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Electronic Data Interchange: EDI One of the Means of Realizing Computer Integrated Manufacturing

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ELECTRONIC DATA INTERCHANGE

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FOREWORD

This paper presents work done during the summer of 1989 by a member of the Young Scientists Summer Program (YSSP) at IIASA. It is of special interest to those involved in the CIM project, and its collaborators.

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ELECTRONIC DATA INTERCHANGE

EDI one of the means of realizing Computer Integrated Manufacturing

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1. INTRODUCTION

The main focus of the CIM[1] research project of IIASA[2] is on flexible manufacturing systems (FMS). FMS is the automation and integration of production.
But FMS is not the end of production automation, integration with other systems will proceed much further than is now the case. FMS, CAD, administrative systems will be part of one integrated system: CIM.

In the present paper, the emphasis is on the integration of the administrative systems, especially between independent companies. In a logical order: First realize the internal integration through FMS, CAD,... Second, the external integration with customers and suppliers. Several companies are at the moment moving in this direction.
Several new means of communications are introduced in support of external integration, as communication is in many cases the weak link in the chain. Examples of these new means of communications are:

- fax
- videotext
- teletext
- electronic dialogue with external databases
- EDI[3]
- tele conferencing
- ....

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[1] CIM = Computer Integrated Manufacturing

[2] IIASA = International Institute of Applied System Analysis in Laxenburg, Austria.

[3] EDI = Electronic Data Interchange

Because of the expected growth and importance of EDI in coming years, this communication technique will be discussed in some detail.
So many companies are interested in implementing EDI, that not to do so is tantamount to being out of date..
Some people think that this 'EDI-boom' is just a new fashion, a modish phenomenon, a simple matter of technique.
But EDI is a new information technology which not only replaces the telephone or post, but also changes whole organizations and branches.
The impact of implementing EDI is far more than expected, what will be illustrated in section 3 with the description of some EDI-related fields.

But first of all a definition of EDI will be given in section 2.
Some figures from literature on the diffusion of EDI and the resultant savings are summarized in section 4.
The main conclusions will be stated in section 5. In section 6 is final observations are written.

2. DEFINITION EDI

2.1. Introduction

The first thing is to explain the phenomenon of EDI. The differences between EDI and the other mayor electronic means of communication mentioned earlier will be discussed in paragraph 2.3.
Reasons for using EDI are referred to in the last paragraph.

2.2. What is EDI?

The proposed definition of EDI is:

'EDI is the automatic transfer of structured business information in electronic form between the computer systems in separate organizations.'

Further elucidation of this definition is given below:

'automatic'
The data flow is produced and initiated by computers and sent to other computers. These other computers will interpret and process the data, and, if necessary, initiate other actions. There is no human interaction in this whole process.

'structured'
The structure of exchanged data is always that of standard messages, which can be automatically processed.

'business information'
The exchanged data deals with information on flows of orders and goods. For instance, delivery schedules, invoices, transport instructions, purchase orders.
Recently EDI has been subdivided into Trade Data Interchange (TDI) and Product Data Interchange (PDI) is used. TDI concerns with the data just mentioned, while PDI is more concerned with specification and design data (CAD/CAM).

'automatic transfer of structured business information'
The data exchange is always in structured and standardized messages. The physical data exchange is done by data communication.

'separate organizations'
We speak of EDI only when there is data exchange between separate organizations. Hence intra company communication is not EDI in the definition used nowadays. It is nevertheless different from EDI, which has extra possibilities and special problems, to which we shall return later.

Examples of organizations that are in communicaton with each other are: Custom, transport companies, customers, suppliers, banks, insurance companies.

2.3.What EDI is NOT

The term EDI is often used in combination with fax, electronic dialogue and electronic mail as identical means of communication. This is not correct: EDI is NOT electronic mail, nor electronic dialogue nor fax!

The main differences between electronic mail and EDI are
1) electronic mail uses unstructured messages, automatic processing is therefore impossible;
2) electronic mail is eventually communication between people.

Electronic dialogue, in my definition, is the communication - queries - of a human being with a database, that is communication between a human and computer. Furthermore, compared with EDI, automatic processing is realized only on the 'database' side.
The main difference between EDI and fax is that automatic interpretation and processing of fax messages without human interaction is impossible.

2.4. Benefits of EDI?

Implementing EDI can provide several benefits, the most important of which are given below.
1. speed
2. time independence
3. no waiting time
4. accuracy.

These categories will be discussed in turn.

First is the increase in speed. Goods don't have to wait on the relevant information, in other words, information goes before the goods and is no longer the weak link in the chain. One of the clearest examples is 'Customs' where goods just have to wait on information, while with EDI information would be - and in some cases already is - ahead of the goods.
Furthermore, all parties concerned are in possession of up-to-date information, so the right decisions can be made. A reduction of safety stock is one of the possibilities.

Another benefit is the time independence. Nowadays doing business with companies at the other side of the earth is very difficult owing to the time differences. EDI facilitates such business with time independent and quick communication!

Automatic processing of large volumes of data, of course 24 hours a day, is now possible with EDI. The order and paying cycle can be accelerated, and in principle nobody has to wait for information.
In practice, for example this means that a company can get all the order information of their subsidiaries in the evening, process them to orders for the several suppliers. Human interaction is not necessary any more. The orders will be sent to the suppliers during the night and be delivered the next day.

The last category is the increase in accuracy. The number of mistakes caused by re-keying the data is very high. With EDI you only have to key-in once. This results in a significant reduction of mistakes.

Automatic processing supports automatic control of payments.
In practice it is found that in order to use EDI, partners should define the information flows in detail, resulting in a significant reduction in the number of misunderstandings occurring in business practice.

3. RELATED FIELDS

Here certain fields essential to EDI, or in which EDI can play an important role, come up for discussion.
In the figure below the related fields are enumerated. They represent fields important to EDI, or those, where EDI can play an important role in future.

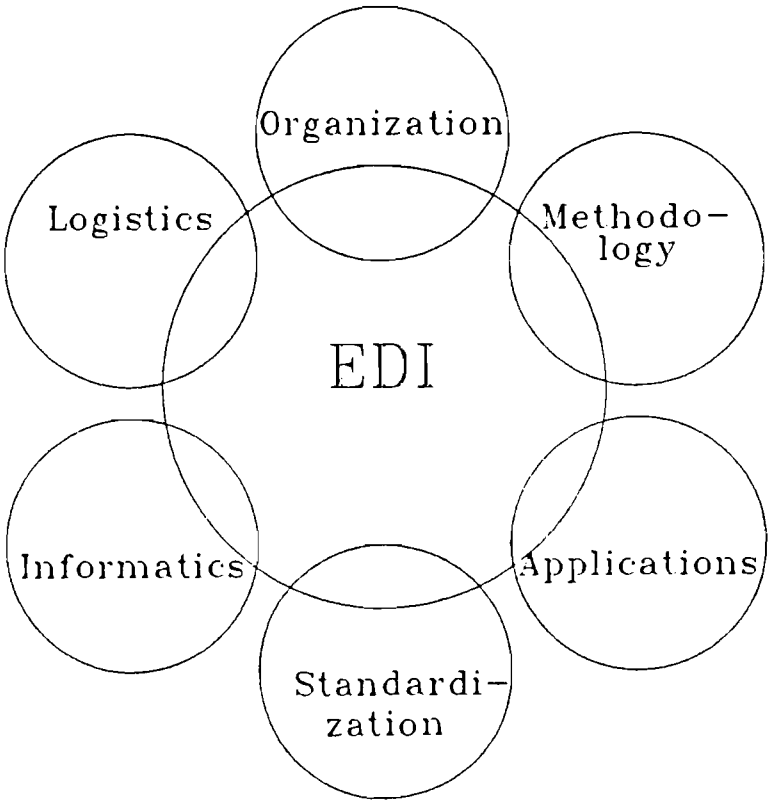

Figure 3.1: EDI-related fields

The fields will be described successively in their relation to EDI.
Each field starts with an important development (in italics), which stimulated the EDI development. The several developments implicitly state the relation of the field to EDI.

3.1. STANDARDIZATION

'The Edifact[4] standardization has undergone an unexpectedly rapid development in the '80s; the standards are no longer a barrier to implemention of EDI.'

Standardization is essential to EDI. It is impossible to negotiate with each partner (customer, supplier, Customs, etc.) on protocols and messages, if messages are to be automatically processed.
The standards can be categorized as follows:

(1) Data communication
The ISO-OSI reference model[5] has been developed to standardize the protocols for data communication [TANENBAUM, 1987]. Data communication becomes possible using these standards, which are independent of the supplier of hardware or software. The most common used standards for EDI are:

- X.25
Layers 1, 2 and 3, mostly supplied by the national PTT. An X.25 network is installed in most countries in North America, Europe and Asia. The national networks are coupled to one another by the various PTT's.
The X.25 network is a so-called packet switched network. This implies that the data which are sent to another party, is divided into several little packages; every package has address information, so that every package can be sent, independently of the others, in the most efficient way. Furthermore, several users can use the same physical connection simultaneously. The PTT is responsible for delivery of the packages (in the correct sequence) to the address.
An X.25 network has no store-and-forward facilities. This means that there are no postboxes built into the network, so that both parties have to be ready to communicate at the same time. There are now some software packages available for tackling this problem.
In general an X.25 network is of good quality and has a wide geographical availability.

