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THE TECHNOLOGY PARADOX: CHARACTERISTICS, CAUSES AND IMPLICATIONS FOR IT MANAGEMENT

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ABSTRACT

The relationship between the implantation and development of information technology (IT) and improvements in business performance has been a matter of interest to professionals and researchers in Management since the 1980's. Despite numerous studies that have attempted to determine the full impact of IT, no conclusive results have as yet emerged. This situation has been termed the productivity paradox (or technology paradox) of the new technologies. In this paper we define this phenomenon and propose some methods of analysis for detecting the kind of situations in which it occurs. Finally we propose an IT management model for use in companies.

1. INTRODUCTION

The paper is divided into four main sections. The first of these will be used to define the concept that is to be the object of our analysis: i.e. the IT productivity, or technology paradox. In this section we will attempt to define the dimensions and extent of the phenomenon, with particular reference to the latest findings of researchers working in the United States and Europe. In the second section we approach the issue from various different perspectives with a view to gaining a better understanding of the nature of the technology paradox, dedicating special attention to those perspectives that have most empirical support. Special emphasis will be given to the strategic necessity hypothesis, the dynamic evolution of IT, transaction cost economics, the complementary resource perspective, and technology-oriented business models. The third section sums up the main conclusions to be made from the above analysis.

The objective of this paper is to provide an explanatory and eclectic model for managing IT paradox that we hope will prove useful to executives trying to decide whether to introduce or further develop new technologies. To gain this objective, we analyse several theoretical frameworks that may help to explain the causes of the technology paradox and, thereby, suggest innovative ways of avoiding it. Previous literature fails to provide a solid framework and is usually based on aggregated data analysis and conclusions drawn from this data. But, without consistent frameworks, researchers can only describe data without adding meaning (Hartley, 1994). Without a framework, data overflows, thus preventing researchers from knowing which data and which issues are relevant, with the result that their conclusions become a succession of disconnected anecdotes (Bonache, 1999).

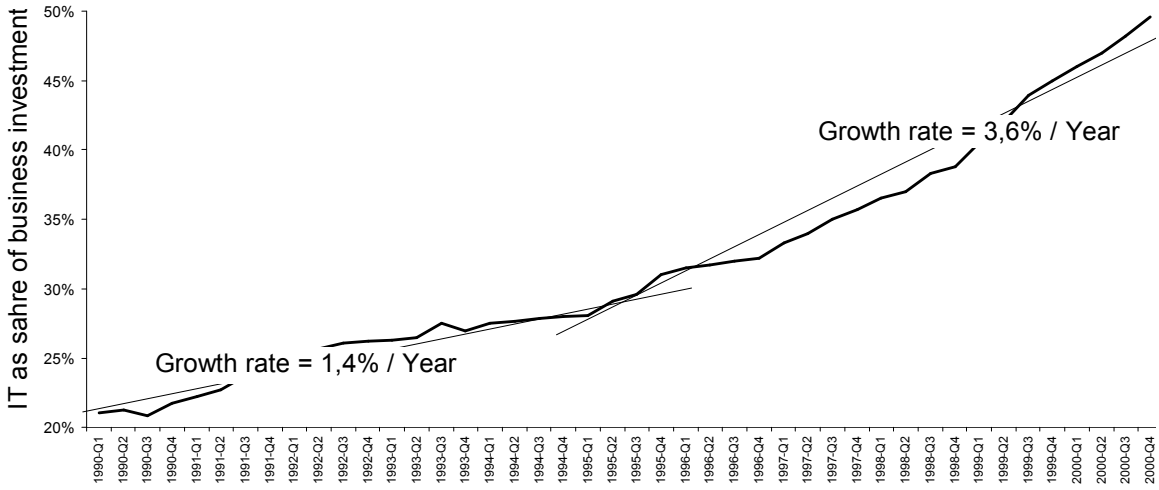
2. THE PRODUCTIVITY PARADOX OF INFORMATION TECHNOLOGY

Over the past three decades we have witnessed a race among companies to develop technologically in computing, robotics and telecommunications. This process began in the United States, Western Europe and Japan in the 1960's, and spread to the rest of the world in the decades that followed. It was in these early years, and in general in the 1980's and 1990's, when development in computing became standard in companies, and there was a belief that this would provide a panacea for management, and would inevitably lead to an increase in the productivity to be obtained from the factors of production and improvement in business performance.

Most companies opted for mass introduction of IT in the form of data processing systems, management information systems, and more recently, strategic information systems. Since the late 1970s, the technology race has led to huge amounts of investment. In fact, nowadays almost 50% of U.S. business investments are in IT (see Figure 1); meanwhile, the output per worker-hour has fallen from its postwar average gain of 3.4% per year to 1.2% per year between 1979 and 1994 (Siegel, 1998) .

According to a London School of Economics survey of more than 500 of the top 3,000 companies in North America and Europe, firms spent more than $800 billion on IT investments in 1997, but only a third turned out to be profitable (Harris, 1999). In 2000, about half of all investment by American firms went on IT equipment and software (Woodall, 2000).

Figure 1.
Growth in IT as a share of total business investment



Source: Strassmann (2002)

In the second half of the 1990's the technological innovation gained force thanks to the emergence of the Internet as a business tool, which in a matter of months led to spectacular growth in some e-businesses. By Spring of 2000, however, these same businesses were under the effect of a crisis, severely affecting international financial markets, and they have yet to fully recover (Lee, 2001).

The bursting of the dot.com bubble led to some researchers resuming studies begun in the late 1980's or early 1990's, which pointed out the negative effect on the productivity of the work factor when a company increases its computing investment. This effect was first described in 1987 (Solow, 1987), and subsequently analysed in more detail for the US economy. Thus Strassmann (1990) and Brynjolfsson (1993) analysed US macroeconomic figures, which showed a constant fall in the productivity of the work factor in US firms during the 1970's and 1980's. Brynjolfsson (1993) noted that the drop in productivity roughly coincided with the increase in the use of IT. Subsequently, Strassmann (1998, 1999a) used various measures of business performance to support his hypothesis that the introduction of IT failed on its own to generate an increase either in the productivity of the factors of production or in the market value of the company.

