A critical perspective on information technology management: the case of electronic data interchange

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Abstract: The managerial studies on technology innovation are sometimes characterised by low criticism. The capability of innovations to radically modify processes, structures, and environment is not thoroughly considered. Information technology presents the greatest assessment difficulties; since it directly influences the cognitive content of firms' activities, it creates totally new opportunities and represents a formidable factor changing organizations, inter-firm relationships and market structures. The potential of Electronic Data Interchange (EDI) has been recognised since the mid-seventies; however, the spread of this technology has been slower than predicted, and it faces difficulties tied to non-technical factors. The existing applications are very differentiated, and partially unexpected. The aim of this paper is to examine the real nature of EDI as a tool for the automation of transactions, and to carry out a more realistic evaluation of the conditions and limits to the adoption and diffusion of this innovation. A non-deterministic evaluation of EDI potential is carried out, in order to reduce the obstacles to the comprehension of the impacts on firms and on market structure. Starting from an analysis of the variety of the existing applications, a taxonomy of EDI strategic advantages is suggested.

Keywords: Information technology; electronic data interchange; technology assessment; strategic technology management.

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1 Is a critical analysis needed for EDI?

The underestimation of the problems raised by the choice, adoption and management of new technologies is rather frequent in the common business practice. This is in part attributable to the growing complexity of technologies and of the environment in which the innovative projects are developed. In the management area, a mix of cultural assumptions and competitive pressures often leads to the belief that the innovation is desirable *per se*, and to a scarce consideration of the risks of failure that are involved.

Perhaps, a wide economic and managerial literature has often justified this belief, facing the problems of technology forecasting and evaluation without a full awareness of the process complexity, and suggesting procedures for planning innovation. This means to assume that it is possible to know or assess *ex-ante* the technology trajectories [1], and then accept a quasi-deterministic perspective on the innovation. Most of works on technology management have been developed first by considering how to reach competitive advantage. Technology innovation has often been 'celebrated', without completely considering its profound implications: the real determinants, their direct and collateral effects, the environmental and social impacts. These aspects are now placed in the area of technology assessment, but they are almost always debated in reference to public policies of science and technology. The consequence is that the studies on technology innovation carried out into a managerial perspective are sometimes characterised by low criticism. The case-studies on new technology development are almost always successful; the cost of failures and the risks of an inappropriate use are less known. Many works focus on the research of competitive advantage exploitable from technology on the short and medium term by organizations that are assumed given, operating in a given context. The capability of innovations to radically modify processes, structures and environment themselves is not thoroughly considered.

Nevertheless, the serious difficulties of a technology assessment have always been manifest. One could quote many cases of evaluation errors regarding past and present technologies (incidentally, such a study might offer interesting insights, as Rosenberg has shown). The technical feasibility of Computer Aided Automation, for example, has generated much speculation in the eighties, and has led to the 'extrapolated' concept of the 'Factory of the Future' as the 'Unmanned Factory'; but things did not exactly turn out in this manner. More recently, towards the end of the eighties, CIM (Computer Integrated Manufacturing) was seen by many researchers and practitioners as a new paradigm of production systems, but the experience has shown that both the market of new equipment and the benefits deriving from applications had been overvalued. Actually, the CIM's paradigm, that aimed to expensively automate idle hierarchies, is practically abandoned.

For some time now a more critical view is spreading in technology management. There is a major awareness of the arising problems related to the management of technology, from those of falling rentability of R&D, to the growing complexity and risks of the implementation of advanced technology projects. An excellent work on this topic and on the needs of a more problematic perspective is the recent issue of Jones, Green and Coombs [2] in this Review. The authors recall the historical reasons for the emergence of a normative (one-dimensional) view on technology management, and underline the need to adopt a more critical approach.

The technology that undoubtedly presents the greatest assessment difficulties, due to its large and multi-dimensional impact, is Information Technology (IT). Since IT directly influences the cognitive content of firms' activity, it creates new learning and

specialisation opportunities, represents a fundamental tool of differentiation and a formidable factor changing organizations, inter-firm relationships and market structures. In theory, the effect of IT is to facilitate the information exchange into economic systems, to reduce uncertainty and existing asymmetries, and therefore to attenuate the market imperfections. Consequently, the perspective suggested by IT has seemed to lead to a more extensive use of the market. However, the conviction that IT could lead to the reduction of system uncertainty corresponds to a neo-classical view of technology, that is, to assume the benefits of technology are well-known and achievable by all the economic subjects, which are able to adopt rationally and at zero-cost. In particular, IT is identified, *à la Arrow,* with perfectly free information: a pool of knowledge existing as a public good.

Experience, however, shows that things are quite different. It is evident that IT can create new asymmetries due to a disequilibrated diffusion of its benefits. Various empirical evidence has demonstrated that IT has offered up to now new powerful tools of managerial control to large (multinational) firms. If IT diffusion favours the reduction of internal co-ordination costs with respect to the costs of transaction governance, it can increase the hierarchies' efficiency rather than the market's [4]. Many authors [5] have suggested that the diffusion of IT may be congruent with intermediate and co-operative organization forms, in particular with the network organizations. The plausibility of this hypothesis depends on the fact that the spread of telematic networks offers a real opportunity of interconnecting different knowledge and specializations, and it could favour the growth of network firms.

As one can see, a general interpretative framework for IT is not yet well-defined. Nevertheless, the advantages of IT in facing problems due to market globalisation and the needs of innovative communication solutions are emphasised in literature. The real innovation in high speed managing of large volumes of information allowed by the telematic networks is the direct computer to computer exchange without human intermediation [6]. Electronic Data Interchange (EDI), based on agreements among subjects involved and on the message codification, is seen at present with great interest. The potential of EDI has been recognised since the mid-seventies, and it has been associated with significant time and money savings related to the dematerialisation and the automation of inter-firm document transmission. Many authors argue that EDI applications will provide a fundamental support to information flow among firms and business activities. Due to the absence of theoretical limits to geographical distances, to the number of interconnected firms and to the volume of information flow, many researchers and practitioners believe this technology could represent an important infrastructural support, facilitate the relationships among firms, organizations and systems [7,8], and favour the growth of production efficiency.