- X.400
Layer 7 was originally developed for electronic mail but is also used for EDI. The EDI message is put into an X.400 envelope by the sender and the receiver removes the envelope again.
The big advantage of X.400 compared with X.25 is the store-and-forward facility. It is possible to send and receive messages whenever you want, independently of your partner.

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[4] Edifact stands for: Electronic Data Interchange for Administration, Commerce and Transport. You can find some more information about the Edifact board at the end of this section.

[5] ISO-OSI stands for International Standards Organization - Open Systems Interconnection. The ISO-OSI reference model is a worldwide standard of data communication standards. New standards are continuously being developed, also for EDI data communication.

There are still problems with X.400 networks, that is with
* speed
* maximum data in one message (about 2 Mbit)
* (still) not applicable to interactive EDI
* several options for packing an EDI message in an X.400 envelope.

In 1992 a new version of X.400 will be announced, in which special arrangements are made for EDI.
Most experts in the field assume that X.400 will become the general EDI standard for data communication.
Until now the X.400 network does not yet have the geographical distribution of like the X.25 network. The implementations are furthermore differently realized in several countries.

The big advantage of both X.25 and X.400 is the independence of hardware and software of the communication partner: you only have to connect to the network.

(2) Data elements, (3) syntax rules, (4) messages
Just sending bits to another partner - by using the standards of the ISO-OSI model - is not enough for meaningful communication. The 'words' (= the data elements) used for the communication must be interpreted uniquely; both partners must also use the same grammar (= syntax rules), and combine grammar and data elements in such a manner - create messages - that the partner knows what the sender wants to communicate.
The worldwide Edifact board was founded to anticipate disorder in used data elements, syntax and messages. The Edifact board has standardized the data elements in the TDED (Trade Data Elements Directory). This standard is certified by the United Nations Workgroup 4 as ISO standard number 7372. The syntax rules (i.e. structure, segments, header- and trailer information) were certified in 1987 as ISO-standard number 9735. The messages or UNSM's (United Nations Standard Messages) are now in the developing stage. Appendix 1 contains a survey of the stages of standardization of the various UNSM's. Normally these UNSM's will also become an ISO standard in a year or two.
These standards are very 'broadly' formulated. In concrete situations, partners have to negotiate about the detailed content of each sort of message.
There are negotiations at branch level for developing guidelines about the detail contents of UNSM's in order to prevent diversity. For instance, in the chemical branch, most of the UNSM's will contain data about quality and composition of the product, whereas in the automotive industry these data will not be used.

Nearly all organizations in the field of EDI have agreed to use the Edifact standards. Unfortunately there are some standards like Odette and the standards of the United Kingdom, already developed before the Edifact board was founded. They have also agreed to migrate to Edifact, but that will take several years because of the amount of existing EDI applications using the non-Edifact standards.

Intermezzo

A short history of the Edifact board:
The Edifact board tries to define a set of worldwide standards for EDI.
Up to 1986 two worldwide EDI standards were available:
1. GTDI[6] rules - Europe
2. ANSI[7] X.12 - USA
The experts of both standards have held discussions in early 1986.
Between March and September they developed an Edifact system.
In September 1986 the United Nations declared the first Edifact standards as an ISO standard; in September 1987 the Edifact syntax rules were also recognized by ISO.
The standards are recognized worldwide by Working Party 4 of the United Nations Economic Commission of Europe in cooperation with ISO. The following representatives are in Working Party 4:
1. ANSI ASC X.12 - USA
2. Edifact Board - West Europe
3. CMEA - Eastern Europe
Australia and the Far East are already represented in Working Party 4; they will found their own Edifact board in the near future in close cooperation with the general Edifact board.

The Edifact board consists of a Steering Committee, to which the following groups will report:
- Message Development Groups (divided into Trade, Transport, Customs, Finance and Special Projects)
- Technical Assessment Group
- Maintenance Group
- Promotion & Documentation Group

The energetic start of the Edifact board and the quick results achieved, prevented a wild development of all sorts of EDI standards. The majority of companies have agreed to use Edifact standards. It is again an example of the phenomenon of the diminishing advantage.

End of intermezzo

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[6] GTDI = General Trade Data Interchange

[7] ANSI = American National Standards Institute

3.2. INFORMATICS

'The availability of technical facilities such as LAN's, WANS's, videotext, X.25 networks, Value Added Network Services, etc., make EDI possible on a wide scale.'

3.2.1. Introduction

In this section two questions will be discussed:
1) What software is required for EDI?
2) How are the physical connections between partners to be realized?

3.2.2. Software

What software is required for EDI?
In order to explain this, a short explanation of the principle of EDI is needed. The EDI communication between partners A and B is shown schematically in the diagram below.

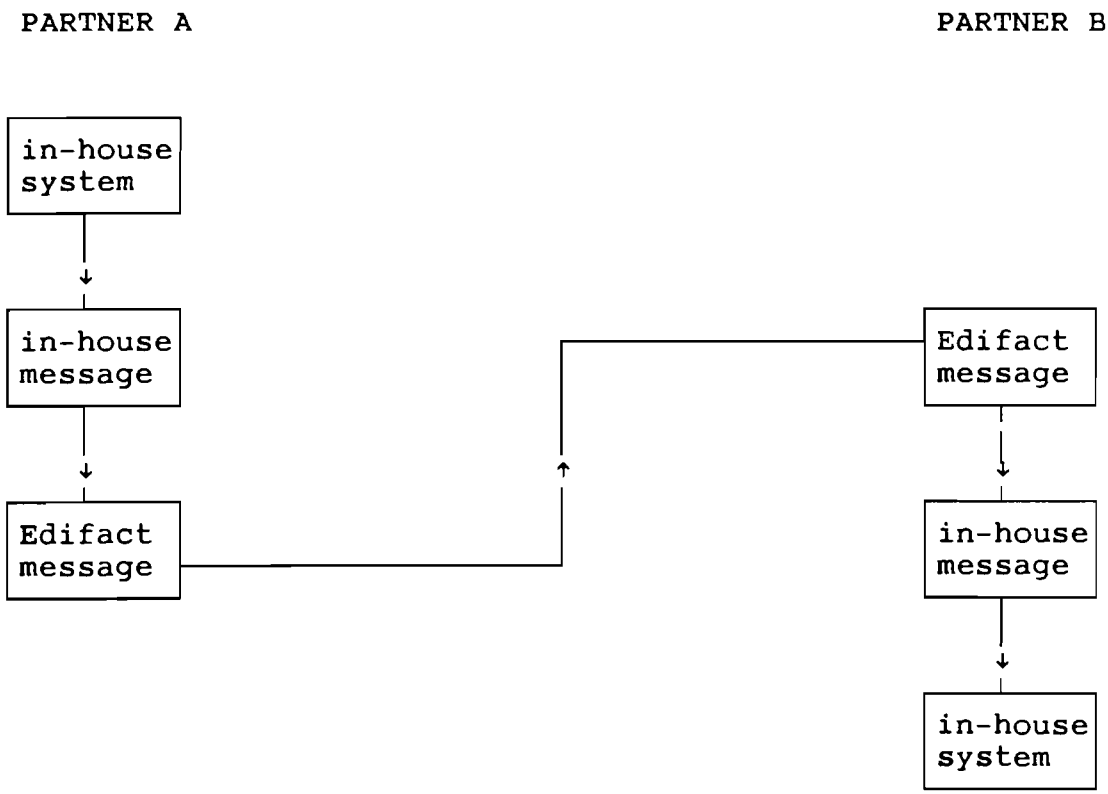

Figure 3.2: The principle of EDI

Step 1: Partner A gets data out of his application system and puts them into an in-house message.
Step 2: The in-house message is translated in a neutral standard, in this case the Edifact standard.
Step 3: The message in neutral form is sent to and received by partner B.
Step 4: Partner B translates this message into a in-house format.
Step 5: Finally the in-house message will be processed by the in-house system.

The software needed for EDI is now the following:
- Translation software for steps 2 and 4 is necessary in order to translate the message from the in-house format to the neutral format and vice versa; there are nowadays several standard software packages for several EDI standards.
- Software for steps 1 and 5 is essential for real EDI; there are no standard software packages available. You have to develop the software yourself (or obtain it form a softwarehouse) in order to get the wanted data out of the application system and also process the received data in the in-house application system. The deviating information structure is in many cases a huge problem.
- Data communication software for step 3 is available; there are several alternatives for the realization of the physical connections (see below).

3.2.3. Physical connections

Two alternatives are available nowadays to realize the physical connections with your communication partner: use the X.25 network of the PTT and/or the facilities of VANS[8]. Both alternatives are described below.

1) X.25
Most national PTT's provide an X.25 network; the EDI messages are directly sent to the partner using the X.25 protocols (see above).

2) VANS
Important VANS suppliers are IBM, Geisco, Mc Donnel Douglas, and some national PTT's. They provide the store-and-forward principle, but also support data communication and EDI standards, security, registration of messages, syntax control, etc. The user can obtain all these services without huge investments. The most essential services of VANS are:
- Store-and-forward principle
- transparency of communication: the user can easily communicate with a partner without taking into account the communication protocols or hardware and software that the partner is using.
  The VANS don't provide the connection of EDI messages with the internal information systems (see step 1 and 5 figure 3.2).

