The effects of ERP implementations on the profitability of big firms: the case of Spain

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Abstract: This paper aims to analyse the incidence of the implementation of ERP systems on the profitability of the biggest Spanish firms. To reach this objective, we sent a questionnaire to a sample of companies. We also gathered the financial statements of these companies. The main results indicate a significant decrement in the profitability of the companies that implemented an ERP system. The reason for this decrement was a reduction in the profit margin, which was caused by an increase in the operational expenses. The results also suggest that adopting firms manipulated earnings to hide the deterioration of their performance. The profitability of non-ERP firms remained unchanged, so the productivity paradox assumption is not supported.

Keywords: enterprise resource planning systems; ERP systems; productivity paradox; profitability; diffusion of innovations; accounting ratios; Spain.

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1 Introduction

Some authors suggest that, as we are entering a new epoch, moving from the industrial age to the information age, companies are being forced to discover new ways of working (Boar, 1997). Environmental and organisational changes imply changes in both the information firms produce and the use of that information for decision-making (Atkinson et al., 1997).

With this scenario, it is particularly interesting to develop new systems for the communication of information, as much inside firms as among firms and the external users. Among these are the enterprise resource planning (ERP) systems.

ERP systems can be defined as customisable standard application software which includes integrated business solutions to the core processes (e.g., production planning and control, warehouse management, etc.) and the main administrative functions (e.g., accounting, human resource management, etc.) in a company (Rosemann and Wiese, 1999). The basic features of these systems are modularity, supplementing other systems in the firm and with the ability to provide management information. As several authors have pointed out (Gupta and Kohli, 2006), this last point is of particular importance. These features have given rise to an exponential growth of ERP implementations over the last few years. This growth has taken place both at a global level (Computer Economics, 1999) and at the Spanish level (Grupo Penteo, 2003). Although, academic interest in ERP implementations is relatively new, has sharpened considerably during recent years (Basoglu et al., 2007; Botta-Genoulaz et al., 2005).

The purpose of this paper is to examine the effects of ERP implementations on firm performance in big Spanish firms. As Hitt et al. (2002) point out, there are many papers that study the benefits of the ERP systems through case studies, but more general studies are also of interest. Poston and Grabski (2001) and Hunton et al. (2003) examined the effect of ERP systems on firm performance, on the basis of a sample of US firms.

Nevertheless, there are reasons to hypothesise that the Spanish case presents important differences.

In pursuit of our goal, the next section explains the special features of the Spanish market, which make the study of the Spanish case a valuable contribution to ERP research. The hypotheses regarding the effects of ERP implementation on firm performance are formulated in Section 3. Section 4 describes the procedures for the selection of the sample, and the empirical methods used. The results are detailed in Section 5. Section 6 is devoted to showing the results of some tests we conducted in order to guarantee the validity of the results. Finally, Section 7 contains the main conclusions of the paper.

2 The Spanish case

During the last 30 years, Spain has undergone a process of rapid industrialisation and drastic political and social change. The Spanish market has had a rate of growth higher than that of the rest of the European market. However, nowadays, there still remain important differences from other European countries and from the USA.

First of all, it must be pointed out that although the involvement of board members of Spanish companies in the development of information systems has increased in recent years, in this respect Spain is still far from other European countries (KPMG, 2003; Andreu and Baiget, 2004). Furthermore, the awareness of top management of technological problems is lower in Spain than in other European countries. Spain's indices of new technology use and operation are below the EU norm, with a wider gap in areas such as the number of internet users, the number of servers connected, technological inventory and human capital [according to Eurostat (2009), the percentage of Spanish enterprises who employed information and communication technologies/information technology specialists is much lower than in other European countries].

So, it is not surprising that Spain rank 16th in the summary innovation index for the 25 EU member states. Spain has poor performance in respect of innovation drivers, knowledge creation and the application of innovation and intellectual property. Regarding innovation and entrepreneurship, the situation is even worse, as Spain ranks 22nd. Other revealing data are that business R&D expenditure is 45% of the EU average, and that the rates of patenting are below 20% of the EU average (European Commission, 2005).

The reasons for this situation spring from the key importance of cultural and human aspects as potential levers or inhibitors of the processes of knowledge creation and transfer (Ruggles, 1998; McDermott and O'Dell, 2001). Many authors have reflected upon how culture affects management systems (Hofstede and Hofstede, 2005; Bhagat et al., 2002) and management control systems (Chow et al., 1996; Williams and Seaman, 2001).

Hofstede (2001) defines national culture as the collective mental programming of people of any particular nationality. He suggests that people share a collective national character which represents their cultural mental programming. This mental programming shapes the values, attitudes, competence, behaviour, and perceptions of priority of that nationality. It is easy to observe that culture is not an easy phenomenon to measure directly as "it is largely invisible and unconscious" (Hofstede, 1987). Hofstede (1983)

identified four dimensions for the description of culture. These dimensions were derived from a survey containing many questions about values. This survey was conducted within subsidiaries of a large multinational (IBM) in 72 countries. The original Hofstede framework consisted of these dimensions: power distance index (PDI), individualism index (IDV), uncertainty avoidance index (UAI) and masculinity index (MAS). Later on, a fifth dimension was added to this framework: long-term orientation (LTO), but it has not been very used in empirical research works. Over time, the validity of these dimensions has been confirmed by many studies [e.g., Van Oudenhoven (2001); for an overview of earlier replications, see Søndergaard (1994)] suggesting that they can be reliably used to classify countries according to their national cultures and to determine the cultural distance between them (Drogendijk and Slangen, 2006).