Weill (1992), using data from US industrial sectors, analysed the relationship between investment in IT and average business performance measured by productivity and profitability. Weill categorized investment in IT as strategic and transactional, with the aim of gain a better understanding of its impact on performance. Results revealed that though there was no relationship between the implantation of transactional IT and profitability or productivity, these did show a more favourable relationship with strategic investment. Other authors (Yosri, 1992; Dos Santos, Peffers and Mauer, 1993 and Loveman, 1994) also studied the firm performance of IT, obtaining diverse conclusions.

According to Roach (1991) the drop in information worker ("white-collar") productivity between the mid-1970s and 1986 was 6.6%. This contrasts significantly with a production worker ("blue-collar") productivity increase of 16.9%. Roughly 80% of U.S. computer investment in 1998 was in the service sector, where output and productivity are hard to quantify; meanwhile, manufacturing industries that had invested heavily in computers saw their productivity growth swell to double that of other industries (Siegel, 1998).

There are also more recent studies (Brynjolfsson and Hitt, 1996a; Brynjolfsson, Hitt and Yang, 2000) which throw more light on the performance of IT and indicate that the introduction of new technologies leads, in the long term, to an improvement in business performance. In any case, this claim is not without its provisos: a long list of determining factors which analysis shows to be necessary in order for investment in IT to lead to the desired outcome. Table 1 summarises the main studies done in the field of the technology paradox.

Table 1.
Studies of IT and performance

Cron and Sobol (1983)	IT investment reinforces existing managerial capabilities, helping well-organized firms to succeed but confusing managers who have not properly structured production
Loveman (1988)	IT investment added zero to output
Harris and Katz (1989)	Weak positive relationship between IT and various performance ratios
Alpar and Kim (1990)	Performance estimates sensitive to methodology
Morrison and Berndt (1990)	IT marginal benefit is just 80 cents per dollar invested
Noyelle (1990)	Severe measurement problems in services
Parsons et al. (1990)	Impact of IT on the performance of financial services firms quite low, but IT has positioned the industry for greater growth in the future
Strassmann (1990, 1997, 1999b, 2002)	No correlation between various IT ratios and performance measures, a situation that has not changed for more than 20 years
Weill (1990)	Contextual variables affect IT performance
Roach (1991)	Vast increase in IT capital per information worker while measured output decrease
Siegel and Griliches (1991)	IT-using industries tend to be more productive; government data is unreliable
Yosri (1992)	No correlation between IT investment and sales growth, market share gain, new market penetration, measures of quality improvement, and productivity
Brynjolfsson and Hitt (1993)	The return on investments in IT capital is over 50% per year in manufacturing. The return on IT investments is over 60% per year in services
Loveman (1994)	Output elasticity of IT investment was negative. Businesses are better off investing in non IT factors of production
Computerworld (1994)	In 782 organizations chosen on the basis of their better-than-average profitability, the top ten were spending less money on IT than the 100 bottom-ranking firms
Kelley (1994)	The most productive metal working plants use computer-controlled machinery
Barua *et al.* (1995)	IT improved intermediate outputs, though not necessarily final product
Brynjolfsson and Hitt (1996b); Dewan and Min (1997)	Average annual contribution of computer capital to total output exceed 60% of capital stock, depending on the analysis and specification
Kivijarvi and Saarinen (1995)	In a study of 200 firms they found no evidence that a high level of spending on IT related to corporate profits
Berndt and Morrison (1995) Morrison (1996)	For manufacturing industries, gross marginal product of "high tech capital" was less than its cost. In many industries the supposedly labour-saving investments were associated with an increase in labour demand
Hitt and Brynjolfsson (1996)	No correlation between spending on IT, total shareholder return, ROA or ROE
Greenan and Mairesse	Positive relationship between a firm's productivity and the proportion of its

(1996)	employees who report using a personal computer at work
Black and Lynch (1996)	Plants where a higher percentage of employees use computers are more productive in a sample containing multiple industries
Clegg et al. (1997)	80-90% of IT investments did not meet performance objectives
Powell and Dent-Micallef (1997)	In order to succeed, IT investments success require certain complementary human and business resources
Weill (1997)	Transactional IT investment associated with firms exhibiting a strong performance. Strategic IT investment associated with poorly performing companies
Doms, Dunne and Troske (1997)	Plants using more advanced manufacturing technologies had higher productivity and wages. Nevertheless, this was already the case before the technologies were introduced
Mahmood (1998)	Positive relation between IT investment and change revenue growth. Relationships between IT investment and other measures of productivity and performance were not as clear
Brynjolfsson and Hitt (2000)	IT value is rooted in its ability to enable complementary organizational investments, such as business processes and work practices, that lead productivity to increase

Source: The authors and Brynjolfsson (1993); Brynjolfsson and Hitt (2000); Stratopoulos and Dehning (2000); and Strassmann, P.A. (2002).

Lack of agreement on this subject between the various researchers (Stratopoulos and Dehning, 2000) may be due to the fact that there are a number of methodological problems, which make it difficult to accurately determine the effective contribution of IT to the results and competitive position achieved by companies (Bruque, 2001). A state-of-the-art review of the IT productivity paradox reveals two problems: Most of literature pays very little heed to the qualitative aspect of the phenomenon, and there is a vast range of perspectives for dealing with the topic but no solid set of core theories.

