EDI and Inter-Firm Relationships: Toward a Standardization of Coordination Processes ?*

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Information, Economics and Policy, vol. 6, N°3-4, 1994, pp. 319-347

Introduction

Electronic Data Interchange (EDI) consists in the interchange of structured and standardized data between computers belonging to parties involved in a business relationship. The potential of EDI has been recognized since the mid-70's when the dematerialization and the automation of document transmission and handling was identified as a source of major time and money savings. Indeed the transmission of electronic information through a telecommunications network is about 10,000 times faster than and one-sixth as expensive as the physical transmission of a paper document by the postal service. Moreover, the manual handling of a paper document by the sender and the receiver is slow, expensive, and generates many mistakes. In 1989, the COST 306 Committee estimated that the automation and dematerialization of inter-firm information exchanges could halve the generated administrative costs; the latter can be estimated at between 10% and 15% of the price of products[1]. Such figures led to the interest in EDI and induced many economic actors — firms, public administrations, governments and international authorities — to support EDI developments and implementation.

It must be understood that EDI does not refer to the transmission of free-form messages[2]. The main interest of EDI is, indeed, in enabling the automation of inter-firm communications and associated information handling processes, allowing business partners to substitute capital for labor, to increase the accuracy of their information exchanges, and to accelerate these exchanges[3]. The exchanged information must therefore be in a standard format in order to be readable by both parties' computers (i.e. the exchanged messages have to be built with standardized data dictionaries and standardized syntax rules, and must be transmitted through standardized file transfer protocols). This does not mean that the parties have to use exactly the same standards; compatible standards would suffice. Standards are compatible when translation (without information losses) is possible. This requires that the standards use similar syntaxes and are based on vocabularies between which a bijective mapping exists[4]. When compatible standards are used, the translation can be automated, and, even if it is more costly than a process without translation, the inter-firm communication can be performed without any human intervention. On the other hand, if the parties do not use the same (or compatible) standards, human operations are required to analyze the content of the transmitted message and to interpret it in the other language. In this case, most of the benefits of the automation of exchanges are lost. Standardized computer readable languages are therefore inherent to EDI.

EDI standards are often assumed to be characterized by strong network externalities (Katz & Shapiro, 1985). EDI communication among firms using different — but compatible — standards is possible, but costly. Business partners consequently have a common interest in using the same standard. By extension, all the firms belonging to the same business network have a common interest in using a single EDI standard. Since indirectly — i.e. through links with other firms — all firms belong to the same and universal business community, there are apparently strong incentives to use one unique, universal standard. Moreover, the existence of a unique standard would decrease the cost of EDI implementation (economies of scale in software and EDI services, amortization of the implementation costs on many inter-firm transactions, etc.). The rationale for a unique, universal EDI standard is even more obvious if EDI sub-standards (e.g. industry standards) are not perfectly compatible (automated communication is then impossible). These are basically the arguments that are commonly assumed in the literature on EDI standards.

Yet when one studies in detail how EDI is implemented among companies, one gets another picture of the economics of EDI and EDI standardization. First, EDI messages are strongly related to specific business practices in the sense that they embody these practices. Second, rather than being implemented only to automate existing coordination processes, EDI is mainly used to metamorphose them. In fact, EDI is a component of the movement seeking to reorganize the whole production process, in order to make it more efficient by cutting costs, streamlining processing, etc. (Cf. Antonelli (1988), Bensaou (1992), Faulhaber, Noam & Tasley (1986), Malone, Yates & Benjamin (1987), Scott Morton (1991), etc...). Its major pay-off is thus due not to the automation of administrative processes, but rather to the greater reactivity and leaner production processes that firms can implement when they transform their business relationships. This radically changes the economics of EDI and EDI standardization because the rationale of EDI is no longer perceived as the simple automation of information exchanges, but as the use of communication techniques suited to business practices, especially to new business practices.

Thus, beyond the question of the standardization of communication, a problem of organizational standardization arises. This can be explained by two factors. First, the nature of messages that are exchanged among companies refers to specific coordination procedures. As a consequence, a standardization of the messages exchanged calls for a standardization of coordination processes among firms. Second, the nature of certain categories of inter-firm relationships requires abilities that induce certain types of internal organizational configurations. For instance, the achievement of a just-in-time purchasing process by a company induces the implementation of flexible organizations by its suppliers, and subcontractors, and transportation companies. The rationale of EDI standardization has thus to be assessed by taking into account the consequences and the constraints of this induced phenomenon of standardization of inter-firm coordination processes.

This paper will deal with these issues. First, I will explain why there is a strong relationship between the spread of EDI, the question of standards, and business processes. I will point out that the spread of EDI standards is strongly linked to the standardization of business procedures. Second I will stress the questions linked to this type of organizational standardization: Is it possible ? Is it

desirable ? This is necessary to get a better understanding of the questions raised by the spread of EDI techniques and EDI standards. Especially, it will be pointed out that there are stronger obstacles than usually stressed to the diffusion of universal EDI standards. It will also be shown that the benefits of such a unique standard could be considerably lower than usually assessed.

This paper is based on several investigations conducted both in the US and in France since 1989. These investigations sought to describe how Information Technologies (ITs) participate in the transformation of inter-firm coordination processes in several manufacturing and service industries. Detailed case studies were written to describe how ITs are used by various firms to transform (or not) their business relationships in diverse coordination processes (buyer-supplier relationship, co-operation, etc.)[5]. Although these surveys were concerned with wider issues than EDI, EDI issues were central. My analysis is thus based on several both successful and unsuccessful experiments of EDI developments and implementation at the small user group, industry, national, or international levels.

It is interesting to point out that any analyst of these issues is struck by the gap between actual realization in EDI and the discourses of policy makers, EDI vendors, Information systems managers, etc. Actually, EDI is not yet widely dispersed. This fact is obviously related to the relative youth of these technologies. However, I believe, it is also due to a lower interest in EDI than usually stressed. EDI is really a key technology in a very limited range of industries. This will be shown by most of the examples reported on here. The reader will see that all the examples come from a very limited number of industries (essentially retailing, the automotive industry, transportation, and banks). Actual applications are rare in other industries.

1. EDI: FROM STANDARDIZED COMMUNICATION TO AN ORGANIZATIONAL STANDARDIZATION

EDI is not a simple technology. It is both a telecommunications technology and a language technology. These specific features are important to an understanding of the economics of EDI standardization. Because it is a telecommunications technology, it is characterized by positive network externalities (Katz & Shapiro, 1985), and by increasing returns to adoption (Arthur, 1989) (see also Blankart & Knieps, 1994). Both induce a rationale in adopting common standards. EDI is also a language technology (Foray, 1991) because it deals with the transmission of intent through a set of formal codes that the two parties must produce, and interpret, and to which they have to be able to respond. This means that EDI standards have to suit each of the users' needs and capabilities. In this section, I will show that these two specificities of EDI induce not only the creation of common languages, but also a subtler and tighter standardization process by which two parties choose a compatible communication convention (namely an interchange agreement). This will lead to a demonstration that EDI *operational messages* embody the specificities of business practices (§ 11). As a consequence, the development of EDI communication is combined with a movement by which

firms make their interactions more uniform (§ 12). This has a strong impact on the issue of EDI standards.