The choice
Choosing between alternatives 1) and 2) depends on the requirements of the communication partners and the evaluation of the benefits of both

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[8] VANS = Value Added Network Services/Suppliers

alternatives.
Benefits of VANS compared with X.25 networks:
- no problems in connecting new communication partners,
- quick start is possible,
- technical differences between partners are transparent,
- improved validation and security (Geisco).
Disadvantages of VANS compared with X.25 networks:
- doubling of communication time and costs,
- fees,
Important criteria are: lead time, order frequency, number of order lines, number of communication partners, level of automation of partners.

Future
The problem at the moment is that the VANS are not interconnected. Several suppliers are obliged to connect to several VANS (costs!) in order to keep their customers. The user-organization pressure will force VANS to interconnect. The VANS are already interconnected in some countries. The services will be quite the same, only the spread of the network, security and costs will be different. The most important services will be the transparency of communication and the store-and-forward principle.

Normally the X.400 protocol will become the data communication protocol for EDI in the years ahead. The store-and-forward principle is provided with X.400, and will be provided by PTT networks. One of the most important extra services of VANS suppliers will then disappear! Consequently the role of VANS will decline considerable.

3.3. LOGISTICS

'Communication is the weakest chain in many implementations of new logistic theories such as Just-In-Time deliveries, especially the external part, EDI can be the solution.'

3.3.1. Introduction

Logistics is often quoted in one breath with EDI. Why this combination, and why nòw? Here we try to provide an answer. First we must provide a short outline of the recent developments in logistics in paragraph 3.3.2. Finally the relation between CIM and EDI is discussed.

3.3.2. Historical development

The most important general change in the market of the '70's and '80's was from a seller's to a buyer's market. The buyer was becoming dominant and demanding tailor-made products with a short delivery time. Companies had to satisfy these demands in order to survive. This entailed a flexible manufacturing process to produce the different products within the short term.

The change to a buyer's market is not without its effects on the relationship with suppliers; it is not only quality and low price that is important, but short reliable delivery times and high flexibility for response quick to market demand. These are what count, too!

3.3.3. Logistics and EDI

What is the relationship between logistics and EDI?
In brief, EDI can support the new logistic theories.

The increased demands of customers, in respect to delivery time and flexibility, has a direct influence on the communication between them. A system based on manual input and exchange of documents doesn't correspond to the automated planned and controlled flow of goods at the present time.
Communication has to be accurate and fast. In business practice nowadays, sending documents by mail to a foreign partner takes weeks. It takes time and man capacity to manually process all the data of hundreds and sometimes thousands of suppliers or customers. Especially when a company wants to process customer demands as quickly as possible, daily receipt and processing of delivery schedules etc. is essential. Without automatic processing this is practically impossible.

In these situations there is no alternative to EDI. When the market requires quick deliveries and/or make-to-order production, quick communication is essential with customer and supplier both automatically. processed. The communication cycles can be shortened by days, in normal cases even weeks, resulting in quick response to the market demand, and reduction of safety time and safety stock.

For example, when a Dutch truck producer sends a delivery schedule to his Dutch or West German suppliers every four weeks, it is found that the new delivery schedule is printed, but the old one is not yet processed by the supplier! With EDI this time lag can be reduced, with a quick reaction in the market and a structural reduction of safety time and stock.

Furthermore, errorless communication is essential. In practice it became clear that the elimination of re-keying errors also reduced the detailed agreements necessary for EDI communications. The number of misunderstandings dropped significantly.

This explains why EDI and logistics are so often bracketed together. EDI is not an isolated goal, but a means of eliminating the weak 'communication' chain in present-day business practice.

3.3.4. CIM-EDI Relationship

One of the most important common aims of CIM and EDI, is their contribution to integration. The difference lies in the fact that CIM and EDI are present at various levels in the company [FLECK, 1988].
Several levels can be distinguished in the drive for integration. First of the all the integration of individual machines into cells on the shop floor. A second level is the interconnection of several cells into certain product groups in group technology.
At shop floor level, cells are linked into overall systems producing a particular variety of flexible manufacturing system, integrated by means of handling devices and linked, in terms of information, by computer-aided production and control systems.
These forms of integration are often related to CIM.

There is also integration of filing systems, printers, word processors, etc. in the office.
At a higher level, a measure of integration between office and shop floor is achieved with production and stock control linked via CAPM, such as MRP I and II. This essentially represents an integration of the warehouse and production processes with certain routine office activities. CAD/CAM systems at this level also integrate of the very different functions of design and manufacture.

At an even higher level, integration via purely information channels, LANS links separate plants or offices within an organization. And nowadays even integration is taking place across organizations, often along supply chains, in a form of vertical integration, by means of EDI.

Summarizing, CIM is especially concerned at the moment with integration at machine, cell and shop floor level. At a higher level EDI contributes to integration across organizations.

In this context CIM is taken as the general consensus in literature and in the field of 'present-day CIM', or perhaps, I think one can even observe a sort of CIM, in which the whole value chain is the basis with EDI a part of or contribution it. It is in this sense that CIM used in the undertitle of this working paper: 'EDI, one of the means of realizing EDI'. After realization of 'present-day CIM, it will be possible to have a broader interpretation of CIM.

3.4. ORGANIZATION

'The trend towards closer cooperation with suppliers and customers - for instance Value Added Partnership, co-makership, has an influence on communication requirements.'
'The organizations which offer new facilities, Value Added Network Services and EDI organizations will form a new intermediate level; furthermore, EDI can initiate structural changes in the value chain, and last but not least, if EDI is implemented quickly the realization of a competitive edge becomes possible.'

3.4.1. Introduction

New forms of cooperation between companies evolved in recent years. EDI often supported or even made these new forms of cooperation possible. Introduction of new forms of cooperation also brings changes in the internal organization. The relationship between EDI and these new forms of cooperation and the changes in internal organization are discussed in paragraph 3.4.2.
EDI also influences branch structures. Examples in paragraph 3.4.3. will enlarge on this theme.
The most successful EDI implementations usually have one thing in common, they realized a competitive edge. The phenomenon of competitive edge is briefly explained in paragraph 3.4.4., and several ways of realizing a competitive edge are distinguished.

3.4.2. New forms of cooperation

The shift from seller's to buyer's market has its effects on logistic management. This change in logistic management also effects consequences the way supplier and customer cooperate. In [JOHNSTON, 1988] the new forms of cooperation, the so-called Value Added Partnership (VAP), is described. The definition used is
'A collection of independent firms, strongly cooperating, focused on the optimization of the goods flow along the whole value chain.'

Every firm maintains close long term relationships with two to six suppliers for every critical component part. The supplier can react quickly and flexibly because of the guaranteed amounts.
VAP is attractive, on the one hand because of the coordination and economies of scale of big firms, and on the other, the creativity and low overheads typical of small firms.

EDI supports the VAP. Flexible reactions to market demand require suppliers to be quickly informed about the most actual data, so that they can react promptly. The frequency and the volume of the information flow increases significantly: daily instead of monthly delivery schedules, special requirements per part, etc. Conventional means of communication (paper, telephone) are no longer adequate.

Thus the implementation of EDI will initiate the following structural changes:
- The cooperation between supplier and customer will be closer, a

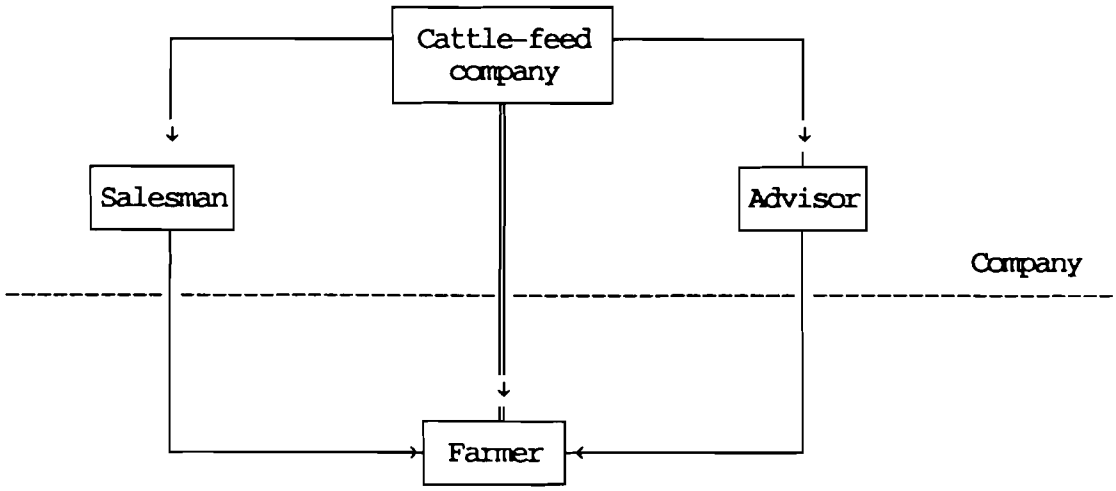
commitment for a long-term relationship. More departments will be directly involved: not only buyer and seller but also logistic planners, EDP experts, etc.
- EDI will stimulate information-sharing, and that, in twin, will stimulate closer relationships.
- The activities of employees will change. Until now the employee decided when to carry out his various activities. Furthermore, 80 % of his activities where routine. EDI will automate many routine activities. The activities of employees will more and more be initiated and planned by information systems, for the information will provide a survey of exceptions which must be managed by him within a certain (short) period.