The diversity of perspectives applied in studies of the technology paradox is an indication of the inadequacy of any of them, considered separately, to give a full explanation of the phenomenon. The topic, therefore, requires a more eclectic approach (Lowendahl and Revang, 1998), so that different core perspectives may offset the constraints imposed by more partial theoretical views. Various explanations for the productivity paradox, for which we have used a wider term, the technology paradox, are discussed in the following section. Subsequently we will derive some implications that may serve as useful guidelines for professionals in the technology and management spheres.

3. SOME EXPLANATIONS FOR THE TECHNOLOGY PARADOX

We now analyse five perspectives that may serve as a basis for understanding the causes of the technology paradox. Each offers a distinct view of the causes of the phenomenon, and therefore genuine ideas for optimising the management of IT-related resources. For the sake of clarity, we will use a chronological approach, starting with longer-standing views, and ending with the most recent. We will begin with the Nolan cycle, before going on to discuss the strategic necessity hypothesis, transaction cost economics, the resource based view, and finally the business models approach.

3.1 The Nolan Cycle

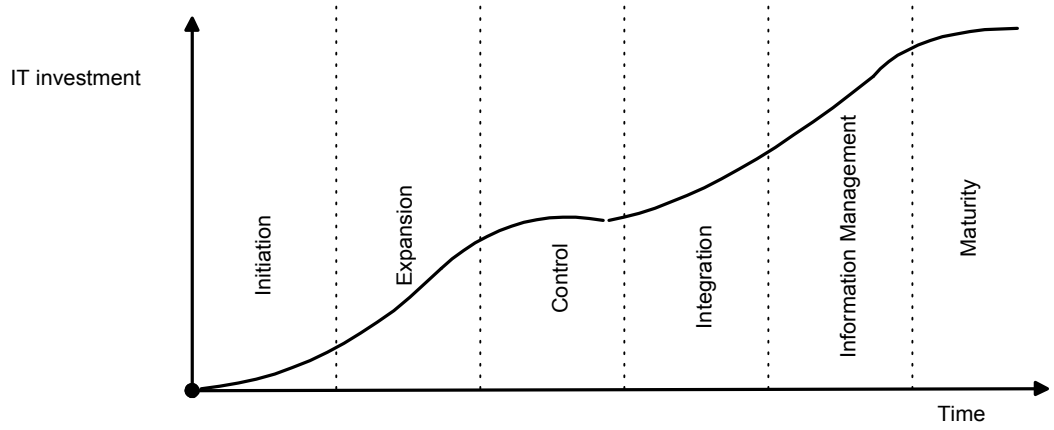
Rationale . Although this perspective was formulated before the discovery of the technology paradox, it contains a number of points that may help to provide an explanation for it. Nolan and Gibson (1974) and Nolan (1981) reaffirm the dynamic nature of IT investment and innovation processes. By applying the life cycle philosophy to the introduction and development of new technologies within a company, they developed a six-

stage model to measure IT investment against its organizational and strategic impact (figure 1).

The first of the six stages is the *Initiation phase,* which is when the new technology is introduced. This phase is characterised by a high level of uncertainty surrounding the potential performance of the technology, scepticism among the majority of the members of the organization, the existence of a small, but active, number of detractors and defenders of the new technologies, incompatibility between equipment and processes, improvisation, etc.

In the second stage, which is *Expansion*, IT begins to show visible results. The whole organization is anxious to obtain immediate advantages, while at the same time suspicion towards the new technologies begins to abate. The third stage may be termed *Control* over the spending resulting from the excessive euphoria that prevailed during the previous stage. Procedures are put into place to control spending, and the different projects are followed centrally. The fourth period is characterised by the *Integration* of the different technologies, with a view to improving the global performance of the system, as well as taking advantage of possible strategic externalities originating from the computing and communications systems. In the last two stages, *Information Management* and *Maturity* the technologies portfolio is re - organised, and only those elements that can provide support for company strategy, or its basic processes, are retained.

Figure 2.
Nolan Cycle
Source: Adapted from Nolan (1981)



Implications for IT management. The Nolan model provides a novel explanation for the technology paradox problem. By observing the characteristics of each stage, it can be appreciated that the organization can only obtain economic or competitive advantages from its investment in technologies in the Control, Integration and Information Management stages. In the Initiation stage the company has to combat organizational inertia and employee resistance to change (Mirvis, Sales and Hackett, 1990), as well as overcoming the friction that is typical during the implantation of new systems. This would not, therefore, appear to be the time to expect any noticeably positive results.

Some empirical studies support the lack of productivity increases in the initial stages of Introduction and Expansion (e. g. David, Grabski and Kasavana, 1996). In this study, the researchers sent a questionnaire to the chief financial officers of the 100 largest firms in the

US hospitality Industry. Respondents were asked whether they believed their information system to contribute to productivity, service quality, guest services and/or competitive advantage. The questionnaire also asked respondents to give examples of productivity improvements and how those improvements had been measured. One of the findings was that the financial officers reported a productivity lag in the first stages of IT implementation, while the positive effects came later, once spending on new equipments had been controlled and rationalised.

Medina-Garrido and Bruque-Camara (2002) carried out a case study in an industrial plant located in the south of Spain, and engaged in the manufacture of electronic components for the automotive industry, mainly for the European market. The case study used four sources for the data triangulation: the analysis of documentary sources, observation, a questionnaire and semi-structured personal interviews. This firm is continuously investing in new IT in order to co-ordinate its activities with customers. Each new customer usually requires different, specific IT, although some sectorial standards exist. Managers claimed to be aware that new IT investment involves high cost in the beginning (effects of the technology paradox), but costs decrease in the long term, giving way to worthwhile benefits, deriving from relationships with customers.