1.1. From EDI standards to specific operational messages

In the early days of EDI, individual user organizations found it necessary to establish rigid and proprietary rules of communication with their close business partners. The spread of these local standards was quickly recognized as an inefficient solution since it obliged the economic agents involved in several relationships to install multiple EDI systems or to process the received documents manually (and that is no longer actual EDI, see note 2 p. 1). This led to the development of intra-industry standards of communication both in the US and Europe: e.g. CIDX in the US Chemical Industry, PIDX in the US Petroleum Industry, AIAC in the US automotive industry, VDA in the German automotive industry, TRADACOMS in British grocery retailing, etc... The rationale for these national intra-industry standards was that they were easier to develop and economically justified. They were easier to develop than wider standards — i.e. standards involving all the participants in the productive system within a country, an economic community, or the world — because participants in a given business community are fewer, have a satisfacting knowledge about each other, and resort to similar business practices and information handling procedures. Moreover, intra-industry standardization institutions and associated traditions often already exist. Intra-industry standards are also economically justified since the bulk of the business transactions of many firms is often intra-industry. By developing national intra-industry communication standards companies were thus able to automate an important share of their external business communications. This is not true, however, for all companies and all industries. The more open to inter-industry transactions the company (or the industry), the less satisfacting these multiple EDI standards. In particular, industries that are inherently linked to all the other industries, such as banks, insurance, retailing and the transportation industries, are severely disadvantaged by the existence of this multiplicity of industry specific EDI standards. First, it generates high costs since these companies have to develop strong (automatic or human) translation capacities. Second, it brings down the functionality of EDI, because specific messages can be misadapted to the needs and capabilities of such transversal industries These called for the development of trans-industry and international standards. Moreover, the national and international authorities pushed for the development of such standards as they were perceived as favoring competitiveness (in the case of national trans-industry standards) and free-trade (in the case of international standards). This resulted in national efforts such as EDIFRANCE or ANSI 12, on the one hand, and international initiatives such as TEDIS (EEC) or UN/EDIFACT, on the other.

This simplified picture of EDI standardization is however misleading since it encourages the idea that EDI standards are just neutral technical solutions to simple problems of (tele)communication between diversified computer systems. It seems to imply that EDI standards are some kind of increasingly perfect Esperanto when one moves from proprietary standards to

UN/EDIFACT. In reality, this is not true. EDI standards are not just technical standards that enable users to transfer data among computers. Rather, they are intended to constitute a *language* that enables both information systems to "understand" each other. The aim of EDI standards is indeed that a received message can be correctly interpreted by the intended recipient information systems and therefore integrated into internal applications software such as inventory or production management systems. The aim is thus to transmit intent, not just data. Like each language, EDI languages embody inherent biases. As pointed out by linguists, languages are not designed to describe and think any objective "Truth". Rather they are designed to meet the communication needs of the users. Since different communities of users do not have the same needs because they live in different natural and social contexts, languages differ (e.g. Hagège, 1985). Such biases are obviously especially strong for those languages which are conceived to support coordination among business organizations, because they are fitted to very specific and narrow needs[6].

EDI standards are designed according to the information exchange requirements of the inter-organizational arrangements for which they are intended. As these arrangements are very diverse among industries, various EDI standards are not meant for the transmission of the same type of information. An electronic order in the petroleum industry will not resemble an order in grocery retail because the traded goods do not have the same features (large quantities vs. various small items, fluid vs. objects of diverse forms, values and packings, non perishable vs. perishable goods, etc.), and because the business practices differ; and not only because the information is coded differently. Moreover, the diverse EDI standards can be constructed according to conflicting logic that reflect divergences between coordination techniques. For instance, some manufacturers do not send orders to their suppliers, but increasingly precise forecasts of their actual needs. These are radically different from orders since forecasts do not give precise volumes, but ranges, not precise references, but group of references. Moreover they have a varying level of commitment. Orders and evolving forecasts are two alternative and incompatible ways to inform a supplier of a company's needs. This diversity in information exchange requirements is basically the reason why there are strong incompatibilities among many EDI standards.

As a consequence, more "general" standards like UN/EDIFACT cannot be the simple HCF (Highest Common Factor) of all other (sub)standards. Rather they are optional standards that do not guarantee mutual understanding, but that avoid misunderstanding. In fact, EDI standards are intended to construct unambiguous messages, but not to define the precise setting of all possible messages. Rather, they set the rules that must be enforced by users to build their messages in order to avoid developing messages that could resemble other messages containing different intents.

An EDI standard can be broken into two major categories of components:

— a Data Directory: Data elements are the equivalent to words in human languages. They must be precisely associated to a meaning;

— a Syntax: the set of rules controlling the structure of a message and akin to the function of a grammar in a human language. These syntax rules define among other things:

* Segments: a grouping of related data elements that are logically associated (such as a name and an address). These segments facilitate the building of messages.

* Service segments: standardized instruction segments are implemented within the message to enable its automatic processing by the receiver.

* Hierarchical rules: the position of the diverse segments in the message influences its meaning. For instance, the same message can define several delivery places and a common address for the billing.

* Messages: a grouping of segments corresponding to a specific transaction such as an invoice

These components enable users to construct usable messages. However, they do not define these messages. In fact, many of the above quoted elements are contingently defined by standardization committees. An EDI standard does not resemble a set of electronic forms with precisely defined rubrics and codification rules. It is rather a set of rules that define some generic syntax rules, a small amount of obligatory segments, some codification principles, and a tremendous amount of optional segments. This is true both for industry standards and for trans-national standards. The rationale for this is the following:

— First, EDI standards have to be adapted to the partners' information systems capabilities. If there were too many obligatory segments, most of the existing information systems would not be able to generate or interpret EDI messages. For instance, a transportation company is not interested in knowing the color of the car or of the jeans it carries. Thus its information system is not designed to process this kind of information. If the color was obligatory in the standardized EDI message it could not receive or send messages enforcing the standard.

— Second, EDI standards have to not only be adaptable to both partners' needs, but also to avoid waste. If the standardized messages had to incorporate all the potential information that is necessary to the direct and indirect participants in a business transaction, they would be immense and unmanageable, since many economic actors are involved in a business interaction, and since all of them need different types of information. Think, for instance, of a simple commercial transaction that involves at least a vendor and a sender that do not always belong to the same industry, two banks that do not always belong to the same country, one transportation company, some public agencies and authorities (tax administration, customs, etc.), and some insurance companies. If an EDI standard had to be fitted to all the potential needs of these diverse partners it would be quite impossible to generate standardized messages, or they would, at least, be unusable and too expensive to manage (They would particularly require the use of gigantic information systems).