3.4.3. Changing branch structures

Not only new organizations (they will be discussed in paragraph 3.6) and new relations between supplier and customer are coming up, but also branch structures are changing structurally because of the introduction of EDI. Two examples from two different branches of business illustrate this.

1. Agriculture
First example is of the agriculture in the Netherlands. A branch that most people do not think of at first sight. But actually, more and more farmers have their own personal computer to manage their farm. This automation is initiated by several agriculture food suppliers; they are supporting the farmer not only with food for their animals but also with recipe's for feeding and management in the terms of hard- and software. This business strategy is reasoned by the philosophy that in the case the farm is managed well, the food business has also good profits.
The field organization of the cattle-feed company consists of an agriculture advisor and a salesman (see figure 3.3). Both advisor and seller visit the farmer regularly, between once a week and once a month, depending on size and the kind of animals on the farm.

The introduction of the personal computer on the farm has an effect, not only on the management of the farm, but also brings new opportunities. The food supply is very time critical, and suppliers have to deliver food normally within two days and sometimes even within 12 hours. Quick communication is therefore very important. With data communication this is possible; it is no longer necessary to try and phone the salesman first, the farmer can contact the factory directly. The factory can process the data automatically and take them into account when making the routing schemes for trucks.
In this case the function of the seller will be partly or fully taken over by data communication, and the field organization will change structurally.



═══ = agriculture food
---- = company border with the outside world.

Figure 3.3 Field organization of cattle-feed supplier.

2. Wholesaler

A second example is the function of the wholesaler in the construction industry. The wholesaler is the link between the producer of building materials and the building company. The functions of the wholesaler are basically:

- to provide a safety stock
- administrative: the construction company and the producer put this out to contract to the wholesaler, because it is a real burden to carry out all the special labour-intensive, administrative tasks.
- financial: the construction companies have longer payment terms and have not always a good reputation in that respect.

The transport (contracted out to a transport company) goes in most cases directly from the factory to the building company, so that the wholesaler does not have an stock function.

There are thus three basic functions left, but with the introduction of EDI at least one of them, the administrative function, can disappear. The burden of administration will be automated. Furthermore, many producers can now deliver within 24 hours, so that the safety stock function is no longer essential and only the financing function remains. But even this function can be dispensed with if building companies are willing to make agreements on this.

Conclusion, if the wholesalers do not take any initiative their position will be eroded in the next few years.

3.4.4. Competitive edge

Realizing a competitive edge is possible by
- increased efficiency: goods/services are cheaper compared to competitors.
- bargaining power: offering a product with unique features, and/or the increase of switching costs and/or quicker customer service. [VITALE, 1988]

Well-known examples of competitive edge is the American Hospital Supply case. An American supplier to hospitals was the first to instal terminals at hospitals, so that purchasers could easily seek out and order products. The turnover increased enormously. Competitors had to pay the supplier to use the same terminal, because the hospitals refused to have another terminal.

There are six main ways in which information technology (IT) such as EDI, can provide competitive edge opportunities.
1. IT can assist in the creation of new products and services that compete with existing offers, e.g. on-line databases.
2. IT can change the scope and size of the market. For instance, 'geographic presence' is no longer necessary because of telecommunications-based systems; time differences do not restrict markets any longer. It supports the trend towards globalization of the market.
3. IT can reduce the life-cycle cost of products. For example reduced development time and cost of cars, and the use of components for a wider range of products.
4. IT can enable more complex products to be produced. For example the use of computer systems in financial services.
5. IT can permit a rapid response to competitive moves by allowing new products to be brought onto the market quickly or by offering new supporting services that increase the attractiveness of existing products.
6. IT can lead to the redistribution of added-value within an industry. For instance the elimination of a layer in the value chain in the Dutch insurance branch, or eroding of the function of the wholesaler. VANS can maybe take over some functions.

Not every company has the chance to realize a competitive edge, that depends on market power. Market leaders especially have the opportunity to realize a competitive edge.
It is very important that EDI is applied to improvement of the critical success factor (CSF) of a specific branch. A rough division is given below.
1. CSF are cost related, in the specific branch/market the profit margins are very low, cost minimization has priority.
2. CSF is related to customer service, good service is essential, profit margins are relatively high.

In situation 1, EDI must be used to reduce costs through stock reduction, etc. For example electronic invoicing and ordering.
In situation 2. EDI must be focused on improving customer service through a quicker response, e.g. in the case of Rolls Royce.

In situation 2. the supplier takes the initiative in order to realize a competitive edge.
The customer will usually take the initiative in situation 2, focusing on cost reduction; suppliers who can first communicate electronically will

have a temporary competitive edge.

Summarizing: EDI is not only a technical phenomenon, but also offers opportunities to obtain a competitive edge; it can moreover change branch structures and power relationships.

3.5. METHODOLOGY

'The development of new EDI applications is very time-consuming, between five and ten years. New methods are necessary to cope with the specific EDI characteristics in order to reduce the development time.'

3.5.1. Introduction

Looking back to advent of EDI applications, it is obvious that implementation normally takes years. EDI needs a specific approach, a new methodology to deal with specific problems, mainly caused by the crossing of company boundaries. In the following paragraphs the next points for discussion will be
- What are the specific problems of EDI implementation?
- How is an EDI-application developed?

3.5.2. Problems

Several problems arise when developing an internal information system, not only technical, but also the introduction of the system, etc. Employees in particular can have several reasons for objecting to new EDI applications.
For example,
* Marketing manager: EDI will weaken the supplier-customer relationship.
* Purchasing manager: The number of purchasers, in other words the power of the Purchasing department will decrease.
* Cash manager: The 'money games', e.g. paying late, are no longer possible.
* Audit manager: How can we audit electronic audits?
* Legal staff: Electronic messages are in general not recognized in law.

These problems are not the greatest problems, they are not the main reason for the long development time. It is the crossing of company boundaries that causes the long development time. The boundary crossing feature of EDI has three consequences.

First, EDI is often very competitive, in other words, it can be very advantageous or disadvantageous in competition with other enterprises. Therefore firms act very cautiously in order to get the maximum competitive advantage.

Second, when developing an EDI application, competitors are in many cases round the table, negotiating for the first time. Often it takes a long time to get accustomed to each other. In combination with the competitive nature of EDI it slows down the speed of development. For example Odette (automotive industry in Europe) started in 1984; the messages were not defined before 1989. Where it is not necessary to become accustomed, where competitors know each other, a quick implementation is possible. For example CEFIC, the European chemical industries, are competitors, but they have been doing business with each other for years; the definition of messages and first pilot projects were

established after only one year.

Finally, a dominant party is absent. Nobody can force a decision, in contrast to the powerful top management in a company. Consultation with competitors takes a long time.

Not all EDI applications have a long development time. Especially those which strive for competitive advantage, in contrast to cooperative applications, have a very short development time. Competitive applications are mostly lad either by one or a few companies. They try to exclude competitors.
In contrast, cooperative applications are open and many competitors join. The sort of application chosen depends on the market situation; it is either competitive or cooperative. For instance, suppliers can be obliged to use EDI in order to supply to a dominant customer, so he has to join a cooperative initiative. A supplier can gain a competitive advantage through EDI; the success depends very much on whether the customer will accept and use his application.

3.5.3. The development of EDI applications

In [BEMELMANS, 1989] a growth-phase model is described, derived from the growth-phase model of Nolan. This model explains the phases a new technology has to go through. This model is also applicable to EDI. The growth-phase model is described below especially for EDI. Some recommendations of Shaw [GIFKINS, 1988] are used in the model.

The model has four successive phases

1. Initiation
This first phase is characterized by experiments, mostly initiated by top management. The purpose is to get acquainted with EDI. Technical issues are dominant. Giving commitment and resources to a few persons is also the task of top management.

2. Diffusion
This phase is characterized by spontaneous and arbitrary growth of applications. Technical issues are dominant. Applications are not reasoned on the basis of cost/benefit analyses. Top management should initiate and stimulate.
This results in a wild development of applications, using several physical connections, standards and software. The wheel is invented many times.
Some do's for the first pilot projects:
- first the fields with the biggest advantages;
- create a win-win situation (motivation of both partners!);
- if internal technical know how is lacking, or quick implementation is necessary, use VANS.

3. Consolidation
In this phase a company wide coordinated approach is necessary in the following three cases:
1. Standardization in software, physical connections, messages on at least a company-wide level is necessary.
2. Tuning to company strategy is necessary. This tuning gives priority to

specific projects.
The following aspects are important in the selection of communication partners:

* volume and time-sensitiveness of the communications
* EDP level and EDI experience
* potential logistic improvements through improved communication
* turnover
* technical infrastructure in the country
* willingness to use the selected standards
* mutual dependence and long-term strategy with the supplier or customer

3. Information to employees and eduction

An efficient use of EDI is obligate in this phase so that a cost/benefit analysis is obligate before starting a project.
Coordination and control is therefore dominant.

