IT Responsiveness in Small and Medium Enterprises: It Pays to Be on Top of IT

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Abstract

Information technology today is a complex area, in which new problems and challenges constantly arise and innovations emerge. The ability to incorporate an innovation in time or to solve a problem efficiently can mean competitive advantages for some firms. Being responsive in IT involves being alert, knowledgeable and prepared to face technical problems and to solve them in appropriate ways. In Europe, the year 1999 confronted firms with two examples of such challenges: the adaptation to the new European currency, the Euro, and the so-called millennium bug or Y2K problem. The present paper studies how fast a sample of 1,700 small and medium enterprises in Spain have reacted to these two problems, and introduces the company's degree of IT responsiveness into a classical production function expressed as a structural equation model. The newly defined construct is found to be positively associated to output generation: firms that are proactive and responsive to their IT-related problems tend to outperform those who are not.

KEYWORDS: Small and medium enterprises, SME, IS responsiveness, productivity, adaptive maintenance, Y2K, Euro.
ISRL categories: DA0201, FB08, EI0205.04

Small and medium enterprises (SMEs) have been very frequently categorized as technological laggards in the organizational literature (see Damanpour, 1992 for a review). With typically less slack resources than their larger counterparts, SMEs invest in technology in a more anarchic way, guided more by the personal perceptions of their managers and administrators than by policies or guidelines dictated by a structured IS department (Ballantine et al., 1998). But lack of resources and anarchic policies do not just affect the way SMEs invest in IT: they also influence the way SMEs maintain and update their systems. Whilst in large firms maintenance and updating is usually linked to structured revisions, periodical audits and preventive procedures, small and medium firms depend much more on a positive attitude of their managers (Blili and Raymond, 1993) or, in contrary, on their tendency to procrastinate.

There is a great variability in how responsive SMEs are to IT-related problems. The degree of IT intensiveness of the firm plays an obvious role in that: firms that rely on technology for their business processes may need to be more "on top of things" than those that make just a circumstantial use of it. There is also a great variability related to size: since the definition of SME covers a wide interval of firms between 1 and 199 employees, larger firms in this interval tend to behave more like large firms, with structured IS departments and processes involved.

In Europe, the approximate coincidence of the monetary convergence with the end of the millennium has brought two situations in which this attitude towards IT responsiveness can be measured. Firms need to adapt their information systems in order to correct the so-called millennium bug before January 1, 2000, and also need to be able to operate using the European currency, or Euro, before January 1, 2002 (although the transition period started in January 1, 1999). Both situations involve quasi-mandatory changes in the software, and in some cases even in the hardware, used by the firms. These problems affect firms in many different ways, which rank from mere inconveniences to a total halt of the operations.

This paper uses the aforementioned problems, the millennium bug and the Euro, as indicators of the attitude of the firms towards their information systems. In this scenario, firms that consider their information systems crucial for their activity and/or a source of competitive advantage will be more likely to be responsive and provide an early solution to these problems, showing a proactive attitude. In contraposition, other firms will simply wait until the problem is imminent, or will not even correct them at all and face the consequences. In the present study, these differences in behavior are related to revenue generation, in an attempt to measure whether firms displaying a higher responsiveness are also being more efficient in their use of technology. The study goes along the lines of several other studies in the IS field that relate the performance of information systems to non-technological variables, such as organizational and structural changes, motivation of the users, etc. In the same way as organizations appear to achieve a higher productivity from IT investment when they perform organizational changes to make a better use of this IT (Brynjolfsson and Hitt, 1998), SMEs could get a higher productivity out of their IT when they display a proactive, responsive attitude towards their information systems.

The potential relevance of this study is related to the importance of SMEs as an economic sector. In Spain, small and medium enterprises represent more than 99.9% of all businesses registered, generate about 70% of the employment and contribute to 65% of the gross domestic product (Faces, 1999). It seems clear that any initiative directed to improve the way SMEs use technology could have a great effect on the economy as a whole.