The Expansion stage, likewise, does not appear to provide the necessary conditions for obtaining a high return on technological renovation. Decisions at this stage are based more on the desire to imitate competitors than on rational economic motives, and normally lead to over-investment that jeopardises profitability indexes. Only if the Control stage is properly managed, and there is a solid basis for the strategic management of the technology, is it possible to achieve positive results, and so overcome the effects of the technology paradox. As Brynjolfsson (1993) points out, if managers are rationally accounting for lags in the first stages of IT introduction, this explanation of productivity growth is particularly optimistic. In the future, not only should firms reap the technological benefits of the technology, but also enough additional benefits to make up for the extra costs incurred in the early stages of IT introduction.

3.2 The strategic Necessity Hypothesis

Rationale **.** The strategic necessity hypothesis was first raised by Clemons and Kimbrough (1986), and later developed by Clemons and Row (1991). These researchers claim that there is a process in business by which rivals in a particular sector rapidly acquire the innovations adopted by their most successful competitors. The strategic necessity hypothesis introduces some modifications to the reasons for which organizations become interested in IT. It is not a question of acquiring new technology with the intention of quickly obtaining a positive return on investment, in financial or competitive terms, rather it is something which is needed to prevent the organization being forced out of the sector. Following this logic, most of the advances that companies achieve via the introduction of computing and telecommunications technologies are rapidly neutralised by their competitors.

From a strictly economic perspective, the strategic necessity hypothesis can be justified in the following terms: investment in IT may increase productivity and efficiency initially, due to the fact that it leads to competition, allowing many companies to offer better conditions to their customers (Bakos, 1991), but this also reduces the prices of the products and services on offer (Hitt and Brynjolfsson, 1996), and therefore also the possibility of earning extraordinary (or Ricardian) rents. Thus IT becomes a source of competitive parity

rather than a net value-creating factor for the company.

There are numerous examples to support the strategic necessity hypothesis. At the global level, the most well known are linked to the implantation of the interorganizational information systems SABRE and ASAP (Cash and Konsynsky, 1986; Neo, 1988, Andreu, Ricart and Valor, 1996). The first is an innovative booking-management system, designed for American Airlines. Before the introduction of this system, airline seats were booked by telephone calls from buyer (normally travel agencies) to supplier (airline companies). After the introduction of SABRE, American Airlines succeeded in becoming leaders in the distribution of airline bookings in the early 1980's, thanks to the electronic link between travel agencies, and, more important from a strategic point of view, between the remaining airline companies in the sector. After a time, however, it was observed that the majority of competitors had managed to "imitate" the main IT-based innovations, establishing systems similar to SABRE. This eroded the initial advantage held by American Airlines.

In Spain there are also many examples that support the hypothesis. Over the past 15 years a similar process to the above has been taking place in the pharmaceutical distribution sector (Bruque, 2001). The introduction of communication systems using basic telephone lines initially, and bi-directional communications in value added networks, subsequently, facilitated the communication between pharmacies and the main pharmaceutical distributors. This innovation spurred pioneering companies to introduce these systems. Companies such as the *Cooperativa Farmacéutica Española* or the *Centro Cooperativo Farmacéutico* among others, achieved advantages by using data-transmission networks. The purchase and distribution of specialised pharmaceutical goods was made much easier, and soon resulted in increased market-share and customer satisfaction. However the remaining companies operating in the sector rapidly imitated the innovation, by adopting similar communication procedures, so that the advantage initially achieved by the innovating companies became considerably eroded. At present telecommunications systems are not viewed in the pharmaceutical distribution sector as generators of competitive advantage. Rather, as executives in the sector acknowledge, they are considered a basic work tool, since operating in the pharmaceutical distribution sector is inconceivable without them.

Further support for the strategic necessity hypothesis came from results achieved in 1999 by Professor Sánchez (1999). In an analysis of the implantation of Electronic Data Interchange (EDI) systems in Spanish companies, executives maintained that the principal motive for introducing them came as a result of pressure from their commercial partners, or customers, or the need to keep up with competitors who had already implanted the system. That is, companies resorted to certain technological innovations because they did not wish to miss the "technology bandwagon", or to be relegated to a marginal position within the sector.

Implications for IT Management. In short, the strategic necessity hypothesis provides a valid explanation for a great number of situations in which the technology paradox emerges. Companies are carried along on the wave of innovation, or pushed by the technology thrust (Wiseman, 1988), with the result that investment decisions do not correspond strictly to issues of economic or financial profitability, but are imposed by competitive dynamics in the company's bid to remain technologically up-to-date. If the situation were to become widespread in the technologically fastest-growing sectors of an economy, then it would be no surprise to find economic results from global investment in IT dropping to zero, or even into negative figures. This would create what has been termed technology anxiety (Savoie and Raisinghani, 1999), which puts the mechanisms of competition under strain without

producing notable results for the majority of companies.

3.3 The Importance of Transactions

Rationale. Some studies of the effect of IT on business performance place the main focus on the effect of investment in IT on transaction costs (Williamson, 1975). An economic transaction takes place when two or more agents contractually agree the time and place that the exchange of the good will occur (Salas, 1987). Exchanges between suppliers and customers, commercial partners, different elements within the same group or between the company and the state all come under the term transaction.

The relationship between IT and efficiency in transactions is a simple one. According to this view, companies obtain their economic incomes by being able to conduct their transactions more efficiently than would be possible in the marketplace. Further, the very existence of the companies can be explained by their ability to internalise transactions efficiently (Williamson, 1979). Thus, for example, commercial distribution companies exist because they have developed a dimension, an experience, a technology and a knowledge of the market which allows them to distribute products more efficiently than would be possible for any isolated producer. IT may help to diminish transaction costs, which are of three main types:

Information costs: these correspond to the amount of resources the intervening parties consume in the identifying and contacting one another.

Negotiation costs: these are the resources consumed in drawing up the contract.

Guarantee costs: these are the resources consumed in order to guarantee fulfilment of the agreement, or to protect either party from the negative consequences of non-fulfilment.