Two of these dimensions may have an influence on the effects of the implementation of an ERP system on firm performance: power distance and uncertainty avoidance.

According to Hofstede, organisations in countries with high power distance are often characterised by centralised decision structures, authority, the use of formal rules, and the sharing of information is constrained by a hierarchy. Power distance is higher in Spain (57) than in other European countries (Germany and UK, 35) and the USA (40). This is an obstacle to open communication, true involvement-winning contexts and transparency of the 'rules of the game'. It also inhibits employee perception of positive and exemplary behaviour by management.

Uncertainty avoidance is the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity. Organisations in countries with a high UAI generally show characteristics such as resistance to innovations, highly formalised management and the constraining of innovation by rules. Uncertainty avoidance is clearly higher in Spain (86) than in other European countries (Germany 65 and UK 35) and the USA (46). This indicates that Spanish companies tend to prevent creativity, proaction and innovative attitudes. Strong uncertainty avoidance hampers the emergence of new ideas and even more the implementation of innovations. The implementation of a new way of management might be seen as one of these new organisational innovations, and therefore, will be more common in low uncertainty avoidance countries. In fact, Boldy et al. (1993) report that risk-taking was not in the top ten most desirable managerial attributes among Spaniards. In sum, strong uncertainty avoidance at the societal level appears to penetrate organisations and managerial behaviour.

Hofstede (1983) asserts that high power distance and strong uncertainty avoidance produce centralised pyramidal organisational structures, where a powerful person will be looked for to resolve uncertainties for the others who are risk-averse, and where there exist rules that the powerful can ignore. Although containing some hyperbole, the Hofstede inference roughly describes the reality of Spain which appears in the comparative literature.

Due to these features of Spanish national culture, particular research for the Spanish case is needed. As some authors have evidenced (i.e., Lorca and De Andrés, 2010), because of uncertainty avoidance, Spanish firms could be more prone to take the decision of implementing an ERP in an attempt to reduce uncertainty by imitating their competitors rather than as a result of a thorough examination of its costs and benefits (efficient choice perspective). Furthermore, the restrictions on the dissemination of information caused by high power distance could inhibit some of the benefits of an ERP model. Finally, the lack of computer and technological skills among Spanish managers

could prevent them from having an adequate perception of the advantages and disadvantages of ERPs.

The results of the present research are interesting as there are other countries, e.g., Italy, Greece and Portugal, whose national cultures and managerial technological skills are more similar to those of Spain than to those of the USA or the UK. So, among the firms in these countries, the effects of the ERP adoption could be better reflected by the findings of this paper than by those of prior research on this issue, which has been mainly focused on the USA case (e.g., Bradford and Florin, 2003; Mabert et al., 2003a, 2003b).

3 Hypotheses development

A model for the diffusion of innovations which is popular among researchers is the efficient choice perspective. According to the efficient choice perspective, firms will adopt an innovation if they believe that it will, all things considered, enhance their utility (Abrahamson, 1991). From this perspective, the innovation decision is made through a cost-benefit analysis. An innovation will be adopted by the firm if the benefits it reports exceed its costs.

Among the types of organisation costs defined by Gurbaxani and Whang (1991), ERPs can have an effect on the coordination costs.[1] The reasons are the following:

- Managers can efficiently and effectively review employee actions in a timely way. Therefore, ERP implementations should reduce monitoring costs by automating process steps and by providing an electronic trail of employee responsibility (Gurbaxani and Whang, 1991).
- Data re-entry errors and omissions are eliminated (Rizzi and Zamboni, 1999; Latamore, 2000).
- Through the creation and maintenance of a central database of corporate information, which can be accessed online and simultaneously by many users, the ability to obtain, process and transform information in real time speeds all the tasks. In this regard, recent research (Su and Yang, 2010) evidences that ERP implementations positively impact firm competences in supply chain management (SCM).
- ERP systems are extremely useful in the integration of global companies and provide a common language throughout enterprises with many geographically dispersed and specialised markets (Bingi et al., 1999). As an option for such firms, ERP software solutions can be ‘built’ using multiple software systems and databases. These components may originate from a single vendor, but often multiple software vendors are involved. ERP systems are designed to solve the problem of the fragmentation of information, particularly in large corporate organisations, and integrate all the information flows within a company (McAdam and Galloway, 2005). Problems of coordination and control are exacerbated when organisations are formally divided into large numbers of functional units. A multi-system or multi-structure solution may give a firm the opportunity to purchase ‘best in class’ versions of each operating module (Bendoly and Jacobs, 2004).

- Also, as Drucker (1988) points out, the availability of information transforms the capital investment analysis from opinion into real diagnosis, that is, into the rational weighting of alternative assumptions. So, the information transforms the capital investment decision from an opportunistic financial decision governed by numbers into a business decision based on the probability of alternative strategic assumptions.
- ERPs are effective with regard to transaction processing (Booth et al., 2000). This is because ERP systems are expected to maintain accurate and more accessible databases of information. This reduces administrative search, transportation, inventory holding and communications overhead costs (Poston and Grabski, 2001).
- Finally, ERPs reduce the opportunity costs caused by to poor information (Poston and Grabski, 2001).

These improvements in coordination costs are translated into a set of benefits for the firms. These benefits, both tangible and intangible (see Table 1), have been evidenced by several research works conducted at the international (Deloitte Consulting, 1999[2]; O'Leary, 2004[3]), Australian (Hawking et al., 2004[4]) and Spanish (Grupo Penteo, 2003[5]) levels.