As a result EDI standards are not usable per se[7]. Economic agents have to precisely define the data they will exchange, as well as agree on the messages, and optional segments they will use. Moreover they have to make message interpretation rules explicit in order to suppress ambiguity. EDI standards only facilitate the development of operational messages by providing actual users with a catalogue of usable and coherent solutions that meet their communication requirements.

This suggests a distinction between EDI standards and "languages". Rigorously, most EDI standards are not languages, but rather a set of rules and codification principles that permit the development of actual languages. It should thus be clear that "universal" EDI standards do not in fact allow universal communication. EDI standards are not Esperanto. Rather, they are tool boxes that enable users to create actual *operational messages*. However, if EDI standards do not allow per se communications, they do influence the communication potentials of their enforcers. As mentioned above, vocabulary set and syntax rules are strongly linked to the intents that their designers want to make transmittable. As a consequence, although EDI standards are a set of options, they also introduce biases in communication potentials in the sense that they oblige the sender to express intentions according to certain rules, and prohibit the expression of certain intents.

A corollary of the previous remark is that EDI *messages* are closely linked to business practices. As operational messages are not universal, they are built by agents to overcome their local coordination problems. This means that they design the messages to exchange the information that is required by their coordination process. As a consequence, these messages represent an embodiment of trading and coordination practices, and many messages are specific to a relationship or a class of relationships. For instance, and as mentioned above, when Just-In-Time (JIT) supply procedures are used, firms do not use orders. If without delay orders were sent by customers according to their immediate needs, most suppliers would be unable to meet their requirements. Thus, to reduce the uncertainty faced by suppliers, clients that need JIT deliveries have to send forecasts to their suppliers. Typically these forecasts are increasingly precise and definite with the passing of time. They are used by suppliers to plan their own procurement of inputs and to pre-schedule manufacturing tasks to fulfill the anticipated needs. This enables the downstream manufacturer to generate daily shipping requirements that describe the product needs for that day. When it is received, it is examined and the supplier confirms (or not) its ability to meet these requirements thanks to an advanced shipping notice. It is used by the downstream manufacturer to rearrange its production schedules and to prepare unloading and receiving. The exchanged messages are quite different from those used in standard commercial transactions: requests to quote, quotation, purchase orders, etc...

This close link between EDI operational messages and business practices causes problems. First, as pointed out above, it prevents universal communication. Second, it brings down the quality of communication[8]. As users tend to accept only messages that fit their needs, many operational messages correspond to the lowest common multiple (LCM), and are therefore very poor. These generate information gaps that are costly, and that limit the interest of EDI. For instance, banks are not interested in communicating the transactional information that gives rise to payments and fund

transfers. This information is voluminous as compared to financial information and its handling by banks would require a noticeable development of their information systems capacities. As their existing information systems are already large and costly, banks refuse to take charge of the processing of such information. Nevertheless, it would be very useful for banks' clients. Indeed when they receive a payment it is often very difficult to reconcile it with actual transactions. Most of the time this fund transfer does not correspond to any order, bill or shipping advice received or sent, since there are often differences among these three documents. A determined shipping advice can refer to several orders because goods were shipped at different dates and grouped according to their date of sending and not of ordering. Similar phenomena generate substantial divergences between bills and orders, or between bills and shipping advices. The buyer also does not pay according to the bills but according to the information contained in its internal receiving advices that are different from the shipping notices because of transportation incidents and scrapped or returned materials (quality, errors, etc.). The consequence of these is that companies that receive a payment have to make a tremendous reconciliation effort to determine to which transactions they correspond[9].

It has thus been pointed out that universal EDI standards does not make it possible to create usable languages that would be independent from specific business practices. First, since they fix codification and expression rules, EDI standards are inherently biased (see also Webster [1994]). Second, and above all, the more universal EDI standards, the less precise these codification and expression rules (because they are contingently defined). As a consequence, universal standards do not constitute languages per se, and actual users have to create their own languages by specifying the set of rules that they will actually enforce. The created operational messages and interpretation rules constitute some kind of sub-standards that are both highly specific and strongly related to specific business practices. In fact, universal EDI standards, like Esperanto, do not make it possible to overcome the strong relationship between the content of a communication and its envelope. Actual EDI languages, like every language, are inherently biased whether they have been constructed with universal or specific EDI standards. This restricts EDI communication to bounded communities.

Beyond these limits in communication due to the high specificity of EDI operational messages, the strong congruence between EDI operational messages and business practices tends to link the spread of EDI to a standardization of coordination processes.

1.2. From communication standards to standardized coordination processes

As pointed out above, EDI operational messages should fit the specific needs of a given coordination process, and therefore constitute the embodiment of business practices. I want now to show that the spread of EDI techniques push for the standardization of the coordination processes used by agents. This is due to two main factors: (1) the implementation of EDI favors the recourse to

standardized coordination processes; and (2) the use of EDI is essentially justified when specific coordination processes are implemented.

First, the existence of EDI operational messages favors the emergence of standardized inter-organization interfaces. As EDI messages are strongly correlated to specific inter-organization arrangements, firms already using EDI with some business partners will try to duplicate their "EDI-zed" transactions with their other partners. This will lead them to reproduce as often as possible the same types of organizational arrangements as those that are already "EDI-zed". There are two main reasons for this: First, it enables them to write off the development and implementation costs of EDI over a wide set of inter-firm transactions. Second, by adapting the coordination arrangement features of the marginal transaction to the existing EDI operational messages, firms avoid spending resources on new message developments and new adaptations of information systems. Moreover, intra-industry or universal EDI standards reinforce the trend toward the emergence of standardized inter-organization interfaces, since firms that want to "EDI-ze" their transactions with other firms will be induced to use existing message components to develop their operational messages, because, (1) as they already exist, they bring the development and implementation costs down; (2) more universal standards make it possible to develop operational messages that *could* be compatible with other operational messages used upstream or downstream in the production process; and (3) messages based on such wide standards could possibly be more easily accepted by third parties (since they are not too specific to a particular pair of business partners, they are eventually usable by each partner with third parties, and they maintain an ability for each trader to switch to another partner).

Second, the usefulness of EDI techniques is strongly correlated to the use of specific coordination processes. In fact, EDI is a major factor in costs-savings and improving efficiency when it is implemented in conjunction with substantial coordination process changes. Roughly, the major potential of EDI is when it enables business partners to implement information intensive coordination arrangements that are globally more efficient than information saving coordination techniques that were used ex-ante (because of the restriction in the ability to communicate and process information).