Despite the predictions of a rapid success of EDI, there is a considerable gap between the actual spread and the forecasts and auspices of salesmen, managers and policy-makers. The works regarding the nature of the factors and limits affecting EDI diffusion provide contrasting interpretations. Many researchers are convinced that a rapid diffusion of EDI applications will take place [9], but various studies show that the spread of this technology is not so rapid, and is clearly facing some difficulties [10,11]. EDI does not yet seem widely distributed as predicted [12,13]. According to some authors this is due in part to the young age of this technology, the relative high costs of implementation should be attributed to the starting phase of a technological cycle. However, this technology is

not really young, and there have been many technical advances; but evidence shows that the slow EDI expansion is mainly tied to non-technical obstacles which are difficult to overcome.

The extreme structural, organizational and cognitive variety of potential EDI users (in principle, the entire business community) has generated a range of differentiated and 'idiosyncratic' applications. Some of these were unforeseen or not assessable *ex-ante*. In a context of substantially normative literature, an empirical survey on up-dated real EDI applications and results can be profitable. By verifying what has happened in the world in recent years, we would like to reach some empirically-based conclusions on adoption problems and on strategic opportunities involved with EDI.

The aim of this paper is:

1 to analyse the deep nature of EDI technology as a tool for the automation of transactions;

2 to carry out a more realistic evaluation of the conditions and restrictions to the adoption and diffusion of this innovation.

Starting from an analysis of the variety of the existing EDI applications and communication standards, a taxonomy of real EDI strategic advantages is proposed. This analysis solicits a solid technology background, for entering 'inside the black box'. In particular, it is necessary to understand the distinctive characteristics and the real applicative conditions of technology; moreover, the constraints which are determined in practice from a technical, economic and mainly organizational point of view, must be explicitly examined. On this basis, a non-deterministic evaluation of EDI potentials will be carried out, so that the obstacles to the comprehension of the impacts on the firm and on the market structure are reduced.

2 On the variety of EDI applications

A rapid excursion in the world of 'real' EDI [13] is sufficient enough to give an idea of the large variety of existing applications, regarding both the goals that are pursued through the adoption of technology, and the specific solutions that are implemented, even by firms operating in the same industry. In this section we will briefly examine a number of cases in Europe and in the USA which were directly investigated in the field or derived from the specialised literature where several empirical studies about EDI applications are now available.

The earliest EDI applications were typically developed by large companies, capable of entirely designing the system and to impose it on trade partners; these applications are generally referred to as 'hub-spoke' projects. This feature still characterises the majority of applications in the automotive sector, one of the pioneering industries for EDI since the beginning of the seventies. The first implemented systems were quite similar, since a common problem for the automakers was the great volume of repetitive transactions that had to be effected with the suppliers. In order to improve the administrative efficiency through the reduction of costs and times of transactions, each automaker established EDI connections *up-stream*, toward the suppliers, for the transmission of a large quantity of daily or weekly orders of the same components. In the eighties the automakers experimented with the possibility of using EDI for more extensive aims. The technology,

Table 1 Examples of relevant EDI applications

Industry	*Company or EDI project*	*Industry*	*Company or EDI project*
Automotive (USA)	GM Ford Crysler	Healthcare and Pharmaceuticals	McKesson Eli Lilly Glaxo
Automotive (Europe)	Renault Saab Volvo Fiat Iveco Peugeot Talbot Volkswagen		
Electronics	IBM Texas Instruments Alcatel Bell AT&T	Food	Barilla Nestlé
Household appliances	Bosch Zanussi Whirlpool	Other consumer goods	Colgate Palmolive Procter & gamble
Small electrical appliances	EASAS project Braun, Dimplex, Moulinex, Tefal, Philips		
Textile – Clothing	Levi Strauss Benetton Courtaulds Textile GFT	Retailing	Sears Wal Mart Penney Marks & Spencer Tesco La Redoute Mothercare EDICOMM Block & Quayle Leroy Merlin
Chemicals and Oil	ICI Ciba Geigy Montedison Union Carbide Enichem	Banking Insurance	Swift Telekurs RNA Metlife
Tyres	Pirelli	Transportation	Union Pacific Kühne & Nagel Danzas Port of Seattle Port of Rotterdam Port of Singapore Frankfurt Airport

allowing a better visibility of the decentralised activities, was intended as a tool for a strong process integration along the value chain, thus favouring the implementation of Just In Time programmes. As a consequence, more complex sets of electronic documents became necessary, and the number of connections for the single automaker grew. In these conditions, due to the fact that many suppliers serve more than one customer, the use of strictly closed networks, generally adopted in the earliest applications, began to show their limits, because several systems had to be used for communicating with different

partners. The major manufacturers were induced to research common sectorial solutions for EDI. Such initiatives played an important role in rationalising the use of EDI in the industry; nevertheless, 'local' customised solutions are still used, therefore preserving the specificity of the supplier-customer relations.

Similar solutions can be found in various industries having an analogous organization of the production process. Very large hub-spoke applications are reported in the electronic sector, for supporting JIT and TQM (Total Quality Management) programmes. Several companies operating in the final stages of the value chain (e.g. IBM, AT&T, Alcatel) have 'EDIzated' the transmission of large volumes of repetitive transactions with the suppliers. In the same sector, there also exist situations where the role of hub is played by large suppliers; Texas Instruments is an interesting example: it uses EDI connections both *up-stream*, toward its suppliers, and *down-stream*, toward its large customers.

Also in the household appliances sector, and especially in the case of the 'white' appliances (refrigerators, washing machines), similarities with the two examined sectors exist. Many projects have been used by large manufacturers toward the suppliers. This logic inspired the large hub-spoke projects of companies like Bosch, Whirlpool, Electrolux-Zanussi. A deep examination of these projects shows the differences both in the specific operational conditions and in the selected solutions; these differences also conditioned the success of the applications. The positive outcome of Zanussi's up-stream project has been probably determined by the limited number of involved partners and the flexible technical solution able to adapt to the different suppliers' equipment. Whirlpool, instead, intended to establish a strict control over the wide international supply (over 1000 partners only in Europe) with a rigid proprietary system. It faced problems due to the high heterogeneity of partners and the project had a slow development. Bosch also experimented the down-stream connection to strengthen the control over distribution, but resistance and a stagnant penetration rate are reported [14].