Table 1 ERP benefits

Panel A. Tangible benefits	*Deloitte Consulting (1999)**	*Grupo Penteo (2003)**	*O'Leary (2004)**	*Hawking et al. (2004)***
Inventory reduction	32	33	16	3.1
Personnel reduction	27	34	12	2.7
Productivity improvement	26	25	20	3.8
Order management improvement	20	15	36	3.1
Financial close cycle reduction	19	19	44	4.6
Information technology cost reduction	14	12	8	2.6
Procurement cost reduction	12	13	12	3.8
Cash management improvement	11	10	4	3.2
Revenue/profit increases	11	10	8	2.5
Transportation/logistics cost reductions	9		4	3.5
Maintenance cost reduction	7	8	4	3.9
On-time delivery	6		4	4.4

Notes: *% of survey respondents; **seven points Likert scale responses.

*% of companies mentioning.

Table 1 ERP benefits (continued)

Panel B. Intangible benefits	*Deloitte Consulting (1999)**	*Grupo Penteo (2003)**	*O'Leary (2004)**
Improve quality/visibility of data	55	62	64
New/improved processes	24		16
Customer responsiveness	22	20	40
Cost reduction	14	25	8
Integration	13	17	44
Standardisation	12	16	28
Flexibility	9	11	40
Globalisation	9	9	24
Y2K	8	11	8
Business performance	7	8	4
Supply/demand chain	5	6	4

Notes: *% of survey respondents; **seven points Likert scale responses.

*% of companies mentioning.

As a final consequence of these benefits, ERP systems should contribute to improve the firm performance. However, it should also be borne in mind that ERP implementations require substantial investments of time, money and, training for system users. This is due to the necessity of customisation, since ERPs usually consist of a common skeleton that requires adaptations to the business type. Mabert et al. (2000) quantified the implementation costs of an ERP system as a figure that oscillates between 0.82% and 13.65% of the sales. This percentage can be up to 50% for the smallest companies. For the Spanish case, it has been estimated that for big companies the implementation costs of ERP systems can amount to 2%–3% of the annual sales (Grupo Penteo, 2003).

In addition, it is necessary to keep in mind that ERP implementations require a wide range of knowledge, including project knowledge, technical knowledge, product knowledge, business knowledge and company specific knowledge (Chan and Rosemann, 2001). So firms must make an additional investment in the training of the users. This training must focus not only on the computer handling of the new application, but also on the new responsibilities that are acquired and on the possible serious consequences of errors that were innocuous in systems lacking the degree of integration of ERPs.

In this respect, firms must take into account that the implementation of an ERP system is not only a technological task (software and hardware), but also involves people. Summer (1999) reported that ERP solutions often caused organisational restructuring, which led to employee resistance to change. So, the employees' attitude regarding ERP implementation is important. According to Foster and Ward (1994), a reason for the opposition to innovations is that employees are not accustomed to dealing with the new system of accountancy, so they resist changes because of the uncertainty about how to behave with this new system.[6]

In consequence, it could be expected that the positive effects of ERPs on firm performance require an adaptation period to be significant (Stedman, 1999; Davenport, 2000; O'Leary, 2000). Implementing an ERP solution disrupts the equilibrium of the company, creating an environment of chaos during the first few months after

inauguration of the system (Benchmarking Partners Inc., 1998). It is very important to carefully determine the ERP readiness of a company before adopting an ERP solution (Razmi et al., 2009).

Furthermore, as Deloitte Consulting (1999) points out, it is often forgotten that performance as a consequence of the implementation of an ERP may fall at the beginning and improve later on. The length of this period may range from two to five years (Stedman, 1999; Davenport, 2000; Wah, 2000). However, some models have been proposed to control the ERP implementation risks (see, e.g., Hakim and Hakim, 2010; Malhotra and Temponi, 2010).

So, although potential benefits may be high, so may be costs, and it is not clear whether the net effect is positive. Many researchers have tried to find a positive relationship between information technology[7] investments and firm performance. However, the majority of the research efforts have yielded inconclusive results (e.g., Weill, 1992; Mahmood and Mann, 1993; Hitt and Brynjolfsson, 1996).[8] This is due to the fact that when evaluating firm performance after innovation implementation, it is necessary to keep in mind a fundamental phenomenon: the productivity paradox.

The productivity paradox means that there is null (or little) increment in firm performance when the expenses in information technologies are incremented. The papers by Roach (1991), Harris (1994), Strassmann (1997), Grover et al. (1998) and Pinsonneault (1998) show evidence of this phenomenon.

The productivity paradox was originally coined to describe the difficulty of linking investments in information technologies to productivity levels (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1996). To understand the productivity paradox, firstly it is necessary to differentiate between innovative and non-innovative technologies. Non-innovative technologies (those that maintain the status quo) are not likely to improve a firm's market value or financial performance, whereas innovative technologies (those that improve business processes) are expected to enhance value and performance (Dos Santos et al., 1993; Peffers and Dos Santos, 1996). As Hayes et al. (2001) point out, ERP systems are perceived to be innovative technologies because they facilitate key business process improvements (Drucker, 1988; Huber, 1990).

