs and benefits manufacturers can derive by participation. The manufacturers' interest in introducing electronic planning systems in the retail of kitchen was to simplify the visualization of a tailored kitchen, to ease the calculation of final prices and to avoid haggling with retailers through inaccurate orders. On introducing electronic planning systems a huge rationalization potential might be realized. On the other hand individual actions of manufacturers were soon limited by the enormous increase in either proprietary systems in retail shops or data volume handled by software companies. Thus rationalization effects tended to be offset by additional costs through the unco-ordinated introduction of planning systems.

The co-ordination of manufacturers' actions, however, initially had considerable opportunity costs, since some manufacturers had to

give up competitive advantages through the introduction of proprietary systems, and others had to confine their product descriptions to the limits of the data format, if they originally did not use their own planning systems but relied upon the services of software companies to supply planning systems. Positive network effects could, nevertheless, be derived from the saved transaction costs that otherwise would originate from the interaction with software companies or retail shops since they could save a lot of duplicate work or duplicate computer systems. In that way the coordination of the manufacturers' actions required that a critical mass of manufacturers participated in it. The question now is how this critical mass could be organized.

The software companies had a major interest in solving the problem which arose form uncoordinated actions since they had to transcribe product descriptions into electronic formats and transfer these costs via the prices for their planning systems to their customers, i.e. retail shops. This way of handling increased costs proved increasingly problematic because small service providers were willing to offer transcription services at low prices. Attaching a data quality guarantee to their products and at the same time reducing the costs of data transcription software companies tried to add value to their products. This required the foundation of a central agency for the data transcription, which also functioned as a quality certification institution. A significant reduction in transcription costs could be achieved by standardization of data material so that any manufacturers' product data could be combined with any software company's planning system. This incentive proved to be sufficient to organize the critical mass of manufacturers that finally agreed on one data format. After one year of operation about 100 manufacturers were participating, with about three new manufacturers currently joining the network every month.

In contrast, the information system in the footware industry was set up by a consulting company which was asked to find measures for improving the competitiveness of German manufacturers. The main insight of the consultant was that the information flow between retail and manufacturers had to be improved. In order to bring this analysis to an operational level, the consultant presented a concept which essentially consisted of a technical system of information exchange. The idea was to establish an information flow and at the same time economise on this information flow by using technical means of information exchange. The information flow was originally designed to be bilateral, i.e., manufacturers receive market data for their products and return compiled data for each retail shop. Nevertheless, only the information flow from retail to manufacturers

was to be supported by new technology. Retail shops and manufacturers were expected to contract the terms of informational support bilaterally through manufacturers, which not only included the transmission of compiled data but also advisory support to the retail shops.

Again the question arises of what benefits the information system might provide for participants. Government intervention sheds some light on this question, as it has been necessary to force manufacturers into this kind of coordination via monetary incentives (manufacturers would have had subsidies cut off if they refused to participate). Thus the government intervention has rather the character of providing merit goods. The larger manufacturers had also their own measures of evaluating their market performance, e.g. panel services or bilateral contracts with some customers providing them with a sample of market data. These companies could not see any additional benefit in participating in the new information system, although they were aware of structural problems in the German footware industry. In their opinion, the system would mainly benefit small companies that could not afford to set up information channels on their own.

Drawing a conclusion from this case, one can say that the benefits of the information system were small compared with existing systems of market data creation, which created high opportunity costs for the large shoe manufacturers. A change from bilateral relationships to a system of multilateral contracting would thus have rendered inevitabe the participation of a great number of manufacturers to offset the high opportunity costs through positive network effects. Accordingly, the development of the information system did not take off. After one year it still remained at the level of a few pilot projects with some of the big manufacturers having adopted a wait-and-see position.

The establishment of a system for the electronic exchange of business data in the clothing industry promised a huge rationalization potential combined with savings in lead time, which is especially important in this fashion oriented industry. It is a classic case of EDI, since it comprises all potential kinds of information flows, initially focussing on orders and invoices. It is normally assumed that a co-ordinated action might increase the benefits of EDI enormously since a vast amount of converters and bilateral contracts would become superfluous. Because of the medium sized character of this industry there are only few EDI links on a bilateral basis demonstrating that the rationalization potential is not as evident as it is normally assumed.

Nevertheless, the benefits of co-ordinated action seemed clear and different solutions were conceived. An important initiative was started by one owner of a retail outlet together with a software company which planned to set up a Value Added Service (VAN) network for the clothing industry. In order to increase the incentives of participating in a coordinated action the initiators tried to define a data format which they wanted to be accepted as an EDIFACT subset. Since this attempt has not been successful industry and retail are still hesitant to participate. A major factor to be taken into account is that there exists an alternative network for the whole consumer goods industry. The operators of this alternative network tried to have their network accepted by the EDIFACT board. This alternative network seems to be much more successful than the initiative of the clothing industry. This is the well established German branch of the International Article Numbering Association, which runs a EDI system and makes considerable effort in establishing an own EDIFACT subset, called EANCOM.

The interesting aspect about this case study is that we have a profit oriented approach in overcoming the problem of the critical mass. This means that different EDI service providers compete on the market, thus increasing the opportunity costs of users, i.e. the critical mass. Although rationalization effects are considered to be relevant and a multilateral approach is welcome by all participants, the efforts of the initiators did not succeed in organizing the critical mass because of a market mediated development process generating external effects which consist of high opportunity costs through competitive actions.