The remainder of the paper is organized as follows: the next section reviews the relevant literature and introduces the theoretical framework for the study. Section 3 briefly discusses the data and research design employed in the analysis. Section 4 presents the results obtained, which are then discussed in Section 5. Section 6 concludes the article and discusses implications, limitations and potential avenues for future research.

1. THEORETICAL FRAMEWORK

According to the classic organizational literature, organizations respond in predictable ways to the conditions that surround them, adjusting their purpose and shape to meet market and other environmental characteristics. Some authors (Child, 1972; Weick, 1977) argue that this process is not unidirectional, that is, organizations can also create their own environments through choices regarding markets, products, technologies, scale of operations, etc. According to these authors, firms constantly adjust to their environments in a dynamic process or *adaptive cycle*, and can be accordingly classified into several *strategic types*: *reactors*, *defenders*, *analyzers* and *prospectors* (Miles and Snow, 1978), from the most reactive to the most proactive. This typology alludes to broad aspects inherent to the firm's nature: organizational structures, processes, management style and others. In our study, we adapt this typology to a narrower field: the way firms react to environmental changes that affect their information systems. The same theoretical approach has been recently used by Aragón-Correa (1998), who measures strategic proactivity in reference to attitudes towards natural environment.

Other authors have related speed of the decision-making processes with organizational performance. According to Eisenhardt (1989), firms that are able to make fast decisions based on the perceptions of their managers, corporate culture and their use of information, can outperform the slower ones, particularly in high-velocity environments. The same idea is also present in the IS field: Zaheer and Zaheer (1997) analyze *alertness* and *responsiveness* in the trading sector, and conclude these attributes are linked to a highest organizational performance. These authors define alertness as proactive attentiveness to information about the environment, figuratively "having one's antennae out"; while responsiveness refers to the quickness with which firms respond to environmental signals, a definition we adopt for the present study. Obviously, the information technology arena has become one of this aforementioned "high-velocity environments", a medium in which firms are forced to be alert and responsive to emergent technologies, or, as in our case, to changes in the present ones that require adaptation processes.

This study tries to clarify whether these characteristics represent also a competitive advantage when applied to the technology scenario. Does a firm get a real advantage by adapting its systems to deal with Euros or by fixing the millennium bug early rather than late? Obviously, firms that perform these tasks get a substantial advantage versus those who do not perform them at all, since the later will most probably face problems such as systems' malfunction or inability to use the new currency, but such extreme case is unlikely to be widespread. But does it really matter whether problems are solved one year or one month in advance? The important issue is, apparently, to be ready in the critical moment, in our case either by January 1, 2000 in the case of the millennium bug or by January 1, 2002 in the case of the Euro adaptation. In this study, we hypothesize that both the millennium bug and the adaptation to the Euro are signals that mark the attitude of the firm towards its information systems. Following Miles and Snow's (1978) terminology, *prospectors* would be firms that are permanently observing the environment, become aware early of the problems, and manage to solve them as soon as possible. In the other extreme, *reactors* would be firms that appear not to care about the problems, and solve them only in the last moment or even when the first complications derived from them finally arise. Following the logic of this argument, *prospectors* will more likely be firms that care about technology, are aware of potential problems, and fix them as soon as they can. On the other hand, *reactors* will probably care less about technology, be less aware of new technologies and incorporate them only when the external pressure is high.

Other factors are also likely to influence the amount of effort required to fix the millennium bug and the adaptation to the Euro problems, and must be taken into consideration. Organizational size, age, availability of slack resources, and the size and characteristics of the systems necessarily affect the scale and scope of the work needed. According to Swanson and Beath (1989), both the millennium bug problem and the adaptation to the Euro could qualify as *adaptive maintenance*, performed in response to anticipated changes in the data and processing environments. The effort needed to perform this maintenance depends, according to the authors, on the diversity, variety and integration of the systems. Typically, SMEs are forced to invest in IT in an incremental

way, due to the lack of slack resources. This fact usually generates a number of incompatible systems that are difficult to network, and also preponderance of old systems due to the longer amortization periods caused by the scarcity of resources (Hasmi and Cuddy, 1990). Therefore, the magnitude of the problems will rank from small issues easily solved by upgrading some software to complete redesign of systems and programs. This factor is likely to affect the attitude of the firms towards the issue.