Indeed, the deep root of EDI is the automation of coordination among companies, not cheaper communication. EDI is not a key technology because it makes possible the substitution of electronic messages for paper based messages, but because it is the necessary condition for an automation of business interactions resulting in the substitution of capital for labor, more reliable and faster coordination processes, etc. To a large extent EDI is an artefact of the control and rationalization revolution pointed out by Bell (1973) and Beniger (1986). This revolution rests on the use of information technology as a means of managing complexity by enabling complex optimization processes and rapid and accurate information transmission. EDI is the technology that enables firms to extend to their external relationships the rationalization revolution they managed within their boundaries. This does not mean, however, that the potential automation of existing relational practices is always useful. Most of the time, firms use inter-firm coordination processes that have been experienced and improved on for many years. Most of these processes were designed before the spread of information technologies to be efficient (or at least satisfying) in a world where these

technologies did not exist. Consequently, many business practices and coordination arrangements rely upon a limitation of the information exchange requirements. The use of buffer inventories belongs typically to this type of coordination technique: as the information about final market needs and upstream constraints were difficult to gather, process and exchange, firms used buffer inventories to regulate the flows of input and output to avoid either input gaps or shortfalls in stock (Paulré, 1976). In the same spirit, coordination arrangements based on routines — i.e. ex-ante designed collective behavior rules (Nelson & Winter, 1982; Favereau, 1989) — also enable users to limit information flows. When these types of information-savings coordination processes are used, information technologies do not represent a high potential for improvement. EDI is thus neither cost-saving, nor efficiency-improving in many inter-firm relationships. This is basically why it is weakly spread — as compared to early forecasts — in many industries. On the other hand, EDI is a technology that make it possible to perform cheap and rich information exchanges when more information intensive coordination procedures are needed because alternatives processes are no longer efficient.

The process of implementation of Just-In-Time (JIT) coordination typically reflects this congruence between EDI and new coordination practices. Surplus production capacities and buffer inventories save information handling expenditures but they also generate costs and inefficiencies (under-usage of equipment, low turnover of circulating capital, long reaction period in case of misadaptations or defects in inputs or products, etc.). When firms are obliged to produce a wide range of differentiated products because of consumers' preferences for diversity, the use of non-flexible production and coordination techniques can become strongly inefficient. This has led several firms to implement JIT processes in recent years. In fact, these companies have been obliged to push for the implementation of JIT processes upstream and downstream in the production process, because this is the only way to secure the supply of inputs while avoiding the maintenance of tremendous stocks, or running out of output. The JIT processing of entire industries induced the development of JIT links between firms, which in turn required the use of JIT communication means, like EDI. The use of EDI is thus not directly due to the efficiency of electronic communication, but rather to the intensive, quick and accurate information flows required by new coordination processes.

EDI (and other electronic communication techniques) are necessary not only when firms implement JIT coordination processes. It is also helpful when they implement more flexible coordination processes — i.e. coordination processes that are not based on routines but on mutual quantitative and qualitative adjustments[10]. EDI is also useful when economic actors design coordination processes based on incentive remuneration systems — i.e. systems that link the remuneration to the actual contribution to productivity — because this type of remuneration requires the reconciliation of much information (for instance orders, invoices and receiving advices, or quality specifications and results of quality tests, etc...). In Brousseau (1993b), I pointed out, from a survey of over 82 inter-company information systems, that these systems were essentially used to perform one of these three objectives: JIT, flexibility, or incentives.

As a consequence, the process of "EDI-zation" cannot be separated from the process of inter-firm coordination transformation. Moreover, the use of EDI is strongly related to a process of coordination arrangement uniformization. There are three justifications behind this:

— First, if firms want to implement more JIT, more flexible or more incentive coordination processes with their partners, this is because these processes better fit the efficiency and cost requirements inherent to their industries. They are thus encouraged to use the same type of coordination arrangements with most of their business partners (as stressed above for JIT).

— Second, firms are interested in writing off the development and implementation costs of new coordination techniques (and associated new communications techniques) over many transactions (even if they were previously performed by very diverse arrangements). Indeed these new coordination processes, especially JIT processes, necessitate substantial changes within firms. The required organizational changes, production process redesign, employee training, new equipment, etc. generate costs that both suppliers and buyers want to write off over the widest possible set of transactions.

— Third, to make external transactions uniform both on the procurement side and on the selling side simplifies the management of external relationships.

The French automotive industry illustrates this trend to inter-firm coordination standardization. The French EDI standardization group, GALIA (Groupement pour l'Amélioration des Liaisons dans l'Industrie Automobile), that is affiliated to ODETTE (Organization for Data Exchange by Tele Transmission in Europe) in developing EDI messages, elaborated many additional standards to standardize coordination processes. GALIA developed standardized packages, tickets, bar-codes, etc. relating to EDI, but also designed standardized supply contracts, and standardized methods to express requirements to suppliers. Today GALIA is not only an arena where EDI messages are matured, it is a bargaining instance where auto-makers and their direct suppliers negotiate and develop new coordination techniques. Indeed — and this is inherent to the EDI development effort in the French automotive industries — EDI is not perceived as an autonomous movement of electronization of inter-firm communication. Rather EDI is a component of a wider trend of inter-firm coordination standardization related to uniformization (to bring complexity down), just-in-time, and information exchange automation.

I am not suggesting however that the use of EDI is only due to the use of new coordination mechanisms. I wish merely to point out that the major payoff of EDI is not due to EDI itself, but rather to the implementation of the new coordination techniques that the use of EDI technologies implies. EDI is the permissive condition for these coordination process changes. In addition, the implementation of EDI provides the opportunity to negotiate and to discuss these types of changes.

Hence, EDI seems to be a communication technique that is really useful when coordination arrangements require intensive information exchanges. Moreover, its use tends to favor the use of a particular type of inter-organizations arrangement.

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In this first section, a paradox has been pointed out: EDI standards are not really standards since they are only tools that enable users to develop operational means of communication. As a consequence, EDI standards are open (or at least universal) and must be clearly distinguished from EDI operational messages that constitute languages. However, it has been shown that the implementation of EDI techniques tends to standardize inter-firm coordination processes. There are in fact two rationales behind this apparent paradox: (1) as EDI standards per se do not allow communication, economic actors have to develop operational messages and interchange agreements — i.e. specific operational languages — that closely reflect their specific practices. As this development process is costly they are intended to use these languages, and thus duplicate these practices over a wide range of relationships; (2) EDI is often implemented to support inter-organizational practice changes. These changes provide economic actors with the opportunity to standardize coordination processes. Here, EDI is not the determining factor of uniformization, but only an indirect enabling condition, because it is one of the technologies that enables firms to implement new and standardized coordination processes.

2. TOWARD A STANDARDIZATION OF COORDINATION PROCESSES?

EDI implementation is thus strongly related to a process of inter-firm coordination process standardization, essentially because the implementation of EDI is an artefact of the achievement of JIT, flexible and incentive inter-firm coordination procedures. The question now is: is this coordination process standardization possible, and if possible desirable ?

On the one hand, the degree and magnitude of the possible standardization of coordination processes has to be assessed. Indeed, since each country, each industry, and each closed group of collaborating companies has its own specific interaction rules and habits, whether standardization is always possible must be carefully examined. Empirical evidence suggests that there are many obstacles to the implementation of these standardized coordination processes (§ 21).