4. Integration
In this phase EDI is fully integrated in the company. EDI is a mature infrastructure like telephone, fax and telex. EDI has become an indispensable means in the communication patterns with other external partners. Top management doesn't concern itself with EDI any longer, it is now the responsibility of a functionary.

This model can help to see what phase a certain company is in, and what the adjacent actions should (not) be, and what phases are still to come. I hope I will to elaborate on this model in subsequent publications.

3.6. APPLICATIONS

'The number of EDI applications in the different branches and countries are increasing exponentially; this will go on in the next few years.'

3.6.1. Introduction

Here the aim is to give some indication of concrete EDI applications and explain the influence it exerts.
Therefore a general division of application areas is given in the first paragraph.
In the second paragraph the influence of EDI on future internal and external applications will be discussed. Next, the recent EDI developments will be touched on. The new phenomenon of EDI organizations is the subject of the last paragraph.

3.6.2. Review of possible applications of EDI in logistics

In figure 3.4 a general division of logistic application areas is given in which EDI can be important. The goal/driving forces, partners and exchanged information (messages) are enumerated for each class. It gives a good insight into the benefits of EDI for certain branches. Because of the low level of implementations until now, there are practically no data available.

3.6.3. Influence of EDI on applications

In this embryonic stage of EDI development, it is difficult to forecast the influence of EDI on internal applications. Indisputably EDI will have great influence there.
In general the influence can be described as follows.
Until now the applications were focused on collecting data in one company in order to make good internal company decisions. In future companies will also collect data of other companies because the external business world will also affect the management and planning of companies. The information exchange between partners will change. The future applications should support this communication process.

The external communication requirements is a condition for application development. First of all it is necessary to accept Edifact standards. For instance, the data dictionary of information systems must be as near as possible to the TDED (Trade Data Elements Directory). Furthermore, the information management must be aware of and take into account the information management requirements of other partners. Negotiation and cooperation with partners on these topics may be necessary.

At the moment, the biggest problem is the absence of a common relational database model for all the UNSM's; consequently it is still difficult to take EDI standards into account when developing new applications.

BRANCH	GOAL	SUB GOAL	LINK FROM-→TO	MESSAGES
Production	decrease stocks	JIT supply	production ---→ suppliers	order[9] stock status progress in production
			production ---→ shipper	status transport
		flexible production management	shipper ---→ wholesaler retail,grocery purchase comb.	stock status demand orders
	increase customer service	JIT delivery	shipper ---→ transport	status transport planning
		supply information	shipper ---→ customer	delivery time info on status
Trade	management of costs + stock + stock-out + transport	flexible supply	customer ---→ supplier (wholesale and retail)	orders
		get info	customer ---→ supplier (wholesale and retail)	info on product
	increase customers service	JIT delivery	trade ←--→ transport	info on status planning
		supply of information	transport ---→ retail wholesaler ---→ retail	delivery time info on status info on product
Transport, storage, and communication-business	decrease standstill time	accelerate transport preparation	transport ---→ shipper, schemes, expediters	info about times routes, reservations, tariffs, etc.
		accelerate transport, contracts/ documents	shipper, expediter ---→ transport	reservations shipment instructions invoices, etc.
		tracing and tracking of transport	transport ---→ customer	info on status

Figure 3.4 Forms of logistic message exchange for several branches and functions in the logistic organization. [TANJA, 1988]

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[9] Order includes all information exchange with regard to ordering, like for instance invoicing, and paying.

3.6.4. EDI current state

The enumeration below of the most important European initiatives in several branches gives a good indication of the major fields in which EDI is being implemented at the moment. More figures about the situation of EDI worldwide will be given in section **4.** together with some quantative figures.

Cost 306
A standardization organization, resorting under the Edifact-board, formulating standards for EDI in transport in Europe.

CEFIC
An organization of the biggest chemical industries in Europe, also using the Edifact standards; they are formulating messages for the chemical sector. The progress of this project is very good, due to the fact that the start of this project was precisely when the first Edifact standards were formulated and because of the already good relations between chemical companies (they have already been doing business with each other for years).

Edifice
An organization of manufacturers of electronic products, formulating EDI messages for this branch.

Edicon
An initiative to develop EDI messages for the European construction industry; it resorts directly under the Edifact board. The countries most involved are UK, Sweden, France, Denmark and the Netherlands.

Intis
An EDI project of the Port of Rotterdam. The objectives are development, realization and exploitation of a communication infrastructure and information structure in the Port of Rotterdam; secondly, the coupling of existing national and international multiuser systems and databases to the Intis-network. At the moment more than 50 companies are using Intis facilities.

Odette
Organization for Data Exchange by Tele Transmission in Europe is one of the first EDI initiatives, started officially in January 1985. It is an initiative of the automotive industry - suppliers and manufacturers, that is the users of hardware and software from the 8 European countries. Nearly all big manufacturers and suppliers are joining Odette. The purpose is to formulate EDI messages for the communication between manufacturers and their suppliers. This year all messages will be formulated. The messages deal with invoicing, delivery schedules and instructions, transport instructions, ordering. Odette is not a system, but just a set of EDI standard messages for the automotive industry.
The most important trigger for implementing EDI in the automotive industry is the potential increase in logistic performance. EDI is quick, errorless communication with automatic processing, by which a reduction of (safety) stock and lead time, and an increase in settling financial affairs will be, and has already been realized.
It is not strange that EDI started in the automotive industry, because all big manufacturers have very advanced automated (MRP) systems; the weak chain has moved to the communication with suppliers!

Sagitta
A nationwide Dutch Customs clearance systems. Their objective is to accelerate Customs clearance of goods. The service started at the beginning of 1989.

Comment
Looking at all these initiatives just enumerated, the problem of interfacing - also a topic in CIM, CAD/CAM - is easy to recognize. A company, of course, need communication with Customs, but also with transportation companies and maybe chemical or automotive companies. So the need of a common language, a role which Edifact may perhaps fullfil, is of enormous importance. Whether Edifact can really anticipate islands of networks, is still unclear. First signs of islands are already apparent. The UK uses its own Tradacom standards, Odette is not yet using the Edifact standard messages, etc.

3.6.5. EDI organizations

EDI initiated the development of new organizations, as you can see in the enumeration above. They are a new intermediate level in the value chain and branch. What function do they provide now and what will it be in the future?

It is necessary to make a rough division of EDI organizations in order to answer this question. There are two categories.

1. First the 'standardization organizations' like CEFIC and Odette. Their aim is to develop EDI standards. An important function is of course the promotion of EDI and their developed standards. The members are mostly big companies (users of hardware and software), mainly multinationals.
   The legal form is the society, that is a non-profit-making organization.
2. A second category are the 'EDI organizations' like INTIS and Sagitta. They also develop EDI standards, provide VAN services. They use the services of the PTT and/or other VANS, in combination with dedicated software specially made for their standard messages. Furthermore, consultancy, courses, etc. are main functions of these organizations. Of course, promotion is a very important activity.
   The legal form is a profit-oriented association.

Conclusions on the function of these two categories now and in future

1. The importance of standardization-organizations will strongly decrease after developing EDI standards. The only remaining function is the maintenance of standards and promotion.
2. EDI organizations of category 2 will also be important after the EDI standards are developed. They try to provide an important function through dedicated software with VAN services.
   These EDI organizations will try in future to absorb functions of the companies using their services, for example administration functions like invoice processing). Their success will depend on the quality of their dedicated software, and on the comparison with X.25 (and in future X.400) infrastructure and other VANS; finally it is uncertain whether the dedicated software and EDI standards will remain 'confidential'.

4. QUANTITATIVE FIGURES

4.1. Introduction

In this section some quantitative figures are given about
- EDI diffusion (paragraph 4.2.)
- EDI developments in several countries (paragraph 4.3.)
- Some figures on driving forces, barriers, changes and savings (paragraph 4.4.)

It was not easy to obtain data on EDI. For instance data about savings; these are mostly indirect; moreover, for marketing reasons, they are often very optimistic. Last, but not least, it was found from the study of [EMMELHAINZ, 1988] few organizations quantified costs and benefits even formally.
Hence the figures in this section should be used carefully. In any case, they are useful as an indication of the growing importance of EDI.

4.2. EDI diffusion

It is difficult to describe the diffusion of EDI applications in general terms. First of all, the various applications are very different. Second, it is difficult to obtain data about diffusion of certain EDI applications, nobody has anything like a complete survey. Nevertheless, some figures are given below to describe the general situation. These figures give an indication of, and confirm the growing importance of EDI.

The worldwide growth of the EDI market (services, software, professional services) is estimated at 25 % yearly by Input (see figure 4.1). The Stanford Research Institute in the USA are predicting a growth rate of about 50 % per annum until the year 2000. Relatively, there is a big difference between these two projections. Partly, this is due to the high level of uncertainty. But I have also the impression that the estimates are optimistic, similar to the blue sky estimates of recent years. Nevertheless, the figures are indicative, they show an inevitable trend towards the significant growth of the EDI market.
The Gartner Group estimates that one third of all business documents will be transmitted by EDI in 1995.

In figure 4.2 a count of articles on EDI is presented. It concerns two databases on management and business literature of the USA mainly. As indicated, the number of abstracts and, for one database, also the number of titles, with the word EDI mentioned are presented. These figures also clearly indicate the growing importance of EDI.