Another way to look at the productivity paradox is suggested by Robertson and Gatignon (1986) and Hitt and Brynjolfsson (1996). They conclude that increased spending on information technologies yields efficiency and effectiveness improvements, but firms will pass on financial gains to consumers through decreased prices in a competitive marketplace. Therefore, under the productivity paradox assumption the performance of non-adopters would be expected to decline. However, it is also possible that in the short term after the adoption, and due to the problems for the adopters that arise in the adaptation period, non-adopting firms obtain a competitive advantage. To investigate these possibilities, it is necessary to examine the longitudinal impact of ERP adoption on firms by comparing financial performance indicators of adopters and non-adopters.

So, keeping in mind all the above-mentioned arguments, and considering the profitability of the firm as a proxy for firm performance, the following hypotheses are formulated:

H1 Compared with non-adopting firms, ERP firms have reduced their profitability in the short term after the ERP adoption.

H2 Compared with non-adopting firms, ERP firms have improved their profitability in the middle term after the ERP adoption.

4 Empirical study

4.1 Sample selection

First of all, a questionnaire was sent to big Spanish firms[9], defined according to the limits established by the European Union. The purpose of the questionnaire was to find out which of them have an ERP system installed, who their supplier was and when the ERP system became operative.

A total of 695 questionnaires were sent by e-mail during October, 2005. 72 usable answers were obtained, a 10.36% rate, which we can consider satisfactory (Hyvönen, 2003; Mabert et al., 2003b; Hawking et al., 2004). We discarded six firms because they were implicated in merger process. The average response time was one day, and in many cases the response was received on the same day the e-mail was sent. No statistically significant differences were noted between the time of response of adopting and non-adopting firms.

The results of the questionnaire reveal that 72.7% of the companies in the sample possessed ERP systems. This rate is very near to the 70% that Grupo Penteo (2003) quantified for the large Spanish firms in 2003. It is also noticeable that the diffusion process of the ERP innovation cover more than a decade, and that the most intense years are those between 1998 and 2002, as 66% of the implementations took place during this period (see Table 2).

Table 2 ERP implementation year (% in the sample)

Year	*%*
1989	2.13
1990	0.00
1991	2.13
1992	4.26
1993	4.26
1994	6.38
1995	2.13
1996	4.26
1997	2.13
1998	10.64
1999	21.28
2000	14.89
2001	8.51
2002	10.64
2003	4.26
2004	0.00
2005	0.00
2006	2.13

Regarding the suppliers of the ERP system, results show that SAP is the unquestionable leader (40% of the companies in the sample), followed by Oracle[10] (see Table 3).

Table 3 Penetration rate of ERP suppliers among the sample firms

Supplier	*%*
SAP	39.58
Oracle	16.67
Interno	12.50
IBM	4.17
BAAN	4.17
Others*	22.92

Note: *Visual Microsystems, Ross, IBM, Centro Cálculo Sabadell, Shebel, Watermark, AS Software, Inforges, SSAGlobal, A3 Software and RPS.

These results are also in consonance with those of Grupo Penteo (2003), which quantified the penetration rate of SAP among the largest Spanish companies to be 62%. These results are also in accordance with those of the studies conducted at the international level (e.g., Bowley, 1998; Mabert et al., 2003a; Hawking et al., 2004). These authors estimated the SAP market share for the segment of multinational corporations in a range between 50% and 65%.

4.2 Financial data

Regarding the source of financial data, in accordance with Spanish legislation, limited liability companies are required to deposit their annual accounts in the *Registro Mercantil* (Commercial Register). This information is gathered and provided by *Bureau van Dijk* and *Informa* for Spanish firms in the *Sistema de Análisis de Balances Ibéricos* (SABI) database. We obtained financial information of the companies in the sample from this database. The companies that responded were compared with those that did not in variables such as total assets and net sales. No statistically significant differences among them at the 5% level[11] were found. So, we can consider that this was a cross-section sample.

To measure profitability, we computed the return on assets (ROA) ratio for each firm in the sample. This was because ROA is frequently used by researchers as an indicator of firm profitability. Nevertheless, results using the return on investment (ROI) ratio are also provided as a check on the robustness of the results using ROA. Such procedure was used, among others, by Mabert et al. (2000) and Hunton et al. (2003).

The ROA ratio can be separated into profit margin (PM) and assets turnover (AT). PM, which is net income obtained per euro of sales, is also a proxy of firm profitability. AT, which indicates the sales generated per euro of average assets, is a measure of asset efficiency. Both variables were also considered for our analysis.

We also considered the numerator and the denominator of the PM quotient, that is, the operational income (OI) and the sales (SL) of the firm. This is because some preliminary tests suggest that, in the case of adopters, the evolution of these variables after the implementation could differ significantly from those of non-adopters. Description and codification of all the indicators used are shown on Table 4.

Table 4 Description of variables

Code	*Description*
ROA	$Return\ on\ assets = \frac{Operational\ income}{Average\ total\ assets}$
ROI	$Return\ on\ investments = \frac{Net\ income}{Average\ stockholders'\ equity}$
PM	$Profit\ margin = \frac{Operational\ income}{Net\ sales}$
AT	$Assets\ turnover = \frac{Net\ sales}{Average\ total\ assets}$
OI	*Operational income*
SL	*Sales*

4.3 Empirical methods

In this research we used a matched pairs design. So, for each adopting firm we selected another firm in the sample that was comparable in terms of size and belonged to the same branch of activity (according to the Spanish Standard Industrial Classification).[12] With this research design we tried to control for certain factors which may have an influence on the analysed variables, as these factors are common to all the companies included in the same sector. Among these factors, we must highlight the personnel politics or the R + D strategy of the firm.