On the other hand, the desirability of the standardization of coordination rules, which induces uniformity, has to be examined. Although standardization may have beneficial effects by generating economies of scale and scope in coordination, as well as by inducing more competition, it can also cause inefficiencies by creating misfits between transaction requirements and coordination solutions, or inadequacies between coordination rule requirements and firms' abilities, or even dynamic rigidity. Moreover, there are inherent defects in the JIT, flexible and incentive coordination mechanisms, and if these mechanisms became too widespread major inefficiencies could occur (§ 22).

2.1. Is it possible ?

There are two other questions behind this question, since we are not speaking of *any* standardization process, but of the organizational standardization that is linked to EDI implementation. The first sub-question is: is EDI implementable in each type of coordination process ? Here we are no longer speaking of the pay-off of EDI that pushes for a joint EDI/JIT-flexible-incentive-coordination-arrangements implementation, since it has been stressed above. Rather, we discuss the idea of the pure technical possibility of implementing EDI in all coordination processes. The second sub-question is: are those coordination rules that are related to EDI implementable in *any* industry. Here again, the question refers to a technical ability and possibility, leaving aside cost considerations. In the following pages it will be pointed out that EDI is a technique which is an efficient means of achieving a particular kind of communication and of performing a certain kind of coordination which are specific, and slightly fitted to many situations. First, it will be explained that EDI is not wholly appropriate to communication needs when future information exchanges are difficult to anticipate. Second, it will be shown that coordination processes well fitted for EDI exchanges cannot always be implemented because they are adapted only to moderate uncertainty.

As pointed out above the use of EDI is not justified by a dematerialization of information per se, but by the opportunity to handle automatically the information that is exchanged among companies. This supposes that companies are able to anticipate all the information exchanges that they will need in the future. This is not always possible because they are sometimes unable to anticipate all these needs. This impossibility is due either to bounded rationality or to radical uncertainty — i.e. the uncertainty in which economic agents are not only aware of the probability of future events, but also the nature of these future events (Cf. Knight, 1921; Keynes, 1937; Shackle, 1973; O'Driscoll & Rizzo, 1985). When protagonists in a coordination process are in such a situation, it is quite impossible for them to forecast the nature of the information they will have to exchange. Thus, they are unable to develop EDI messages that would meet all their future needs. When the future is only risky in the sense of Knight (1921) — i.e. agents know the nature of the possible future events and their probability of occurrence — or even uncertain in the bayesian sense — agents only have a subjective knowledge about the probability of occurrence of the possible future events, but they know the nature of these events (Cf. Savage, 1954; Anscombe & Aumann, 1963) — agents are in a different situation because they know all the possible situations they will have to face. EDI implementation is thus, at least theoretically, possible.

From a didactic perspective let us assume that there are two opposite types of coordination process among companies: the assembling of pre-manufactured goods (or services), on the one hand; and the co-operation of productive assets, on the other. In the first case, each firm autonomously operates its own facilities, then one of the firms buys the others' output and assembles the different parts. The collective output is then an assembly of provisions (of goods and services) whose features have been qualitatively adjusted and designed ex-ante. This type of organization is implementable when the whole production process can be rigorously modeled ex-ante and divided into a set of separable independent tasks. Put another way, it is applicable when there is no innovation during the manufacturing process. In the second case, the collective output is the result of the joint intervention

of the human, physical and intangible assets of several firms in a collective production process. Ex-ante the precise output of each of these assets has not been fully stated because it will be specified during the production process by mutual adjustments. The precise inputs that the two parties have to bring are also not completely ex-ante stated. These situations correspond to increasingly uncertain coordination situations[11]:

— When coordination is reduced to the assembling of pre-manufactured goods (or services), it can be complex, but it is foreseeable. Indeed, in such cases we are in a risky but not radically uncertain situation. Once the service provided by each participant in the process has been fixed, the only problem is to adapt the actual intervention to the real situation. Since most of each participant's behavioral requirements were specified ex-ante, the sole coordination problem that has not been solved is that related to the logistics. Participants do not know the precise place, time and amount of pre-defined goods or services they have to deliver. Coordination is thus solved through the implementation of information transmission procedures that clearly state requirements in these matters throughout the production process. The information exchanges that will be needed in the future are well-known ex-ante (this is, indeed, the extension to inter-company coordination of the logistic management methods that are used internally). This corresponds typically to the situation between automakers and their suppliers once the manufacturing of a model has been launched. Most of the suppliers have to deliver a set of completely defined and non-evolving parts. Uncertainty is reduced to uncertainty over the date of shipment and the quantities to be delivered. This is also the case in the relationship between retailing companies, transportation corporations, banks and their clients since these companies deliver pre-defined services. In these cases, EDI systems are easily implementable because the low level of uncertainty enables corporations to design languages that will ex-post meet most of their coordination needs.

— When the collective output is not completely ex-ante specified, and the precise inputs that the two parties have to bring are not completely stated ex-ante, coordination is highly uncertain because the output to be jointly produced, and the inputs to be coordinated, do not exist, or are unknown ex-ante. Take a joint R&D effort to produce and market, for instance, an innovation: generally, the parties do not and cannot completely specify what each will have to provide in the future, since they do not know exactly the result of their joint effort, or even their actual potential. Indeed most of these co-operation processes begin by a phase of mutual learning about the other's intents and effective potential (e.g. Ciborra, 1990; Niosi, 1992). Since the parties don't know exactly what they will jointly do, they don't know ex-ante the type of information exchanges they will need during coordination. As a consequence, EDI is not implementable to manage this type of uncertainty. This type of situation is more frequent than usually assessed. In fact, it concerns not only the joint R&D processes, but also all the situations in which there are innovations — even minor innovations like incremental process or design innovation — during the manufacturing process, and the situation in which the product and each party's inputs are not ex-ante specified. This is, for instance, the case in the

French construction industry. In a recent study, Brousseau & Rallet (1993) pointed out that the construction process is highly uncertain. First, there are numerous hazards (weather, ground features, etc...) that can cause important dysfunctionings since the construction process is composed of many highly interdependent sub-processes from which chaotic processes can emerge. Second, the final product is often not completely specified ex-ante, because it is a very complex product, because most buildings are prototypes, and because latitude must be maintained to enable participants in the process to adapt their local actions to ex-ante not forecasted events and constraints (like a non-obvious defect in the ground). As a consequence, the diverse companies involved in a construction process have to adapt their intervention locally to unforeseen local problems that arise during manufacturing, because uncertainty is too great to forecast all the future necessary adaptations. These local adaptations require local bargaining, because they affect the other participants' intervention in the process, since interdependencies are strong. These diverse negotiations — that have to be performed in-situ and in a timely fashion to avoid slowing down the process — cope with very diverse questions: the nature, time, duration, etc. of the interventions. Thus, since the type of actual coordination problems that will arise is difficult to foresee, and since the variety of the arrangement dimensions is too great, agents cannot forecast the information they will have to exchange in the future. As a consequence, the development of EDI is almost impossible. In the French construction industry, these numerous mutual adjustments rely on face to face meetings, informal bargaining, in-situ communication, graph exchanges, etc... and not on formal paper-based and institutionalized coordination processes.