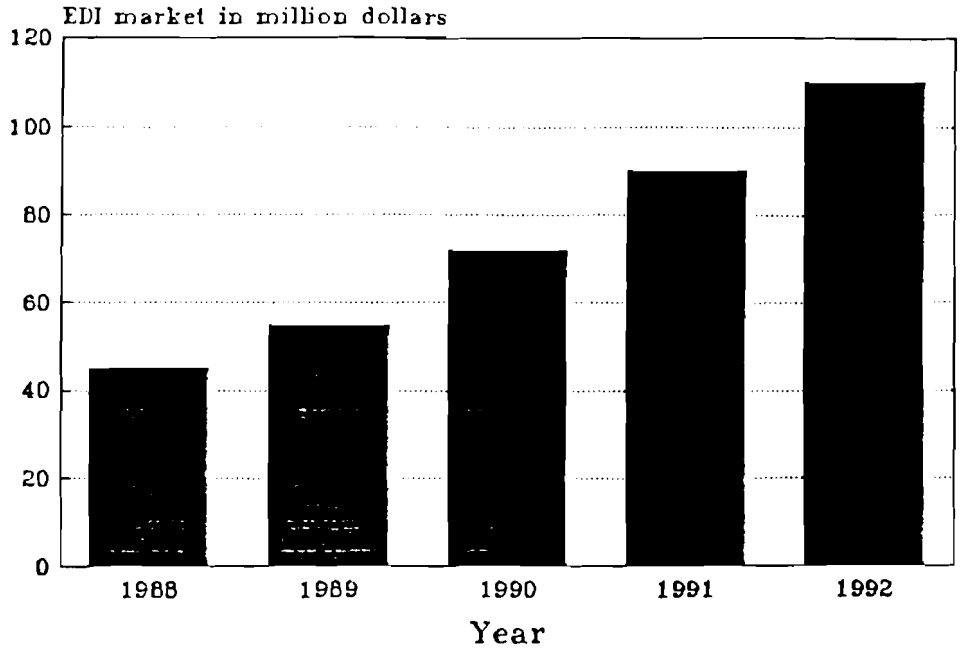

Figure 4.1 The worldwide growth of the EDI market (Source: Automatiseringsgids 28-06-1989).

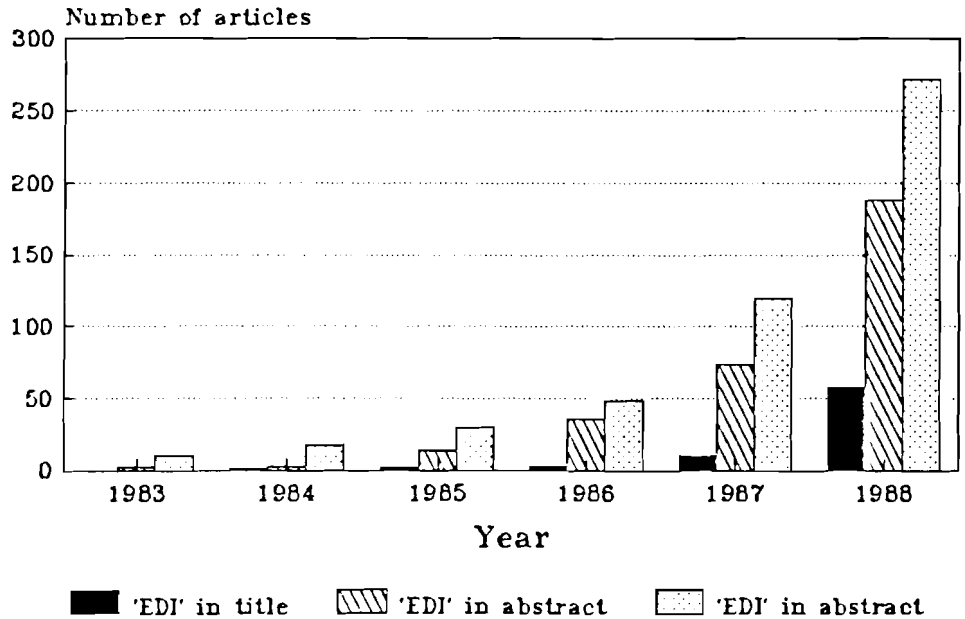

Figure 4.2 Number of published articles on EDI (Source: Trade and Industry ASAP[10] and Data Courier Inc.[11]).

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[10] Trade & Industry ASAP is literature database produced by Information Access Company, and provides access to trade and business publications, as well as news releases and wire stories. The file had approximately 350,000 records, and is updated monthly with approximately 10,000 records per update.

[11] This literature database is produced by Data Courier INc. and consists of abstracts of articles appearing in more than 660 business and management periodicals worldwide. The file size is approximately 317,000 records as of June 1986. It is updated weekly (approximately 825 records

Why now?

Looking at figures automatically raises the question, Why now? There are two main reasons for this diffusion,

1) Basically, it is the business environment that contains the elements that make EDI possible (technical push) thanks to
   * Widespread use of computers.
   * Standards development.
   * Availability of integrated software and network infrastructures.
2) The market pull aspects are
   * The cascade effect: each buying and selling exchange triggers a dozen or more electronic transactions. For example, a request for information requires a response.
   * Enormous growth of paperwork in information-intensive branches.
   * The increasing importance of customer service in combination with the trend towards a buyer's market.
   * The globalization of the markets and companies.

Sectors

It was very difficult to obtain data about the diffusion of EDI in several industry sectors. An indication for sectors where EDI is developing fast, are the European initiatives described above.
1987 data from the report 'Companies in the USA' indicates that the transportation sector especially is very quick in taking up EDI. Manufacturing (Fabricated machining and Assembly) are average. Furthermore, it was found that big companies especially are implementing EDI at the moment. For detail data please see Appendix 2.

4.3. The EDI development in several countries

An impression of EDI development in a number of countries is given below.

USA

The EDI leader in the world is the USA. Variable-format EDI implementation first started in the USA in 1978 and multiplied rapidly. At the moment more than 34 % of the Fortune Top 1000 companies already used EDI in 1988, another 20 % said they had concrete plans to implement it within 2 years; 24 % are thinking of using EDI (according to W. Wheatman Input, Mountain View). Experts estimate the total number of companies using EDI nowadays at 6,000.
A projection of the number of EDI users in the USA is given in figure 4.3. It again confirms the growing importance of EDI.

According to a recent Delphi Study [EMMELHAINZ, 1988] conducted for the Council of Logistics Management, most logistics executives believe that the use of EDI will become widespread sometime between 1990 and 1995. Further, the 1988 Council of Logistic Management and The Ohio State University Customer Service Study indicated that approximately two-thirds of shippers are currently involved in some level of EDI activity and that by 1995 over 60 % of shippers will be operational with

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per update).

EDI.
The International Data Exchange Association (IDEA) estimates the growth of companies in the USA using EDI at 70 % each year.

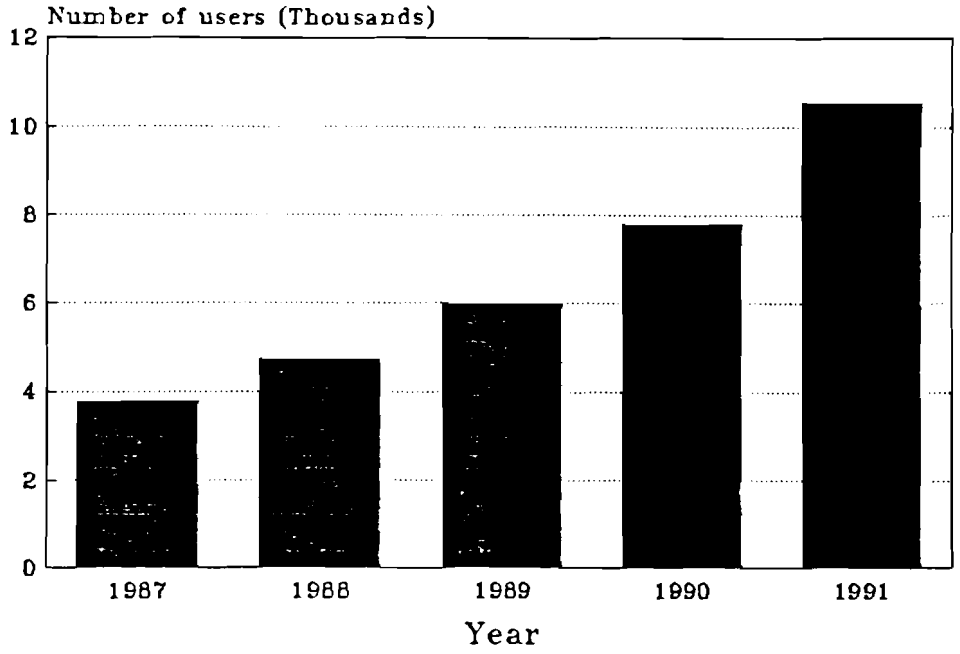

Figure 4.3 Projected EDI user community in the USA (Source: Link Resources Corp.)

Sweden and United Kingdom (UK)
In Europe the UK and Sweden are ahead. In the UK EDI implementation started in 1982; by now approximately 2,200 companies are using EDI in several branches. IDEA estimates a yearly growth of companies using EDI in the UK at 70 %. These quick developments in the UK are caused by

- The stimulating activities of the British government. The electronic messages were already valid in law in 1982, and the British Customs implemented EDI as one of the earliest.
- The VANS provided the technical realization, so a quick implementation was possible; 95 % of the companies (who implemented EDI) are using VANS.
- The strong relation between the USA and UK has stimulated the EDI implementation.