In the appliances industry, it is possible to find different EDI solutions when a diverse type of product or a different process organization is concerned. A vast project in the field of the small electrical appliances, the EASAS project [15], greatly differs from the previously examined EDI connections. Probably due to the relatively less complexity of products and process with respect to the white appliances, the linkage with suppliers is not considered so critical; instead, the focus is the down-stream connection with distribution. The large manufacturers involved in the project (Braun, Dimplex, Moulinex, Tefal, Philips) have to manage a vast number of international distributors, and the efficient communication with agents is considered the critical element. The EASAS system has been realised through the co-operation of several companies, in order to overcome difficulties deriving from the non-exclusivity of sole agencies.

In the clothing industry the EDI connections developed by the major firms are often down-stream toward distribution. The up-stream applications (toward fabric suppliers and subsuppliers) are instead rare, despite their theoretical utility. Well known examples of hub-spoke EDI systems are those of two multinational informal-wear producers, Benetton and Levi-Strauss; they established EDI connections down-stream for shortening the 'distance' between production and distribution. The diverse characteristics of the distributive organization influenced the solution adopted in the two cases. Benetton intends to exchange information electronically only with long-run partners, and therefore with the agents, through strictly closed networks; while the point of sales, that can continuously change, are deliberately excluded. The Levi-Strauss system, instead, connects all the partners involved in the distribution activities (agents, exclusive point of sales, big and small retailers); the EDI network is therefore more complex, since the different communication needs of the heterogeneous partners had to be taken into account [16].

It is worth noting that the success of these two hub-spoke projects in the clothing sector has been probably facilitated by two factors: the relative 'stability' of the product range, and the strong influence over distribution. These conditions cannot always be found. In some cases, for example, the variety and variability of the proposal and therefore the difficult automation of transactions or the limited influence over distribution can make the development of a hub-spoke project very difficult [17].

In other cases, clothing companies have been compelled by their trading partners to act as spokes. The large British company, Courthaulds Textile, for example [18], introduced EDI under the solicitation of large customers, like Marks & Spencer, Tesco, and Mothercare, which imposed the technical characteristics of the system. Similar situations can be found in the USA.

In the chemical sector, even if characterised by a strong presence of large multinationals that should favour hub-spoke applications, the implementation of EDI projects seems to face several difficulties [19]. For many companies the critical relations are down-stream, toward the customers. However, when these customers are very large manufacturers, they rarely accept an imposed connection. An interesting case is that of Enichem Polimeri, a world leader in the production of polystyrene. The use of EDI was very troubled due to the limited power over the customers, that are for the most part big manufacturers. Also successful initiatives, e.g. the connection of ICI with its world-wide customers [20], implied a long start-up time. An opposite situation is that of Colgate-Palmolive, that produces consumer goods; EDI has been introduced under the solicitation of big retailers.

In the pharmaceutical sector large companies like Glaxo and Ciba-Geigy, that control a widespread distribution in a multinational market, implemented effective down-stream hub-spoke systems; these projects have been facilitated since they were essentially 'internal' applications with subsidiaries [21]. In other cases it was a wholesaler that acted as a hub toward its pharmaceutical suppliers, as the example of McKessons in the USA testifies [22].

The use of EDI is not bound to manufacturing industries. Since the seventies important projects have been promoted by large distribution companies, acting as a hub toward their suppliers. The main goals of the electronic connections are the rationalisation of the purchasing activities and a stronger control on the supply. The contractual power of these companies can be really large. In the USA important retailers and wholesalers (such as Sears, Wal-Mart, J.C. Penney) have threatened to stop doing business with any supplier that does not begin allowing the electronic transmission of purchase orders [23]. A similar situation characterises the largest UK companies, like Marks&Spencer, Tesco, Block&Quayle, able to impose EDI also to their largest partners [24]. More recently, similar solutions have diffused in other countries, like France [25,26].

In some national contexts a different market structure of the retailing sector, a more deconcentrated one, seems to lead to different EDI solutions. In Italy, together with hub-spoke projects (as in the case of La Rinascente), co-operative solutions have also been pursued, e.g. the EDICOMM project, promoted by the retailers' trade association with the aim of defining a 'sectorial' solution. Another interesting application in the Italian

scenery is the Barilla systems; this project also regards the linkage between suppliers and a number of large Italian retailing companies, but it has been promoted by a supplier, Barilla [27]. Even if Barilla sponsored the initiative, in any case the technical solution had to be agreed upon by all the partners; in particular, since the retailers were interested in maintaining their autonomy, a non-closed system had to be adopted.

In other non-manufacturing sectors, there exist applications based on a philosophy different from the supplier-customer logic. For example this is the case of the banking and insurance sectors. In the banking sector, where EDI has a long history, the electronic links are horizontal, i.e. between autonomous subjects, the banks, that play a similar role in the market. There are several factors that seem to have favoured the diffusion of EDI among banks [28]. The nature of the service itself offered by the banks is fit for electronic communication. Banks all over the world have to manage the same types of transactions, and therefore they face similar communication needs: efficiency, speed, and security. The existence of a common interest, joint with the possibility of maintaining a specific marketing strategy, is therefore the reason of a rapid diffusion of EDI interconnections in the banking sector. The principal applications (fund transfer, electronic payments, and so on) are widely spread in all the advanced countries; indeed, the electronic connection is a necessary condition for operating in the main markets.

At present, the further development of banking EDI faces the challenge represented by the international connections. In many countries the diffusion of EDI has been primarily directed to the single national context. In Europe, for example, the systems have been strongly conditioned by government regulations, aimed at guaranteeing security and efficiency to the single nation's banking sector. As a consequence, national incompatible networks have been developed, while communications at the international level are performed through voluntary networks, like SWIFT, developed and agreed only within a restricted 'club'.