Hence, EDI is not implementable in all business relationships because EDI is associated with an automatic handling of information that both induces the ability to forecast future communication needs and to ex-ante design firms' possible behaviors. In fact EDI is useless both when the future is certain (because planned coordination is implemented), and when the environment is highly uncertain.

Not only is EDI not implementable in all types of existing relationship, but also it is difficult to implement coordination procedures which would be well-fitted for EDI exchanges in certain types of relationship. Let us continue the discussion of the French construction industry: if the actual coordination processes are not well adapted to the implementation of EDI communication processes, why not implement new coordination processes in which information exchanges would be more foreseeable ? The answer is simple: if the actual coordination is really radically uncertain, implementing rigidity in the coordination processes will decrease future flexibility and thus the efficiency of inter-firm coordination mechanisms. In the construction industry, a part of the uncertainty is endogenous in the sense that neither the project nor each participant's intervention in it are completely stated ex-ante. Moreover, it results from local adaptations and bargaining processes. At first sight, one might thus think that the implementation of more rigidity and formality in the coordination procedures — i.e. a centralized coordination process with ex-ante precisely designed interventions — will decrease the level of endogenous uncertainty, and will thus engender a more

efficient process. This is often actually impossible. First, the diverse firms involved in a construction process perform highly specific tasks, and there are very few "central coordinators" that would be able to take all these specificities into account simultaneously. Moreover, since firms on a construction site often operate on several sites, each central coordinator on a site would have to take into account the interdependencies among diverse sites to give instructions that meet the constraints of the diverse participants. A highly complex optimization process would be thus attained. Second, more formal coordination — i.e. ex-ante precisely stated interventions — will decrease the adaptation ability of the industry which is the key to its productivity. Indeed, as firms' behaviors are not completely bounded, the diverse participants in a construction process can flexibly and pragmatically adapt their interventions to the actual situation they face both in terms of physical constraints (unforeseen difficulties, weather, etc...) and coordination constraints (e.g. impossibility for a painter to operate simultaneously or before the plumber and the electricians, necessity for these last two to adapt their provision of service to the actual shell, etc...). Thus, the high uncertainty level which is both exogenous (physical constraints) and endogenous (relational constraints) in the construction industry cannot really be reduced. As a consequence, the type of relationship that is today implemented in many industries (programmed flexible logistics) is not adapted to the construction industry. More generally these inter-firm coordination solutions that are today implemented in the industries where coordination was ex-ante relatively rigid (automotive, transportation, retailing,... industries) are not sufficiently flexible in several industries where a high level of flexibility is really needed.

On the other hand, it must be pointed out that the manufacturing of large quantities can push for the adoption of rigid coordination mechanisms to benefit fully from economies of scale and from positive technological externalities due to the stabilization of operations at a high output level. Such technological externalities often justify integration (see for instance Kindleberger (1968) and Caves (1971) for the case of Trans-National Corporation). But, in fact, when stable inter-company coordination processes are implemented, the stabilization of operations at a high level of output is also guaranteed. Recent contract theories (e.g. Hart & Holmstrom, 1987; Williamson, 1985) have indeed shown that it is possible to implement contracts that provide parties with a high level of reliability in the behavior of the others. Moreover, numerous research work on applied long term contracts indicates their stabilization properties (e.g. Goldberg & Erickson, 1987; Joskow, 1989) Thus in many capital-intensive industries — petroleum, chemicals, metal, food, textiles, etc...— relatively rigid coordination processes continue to be operated since they make it possible to fully benefit from economies of scale. Most of the time it would be inefficient to implement JIT and flexible coordination processes, since flexibility and diversified output are not required by competition and consumers.

To conclude: (1) there are coordination processes that require the use of informal communication techniques — i.e. human-intensive and based on face-to-face interactions — because, ex-ante, it is too complex — i.e. too long, too costly, or simply impossible — to foresee all the future information exchange requirements. As EDI techniques and related efficient coordination processes

can be implemented only when most of the future possible operations can be ex-ante planned (i.e. when innovation in the processes will be useless in the future), EDI techniques cannot always be implemented; (2), the coordination procedures that strongly require the use of EDI implement a special type of flexibility: programmed flexibility. This type of flexibility is misadapted either to industries where a very high level of uncertainty has to be overcome, or to industries where the fulfillment of potential economies of scale and technological externalities requires the use of relatively rigid coordination rules (i.e. coordination based on long term planning).

2.2. Is it desirable ?

The emergence of information technologies radically changed the ability to process and communicate information and made the coordination techniques that are intensive in information requirements relatively more efficient. But it did not make them absolutely more efficient. As pointed out above, coordination techniques based on weak information exchanges during the coordination process can continue to be the best available solution in many contexts. It would thus be dangerous to push for a generalization of the use of EDI and related JIT, flexible and incentive coordination solutions. One might think that this danger is only potential since EDI and related coordination techniques will be implemented only when these are efficient. Because of political or market power effects, however, some firms could be forced to use coordination techniques that do not meet their needs, and that can be sub-optimal from a collective point of view. Indeed some economic actors — civil services, large corporations, etc. — can impose the use of EDI systems and related coordination techniques through fear of diverse types of sanction (especially the stopping of orders to recalcitrants) (e.g. Webster, 1994). This would amount to imposing misadapted coordination techniques that can generate dysfunctioning or simply transfer inefficiency sources from one firm to another. Consequently, although EDI and related coordination techniques could be spread though the industry, this does not mean that this movement always results in improvements in efficiency.

Beyond this point, it is important to note that there are several potential dangers associated with creating uniform coordination features, and especially in making them uniform around JIT, flexible and incentive coordination processes.

In a world of radical uncertainty, there is a strong potential danger in making uniform organizational responses to coordination problems. Indeed, as pointed out by Gaffard (1993), in such a world, firms cannot base inter-temporal optimization processes on rational expectations; being thus certain to discover solutions that will be optimal whatever the future. Choices have to be performed step by step according to resource constraints (physical, human, financial) that were inherited from the past. Strategies have to be adaptive strategies through which firms try to optimize the valorization of their present resources, while avoiding their use in a way that will bound their future possible behaviors too much. This means, for instance, that they will choose market and investment strategies that will minimize sunk costs (Caves & Porter, 1977). It also means that firms have to avoid over-

specialization in order to be able to adapt to new and unexpected situations. The translation of this in organizational terms — either internally or at the inter-organizational level — is that firms should not implement organizational arrangements that would bound their future potential to adapt to contingencies. Since most coordination processes are not completely flexible — they are embodied in manufacturing capabilities, firms know-how, human capital, etc., and therefore are hard and long to transform — maintaining a minimal level of flexibility at the firm and industry levels induces the maintenance of diversity in the coordination processes. This ensures that a minimal amount of coordination procedures will always be adapted to new situations, while avoiding an over-specialization of firms' competencies in a specific type of coordination procedure.