With this sample, we tested if each one of the considered indicators experienced a significant variation from the year prior to the ERP implementation to, respectively, one, two and three years after the implementation.[13] The aim of this was to gain evidence on the evolution of the firms after an ERP implementation. We discarded the consideration of a time span longer than three years because the majority of the ERP implementations took place during recent years. So, a time span of, say, four or five years would have caused a considerable decrement in the number of analysed companies, thus reducing the power of the statistical tests.[14]

At the first stage, the analysis was carried out separately for the adopters and the non-adopters groups. As settled before, the adoption of an ERP system can have effects both on the firm that implements it and the non-adopting firms that are competitors of the adopter. We must also bear in mind that the positive effects of an ERP implementation will appear only when an adaptation period has elapsed. During this adaptation period, the financial performance of the firm could experience a certain impairment. So, as we consider that both increments and reductions in the analysed variables are feasible; two sided p-values were computed.

Furthermore, we can also hypothesise that the financial performance of non-adopting firms can experience either improvement or impairment. If the adaptation period for ERP adopters lasts long enough, then non-adopters will benefit from the problems of their competitors. However, if the implementation is successful, non-adopting firms will face a disadvantage.

So, for each group of firms and each indicator we tested if the differences between the values before and after the implementation are significant. The statistical method we used

was the Wilcoxon matched-pairs signed rank test. The reason for choosing a non-parametric test lies in the lack of normality of the data.[15]

At the second stage of the research, we conducted a regression analysis of performance differences between ERP and non-ERP-adopting firms. In the regression model, we regressed each indicator at its pre-adoption value and a dummy variable representing ERP versus non-ERP adoption as follows:

$$I_a = c_0 + c_1 I_p + c_2 SGR + c_3 ERP + e \tag{1}$$

where, I_a = post-adoption value, I_p = pre-adoption value, ERP = 1 if the firm was an adopter and 0 if an non-adopter, e = error term and SGR = sales growth from the year prior to the implementation to the considered year (respectively, one, two and three years after the implementation). The reason for the inclusion of the sales growth as a regressor lies in the need to control for the firms' growth strategy, as this factor could cause distortions in the analysed indicators. This is because many of the variables we consider are accounting ratios, and these kind of variables are affected by changes in firm size [see, e.g., Whittington (1980), or Tippet and Whittington (1995), for a thorough review of the properties of accounting ratios].[16]

This regression model allowed us to compare the performance of adopting and non-adopting firms. For those indicators where the Wilcoxon test evidences the same behaviour for adopters and non-adopters, this comparison is necessary to determine if the ERP implementation is an influential factor (Hunton et al., 2003). This influence is measured through the coefficient of the ERP dummy variable (c_3). As mentioned above, both increments and decrements in the indicators used to measure firm performance are possible, so two-sided tests are used.

5 Results

Table 5 and Table 6 contain the results of the Wilcoxon matched-pairs signed rank test. For each group (adopters and non-adopters), each of the analysed indicators, and for each one of the comparisons between the pre-adoption value and the post-adoption considered values (those relative to one, two, and three years after the adoption, respectively), the Z statistic and the two-sided p-value are shown. The tables contain also some descriptive information (mean and median).

Table 5 Evolution of ERP-adopting firms

	One year before		*One year after*			
	Mean	*Median*	*Mean*	*Median*	*Z*	*p-value*
ROA	0.069	0.064	0.055	0.059	–1.954	0.051
ROI	0.168	0.152	0.186	0.134	–0.880	0.379
PM	0.113	0.086	0.077	0.066	–3.032	0.002
AT	0.885	0.764	0.879	0.838	–0.267	0.789
OI	68820	13372	71046	10879	–0.487	0.626
SL	689949	140620	888478	179274	–4.051	0.000

Table 5 Evolution of ERP-adopting firms (continued)

	Two years after				*Three years after*			
	Mean	*Median*	*Z*	*p-value*	*Mean*	*Median*	*Z*	*p-value*
ROA	0.050	0.051	–1.744	0.081	0.046	0.053	–1.783	0.075
ROI	0.146	0.113	–1.097	0.272	0.097	0.117	–1.440	0.150
PM	0.080	0.061	–2.424	0.015	0.065	0.055	–2.626	0.009
AT	0.898	0.851	–0.721	0.471	0.959	0.919	–0.039	0.969
OI	84778	9234	–0.557	0.578	68267	12755	1.491	0.136
SL	1052296	220933	–4.430	0.000	993148	231178	4.272	0.000

First of all, it is noticeable that ERP-adopting firms show an impairment in their ROA ratio. However, the change in ROA of non-ERP firms was not significantly different from zero. These results are not in accordance with those obtained by prior researchers on this issue (e.g., Poston and Grabski, 2001; Hunton et al., 2003). These authors found that performance of ERP firms did not change significantly after the implementation. They also found that, due to the productivity paradox, the performance indicators of non-adopting firms showed a significant decrement. As prior research was conducted using data from US companies, it is evidenced that Spanish national culture and the technological skills of managers, which are very different from those of the USA, make the ERP adaptation period much longer. It is also evidenced that non-adopting firms do not take advantage of this.