Conclusion

Our conclusion is two-fold. On the one hand we refer to the political implications of different set-up patterns. On the other hand we analyze the consequences of our case studies for theoretical approaches towards understanding the development of EDI networks.

The case studies demonstrate that different ways of overcoming the problem of the critical mass could result in different development patterns. In the case of the EDI network in the clothing industry a market oriented approach was started to combine the efforts to organize a critical mass with the commercial activity of setting up a VAN. From this we draw the conclusion that such an approach might cause problems when different systems compete, due to positive network externalities that are expected, if one of the systems will take

off. These effects will force potential participants into a wait and look position since they would otherwise take the risk of having put their stakes into the wrong system. (see figure 5)

In the case of the information system in the footware industry the attempt to externally organize the critical mass came up against the problem of proper examination of the costs and benefits of a mulitlateral approach compared with different bilateral contracts. In this case it seems as if the benefits were not properly calculated and monetary incentives not sufficient to move potential participants into a multilateral system of information exchange.

The example of the data format in the kitchen industry reveals an interesting solution because of the combination of market and organizational mechanisms. On the one hand the software companies had a commercial interest in organizing the critical mass of manufacturers, on the other hand they restricted themselves by setting up a non-profit organization for the operation of the system. This result could be achieved, because the market for software products is complementary related to the kitchen market, thus enabling software companies to take over the role of a catalyst. They could organize the critical mass without linking this effort with an immediate commercial interest. Instead they were collectively able to neutralize the commercial aspect via a non profit organization. Nevertheless, their effort was economically motivated by increasing the quality of their products and reducing prices. But these economic effects are not deriving from the operation of the network itself. This is the important difference between the EDI network in the clothing and the kitchen industry.

Finally some conclusions on the more theoretical level should be drawn. The three case studies demonstrate that the logic of networks is different from the logic of markets and hierarchies (Mayntz 1992). Whereas actors in a market setting interact via bargaining procedures which might have some unintended results, e.g. negative internal effects through a strictly bilateral EDI approach, the set up process of the analyzed EDI networks required coordinated action which intentionally aimed at a collective result. In contrast these forms of coordinated actions could not be achieved by a command mechanism as it is used with hierarchies (like companies). Instead a negociation process had to be used in order to coordinate individual activities. We found, however, that the coordination of individual actors is itself shaped by economic factors which are described by the problem of critical mass. Different institutional settings are possible in overcoming this problem. Among the three presented solutions - market coordination, government intervention, coordination through complementary markets - the latter proved

most successful. Here a third party acts as a catalyst neutralizing economic motives and at the same time being itself driven by commercial interests.

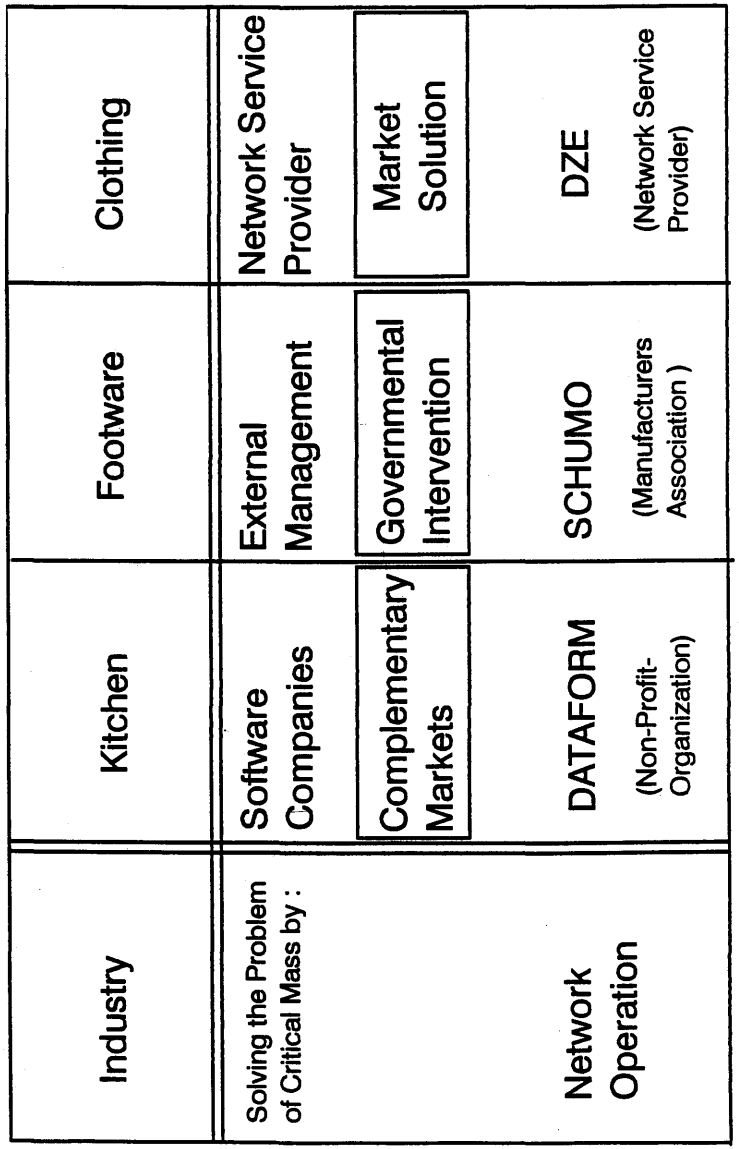

Figure 5: Comparison of the Three Cases

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