Another important area for EDI is transportation. In this field there is the necessity of an intense flow of bureaucratic and administrative documents among a plurality of subjects (agents, forwarders, transport companies, customs, airport and port authorities, and so on). In principle, EDI can represent a fundamental tool, since the quickness of the information flows is a competitive factor for the whole sector. However, very differentiated solutions can be found. In some case specific bilateral agreements have been established between a single customer and its carrier. For example, these have been promoted by large manufacturers aiming to resolve their specific logistic problems, e.g. Procter&Gamble [29]. Instead, carriers with a sufficient dimension can develop their own EDI connections in order to gain an advantage against competitors [30].

Another possibility is when the EDI project is promoted by port or airport authorities, with the aim to improve the efficiency of the formal bureaucratic procedures and, in general, of the whole transportation system. The network tends to assume an 'open' configuration, in the sense that, at least in principle, the number of the potential users is not defined in advance. Important applications exist e.g. in the Port of Rotterdam, in the Port of Singapore, in the Frankfurt Airport [31,32]. However these systems, even if they can reach a remarkable dimension in terms of number of connections, appear to be highly specific for the particular communication needs of the sector.

3 The proliferation of standards

The extreme variety of applications have necessarily led to the proliferation of different and often incompatible EDI message standards. In the earliest hub-spoke applications the unique possible choice was strictly private standards; these were used only for the exclusive communication within a well-defined network of users. The use of private standards is diffused also today, especially when firms intend to maintain a strong control over the network.

The proliferation of incompatible private standards necessarily lead to closed systems that cannot be interconnected or can communicate only with costly message translations. In general, the use of sectorial standards originates from the needs of overcoming such a problem. A sectorial standard is developed by an association of firms, eventually supported by public institutions, in order to facilitate the electronic communication inside the same sector. Well-known examples come from the automotive sector: in the USA the Automotive Industry Action Group (with a central role of the Big Three manufacturers, Crysler, Ford, GM) promoted the development and diffusion of a subset of ANSI X.12 standard. In Europe, the major auto-makers created a similar Group for the development of the ODETTE standard. The success of these projects has probably been facilitated by a number of factors. A first factor is the relative homogeneity of goals and communication needs of automakers. Secondly, the adoption of the sectorial standard does not compel the users to also standardise the business transactions. In other words, even when ODETTE or ANSI X.12 are adopted, each auto-maker can maintain the specific bilateral relations with its suppliers. Finally, the great power of the automakers, when considered on the whole, has facilitated the diffusion of the standard also among the largest suppliers.

In any case, the development and the spread of a sectorial standard has proved to be a difficult process, costly and time spending. Not all the initiatives that have been started up were always successful. In the clothing sector, for example, the EDITEX project was aimed at developing a European sectorial standard. Having the purpose of favouring the interconnection among all the firms operating in the value chain, the project focused on the development of an 'open system' to easily connect 'anyone anywhere' in the industry. This initiative faced several problems, for example the difficult definition of a system adequate for all the potential users and uses, and the difficulty of reaching a sufficient number of adopters for justifying the entire project. Even in the chemical sector the definition of a sectorial standard meets several difficulties, as the experiences of the European trade association (CEFIC) testifies. An obstacle is surely the extreme differentiation of both the final and the intermediate products; thus the definition of product codes and of the transaction messages is more complex than, for example, in the case of the automotive components. Furthermore, as we said, the competitive advantage of many firms stays in its specific relations with its customers; therefore a sectorial standard would not be adequate.

It is also evident that a sectorial standard is unlikely used out of the restricted number of the companies that can be really interested in it. Documents and codes are defined on the basis of the specific communication needs of the users. Therefore, a standard defined, for example, for retailers and their suppliers is rarely used in other contexts, since a costly adaptation of documents, codes, and programmes is required. ODETTE, for example, has

few applications out of the automotive sector, as TRADACOMS has few applications out of retailing. Similarly, the linkages between manufacturing firms and banks are still very difficult, and applications are only limited to bilateral agreements.

Furthermore, even within the same sector different national standards are still used (Table 2). In the automotive sector, ANSI X.12 is adopted only in the USA. Similarly, in Europe, ODETTE still faces the strong competition of national standards, for example in Germany and in the UK. Also in the retailing sector, TRADACOMS is widely diffused in the UK, but rarely adopted in the rest of Europe; on the other hand, EANCOM, proposed

Table 2 The proliferation of EDI sectorial standards

European projects based on non-edifact standards	
ODETTE	Europe – automotive
GALIA	France – automotive
VDA	Germany – automotive
TRADACOMS	UK – retailing
GENCOD	France – retailing
BSL	Germany – retailing
IDS	Germany – retailing
SEDAS	Germany – retailing
SWIFT	World – banks
IDX	UK – banks
SETIF	Italy – banks
TELEKURS	Switzerland – banks
ETEBAC	France – banks
European projects based on subsets of EDIFACT standard	
EDI CEFIC	chemicals
EDIFICE	electronic
EDITEX	textile – clothing
EDITRANS	transportation
EDIWHITE	household appliances
EANCOM	retailing
RINET	insurance
American projects based on subsets of ANSI X.12 standard	
CIDX	chemicals
PIDX	petroleum
UCS	grocery
VICS	retailing
TDCC	transportation
TCIF	telecommunications
AIAC	automotive
EIDX	electronics

Sources: Harris *et al.*, 1993; TEDIS, 1993

as the standard for retailing in continental Europe, still has competitors at the national level (e.g. GENCOD in France and various codes in Germany). Even the banking sector, as mentioned previously, is characterised by a plurality of national systems.

Therefore, if on one hand the diffusion of sectorial standards facilitates opening the EDI networks, on the other the proliferation of a 'local' incompatible sectorial standard, and therefore the problems of interconnection out of the specific sectorial and/or national 'club', are still a reality. It is with the ambitious aim to put the babel of EDI standards definitively in order that the EDIFACT project was promoted by the Commission for Europe of UN.

The EDIFACT organization is vast and complex, gathering the delegates of EDI potential users in various areas [33]. Several technical commissions are responsible for producing, on the basis of common guidelines, different EDI documents for all the possible business areas (manufacturing, services, public administration, and so on). The coded messages are then submitted to committees of users and politicians, and finally issued and diffused. In such a way, even if EDIFACT messages cannot be imposed by law, they are hoped to progressively regulate all the possible uses of EDI.