Sitpro UK[12], using several sources, estimates the annual growth rate in the UK at about 100 % per annum.
In Sweden the high level of automation (e.g. automotive industry) has stimulated EDI development.

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[12] Sitpro UK is one of the organizations who stimulated the EDI development in the UK. Sitpro UK is part of the international Sitpro organization. Sitpro stands for Simplification of Trade Procedures.

The Netherlands
In the Netherlands the 'EDI boom' is coming up. An indicator for this approaching boom is the relatively large number of Dutch employees of very different companies in the different standardization organizations. Experts estimate the number of EDI implementations in the Netherlands now to be between 200 and 300[13]. IDEA estimates the growth of companies using EDI at 45 % yearly.

Austria
Austria is a country where the EDI boom has not taken place yet. Not more than 30 are listed; mainly national standards are used. The EDI boom is expected in the years immediately ahead. Most important application areas are grocery/retail, transport and the automotive industry.

Japan, Far East and Australia
In these countries the EDI development is in its first embryonic phase. Until now, most representatives are positive with respect to implementation of EDI. They are afraid of lagging behind. Takeoff is expected in the coming year, probably strongly stimulated by the foundation of a Japanese/Far East and an Australian Edifact board. IDEA estimates the yearly growth of companies using EDI in Australia and the Far East at 55 %. They estimate the number of companies using EDI nowadays as 1,000 overall.

CMEA countries
The CMEA countries are attending all ECE Working Party 4 meetings. They are very interested, especially Poland, GDR, Czechoslovakia and Hungary. They are very active in several working groups. The high activity of the USSR and Bulgaria in recent years has decreased.
Most CMEA countries are afraid that the technology gap is increasing more and more, also in the field of EDI. This is probably the main reason why these countries attend so actively[14].
Unfortunately there are almost no EDI implementations in the CMEA countries. They have to cope with two main problems, a lack of education and a poor telecommunication infrastructure.
A pilot project between Austria and Czechoslovakia is planned for next year in the framework of the planned TER project[15].

EDI implementation in the CMEA countries is quite difficult without help from the West. USA is probably willing to help, especially Poland and Hungary. Perhaps IBM and GEISCO will help in order to improve the infrastructure.
Another opportunity probably used to implement EDI in CMEA countries is the 1995 World Exhibition in Budapest and Vienna.

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13 According to Henk C. van Maaren in [VLIET, 1989].

14 According to H.J. Schöner, manager of AustriaPro, representative of Austria on the Edifact board. Interview in July 1989.

15 TER project stands for Trans European Railways; the goal is to realize a direct connection between Scandinavia and Italy through Eastern Europe.

Thus only a few pilot projects are expected to be implemented in the near future.

Final observation
Although the USA have the lead in non-Edifact EDI applications, it is clear that Europe is trying to obtain a competitive advantage over Japan and USA as first users of the Edifact standards.
The cooperation with USA, Japan, the Far East and the CMEA countries on the Edifact board is at first sight in contrast with this strategy. However, this cooperation is just to ensure that the Edifact standard will become the world standard. Recently ANSI have declared that they will migrate to Edifact in the next 5 to 10 years. Currently, Europe has taken the leading position in the Edifact applications, partly due to the strong stimulations of the European Community by means, for instance of the TEDIS project[16].

4.4. Some figures on driving forces, barriers, changes and savings

In the USA some research is done on driving forces and savings thanks to EDI applications. Most important reasons for implementation are, in sequence of importance:

1. Quick response
   * An average reduction of one week between ordering and delivery is realized by Volkswagen.
   * General Motors realized a lead-time reduction of four days.
2. The customer asks for EDI
3. Cost reduction
   * Tennessee Service Merchandise Co. estimates the total cost of processing a purchase order in written form at $50. With EDI these costs have decreased by between $12 and $14.
   * Bank of Chicago calculates that savings between $3.75 and $6.50 per document can be made using EDI.
   * The big four automotive producers in the US estimated their savings at $200 on each car produced. The Automotive Industry Action Group (American organization of automotive industry) estimates the costs of processing purchasing orders at $50 - $75. EDI reduces this to $12 according to their estimations. With mail there is a 7-10 day lag for the time a part is ordered until it is received. The use of EDI has reduced this cycle time to less than two days. [SADHWANI, 1987]
   * Super Value Stores, a Minneapolis-based wholesaler, serving 3.000 independent food stores are using EDI in 12 of their 20 divisions. The purchase orders are sent electronically. The experiences show that EDI at 300 vendors (submitting purchase orders automatically and computerized manual reconciliation of purchase orders against receipts) saves $6,000 per day. For every 100 vendors 15 fewer people are needed.
   * Navistar International Corp. has cut its truck stock by a third or $ 167 Million. This represents a reduction from a 33 day-

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[16] TEDIS stands for Trade Electronic Data Interchange Systems. It is a European Community programme that aims to stimulate cooperation in order to realize projects on electronic transfer of commercial data using telecommunications networks.

supply to a six-day supply. [TSAY, 1988]

Based upon study results [EMMELHAINZ, 1988], it is found that the decision to implement EDI is neither cost driven nor technology driven, but rather driven by the desire to obtain a competitive advantage.
In this study, 15 companies with several branches have been interviewed. Some other figures are given below, the number of companies confirming the statement is indicated between brackets.

The three most important factors influencing the implementation are:
- a talented and competent champion, a person championed the use of EDI to both top management and users, (10)
- top management support, (9)
- early user involvement. (9)

According to research the barriers for EDI implementation are:
- resistance to change, (9)
- lack of standards, (5)
- Lack of third-party network support. (5)

All fifteen companies confirmed that EDI implementation resulted in changes in the administrative procedures, but only five companies confirmed that the buying procedures have changed.
Eleven companies stated that, through EDI implementation the necessary commitment and cooperation resulted in a closer relationship.
Six companies stated that EDI encouraged the sharing of information and enhances trust between the partners.
Five companies said that EDI eliminates nuisance factors, such as lost orders, incorrect information, etc., which often create conflict between buyer's and vendors.

The figures given in the section are very difficult to obtain because they are mostly indirect. Moreover, for marketing reasons, they are often very optimistic. It is found from the study of [EMMELHAINZ, 1988] few organizations even formally quantified both costs and benefits.
Thus, the figures can only be used as indicators for the growing importance of EDI.

5. CONCLUSIONS

- EDI is one of the newest booming forms of electronic communication and information technology. It is a structured and automated electronic exchange of messages for order and goods flows between independent companies. Its implementation is a necessary step towards overcoming the communication problems in business/logistics.

- The common objective of 'present-day CIM' and EDI is integration. The difference between these two phenomena is the level on which they make their contribution to integration: CIM especially on machine, cell and shopfloor level in companies; EDI in integration across organizations. CIM interpretated in a more broader sense, in the sense of integrating to whole value-adding process across the whole value chain, contains EDI as a contribution to the realization of CIM.

- EDI-related fields are:

Standardization	The worldwide EDI standardization called Edifact - a must for worldwide diffusion of EDI - is developing very fast.
Informatics	The availability of physical connections (VANS and X.25 infrastructure) and software (for translation and communication stimulates diffusion of EDI. Its influence on internal information systems is just partly known.
Logistics	EDI is a solution to the communication problem of the implementation of JIT philosophy.
Organization	EDI is essential to implementation of new cooperation forms between supplier and customer, like Value Added Partnership. EDI also changes the internal organization because the traditional paper exchange, the authorization and documentation has been eliminated. Furthermore, EDI provides possibilities for realizing a competitive edge; in some cases the key activity of company changes, because a new process by EDI was introduced. In these cases particularly EDI is most profitable. Attuning EDI to the strategic policy of the company is necessary.
Applications	USA is the world leader in non-Edifact EDI diffusion. Leaders in Europe are the UK and Sweden. Other countries are following quickly. The European Community will, through EDI and using Edifact standards, try to realize a competitive edge on Japan and the USA. The future function of VANS and EDI organizations is still unclear.
Methodology	The crossing of company borders by EDI, especially the competitive character and the habituation period between competitors, reduces the speed of development of applications. Only competitive applications, in contrast with cooperative applications, are developed very quickly.

- The few quantative figures confirm the exponential growth of EDI and its future importance. EDI is expected to become normal business practice between 1990 and 1995. The biggest potential problem is the creation of 'islands of networks', in other words EDI applications which can not speak with others because of the lack of a common language.

- Summarizing
  1) EDI is much more than the substitute for telephone or mail; not only are benefits realized, but a structural change in the branch and/or company and/or key activities of a company can also occur.
  2) The importance and number of EDI applications is increasing exponentially. Whether we like it or not, within a few years the closing quote will appear to a lot of companies, 'Without EDI, no business!'

6. FINAL OBSERVATIONS

Now that we are at the end of this working paper I hope I have been able to explain the phenomenon EDI and emphasize its importance. The latest statements by top management of companies like General Motors, General Electric, IBM and Philips again underlined the importance of EDI: they have declared EDI to be one of the key points and CSF's of their business in the coming years. The Department of Defence of the USA has declared that from 1990 on, all suppliers have to use EDI!