The danger of organizational uniformity is reinforced since the standards to expand to are JIT, flexible, and incentive coordination mechanisms. Indeed each of these virtues can have harmful effects:

— JIT is extremely vulnerable. A JIT process requires a high level of reliability of each component since the absence of buffer inventories no longer permits the absorption of the effect of local failures. Moreover, a JIT process can easily become chaotic because the high level of interdependence of the diverse components in the process can dramatically amplify small local shocks.

— In the same spirit, flexible coordination rules can generate endogenous uncertainty since they enable local adaptations to local situations that can have dramatic and unforeseen collective effects. On the other hand, the implementation of rigid coordination rules can contribute to reduced uncertainty by locking in relational behaviors. In a decentralized system — like an industry — flexible coordination processes can also generate difficulties in the optimization of the use of resources. Indeed, local adjustments can thwart global optimization. Last but not least, flexibility is useful only when the components in the process — i.e. firms — can efficiently match their processes to the reduced reaction delays. Often this is not the case, and flexible inter-firm coordination is then not efficient.

— Incentive coordination mechanisms can also have harmful effects. For reasons of clarity, we will hereafter restrict ourselves to a discussion of the case of an agency relationship (Ross 1973; Arrow, 1985). On the one hand, incentive systems based on the combination of supervision and incentive remuneration schemes lead agents to be more efficient, while, on the other hand, strong supervision and a strongly incentive remuneration system can become counter-productive. First, it can become very costly for the principal, especially as there is decreasing marginal efficiency of the incentive schemes — in terms of reduced shirking — while marginal costs are increasing. Second, supervision and incentives can become unbearable for the agents, resulting in decreasing productivity. Third, the agent can learn the failures in the supervision system and then adopt strategic behavior through which he decreases the quality he provides without this being observed by the principal, etc. The agency literature has developed important analyses of the limits of incentive and supervision

systems. (Cf. for instance the surveys by Lazear, 1987; Hart & Holmstrom, 1987; Brousseau, 1993a)

Consequently, there are many reasons for maintaining types of coordination process other than those based on JIT, flexibility and incentives that are associated with EDI. These alternative coordination processes obviously have their own shortcomings, but they also make it possible to secure coordination, limit endogenous uncertainty, develop trust, etc.

There is a another reason that makes a uniformization of coordination processes around the processes related to EDI not completely desirable: the low level of dynamic flexibility. As pointed out above, the implementation of EDI and combined coordination techniques requires some type of specific investment (Williamson, 1985) since two parties deciding to use JIT, flexible, incentive and EDI-zed coordination techniques will mutually agree on common business practices and information systems features. The resulting specific investments limit the ability to switch easily to another partner, or at least, limit the switching potential to the small community of firms using the same practices and information systems. Even if it was not perfect, the switching flexibility was greater before since specific investments were at a lower level. Moreover, EDI tends to rigidify organizational responses. The removal of human mediation in inter-organizational coordination requires an ex-ante agreement over the content of the messages that will be exchanged. This limits the magnitude of future organizational evolutions. Since a given EDI message fits the information exchange requirements of a specific type of inter-organizational arrangement, it is probable that it would not meet the information requirements of new arrangements. As a consequence, these new arrangements would require the development of new messages. These will make organizational changes more difficult because, on the one hand, EDI increases the efficiency of the existing arrangement, and on the other hand, EDI adds to transformation costs. In fact, EDI and related coordination techniques implement flexibility, but of a very particular type: *pre-programmed* flexibility. This static flexibility is quite different to dynamic flexibility (Cf. Klein, 1986; Coriat, 1990; Bar, Borrus & Coriat, 1990[12]).

Thus the generalized use of JIT, flexible and incentive coordination techniques is neither possible, nor desirable. Although EDI and its related coordination procedures are in some cases a factor of rationalization and of coordination improvement, the spread of these techniques has to be bounded. First, these coordination techniques have some defects that could be considerably emphasized if their use were generalized. Second, alternative coordination techniques continue to be more efficient in certain contexts. Third, alternative organizational options have to be maintained because the future is radically uncertain and because dynamic flexibility relies on maintaining several concurrent and complementary coordination procedures.

Conclusion

The diffusion of EDI techniques and EDI standards is often perceived as a (now) classical problem of the spread of a "traditional" technology and "traditional" standards. This lead to the analyzis of the relative slowness of "EDI-zation" as linked to the well known high cost of adoption in the starting phase of a technological cycle. It is assumed that this difficulty will be overcome in the future because of increasing returns of adoption that characterize most communication technologies. This also lead to the interpretation of the difficult construction and spread of EDI universal standards in terms of lock-in effects (that will also be overcome because of the potential strong network externalities of universal standards). In this paper, I have tried to point out that since EDI is not a simple communication technology, but a technology that makes it possible to automate inter-firm coordination, the economics of EDI and EDI standards diffusion is different from that usually stressed. Because EDI-zation is linked to organizational phenomena, the outcomes of EDI-zation and universal standards change.

Basically, the argument is this: EDI is a technology which is — unlike the telephone — not a generic telecommunications technology but a language technology that is useful only to perform certain coordination practices. This implies that one must study EDI in relation to the coordination processes that are linked to EDI, and not as a technology that, per se, enables users to dematerialize information and to automate its processing. The use of EDI by itself, and a fortiori the use of universal EDI standards, are strongly linked to organizational standardization issues both within and between firms. This radically changes the pay off of EDI and EDI universal standards.

On the one hand, the implementation and the use of EDI techniques and universal standards are more expensive than usually stressed. Most often, the implementation of EDI is made in conjunction with organizational changes, that are inherently costly. It has also been pointed out that EDI languages have to be closely suited to the specific needs of specific users to be really efficient. As a consequence, EDI is often expensive to implement event if EDI standards exist. On the other hand, the benefits of EDI and universal standards also appear to be much lower than usually stressed. First, EDI makes it possible to react better to a certain kind of uncertainty — because it increases static flexibility —, while it generates higher dynamic rigidity. Indeed, as specific EDI languages are closely related to business practices, they do not make it possible to permanently adapt these processes. Second, to be really efficient, EDI languages have to be made specific, which is opposed to universal communication. Indeed, the more specific an EDI language, the greater inter-firm integration. In this paper we have developed the provocative and sometimes contra-intuitive idea that this situation is not automatically inefficient. Third, JIT, flexible and incentive coordination that are related to EDI techniques have intrinsic biases. Fourth, uniformization is impossible in a world of diversity and radical uncertainty. Moreover EDI and related coordination techniques seem to be sometimes radically impossible to implement, since they are usable only in specific contexts.

These impossibilities, higher costs and lower benefits considerably reduce not only the desirability of "EDI-zation" by itself, but also the interest of an evolution toward universal EDI standards. Many firms are probably conscious of these high costs and of the danger of the uniformity and of EDI-zed transactions. This possibly explains the low diffusion of EDI and the

relative under-development of universal standards. This reluctancy of users to EDI can also be explained by the fact that organizational transformations often have redistributing effects.