Undoubtedly the EDIFACT project has produced some important results. It has favoured the diffusion of EDI and offered a rational reference framework for the development of electronic messages [34]. Many systems claim to use messages developed on the EDIFACT framework [35]. In any case, we cannot deny the limits that a similar project seems to have. First, the realisation of a 'universal' EDI standard, adequate to all the potential uses, is quite impossible, even conceptually [36]. Furthermore, the use of a universal code would imply a total standardisation, among potential users, also in business transactions' procedures; this would not always be possible or desirable. It would be more likely, and this actually occurs, that the interest of specific user groups is bound to a determined 'subset' of the general standard. In fact, today the various EDIFACT-based standards (Table 2), even if they are not completely incompatible, since they have been developed basing themselves on the same framework, at the same time however they are not totally compatible. The same situation characterises, *mutatis mutandis*, the ANSI X.12 American standard. Furthermore, the EDIFACT-based standards must face the terrible competition of the existing message codes (like TRADACOMS, ODETTE, SWIFT, or the private ones) that have already been used for many years, and still have a great success among their users. These users can therefore have few reasons to sustain the high costs that are implied in the migration to a universal standard [37].

4 Discussing EDI advantages

As we have seen, the existing EDI applications greatly differ as regards network dimensions, interconnection features, transactions characteristics, message standards, nature of achieved benefits. Therefore, the consequences on the inter-organizational relationships appear to be different for the different applications. The modalities with which a user group develops EDI appear strongly tied to the type of business and user capabilities, and depend on the particular project aims. The achievement of competitive advantages solicits the solution of highly specific problems and leads to innovations 'localised' on the user side [38].

Various international surveys and case-studies on the effects of the adoption of EDI technology are available in recent literature. Prekumar *et al.* [39] studied the EDI applications of about 170 different sized firms in the USA belonging to many different industries, and analysed the motivations and phases of EDI implementation. Bamfield [40] examined cases of representative business in the textile and grocery sectors. Bouchard [41] worked on a sample of about 80 US firms, half of these belonging to the textile and food industries in the final stages of the value chain. Kremar and O'Callaghan [42], in the framework of the TEDIS Programme, considered various companies of different sectors operating in eight States of the European Community. Vairan [43] profiled 180 companies in the USA operating in the services sector (retail, transport, health services), and Zack [44] carried out an analysis on 183 manufacturing businesses in the same country. Banerjee [45] made a comparison between firms generically using EDI and others in which EDI is a tool for just-in-time applications.

These surveys are sufficiently numerous and diversified to let us formulate some general considerations. The resulting picture is interesting because it modifies several convictions on the EDI. First of all, it is clear that EDI applications require to operate in the presence of *static* flexibility, i.e. of well-defined processes and relatively standardised procedures in which the informal communication flows are absent or rare. Consequently, all the inteorganizational relationships based on informal knowledge and non-repetitive transactions must be excluded. This explains why EDI is inapplicable in many situations.

Secondly, until recently, EDI has essentially been considered a labour-saving technology: as a source of efficiency of clerical activities. Indeed, the opportunities of an appropriate use of EDI does not seem to be related to the savings which derive from the dematerialisation of administrative procedures so much as to the transition to a *leaner production process* through new inter-organizational relationships. Various surveys show that, when EDI is used for increasing the efficiency of clerical work, the resulting benefits can be modest. The reason is that it is very difficult to automate entirely the administrative procedures of a firm. A hypothetical paperless system would require the complete automation of up-stream and down-stream information flows, as well as the connection with banks, transport agencies, tax offices etc., and a complete integration with the internal information system, book-keeping, production planning, MRP and inventory procedures. But today such an electronic interconnection is extremely difficult and expensive [46]; therefore, any EDI implementation needs to keep two systems alive at the same time. This determines a scarce reduction of the pre-existing costs and the emergence of new ones. For these reasons the growth of administrative efficiency due to the EDI may be relatively small and difficult to evaluate. Excluding the case in which the number of documents is very high, the benefits must be looked for elsewhere [47].

With reference to the above-mentioned studies, the main barriers to EDI adoption happen to be in substance:

- the difficulties of a cost / benefit evaluation: these are due to the great number of qualitative aspects involved, and to the fact that the project necessarily regards more than one firm; an *ex-ante* evaluation of costs and returns on the investment requires hypotheses on their allocation;
- the applications' parallelism: the need of keeping in use two information systems may discourage potential adopters;

- the question of standards: EDI requires the standardisation of the message structure as well as the message content and the involved procedures. This problem can be very relevant, especially in case of changing and informal relationships.
- the nature of externalities: the EDI application oversteps the firm boundaries and modifies the business and market perspective, from competition to collaboration;
- the resistance to the organization changes: the EDI adoption, as we will explain later, has a very strong organizational impact.

Many works have shown that the EDI adoption also implies disadvantages. The most frequent ones are: higher than expected costs (parallelism of applications, learning costs), problems of organizational adaptation, flexibility reduction, scarce congruence of project to the strategic objectives. These disadvantages are often underestimated by the adopters. EDI allows the partial automation of clerical activities (as computing, stock control, preparation of shipping documents, invoicing) that are relatively independent from the kind of product and time of the operations. Instead, the physical aspect of operations are hardly influenced by the use of this technology.

Given that the time savings associated to the EDI adoption are relatively fixed, these are as important as much as the total lead time of the logistic chain is low. From this point of view, the benefits can be much higher in the food industry than in textiles [48]. Finally, it cannot be put aside that most of the EDI applications have been implemented because of the pressures of the customer having a contractual power over his suppliers [49].

This critical review on EDI therefore lets us single out the beliefs on EDI which have a weak foundation. To dramatise the topic, we formulate these issues as *erroneous statements:*

1 *EDI technology brings to a reduction of operative costs, mainly clerical costs.* Instead, these savings are generally modest; rarely they generate a sufficient return on investment.

2 *An EDI system is a tool for a paperless administrative system.* On the contrary, only the pure transactions can take place without the paper support; the absence of any accompanying documents in exchange of goods and services requires an extremely high electronic integration among all partners that at present is not feasible.