Table 6 Evolution of non-ERP firms

	One year before		*One year after*			
	Mean	*Median*	*Mean*	*Median*	*Z*	*p-value*
ROA	0.086	0.077	0.088	0.074	–0.460	0.645
ROI	0.188	0.191	0.177	0.168	–0.732	0.464
PM	0.119	0.088	0.135	0.111	–0.704	0.481
AT	0.942	0.837	0.922	0.829	–1.458	0.145
OI	57769	19587	87483	20216	–2.162	0.031
SL	546722	237320	705371	246750	–2.932	0.003

	Two years after				*Three years after*			
	Mean	*Median*	*Z*	*p-value*	*Mean*	*Median*	*Z*	*p-value*
ROA	0.087	0.076	–0.817	0.414	0.079	0.066	–0.745	0.456
ROI	0.167	0.139	–0.204	0.838	0.154	0.124	–0.748	0.454
PM	0.132	0.092	–0.819	0.413	0.105	0.068	–0.960	0.337
AT	0.946	0.817	–0.213	0.831	0.936	0.797	–1.039	0.299
OI	64931	21910	–2.883	0.004	44354	18771	–1.533	0.125
SL	591417	281290	3.718	0.000	462024	218863	–3.713	0.000

Another interesting finding is that although ROA ratios of adopting firms show impairment, ROIs do not appear to vary in a significant manner. This may be due to

earnings management. Earnings management means that extreme performance appears to be mean-reverting whereas average performance is quite persistent. Managers of big firms are more prone to these practices, as these firms are politically more visible (Zimmerman, 1983). As the OI excludes extraordinary items, which are often used to manage earnings, ROAs are not as biased as ROIs.

In order to gain further knowledge of the features of the adaptation process, we must comment on the behaviour of the components of the ROA ratio, that is, AT and PM. Wilcoxon tests indicate that the reason for the ROA impairment in ERP firms lies in the reduction of the PM, as AT remained unchanged through the considered time span. However, for non-adopting firms neither PM nor AT experienced significant variations.

An interesting question arising from these results is whether the numerator (OI) or the denominator (sales) of the PM is the cause of the observed PM reduction in ERP firms. Wilcoxon tests indicate that sales figures of adopters increase consistently but the operational results show a considerable stagnation. This evidence suggests that the implementing firms faced a significant increase in their operational expenses. However, non-adopters experienced a significant increase in their operational results in the two years subsequent to the implementation of the ERP in their counterparts, but suffered a reduction in the third year. This could be a signal for the end of the adaptation period. As established in the earlier sections, the productivity paradox means that a successful innovation causes an impairment in the performance of non-adopting firms rather than an improvement in that of the adopting ones.

Once the evolution of each group of firms was studied through Wilcoxon tests, we compared ERP and non-ERP firms through regression analysis. This comparison allowed us to determine if the productivity paradox has an influence on the performance of both groups of firms. The main results of this part of the study are detailed in Table 7 to Table 9, which contain the results of the regressions conducted using data from one, two and three years after the ERP adoption, respectively. In these tables, for each indicator and each regressor, the estimated coefficient, the *t* statistic and its two sided p-value are shown. The adjusted R^2 of each regression model is also shown. Furthermore, the reader will notice that besides the code of some of the indicators we include one or more numbers in a range from one to five. Each one of these numbers stands for a particular problem found during the process of validation of the results. These problems are explained in the following section, as well as the solutions we proposed to guarantee the validity of these research results.

Table 7 Results of the regression analysis (one year after the implementation)

	Intercept term			*I_p (preadoption value)*		
	C_0	*t*	*p-value*	*C_1*	*t*	*p-value*
ROA (3)	0.021	1.428	0.158	0.654	5.789	< 0.001
ROI (3)	0.022	0.500	0.619	0.682	4.812	< 0.001
PM (3)	0.050	0.541	0.590	0.933	14.188	< 0.001
AT (4)	0.050	0.541	0.590	0.933	14.188	< 0.001
OI (1)(5)	18379	1.531	0.131	1.058	12.611	0.000
SL (2)(5)	–10738	–0.590	0.568	1.173	28.842	0.000

Table 7 Results of the regression analysis (one year after the implementation) (continued)

	SGR (sales growth)			*ERP (1 = adopter, 0 = non-adopter)*			*Adjusted* R^2
	C_2	*t*	*p-value*	C_3	*t*	*p-value*	
ROA (3)	0.068	4.069	< 0.001	–0.030	–2.286	0.025	0.409
ROI (3)	0.197	3.543	0.001	–0.025	–0.587	0.559	0.285
PM (3)	0.082	4.044	< 0.001	–0.047	–2.951	0.004	0.711
AT (4)	0.153	1.357	0.179	–0.031	–0.350	0.728	0.740
OI (1)(5)	Not included			–17781	–1.091	0.279	0.699
SL (2)(5)	Not included			46260	2.157	0.036	0.967

Regarding the regression results, it is confirmed that the ROA ratio of ERP firms is significantly lower than that of non-ERP companies. The regressions also confirm the null effects of ERP adoption on the ROI of ERP firms. As mentioned before, the reasons for this could be the earnings management practices which affect ROI but not ROA.

Regarding the components of the ROA ratio (PM and AT), the regressions also confirm the evidence obtained through Wilcoxon tests, that is, the cause of ROA reductions is the reduction of the PM. However, the stagnation in the operational results of adopting firms which was evidenced by the Wilcoxon tests is not confirmed.

To sum up, the results lend support to hypothesis H1 (in the short term, after the implementation the performance of ERP firms is impaired) but not to H2 (later on, once a short adaptation period has passed, the performance rises again). Furthermore, our results do not support the productivity paradox assumption. These results mean that either the adaptation period is longer than the time span considered for the present research, or most of the ERP implementations were not successful. As indicated before, the reasons for these findings could lie in the particular characteristics of Spanish national culture and management technological skills.