There are however industries where EDI and related coordination techniques are desirable. Here again, taking into account the organizational issues linked to EDI issues is important to obtain a better understanding of the slowness of the movement. Indeed, organizational changes are inherently slow because they require material and human investments and are constrained by past choices (routines and habits, regulations, limited know-how of participants in the industries, capital accumulation abilities, etc. Cf. Brousseau & Rallet, 1993). Path dependencies phenomena in organizational matters are comparable to those pointed out for technological issues (Arthur, 1988; David, 1988 a & b). They also explain why the implementation of coordination procedures requiring EDI is slow even when desirable.

These diverse elements call for a pragmatic approach to standardization in EDI. Most of the EDI standardization processes should be aimed at avoiding incoherences in messages structure and data dictionaries; especially to avoid ambiguities. However, trying to develop a real universal/non-optional standard is doomed to failure. Indeed, this is what is actually happening.

Several "levels" of standardization can, however, be distinguished. Since commercial documents — i.e. those documents that are exchanged to complete a transaction, like bills, payment advices, etc… — are not too strongly connected to special types of coordination processes, the handling of this information could be standardized at the national, and even at the international level (as it is often already the case). There is thus a small space for international/universal EDI standards. But the automation of these information exchanges is unlikely to lead to major efficiency improvements. Logistic information handling can probably be standardized at the industry level since the handling of this information is often already pre-standardized at this level. However, as pointed out in this paper, logistic information handling rules are strongly related to business practices intrinsic to a national industry. As long as these national industries remain coherent, and as long as changing inter-organizational coordination rules is costly, there will be no real movement toward an actual EDI universal standardization process in logistic information. Moreover, it would be useless: since the handling of technical data concerns the core competencies in a business, the standardization of these information exchanges will probably continue to be restricted to small groups of collaborating firms. Indeed, most firms are dissuaded from sharing with their competitors their knowledge about the methods they use to code and automatically process information.

This obviously concerns EDI exclusively: i.e. the information that is destined to be automatically handled. Problems of information coding and standardization are less complex and less crucial when one speaks of the simple dematerialization of information exchanges. Indeed, in this case, completeness, unambiguity, etc., requirements of the used communication languages are less crucial since the interventions of human beings in the communication process authorize translation and interpretation. But as pointed out in this paper, EDI is the key-point in inter-firm coordination since it is the real enabling condition of major organizational changes.

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[*]Helpful comments were made by Cristiano Antonelli, Godefroy Dang N'guyen, Almarin Phillips, Alain Rallet. I thank each. The usual caveats apply.

[1]The comparison for transmission was quoted by Ungerer (1988), It is based on the duration and cost of transmitting a commercial document within the EEC (36 hours vs 13", 0.3 ECU vs. 0.05 ECU respectively for electronic and postal communication). Estimations for information handling cost differences were made in EEC (1989).

[2]In this paper it will be question of *actual* EDI, i.e. fully automated communication among Information Systems. As a consequence our analyses are not intended to cope with the cases in which messages are exchanged among two dedicated computers that are not linked to both parties' ISs; i.e. cases in which human interventions are required to feed ISs.

[3]EDI is a technology that enables the extension to inter-firm relationships of the major changes brought about by the Information Revolution depicted by Freeman (1987), Jonscher (1988) or Simon (1982), etc. The main advantages of information technologies is not their ability to dematerialize information, but to automate information handling and decisions.

[4]Let us assume that A and B are two vocabularies, y = f(x) are the elements (words) of B, x those of A, and f is an application of A in B which is the correspondence relation between the two vocabularies. As we all know, when the relation between two vocabularies is neither perfectly injective — i.e. (x_1, x_2) A^2, $x_1 \neq x_2$ $f(x_1) \neq f(x_2)$ —, nor perfectly surjective — (y) B, x A, y = f (x) — (i.e. if the function is not perfectly bijective), there are ambiguities between the two vocabularies. These generate misunderstandings when translating from one language to the other.

[5]These case studies have been collected in several Working Papers: Brousseau E., 1990, Information Technologies and Inter-Firm Relationships, an Economic Study of the Strategic Issues and Contractual Impact of 36 Inter-Company Telematic Systems Implemented by US Firms (Document de travail, CREI, Université Paris-Nord) — Brousseau E., 1990, Les stratégies de 17 entreprises françaises en matière de développement de moyens d'échanges de données inter-entreprises: Aspects économiques et étude de l'impact des systèmes et applications sur les procédures de coopération inter-entreprises (Document de travail, CREI, Université Paris-Nord) — Brousseau E. & Rallet A., 1992, Développement des systèmes télématiques et évolution de l'organisation interne des grands groupes du Bâtiment (Rapport pour le CNET, Paris) — Brousseau E. & Rallet A., 1993, Développement des systèmes télématiques et évolution des relations interentreprises dans la construction (Rapport pour le Plan Construction et Architecture et le PIRTTEM, Paris)

Some of these case studies were synthesized to build a database which has been used to perform statistical studies — relying on contract theories — on the organizational impacts of ITs (e.g. Brousseau, 1993b).

[6]Indeed, as pointed out by the economics of organizations (e.g. Aoki, 1988; Ménard, 1990; Williamson, 1985) information flows within firms are richer and more intensive than information flows between firms, even if these inter-firm information flows are not reduced to prices.

[7]In addition there are often variations within each EDI standard. There are indeed often several generations of a same standard and also subtly differing versions of “universal” standards (developed, for instance, by different industry groups). Cf. P. & P. Swatman (1994).

[8]There is also a third implication: since EDI standards and operational messages are biased by the information needs of the users, and since these needs are very diverse among industries and companies, the standardization processes and the operational message design do not often result in a mutually beneficial solution. Rather it is a process in which bargaining power asymmetries play an important role.

[9]The EDI alternative to overcome this problem is that the buyer sends a message in which he gives detailed information on how he calculated the amount corresponding to the payment. This is applicable if the banks do not process any consolidation of payments and transmit to the vendor an ID of each payment from the buyer.

[10]As pointed out by contracts theories, this does not means that these adjustments are always mutually beneficial and mutually decided. They are made possible by the implementation of authority mechanisms that are individual or collective. These mechanisms institute for one party, or both, the right to decide how the parties should behave when this is unspecified by the initial contract. Cf. Hess (1983), Williamson (1985), Hart & Moore (1990).

[11]This is inspired by Rallet (1994). However, I do not consider exactly the same categories as he does. Moreover, the categorization proposed by Rallet sought to cope with a similar, but different, problem: the ability of tele-computing to re-organize production and coordination processes. Rallet opposed the process based on human interactions to the process based on pre-designed formal coordination procedures.

[12]Static flexibility consists in the ability to use existing equipment in order to made it execute several pre-planned options in order to optimize its utilization intensity. Dynamic flexibility refers to the ability to redeploy resources through time and space in order to be able to always operate resources that can be efficiently exploited.