3 *The up-to-date technologies allow a quick project implementation and rapid achievement of EDI benefits.* The implementation is made difficult not by technical aspects, but by the need to harmonise the organizational structure and procedures. EDI should be considered as a tool of corporate strategy and it must be planned in a long term perspective.

4 *An EDI system, enables the firm to operate in the global market, or in telematic community.* Any EDI application requires not only the choice of a particular transmission protocol and message standard, but also the definition of the message subsystems, optional fields and common codes. It also needs well-defined organizational and legal agreements, and this limits enormously the number of partners with which one can interconnect.

The EDI implementation can offer several benefits regarding the management of the orders and suppliers, reduction of document errors, rapidity of inventory control, cash

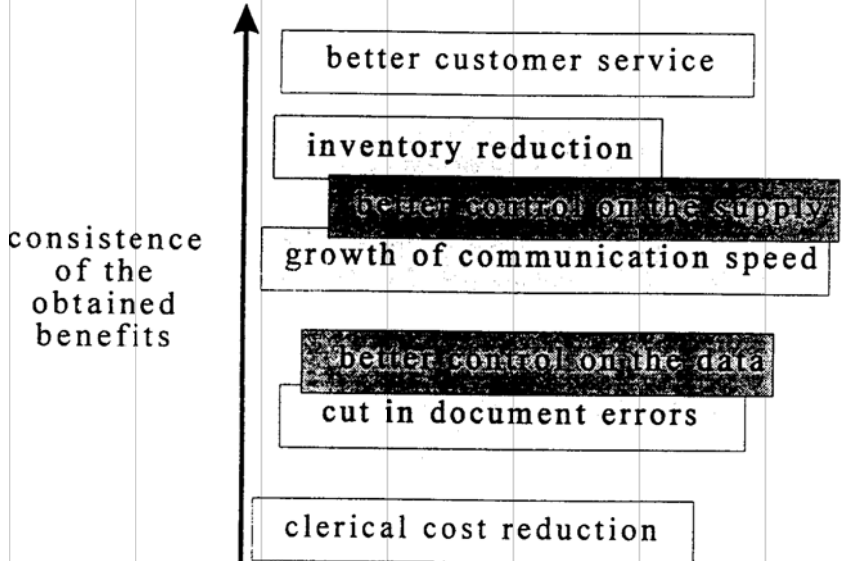
operations speed; but these results justify the investment only in particular cases. To date the diffusion of this technology often occurs when EDI is imposed by a dominant customer to its suppliers or sub-suppliers. This reason should be openly admitted, particularly when the investment could not be justified by a great number of transactions with single partners. Note that the concept of *critical mass,* often employed in describing diffusion patterns of interactive technologies (as telecommunications are), seems inappropriate in the case of EDI. This concept should be substituted by *transaction volume* among connected subjects.

In conclusion, the consideration of all the barriers and constraints described allow us to draw an important conclusion: it must be excluded that, by means of EDI, one can enter the 'global village' or create the electronic market (which is based on rare and opportunistic relationships in the short term). Instead, the EDI perspective favours the electronic hierarchies and relatively stable organizational relations. The implementation is attained only by complex processes of organizational learning and it should be carried out in a strategic perspective. The motivation of the projects aiming at implementing the electronic document interchange cannot be seen in a static context as a cost-saving opportunity, but it should concern the achievement of competitive advantages.

5 Strategic advantages from EDI: building a taxonomy

In a correct perspective, therefore, EDI should be considered as a component of the corporate strategy. Appropriate questions are for example: will the uses of this technology be congruent with business and corporate strategy? What will be the impact of EDI on the structure of interfirm relations and on the inter-organizational co-ordination procedures? How will the benefits and costs be distributed among partners? The answers are necessarily contextual to the particular environment: the benefits and costs can be evaluated only by referring to a specific inter-organizational situation.

Figure 1 Benefits from EDI (various sources)

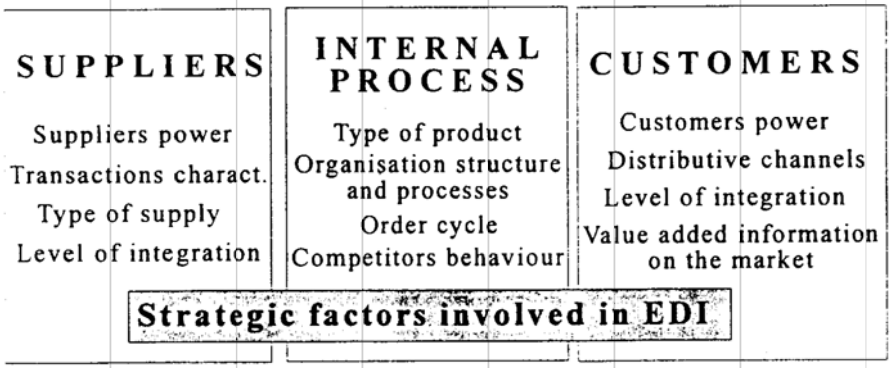


A result emerging from several surveys (many of these quoted before) is that among the numerous predicted potential advantages, the really important ones are few and not easy to obtain. Apart from the modest savings on the clerical activities, there are other significant benefits: e.g. the growth in communication speed, better supply control and inventory reduction. These outcomes (grey areas in Figure 1) may be more or less important depending on the sector, the firm's objectives and the particular application. The highest 'score' claimed by many firms is attained by customer service. Its importance is evident; but this result is difficult to quantify and to achieve.

The most significant benefits do not derive from the technology itself, but emerge from the changes in production and organization processes, from new partnership relations that EDI solicits. The closer co-ordination between customers and suppliers that is requested leads to adapting production systems and enables them to react more quickly. Due to the lead time compression and better knowledge of single products demand trend, substantial inventory reduction can be obtained. But this result requires a tight collaboration among partners and important organizational adaptations and it is generally obtained in the medium term.

How EDI influences the corporate and business strategy can now be analysed in detail, aiming at building a taxonomy of the strategic uses of this technology. We can assume, for the moment, the Porterian perspective. Porter has clearly underlined the *strategic content* and implications of New Information Technologies (NIT), and he has excluded that they can be considered as simple supports to business activities. In the Porterian vision, each organization must understand that the applications of NIT may create substantial competitive advantages. Many experiences have shown the scarce relevance of EDI when a clear strategic vision of technology is lacking. Following the scheme of the value chain, some considerations can be developed on the principal factors involved [50] (Figure 2).