Table 8 Results of the regression analysis (two years after the implementation)

	Intercept term			I_p *(preadoption value)*		
	C_0	*t*	*p-value*	C_1	*t*	*p-value*
ROA (3)	0.044	3.205	0.002	0.496	4.624	< 0.001
ROI (3)	0.071	1.479	0.144	0.483	3.097	0.003
PM (3)	0.018	0.988	0.327	0.842	10.806	< 0.001
AT (4)	0.079	0.734	0.465	0.930	7.185	< 0.001
OI (1)(5)	13952	1.669	0.100	1.364	15.526	0.000
SL (2)(5)	–12836	–0.525	0.602	1.482	33.781	0.000

	SGR (sales growth)			*ERP (1 = adopter, 0 = non-adopter)*			*Adjusted* R^2
	C_2	*t*	*p-value*	C_3	*t*	*p-value*	
ROA (3)	0.008	0.965	0.338	–0.033	–2.704	0.009	0.299
ROI (3)	0.021	0.624	0.535	–0.043	–0.892	0.375	0.095
PM (3)	0.047	3.009	0.004	–0.057	–2.962	0.004	0.643
AT (4)	0.136	1.333	0.186	–0.088	–0.989	0.325	0.733
OI (1)(5)	Not included			–18189	–1.579	0.119	0.788
SL (2)(5)	Not included			22316	0.766	0.477	0.951

Table 9 Results of the regression analysis (three years after the implementation)

	Intercept term			*I_p (preadoption value)*			
	C_0	*t*	*p-value*	*C_1*	*t*	*p-value*	
ROA (3)	0.040	2.501	0.015	0.451	3.690	0.001	
ROI (3)	0.051	0.162	0.872	0.327	0.326	0.746	
PM (3)	0.010	0.584	0.561	0.704	9.540	< 0.001	
AT (4)	0.213	1.602	0.115	0.846	0.525	< 0.001	
OI (1)(5)	8794	1.199	0.236	1.396	16.843	0.000	
SL (2)(5)	–62114	–1.727	0.090	1.657	48.714	0.000	
	SGR (sales growth)			*ERP (1 = adopter, 0 = non-adopter)*			*Adjusted R^2*
	C_2	*t*	*p-value*	*C_3*	*t*	*p-value*	
ROA (3)	0.006	0.763	0.448	-0.030	–2.042	0.046	0.218
ROI (3)	0.138	0.748	0.458	0.111	0.343	0.733	–0.037
PM (3)	0.050	3.355	0.001	-0.046	–2.484	0.016	0.646
AT (4)	0.031	0.317	0.753	-0.050	–0.422	0.675	0.604
OI (1)(5)	Not included			-8032	–0.802	0.426	0.833
SL (2)(5)	Not included			90009	1.867	0.067	0.977

However, it should also be pointed out that these results are in accordance with the findings of some prior researchers (e.g., Stedman, 1999; Davenport, 2000; O'Leary, 2000), who concluded that several years are needed to gain significant yields on ERP investments. Another reason for these results could be the low rate of successful ERP implementations. The high risk of failure in the implementation of an ERP system was first pointed out by some consulting firms. A study conducted by the Boston Consulting Group (2000) showed that only one out of three enterprise applications could be classified as successful. Another study (Booz-Allen and Hamilton, 2000) concluded that there is growing evidence that the returns on ERP investments have been poor. Later on, Krumbholz and Maiden (2001) detected that ERP implementation projects were, on average, 178% over budget, took 2.5 times as long as intended and delivered only 20% of promised benefits. As Madapusi and D'Souza (2005) point out "there is no magic in ERP application software". The benefits that accrue from an ERP system are a direct consequence of a carefully configured ERP system, a well-planned and efficiently executed implementation process, and a judicious use of system capabilities (Madapusi and D'Souza, 2005). All these features are intrinsically connected with national culture.

6 Validation of results

Due to the small size of the sample we considered for the present research, we decided to conduct some further tests in order to validate the results discussed above.

First of all, the results of the Wilcoxon tests were validated using a paired samples t-test. As this procedure requires normality, and the data do not fulfil this requirement[17], we restated outliers to the 5th and 95th percentiles. This procedure helps to reduce the influence of extreme performance measure observations, and is recommended by Barber

and Lyon (1996), Balakrishnan et al. (1996) and Hunton et al. (2003), among others. The results, which we do not report due to space limitations, were essentially the same as those obtained using the Wilcoxon non-parametric test.

Regarding the proposed regression model, some further validation procedures were also conducted. First, we identified influential observations through Cook's D test (Cook, 1977). In case there were one or more observations with a D statistic larger than one, these observations (firms) and their pairs were deleted from the sample and the regression coefficients were again estimated. This expedient was repeated until no influential observations remained in the sample. The cases where some observations had to be deleted but the results did not differ significantly from those obtained using the original sample was labelled with the code '(1)' in Table 7 to Table 9. In these cases, the results reported are those from the original sample. However, when some observations were deleted and this significantly altered the estimated coefficients, the results reported were those from the final sample. These cases were labelled as '(2)' in the tables.

Additionally, we tested for heteroscedasticity using White's test (White, 1980). Results indicated that heteroscedasticity was a problem for some of the regression equations. In the cases where White's correction yielded essentially the same levels of significance as those of the uncorrected models, the uncorrected statistics were reported in the tables. These cases were labelled as '(3)' in the tables. The cases where White's correction altered the levels of significance were labelled as '(4)', and the results reported are those including White's correction.