On the other hand, Clemons and Row (1992) assert that transaction costs are made up of co-ordination costs and transaction risks; the latter deriving from the risk of being exploited within the relationship.

The new technologies might reduce costs associated with travel expenses, physical space at the workplace, and the processing of the documentation. Additionally technology can reduce other types of indirect transaction costs, such as those deriving from the risk of non-fulfilment of the contract by one of the parties involved. The new telecommunications tools, for example, facilitate interactions between the economic agents when they are at a physical distance from each other. This can increase the security of the transaction. Also, some technological solutions, such as the Internet, can help to create new business models by allowing transactions to be carried out between customers and geographically dispersed small-scale suppliers (Amit and Zott, 2001).

Implications for IT management. From this perspective, the technology paradox is considered to occur whenever technology is implemented and: (1) Fails to achieve a reduction in transaction costs and/or (2) Reduces transaction costs but not enough to offset the IT costs incurred. In other words, the investment in technology fails to deliver the expected benefit. A company can prevent the failure of technology by evaluating the impact that the implantation of the new technologies is likely to have on business transactions. If investment in technology does not lead to a reduction in transaction costs, the company should opt for an alternative strategy.

The aforementioned case of a manufacturer of electronic components for the automotive industry located in the south of Spain illustrates a typical example of the

technology paradox. Managers claimed both in questionnaires and interviews that in spite of the fact that IT reduces their co-ordination costs, its impact on transaction risk is ambiguous. On the one hand, the transparency of the information provided through the IT prevents the information asymmetry that leads to opportunistic practices, thereby reducing transaction risks. On the other hand, almost all this firm's relationships with customers require specific IT investment that is of little value outside the relationship, thus increasing transaction risk in excess of the mentioned reduction (this is a qualitative judgment of this organisation managers). The final balance between co-ordination reductions and transaction risk increases, usually results in high transaction costs (it depends on the amount of specific IT investment required by each customer).

3.4 Information Technology and Complementary Resources

Rationale **.** The strategic necessity hypothesis, transaction cost economics and the Nolan cycle may be of use in explaining mediocre results from the implantation and development of new technologies. However, the corpus of business experience provides cases of organizations that have been able to adapt successfully to fluctuations caused by changing fashions in technology. Among these, Microsoft has remained the leading company in its field since it was founded in the early 1980's. In Europe, other companies like Nokia or BT have maintained privileged positions for the past two decades. In Spain, some companies, such as Inditex or Corte Inglés, have adapted to the new technologies, integrating them into a business system based on resources that had already proven their strategic effectiveness. What then, are the circumstances that have allowed this type of company to remain predominant for so long? And what role does information technology play in the process?

The answer is not to be found in any previous paradigm, since the strategic necessity hypothesis, as well as the Nolan cycle, are standardised models of evolution which do not provide alternative solutions, while transaction cost economics does not consider sources of technology value in which no type of transaction takes place. One of the most convincing explanations for this problem was provided by Kettinger *et al.* (1995) and Ross, Beath and Goodhue (1996), authors who stressed the importance of certain human and management elements as facilitators of a positive impact from technology. According to this current, the key to the success of IT lies in an organization's ability to combine IT with specific latent advantages that are enjoyed by the company and are difficult to imitate. The main difference in the economic and competitive benefits that companies obtain from IT lies in the difference in management and not in the difference in technology: "some business leaders are able to fit the pieces in better than others" (Keen, 1993).

It is clear that, whatever their stage of technological evolution, the level of technological performance differs from one organization to another. It is a question, in other words, of changing from a macroeconomic towards a more microeconomic perspective, centred around the "business black box", within which the various human and management resources can act out their influences along with the technology. What are the elements that help to sustain the positive effects of technology? Ross, Beath and Goodhue (1996) stressed three resources: namely, human, technological and relational. The first refers to the degree of motivation among technical personnel and their capacity to resolve business problems using the technological skills acquired in training.

The second (technology resource) refers to the existence of technical infrastructure and databases shared throughout the organization. In this way companies can fix rules for

distributing hardware, software, and technological support throughout the organization, irrespective of the specific applications used by the different company departments. Some companies lacking in a solidly defined architecture, on the other hand, have tried to implant computing or telecommunications equipment before considering how to inter-connect and use them. This generally results in either poor use of the information systems, high operation costs, or both.

The third (relational resource) is optimal when the IT department and company management share the risk and responsibility of applying IT in the company. Shared risk and responsibility requires mutual trust and respect between technical staff and the users of their services, as well as an ability to communicate, co-ordinate and negotiate rapidly and effectively. There are two distinct indicators that reveal the presence of a strong relational asset: (1) the involvement of non-technical, especially executive, staff in all IT projects, and (2) the leadership of upper management in setting the criteria for technological priorities.

Subsequent studies have demonstrated the interdependence of hard and soft elements in successful implantation of technology (Powell and Dent-Micallef, 1997; Bharadwaj, 2000). Among them, Powell and Dent-Micallef (1997) analysed 65 American firms from the retail Industry. The findings showed that IT alone did not produce sustainable performance advantages in the industry, but that some firms gained advantages by using IT to leverage intangible, complementary human and business resources, such as a flexible culture, the integration of strategic planning and IT, and strong relationships with suppliers. The results also helped to explain why some firms outperform others using the same ITs, and why successful IT users often fail to sustain IT-based competitive advantage (Powell and Dent-Micallef, 1997, p. 375).

In a previous work, (Bruque, 2001) in Spain, the impact of the interaction between some human and managerial resources and IT on competitive advantage has been analysed. The study analysed 16 firms (the whole population) and a sample of 231 clients operating in the pharmaceutical wholesale industry in a wide area of the Centre and South of Spain. To measure competitive advantage two variables were used: the market share variation during the period 1994-1998 and a subjective index based on client perceptions of service excellence. To measure the weight of intangible (human and managerial) IT-complementary variables an interview-based procedure was developed. Interviewees were taken from three levels of the companies: top managers, IT managers and operations personnel. After analysing the literature, we designed a different questionnaire for each level, with a maximum of 45 items on 5 point Likert type scales.