Figure 2 Factors involved along the value chain (modified from Holland, Lockett, 1992)



- *Supplier and customer power.* It is the influence that the customer can exercise on the supplier, sometimes *vice-versa*. In a cost-saving perspective, EDI can be employed to manage a large number of suppliers. In a strategic perspective EDI can be utilised to improve the relationships with some of these, looking for a better co-ordination, higher flexibility and reliability, more than for an administrative cost reduction. It can also be a tool to manage total quality programmes.
- *Transaction characteristics.* They define the interdependencies between customer and supplier and determine the importance of a rapid and accurate information exchange. The opportunity of EDI adoption is strongly related to the nature of transactions. If the transactions are made desultorily on the market, EDI is unpracticable.
- *Organization structure and processes, order cycle.* The EDI interconnection almost always requires a deep transformation of intra-organization procedures. In certain cases EDI allows a higher frequency and a time reduction of order cycles, then contributing to contraction of the inventories. In some cases this leads to substantial cuts in operating assets and costs.
- *Market and distribution channel.* Having rapid and accurate information available assumes a strategic importance on the markets characterised by strong volatility or demand instability. Moreover, in case of 'long channel', EDI can favour the direct vision of the final market.
- *Value added information.* The advantage of creating or adding information content to the products or services may be an important occasion of strategic differentiation and a source of new business opportunities.

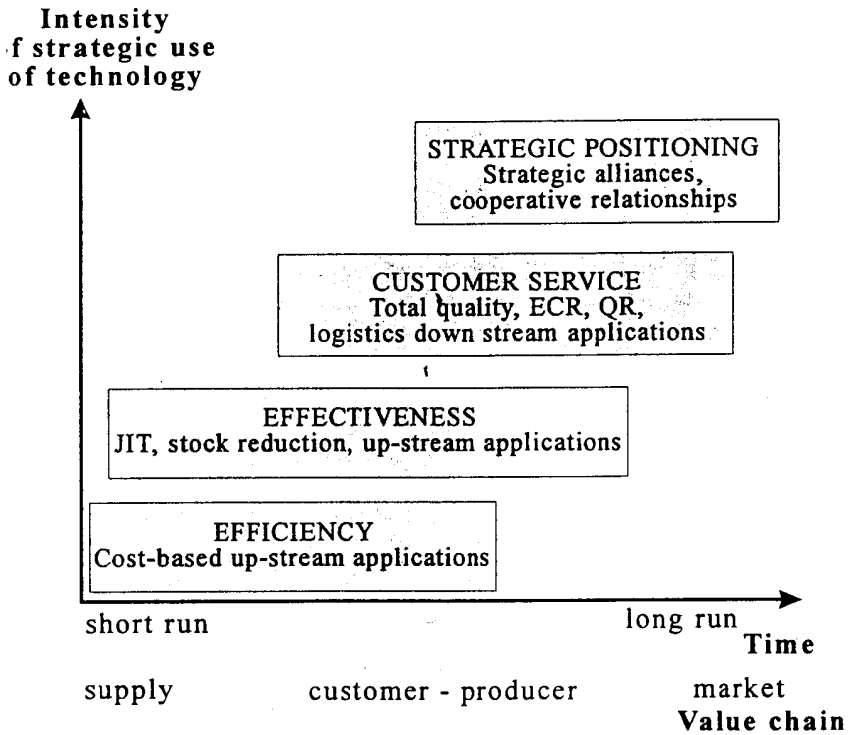
It should be evident, at this point, that real EDI opportunities do not interfere much with the automation of the administrative procedures or the capability of dematerialising information, as much as the automation of the information exchanges and, more in general, the automation of the transactions among different organizations. The transactions may include both vertical relationships in the value chain, and horizontal ones (Figure 3), i.e. competitors or other firms operating in different industries and markets (as in the case of the strategic agreements, joint ventures or network firms). The fact that the transaction automation is possible and advantageous depends on the particular business, organization structure, capabilities and skills, and on environmental conditions. EDI potentials can stimulate a better interfirm co-ordination, a more rapid adaptation to the market changes, going from sequential to simultaneous response [51], and the introduction of innovative products. Of course, this involves strong organizational efforts and the solutions of highly specific and 'localised' problems.

On this basis we may classify the strategic EDI impacts by analysing them along two fundamental directions:

a *vertical applications:* influence the contractual suppliers/customers power and support service strategies;

b *horizontal applications:* deal with the new entry threats and/or substitute products by means of new partnerships, co-operating firms or new competitive equilibria.

Figure 3 Strategic uses of EDI



In these directions, a taxonomy of the strategic advantages achievable from automation of transactions may be suggested. EDI applications aimed at this objective can be classified in four different types.

1 The advantage is achieved into a Just-in-Time and/or Total Quality perspective. This typically is relevant to a large firm and its suppliers, and is carried out in a framework of up-stream applications. The leading role is held by the customer firm, which is generally a cost leader belonging to a scale intensive industry. Examples are in the automotive and household appliances industries.

2 The advantage is achieved in a Quick Response or Efficient Consumer Response (ECR) perspective. This generally regards the relationships between a manufacturer and its dealers or retailers; in this case down-stream applications are involved. Examples are in low-tech, service oriented industries (e.g. clothing, food) where the rapidity of reaction to final demand and the service at the selling point are the principal variable of competitive strategy.

3 The advantage emerges from a stronger power or control in a network-firm and from the management of entry-exit barriers by a hub-firm. This substantially corresponds to a reduction of the market area. In fact, the higher stability of inter-organizational relations due to EDI interconnection can exalt the power of the leading firm. We can speak in this case of 'closed group' applications.

4 The advantage can be obtained in a logic of co-operation or strategic alliance. This may apply to two or more potentially competing enterprises, having complementary assets, that agree to exploit new businesses or to obtain economies of scope. We can speak of 'synergetic' or co-operative applications. Cases are in high-tech industries, banking, transportation, etc.