Recent works by Gordon and Loeb (1999) and Verdin and Van Heck (1999) portray interesting viewpoints on the millennium bug and the Euro adaptation problems respectively: according to these authors, the final outcome of these problems could be positive, both for the firms and for the global economy. The reason is that such problems will force firms to look carefully at their systems and determine their needs in terms of hardware and software. This should bring, as a direct consequence of replacing and upgrading, better system portfolios more organized, integrated and modern. Additionally, in the case of Euro adaptation, it can be seen as a strategic opportunity to lower barriers to foreign trade, and therefore early adopters could benefit from it. As we mentioned earlier, this could have a big impact in the context of SMEs given their special characteristics.

In light of the previous work, the following hypotheses can be developed:

Hypothesis 1: The output contribution of IT responsiveness is significant and positive.

This is the main hypothesis of the study. It follows from Eisenhardt (1989) and Zaheer and Zaheer (1997), as indicated earlier. Following Miles and Snow's (1978) terminology, *prospectors* should generate more revenues than *reactors*, all other factors being equal. It attempts to test whether the contribution of the newly defined construct, IT responsiveness, is significant and positive once the remaining components in our production function –non-IT capital, IT capital, labor and firm's age- have been controlled for.

Hypothesis 2: The correlation between IT responsiveness and firm size is significant and positive.

Hypothesis 3: The correlation between IT responsiveness and system size is significant and positive.

Following from Swanson and Beath (1989), these two hypotheses are based on the consideration of the two tasks, correction of the millennium bug and adaptation to Euro, as adaptive maintenance, thus influenced by the availability of slack resources and the size of the systems. Both hypotheses attempt to anchor the IT responsiveness construct in relation to the other components of the function. Note that no relationship is hypothesized within IT responsiveness and firm's age. Although it has been proven that firm's age is a determinant characteristic for SMEs (see Storey and Cressy, 1995; Levy and Powell, 1998), there is no theoretical reason to believe that either younger or older firms will be more or less responsive or proactive in relation to IT.

2. DATA AND METHODOLOGY

2.1. Data Collection

The data for this study belong to an extensive survey conducted by the Consortium for Technological Development of SMEs[1], in whose design the author participated. The survey was administered in March 1999 by Sigma Dos, one of the leading firms in survey research in Spain, via telephone interview with the owner or general manager of the company. The sample covered a total of 1,700 SMEs selected from CAMERDATA, a widely known Spanish business directory. We define an SME using the definition of the U.S. National Institute of Standards, namely, less than 200 employees and $50 million in revenue. The data gathered included specific information about the use of IT, system size, technologies employed and situation in respect to the millennium bug problem and the

[1] The Consortium for the Technological Development of SMEs is a not-for-profit initiative of the Instituto de Empresa, Hewlett-Packard, Microsoft, Telefónica and Telefónica Móviles.

adaptation to the Euro. Data about revenues and capital were added later on by using data from Informa, S.A., a Spanish database.

The instrumentation and metrics of the variables are the following (see Table 1 for a summary of descriptive statistics):

Revenues (*REV*): Total annual revenues of the firm, in thousands of dollars. It is used as a measure of output, as the dependent variable in our instrumentation.

Employees (*EMP*): Total number of employees in the firm. It represents labor, one of the classical inputs in the production function.

Capital (*CAP*): The capital of the firm, in thousands of dollars. It represents the book value of the total assets of the firm.

PCs (*PC*): Number of personal computers in the firm. It represents the main quantitative measure of IT investment.

Functional areas (*AR*): Number of functional areas making active use of IT for its daily activities. The survey proposed seven functional areas, so a seven indicates that all business functions in the firm make an active use of IT, while a zero indicates no IT use. It is employed as a concurrent measure for evaluating IT investment in the firm.

Internet (*INT*): A dummy variable indicating whether or not the firm has Internet access. It represents another concurrent measure for evaluating IT investment in the firm.