The human variable measured concepts such as open and frank internal communication, organizational consensus, cognitive and creative capacity of technical personnel and level of acceptance of change. The management variable, likewise, measured use of interdepartmental teams in the resolution of key problems, organizational flexibility and managerial support for the implementation and development of new technologies. Meanwhile, the level of presence of IT was assessed using two variables: IT investment over a four-year period and an IT utilization index, a perceptual variable measured through the interviews described above. This variable was measured as the mean level of utilization (on five-point Likert-type scales) of 17 robotic, computing or telecommunications tools.

Results showed that there was no positive link between IT investment, considered separately, and competitive advantage (see Table 2). More interestingly, IT utilization

appeared to be associated to better competitive performance; this relationship, however, was heavily conditioned by the effect of the size of the company and the strength of competition it had to face (two control variables). Results also revealed that, taking into account human and managerial variables, firms with a better intangible endowment achieved a better competitive performance.

Table 2.
Correlation matrix: IT-endowment and competitive advantage

Variable	1	2	3	4
1. IT Utilization Index	---			
2. IT Investment	.95 (**.88**)			
3. Client Valuation	.46 (**-.12**)	.21 (**-.31**)		
4. Market share variation	.45 (**-.04**)	.39 (**.17**)	-.03 (**-.41**)	

Note: Shown in brackets, the partial correlation indexes, with size and competitive rivalry as moderating variables. In this case, there was no point in calculating the level of confidence because the data comes from the whole population (there is no sample error).
Source: The authors.

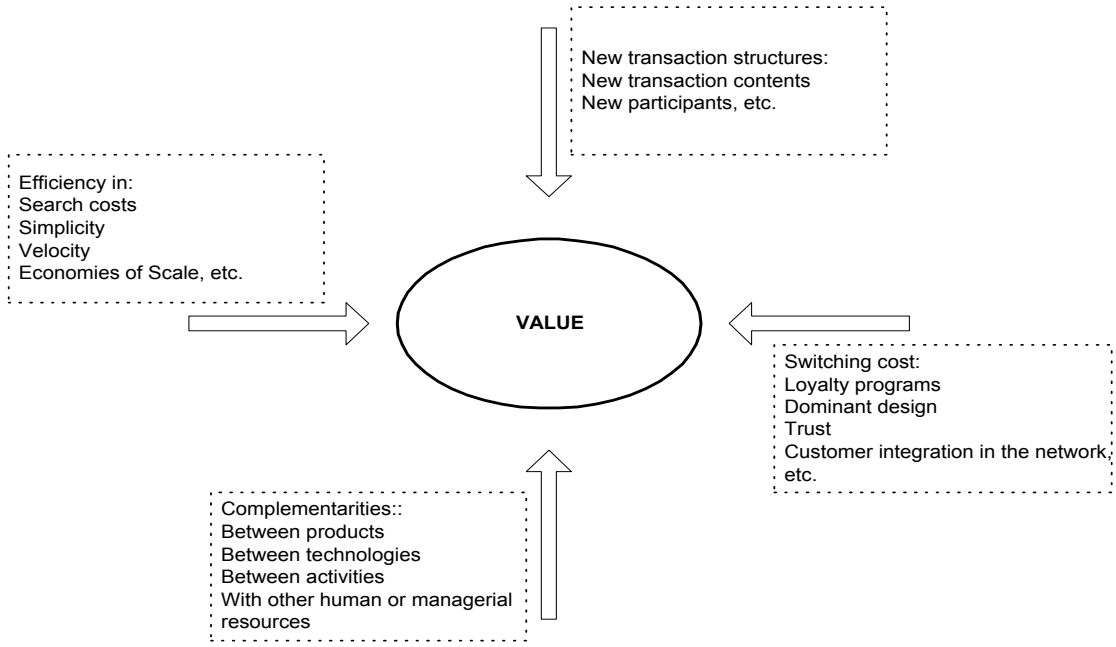
Implications for IT management. The proposed model demonstrates the need for a high level of co-ordination between the social system, management and the implantation of technology in order to achieve the optimal combined effect. According to Davenport (1999), a mere change in the information systems is not enough to change the culture of the organization. Technology cannot transform a company by its mere presence. The necessary transformation requires a basic change in habits, attitudes, values, expectations and incentives relating to information management. In this way it is possible to create a standard framework in which individuals can work effectively with the technology their company provides.

From this perspective, the technology paradox could be explained by focusing on situations in which the social and technical systems do not have the same interests, format or structure, with the result that the potential positive effects of the technology do not lead to improvements in profitability, market-share or customer satisfaction. This perspective also offers a more wide-ranging explanation for the problem, since it not only explains those cases in which the paradox appears, but also those in which the technology, adequately combined with other human and management resources, does actually provide a significant advantage to the organization.

3.5 The Business Model Approach

Rationale. A more recent explanation for the impact of IT on business performance is provided by Amit and Zott (2001). Although this approach basically applies to the technologies involved in electronic commerce, it offers a number of interesting ideas as to the causes of the paradox in terms of IT in general. These authors claim that when it comes to explaining the value generated and captured thanks to investment in technology the best unit of analysis is not the transaction, nor, exclusively, the complementarities with other human or management resources. The unit of analysis that can participate in the creation of value with regards to technology is the business model, that is, the model that defines the content, structure and management form of those transactions that are designed to create value through business opportunities (Amit and Zott, 2001, p. 511). A successful business model must contain at least some of the value-creating capacities that are referred to in figure 3.