6 Conclusions: lessons from experience

The critical analysis of EDI has led us to review some of the beliefs regarding the benefits and future prospects of this technology. New evidence emerges from experience: slow *versus* rapid diffusion, effectiveness *versus* efficiency; strategic *versus* cost-saving advantages. An actual diffusion of EDI benefits derives from the dematerialisation of administrative procedures, and demands facing complex problems regarding the message codification and the procedure co-ordination. The implementation of an EDI project has a strong organizational impact: removing human mediation in inter-organizational co-ordination requires specific agreements on the content of the exchanged information and solicits the introduction of real organizational innovations on the user side.

All this, together with the impracticability of a universal communication standard, constitutes a serious obstacle to the wide diffusion of this technology. Since EDI can be applied within a framework of clearly-defined processes and procedures, the presence of inter-firm relationships based on non-repetitive transactions and on the exchange of informal or tacit information, hampers the use of this technology.

Experience, however, is showing that the biggest EDI payoff does not concern the dematerialisation of information so much as the automation of information exchange and, more generally, the automation of the transaction decision processes. In this perspective, the potential of EDI may be greater than those initially considered, because the benefits are directly inherent to the business and corporate strategy. EDI may constitute an essential tool in the application of new paradigms of lean production and market quick response, as well as in the rationalisation of inter-firm relationships. On the whole, whether or not to implement EDI is a complex decision that requires first strategic and then economic and technical evaluations. The benefits derive from the re-engineering of the inter-organization relationships and the business process redesign. The use of an EDI system does not, in itself, guarantee a re-configuration of firm relationships. The real value accruing must be looked for not in the technology itself, but rather in the opportunity of re-modelling relationships, with the aim of creating competitive advantage; this is the outcome of a process of organization learning. At present, the diffusion of EDI is bound not so much to the availability of low-cost hardware or software, but rather to the possibility of generating localised innovations regarding structure, processes and skills. These difficulties are part of the reason that EDI projects developed so far have been implemented, or imposed, by a leading firm which takes all the major decisions (such as the choice of EDI standard, tuning of the organizational solutions).

The adoption of EDI triggers a firm-specific learning process that generates different strategic opportunities. According to the structural characteristics of the industry, to the position of the firm in the value chain and to its strategic orientation, up-stream or, *vice versa*, down-stream or horizontal networks may be preferable. It is to be noted that any efficient EDI solution will 'freeze' the content and the modalities of the transactions; in some cases it does increase flexibility, but this is always a pre-programmed flexibility [52]. Since EDI makes connections more rigid, important organizational changes (as partners change, new business entry or new management practices) will be more difficult to enact. If, on one hand, the efficiency of the existing arrangements improves, on the other the sunk and switching costs increase [53]. EDI makes network relationships more specific, increases the level of integration, together with the entry and exit barriers.

We can derive some consequences from the analysis of the EDI experiences, regarding the technology itself, its diffusion barriers, the innovative potentials, the impact on roles and skills and the foreseeable effects on industrial organization structures.

EDI as communication technology. EDI communication brings with it problems of the formal codification of words, phrases and meanings. If the standards are not strictly compatible and translation or human mediation of some sort is required, then most of the benefits inherent in inter-firm communication automation are lost. The impossibility of tuning a universal EDI standard is becoming clear [54]. In the real world, the specificity of EDI operational messages restricts the communication to well bounded communities.

Barriers to a rapid EDI diffusion. The structural heterogeneity and the cognitive and organizational asymmetries among business partners greatly limit the possibility of an EDI employment. This, together with the fact that a project is justified only if the volume of transactions is very high, would explain why the present number of economic operators which are really interested in an EDI link-up is relatively small. In practice, only the major enterprises in a restricted range of industries (mainly in the retailing, automotive, transportation and banking sectors) have actually adopted this technology.

Innovative potentials of a 'stabilised' technology. Even if EDI is considered a new technology, the paradigm and the applicative systems are well known. The major difficulties concern not so much technical problems as the tuning of strategic aims and organizational solutions. Firms have to develop capabilities and localised innovations tied to their specific market position and particular environment.

Changes in roles and skills. EDI is changing the ways in which transactions occur as well as the role of the operators themselves on both the production and market side. Automating the re-ordering process, for example, reduces or eliminates the need for a contract or negotiation for any supply, and this not only unloads the buyers' activities, but also reduces their market power. EDI brings with it important changes in the skills required and roles of other important business functions: logistic managers, information system and network managers.

Impacts on the industrial organization structures. On the basis of what has occurred to date, it would seem that the effect of the spreading of EDI is not at all to widen the market, as is generally presumed will happen for telematic applications. Rather, EDI seems to determine an evolution toward industrial organization forms which are characterised by higher integration: verticalised or quasi-hierarchical networks in manufacturing sectors, and integrated horizontal networks in service sectors (e.g. banks). For the time being, therefore, the EDI interconnection leads to systems characterised by a stable integration between operators rather than to competitive relations. We shall have to wait and see whether or not competition between these systems will expand.

The risk of a deterministic perspective. The deep nature of this technology regards the automation of transactions, much more than labour or resources savings. Therefore, the possible scenarios are numerous, and there are few deterministic elements in the outcome. There will be a great deal of organization learning going on and, more than likely, great

'emerging' opportunities. The difficulties of technology assessment depend on the fact that so far no satisfactory theoretical model has been advanced to describe the inter-organizational impact of EDI. Maybe, a reflection which applied the three key-concepts (theories) of Transaction costs, Resource dependence and Network firm could be fruitful [55].

From EDI experiences, two issues for Technology Management

Firstly, that the analysis of organizational impact and the business process re-design are likely to be a 'constant' in managing any new technology. These are essential matters for Technology Management as a discipline. Secondly, that for each new technology learning is the real question. What learning models could be suggested? The originality of any new technology would seem to reduce or deny the possibility of learning from past experience. But, any learning attempt must, perforce, be based on experience and this is to be sought within and outside the firm. The aim of empirical research in Technology Management is to rationalise the range of technological experiences and produce knowledge models by establishing and classifying the relevant variables and factors involved. This has been attempted here by singling out the strategic uses of EDI technology.

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