But I want to add that EDI is just one example of new information technology. It is clear to me that information technology will have an enormous influence in the nineties, not only in technological sense but even more so on business and society. The consequences of information technology are numerous and first signs are already on the surface: homework, structural changes in doing business, information overload, function-deskilling and unemployment in the areas of bookkeeping and administration.
I welcome the idea that the CIM project will undertake research on this topic in the near future.

Last but not least, I take this opportunity to address some words of thanks to IIASA, especially to my supervisors, Pavel Dimitrov, Jukka Ranta, and Bob Ayres and the other members of the CIM project. I very much liked the informal and open atmosphere and I hope that the contacts will be maintained in the future.
A special word of thanks also to my colleagues of East and West of the YSSP program: the Summer of 1989 is one I shall not easily forget. Not only the discussion during working hours, but also the several parties and excursions in the weekends made it a wonderful time.

Coen Kreuwels.
November, 1989.

7. LITERATURE

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APPENDIX 1

THE EDIFACT BOARD

SECRETARIAT

COMMISSION OF THE EUROPEAN COMMUNITIES, Directorate General XIII D/5
Address: Rue de la Loi, 200 (ARTS LUX 3/26) B-1049 Brussels
Phone: +32 2 235.14.75 - Fax: +32 2 235.02.99 - Telex: 63425

Brussels, 89.03.01

EDIFACT MESSAGE DEVELOPMENT STATUS

22 messages at reasonably advanced stage ; 1 AT DRAFT STAGE ; 3 in early stages.

	STATUS	
TRADE		
Invoice	2	Approved
Purchase Order	P	Being submitted for trial use, (being
P.O. Response	P	used/trially)
Request for Change to P.O.	P	" " " " " "
Just In Time Delivery	O	Fairly advanced
Despatch Advice	O	" " "
Delivery Schedule	O	" " "
Price Sales Catalogue	O	" " "
Quality Message	O	" " "
FINANCE		
Payment Order	O	First clean draft
Remittance Advice	O	" " (developed with Trade)
Credit Advice	O	Early stages, but should arrive Fairly
Debit Advice	O	quickly once the above 2 are finalised
Statement	O	" " " " "
TRANSPORT (sub-sets of the IFTM)		
Provisional Booking	O	Fairly well advanced, but will need
Firm booking	O	revision and consolidation with other
Booking confirmation	O	MDGs messages.
Instruction	O	" " " " " "
Instruction Contract status	O	" " " " " "
Arrival Notice	O	" " " " " "
CUSTOMS		
Customs Declaration	O	Well advanced. (Being trialled)
Customs Response	O	Fairly advanced.
CEC Subset/SAD	O	" " "
SERVICE MESSAGES		
General	O	Well advanced. (Being used)
Control	O	" " " " "
Directory Exchange Message	O	2nd draft.

APPENDIX 2

Percentage of Establishments Using, Planning, or Not Planning to Use: Intercompany Computer Network Linking Plant to Subcontractors, Suppliers, or Customers

Establishment characteristic	Number of establishments[1]	Percent distribution							Standard error[2] (percent)
		Used in operations	Plan to use within		Do not plan to use because				
			2 years	2-5 years	Not applicable	Not cost effective	Other reasons	Not specified	
All establishments	39,556	14.8	7.9	12.4	34.0	13.9	7.6	9.1	0.3
Major Group:									
34, Fabricated Metal Products	12,746	14.9	7.5	11.3	34.6	13.4	8.7	9.6	0.5
35, Industrial Machinery and Equipment	13,176	12.4	7.6	12.9	37.2	14.5	7.1	8.1	0.5
36, Electronic and Other Electric Equipment	7,293	16.2	9.3	13.0	29.5	13.5	8.2	10.3	0.7
37, Transportation Equipment	3,425	21.7	7.4	12.7	26.9	12.1	7.0	10.3	0.8
38, Instruments and Related Products	2,916	13.8	7.6	13.3	33.9	10.9	7.3	7.3	0.7
Employment size:									
20 to 99	27,369	9.7	6.5	10.9	40.3	15.2	7.3	10.1	0.3
100 to 499	9,903	22.7	10.5	15.7	22.0	12.1	9.7	7.3	0.4
500 and over	2,284	41.8	13.2	16.8	10.4	5.9	6.6	5.3	0.7
Age of plant (years):									
Under 5	4,731	11.9	9.7	14.3	38.1	16.3	8.6	1.2	0.5
5 to 15	12,295	16.2	9.1	12.8	35.9	16.1	8.3	1.6	0.4
16 to 30	10,690	16.6	8.1	14.4	35.9	14.4	9.5	1.4	0.5
Over 30	8,464	18.0	6.1	13.0	37.6	13.1	7.9	1.4	0.4
Not specified	3,377	0.3	0.3	0.7	6.1	0.4	0.7	91.5	0.1
Manufacturing process:									
Fabricated machining	6,870	14.6	8.5	12.1	38.9	16.5	7.8	1.7	0.5
Assembly	5,088	18.3	8.4	14.1	36.3	15.4	6.2	1.3	0.5
Both	21,016	16.6	9.0	14.4	33.9	15.0	9.8	1.3	0.3
Neither	2,619	11.9	6.8	9.0	52.4	12.3	4.8	2.6	0.6
Not specified	3,363	0.5	0.3	0.3	6.0	0.5	0.9	91.4	0.2
Market for most products:									
Consumer	4,451	17.5	9.4	12.8	38.0	14.3	7.2	0.9	0.5
Commercial	5,342	16.4	8.7	16.6	33.7	15.6	8.2	0.8	0.5
Industrial	17,861	13.6	8.7	13.5	37.5	16.5	8.7	1.5	0.3
Transportation	3,243	32.6	10.4	11.8	27.0	9.5	6.9	1.8	0.8
Government	2,626	13.9	8.1	15.5	36.4	16.2	8.6	1.3	0.7
Other	2,137	12.2	5.9	10.2	43.1	12.2	12.9	3.5	1.1
Not specified	3,896	2.6	0.5	1.4	12.6	2.6	1.8	79.2	0.7
Market price of most products:									
Less than $5	5,101	21.5	9.3	12.5	33.3	14.3	8.3	0.8	0.5
$5 to $100	9,209	19.0	8.9	12.5	35.9	13.7	8.6	1.5	0.4
$101 to $1,000	7,643	13.7	8.9	14.1	39.8	13.9	8.7	0.9	0.4
$1,001 to $2,000	2,002	14.1	7.0	16.0	33.1	19.5	9.8	0.5	0.6
$2,001 to $10,000	4,456	11.8	7.7	14.6	36.5	18.6	8.6	2.0	0.6
Over $10,000	6,328	14.4	9.4	14.0	35.5	16.2	8.5	2.0	0.4
Not specified	4,639	4.8	1.4	3.7	16.6	3.6	1.7	68.2	0.8
Products made to military specifications:									
Yes	14,588	17.2	11.3	14.7	33.2	14.1	8.2	1.4	0.5
No	19,439	15.4	6.6	13.0	39.4	15.1	8.6	1.6	0.4
Don't know	2,141	15.7	6.6	10.8	34.2	22.6	8.7	1.1	0.7
Not specified	3,388	0.6	0.5	0.3	5.8	0.9	0.9	91.0	0.1
Prime defense contractor:									
Yes. Percent of products shipped to defense:									
1 to 25 percent	10,010	16.3	9.5	17.4	31.1	14.9	9.4	1.5	0.5
26 to 75 percent	1,012	16.3	9.0	15.7	35.0	15.5	7.1	1.3	0.9
Over 75 percent	683	17.0	9.9	11.3	36.2	14.6	7.9	3.0	0.9
Don't know	601	18.7	12.2	7.0	36.9	16.4	7.7	1.0	0.9
No	22,874	15.8	8.2	12.1	39.4	15.1	8.1	1.4	0.3
Don't know	1,028	16.4	6.9	12.4	32.7	16.6	11.0	1.4	1.1
Not specified	3,349	0.9	0.2	0.1	4.6	1.0	0.9	92.0	0.3
Subcontractor to defense:									
Yes. Percent of products shipped to prime defense contractor:									
1 to 25 percent	11,533	17.3	10.6	15.0	32.4	14.0	8.1	1.9	0.4
26 to 75 percent	2,738	15.3	9.7	17.0	35.0	16.5	5.2	0.6	0.5
Over 75 percent	660	16.6	4.8	10.3	42.1	11.2	6.1	0.9	0.7
Don't know	1,830	14.4	9.1	13.8	37.8	13.4	10.3	1.3	0.6
No	12,901	15.3	7.4	11.3	40.7	15.4	8.5	1.4	0.3
Don't know	6,070	10.1	7.3	13.9	35.2	15.8	10.6	1.1	0.4
Not specified	3,605	1.6	0.9	0.7	7.3	2.1	1.1	86.2	0.3

- Represents zero. (Z) Represents less than .05 percent.

[1]For each characteristic, excluding all establishments, major group, and employment size, the numbers shown in this column are sample estimates. Relative standard errors for these sample estimates can be found in Appendix D.

[2]A description of the standard error of the estimate is given in Appendix C, "Sampling and Estimating Methodology."