Figure 3.
Business Model Criterion



Source: Adapted from Amit and Zott (2001, p. 504)

The value-creating capacities of the business model are divided into four main types: the first are those that create new transaction structures, with new contents and new participants. Next, come those that affect the efficiency of the transactions, either by reducing the search costs or by increasing the speed and simplicity of the economic exchange. The third group explains the creation of value by means of IT, when this enhances the positive effect of other pre-existing resources, whether human or management. The last group of capacities are those relating to the exploitation of the technology as a means of increasing the cost incurred by customers' changing service, and hence increasing their loyalty, or, alternatively, improving customer confidence by integrating them into the organizational network. The Spanish company Axesor has become one of the country's fastest-growing dot.com companies. This company supplies value-added information about Spanish companies, which includes data about partners, accounts and finances. The business model has introduced new transaction structures and contents, providing its customers with savings in research time, while simplifying and speeding up processing. This, and the fact that it is one of the pioneers in the sector, has gained it a large number of clients.

Perhaps, one of the best-known examples of success and failure regarding business models is shown by the contrasting experiences of Monster.com in the United States and Boo.com in Europe (Eisenmann, 2002). Monster.com's $50 million investment during 1999 in customer acquisition and brand building paid off brilliantly. In 2000, the company offered a 460,000 job listing to 10 million registered job-seekers, nearly 5 million of whom actively maintained online resumes accessible to recruiters. Monster.com was also profitable in other ways: its operating profit for 2000 was projected to be over 16% of revenue. Monster may have benefited from some of the value generating capacities mentioned above. The firm clearly created new transaction structures with new content and new participants. With the launching of the web in 1994, the possibility of using the Internet to access databases from remote locations transformed the hiring process.

Furthermore, the sale of the company in 1995 to the market-leader in recruitment advertising (TMP worldwide) accelerated the entry of a large number of participants to the project. Secondly, Monster.com was able to reduce search costs both for job seekers and employers, offering its services free to customers in order to increase its volume and, thereby, reduce operating costs. Thirdly, the Monster.com business model enhanced the positive effect of other pre-existing resources. The founders and the owners of the company provided it with a consistent background in industry know-how, wide experience in sales force management and a huge client base. Fourthly, Monster.com introduced several ways of increasing client loyalty by offering personalised products in the form of customised job-seeking processes from which solid switching costs emerged.

Boo.com (Eisenmann, 2002), on the other hand, was an online retailer of hip, up-market sportswear. The company was founded in 1998 in Sweden and used sophisticated 3D graphics that allowed prospective buyers to spin mannequins and zoom in on merchandise. The site offered a choice of seven languages and multiple currencies, plus 5-day shipping anywhere in Europe or North America. The initial investment of the company raised $135 million from different investors. However, the firm had serious problems in creating the e-business system it needed to link Boo.com's software to the operations systems of its suppliers. When the web page went into operation, navigation was confusing and the site crashed frequently. Sales never met expectations and finally the company ceased operations, by liquidating its assets, in May 2000. Analysis of the Boo.com business model shows that the four value-creating capacities mentioned above were all difficult to achieve for this firm: The new transaction structures did not provide added value for clients. Secondly, the system was slow and confusing, so the transactions made in the traditional marketplace were more efficient than those carried out through the web. Thirdly, the project did not provide complementary effect with existing know-how, client base, marketing experience, etc. Finally, not having met the previous conditions, the firm was unable to achieve effective IT-based switching costs.

Implications for IT management. In short, if a company chooses technology that is not supported by a value-generating business model, it will not derive benefit in the form of an improvement in its business performance or competitive position. The minimum requirement is for the company to build positions of strength in one or more of the four value-creating formulas. To achieve this, the firm has to develop a planning process based on a well-defined business model, that highlights the ways in which the value-adding capacities described above are to be addressed. To do this, a global analysis including the other models mentioned above (Nolan cycle, strategic necessity, complementary resources, transaction costs) may be more effective when assessing new IT-based business initiatives. This kind of eclectic analysis may be more effective when the project is not directly related to market performance (e.g. IT-based production and operations management systems).

Table 3 s shows a summary of the different models analyzed and some empirical support that may help to explain the relationship between the models and the technology paradox.

Table 3.
Analysed models. Summary and empirical support

Model	Argument	Support
Nolan cycle	IT follows a dynamic process of evolution (or cycle) in the firm. Neither the initial nor the maturity stage of the cycle is favourable to positive outcomes	Lag in the first stages of IT implementation, while the positive effects came after spending on new equipment was controlled and rationalised (David, Grabski and

	from IT implementation.	Kasavana, 1996; McAfee, 2001).
Strategic Necessity Hypothesis	Most of the economic and competitive advances that companies achieve via the introduction of computing and telecommunications technologies are rapidly neutralised by their competitors.	SABRE and ASAP cases (Neo, 1998). Other recent cases of competitive neutralization after introduction of new IT.
Transaction Costs	Some IT investments do not reduce negotiation, information or guarantee costs.	Manufacturer of electronic components for the automotive industry (Medina-Garrido and Bruque-Camara, 2002).
Complementary Resources	The main difference in the economic and competitive benefits that companies obtain from IT depends on differences in management and human endowment; not on differences in technology.	American retail industry (Powell and Dent-Micallef, 1997). Several American industries (Bharadwaj, 2000). Spanish Pharmaceutical Industry.
Business Model Approach	The unit of analysis that can contribute to the creation of value by means of technology is the business model. Some value-added- capacities are needed.	E-business cases (Amit and Zott, 2001) Monster.com and Boo.com cases (Eisenmann, 2002). In Europe: Axesor case.

Source: The authors.