Finally, we computed the variance inflation factors (Netter et al., 1990) and conducted multicollinearity diagnostics (Belsley et al., 1980), in order to determine if multicollinearity was significant among the independent variables included in the regression models. In the cases labelled as '(5)' the tests revealed a certain level of multicollinearity, which could not be mitigated by changing the scale and/or centring the collinear variables. So, we decided to delete one of the control variables (SGR, sales growth).

7 Summary and conclusions

During the last years, the diffusion of ERP systems has grown following an exponential pattern. This is a worldwide phenomenon, and at the present moment most of the multinational corporations have an ERP installed. So, some researchers (e.g., Poston and Grabski, 2001; Hunton et al., 2003; among many others) have studied the process of diffusion of the ERP innovation.

This expansion has also taken place in the Spanish market. However, it must be taken into account that both Spanish national culture and management technological skills are different from those of the countries where prior research efforts were focused, that is, the USA and the UK. So, the conclusion of those papers cannot be extrapolated to the Spanish case, and this is the main motivation for the present research.

The research design we use is based on a matched-pairs sample in order to deal with the productivity paradox. Under this assumption, the performance of non-adopters is expected to decline relative to adopters. This study examines the changes in firm performance from one year before to one, two, and three years after the implementation of the ERP system.

The main results indicate that ERP-adopting firms experienced an impairment in their performance measured through the ROA ratio in the years subsequent to the implementation. However, no significant reductions were detected in the ROI ratio. The cause of this last finding could lie in the earnings management practices, which are common in big firms and have an influence on the net income rather than on the OI.

The cause of the reduction of the ROA ratio of adopting firms was a decrement in the observed PM, as the AT did not change in a significant way. The reasons for the reduction in the PM lie in the increase of operational expenses. Furthermore, performance indicators of non-ERP firms showed neither increases nor reductions, so we can conclude that the Spanish case does not support the productivity paradox hypothesis. These results also suggest that either most of the implementations were not successful or the adaptation period that the adoption of an ERP solution involves is longer than the time span considered for this research.

The results of this paper could provide an indication of the effects of ERP implementations in countries whose culture is similar to that of Spain, as much in the case of the EU (as e.g., Italy, Greece or Portugal) as in Latin America (as, e.g., Uruguay, Peru, Argentina, Chile, Colombia or Brasil).

Additionally, we must indicate that the present research has some limitations which must be discussed in order to allow the readers a deeper understanding of the above-mentioned results. First of all, the small sample size advised us against the use of some multivariate methods (e.g., cluster analysis) which could have been useful in order to identify groups of successful and unsuccessful ERP implementations. Secondly, due to data availability restrictions we had to consider a time span of only three years after the adoption. This hampers a full study of the adaptation period. Thirdly, in some cases ERP and other innovations are implemented at the same time (Wortmann, 1998; Davenport, 2000), so it is difficult to separate the effects of each one on firm performance. In this respect, it should also be pointed out that the basic levels of some techniques such as B2B, B2C and CRM are nothing but ERP extensions (Jacobs and Bendoly, 2003).

Finally, as directions for future research, with reference to the second point in the last paragraph, we must mention the study of an interval of more than three years after the ERP adoption in order to gain further evidence on the length of the adaptation period. Another interesting research avenue could be to gather additional data to determine which of the components of the operational expenses causes the observed PM reduction in the adopting firms.

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Notes

1 These types are the following: internal coordination costs (agency costs, decision information cost) and external coordination costs (operational, contractual). Since ERP systems are not production automation tools, they are not expected to impact production costs (Poston and Grabski, 2001).

2 This study was based on interviews with 62 clients firms of *Fortune 500.*

3 This study was based on a repository of data of 25 companies that used Oracle applications.

4 This study was based on a questionnaire of 48 companies that used SAP applications.

5 This study was based on a market investigation of 342 Spanish companies with more than 20 million € total sales.

6 Caglio (2002) examines how the adoption of ERP systems challenges the definition of the expertise and roles of accounting within organisations.

7 O'Leary (2000), Hayes et al. (2001) or Grabski and Leech (2007) consider that ERP systems are information technology investments.

8 For a revision of the related literature see Brynjolfsson and Yang (1996) and Bharadwaj et al. (2000).

9 The study covers only the ERP implementation effects on Spanish firms, so we excluded firms owned by a foreign company.

10 However, after the acquisition of PeopleSoft and JDEdwards by Oracle, the distance between the two market leaders is smaller.

11 The t-test for independent samples and the U Mann-Whitney test were used.

12 It must be taken into account that the same firm can be both in the adopters and the non-adopters groups. This is because late adopting firms were included in the non-adopters group, each one paired with an early adopter. At the same time, these companies were also included in the adopters group, each one paired with a firm not implementing an ERP in any of the years included in the time span considered for the present research.

13 The answers of the questionnaires allowed us to know when the ERP was implemented. So, we identified this year as the baseline.

14 The number of firms with data available for comparisons between the year prior to the implementation and one, two and three years after the implementation was, respectively, 74, 72 and 62.

15 To test for normality, we used the Shapiro-Wilk test (results not shown).

16 For OI and SL, we did not include this regressor in the equation due to collinearity problems. Further details are given in Section 6.

17 In order to test for normality, the Shapiro-Wilk test was used. The normality assumption was rejected in all the cases (results not shown).