4. CONCLUSION: AN IT ASSESSMENT MODEL

In conclusion, of all the different perspectives analysed, we propose the eclectic model that is illustrated in figure 4. This model integrates the five perspectives of the Nolan cycle, IT-complementary resources, business model approach and transaction costs economics and is based not only on the analysis of the different theoretical approaches used to explain the technology paradox but also on the empirical evidence (case analyses and quantitative studies mentioned above). The approach used in the analysis is both eclectic and systemic in the sense that the models can interact and therefore the final impact of IT can be better explained if several approaches are applied at the same time than if any of them is applied in isolation. We have introduced in figure 1 a "+" or "–" sign to show a positive, or negative, impact of the different relationships on the value- generating capacity of IT, and we use continuous arrows to mark the links identified between the different models and between these and firm performance.

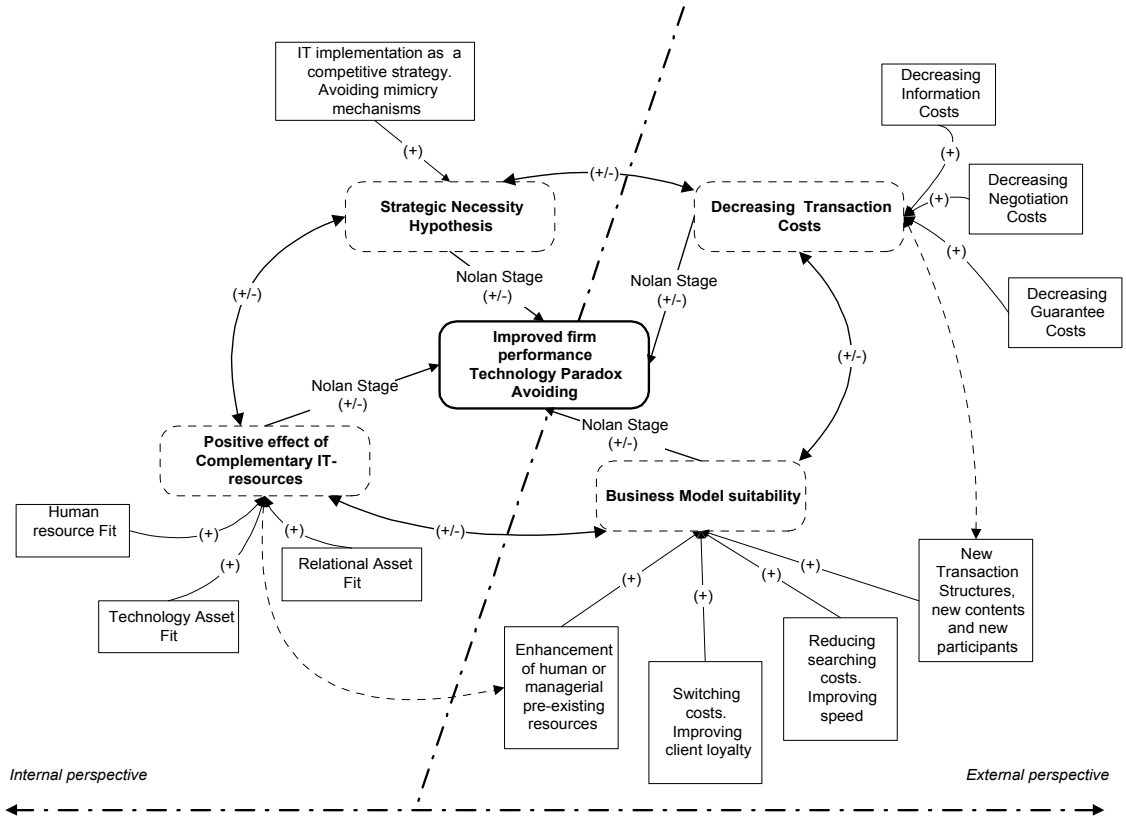
We have also ordered the different approaches with respect to two different criteria. The first of these is the dynamic/static criterion. The nature of the strategic necessity hypothesis, the business model approach, complementary IT-resources and transaction costs economics are static frameworks in the sense that they are independent of time. The Nolan cycle model is clearly a dynamic model, strongly connected with the evolution stage of the implementation of IT in organizations.

Each of the static perspectives is useful in explaining the value- generating capacity of IT on a specific value generation path. A firm can escape the technology paradox by guarding against mimicry in adopting and developing new IT technologies. From the point of view of complementary IT-resources, an exhaustive analysis of the fit between human, technological and relational assets and the new IT can be of assistance in improving firm performance. Business model suitability can also be a good predictor of the value-generating capacity of the new IT, due to the fact that it takes into account four ways of improving business performance: enhancing pre-existing human or managerial -existing resources, creating and maintaining switching costs, improving operational speed and search costs and gaining new transaction structures, new contents or new participants in the business after the

implementation of IT. Lastly, in relation to the business model approach, the analysis of the impact of new IT on information, negotiation and guarantee costs will provide a solid basis on which to predict the business impact of IT.

The explicative capacity of the static approaches is moderated by the introductory stage of new IT in organizations. New IT technology that supports a strong business model and is well-fitted to the human, technological and relational endowment of the firm and reduces transaction costs may not positively affect business performance. This may be because IT introduction is either in the initial stage (initiation) or in a very mature stage, and hence is unlikely to provide strong, positive economic or competitive returns.

Figure 4.
Technology Paradox. An eclectic model



The second criterion refers to the internal/external emphasis made in the analyses. The complementary IT-resources perspective and the strategic necessity hypothesis are focused on an internal analysis of the firm, while the business model approach and transaction costs economics are mainly centered on the market side of IT impact. Figure 4 depicts the internal/external level of analysis with a broken horizontal line at the bottom of the figure.

This study has some limitations that may give rise to further investigation. Firstly, we have proposed a new model constructed from a synthesis of the evidence from primary and secondary empirical data. Nevertheless further study is required to test this new model in different industries and with different types of information technology. Secondly, the analysis focuses mainly on Europe and the United States. Future research could address the more global impact of IT, by analyzing the differences of IT implementation between different countries and cultures.

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