Network (*NW*): Another dummy variable indicating whether or not there is a network in the firm. It is used also as another indicator of technology investment.

Age (*AGE*): The age of the firm, divided in several intervals ranking from 1 (less than a year) to 6 (more than 20 years). It is used as a control variable.

Situation in relation to the millennium bug problem (*Y2K*): A qualitative variable reflecting their current situation: 0 (nothing has been done), 1 (we have started the process), 2 (the solution is almost ready) and 3 (the problem has been solved).

Situation in relation to the adaptation to the euro (*EU*): A qualitative variable reflecting their current situation, with the same scale as the previous variable.

2.2.Data Analysis

Simple descriptive statistics for the nine variables are shown in Table 1. The process of gathering additional data from a secondary source generated a large number of missing values. Many SMEs in Spain (particularly the smaller ones) are not legally required to file audits, so data were not available. The number of complete cases once the original sample and the additional data were pooled was 437. Several variables, particularly revenues, capital, number of PCs and number of employees, presented naturally skewed distributions that called for logarithmic transformation prior to subsequent correlational and other parametric analyses.

In order to evaluate the robustness of our model to the impact of the sample selection process we applied a technique described in Muthén, Kaplan and Hollis (1987) for multivariate estimation. The technique is particularly well-suited for cases in which a clear pattern of missing data is identifiable. The sample is split into complete and incomplete cases, and a multi-sample analysis is run. In the incomplete cases subpopulation, the model being tested is the same as the other one, but obviously without the missing variable, capital in our case.

Table 1 allows us to characterize our sample of firms. The average firm has 42 employees, its plant and equipment are worth approximately 1,600 thousands of dollars, and generates 7,740 thousands of dollars in revenues. It has about 9 PCs, connected by a network in 75% of cases, and with access to the Internet in 70% of them. It is fairly old,

between 10 and 20 years. Close to 23% of the firms claim to have fixed the millennium bug problem by the date the survey was administered, and 19% were ready to use Euros in their transactions.

Table 1: Descriptive statistics

Variable	Mean	Standard deviation	Skewness	Kurtosis
EMPL	41.8	40.0	1.4	1.4
CAP	1,546.6	6,299.8	16.5	312.0
REV	7,491.7	11,151.5	3.9	20.3
PC	8.7	10.0	2.7	9.3
AREA	5.0	2.2	(0.9)	(0.5)
INTERNET	0.7	0.4	(0.9)	(1.1)
NETWORK	0.7	0.4	(1.1)	(0.6)
Y2K	0.9	1.2	0.8	(1.1)
EURO	0.8	1.2	1.0	(0.7)
AGE	5.2	0.8	(0.9)	0.3

The correlation matrix, shown in Table 2, reflects logically high associations among some of the variables. The various measures of size (capital, revenues and number of employees) are correlated among them with magnitudes of about 0.6, and number of PCs is also strongly associated with them. All the IT variables are also highly correlated, as we might expect. Finally, an unusually high correlation is displayed between firms that have fixed the millennium bug problem and those that are ready for the Euro, probably due to the approximate coincidence in time of both events.

Table 2: Correlation matrix

	EMPL	CAP	REV	PC	AREA	INTERNET	NETWORK	Y2K	EURO	AGE
EMPL										
CAP	.28*									
REV	.44*	.38*								
PC	.51*	.35*	.53*							
AREA	.31*	.11*	.22*	.37*						
INTERNET	.25*	.11*	.25*	.35*	.30*					
NETWORK	.26*	.09	.22*	.34*	.37*	.37*				
Y2K	.05	.01	.08	.11*	.10*	.15*	.10*			
EURO	.05	.01	.06	.10*	.07	.15*	.09	.84*		
AGE	.23*	.11*	.20*	.19*	.08	.06	.04	.03	.03	

* Indicates correlation significant at the .05 level

In order to test our hypotheses, we specified a structural equations model (SEM) with two latent variables. The SEM approach seems particularly appropriate as we are

testing a priori theoretical assumptions against empirical data, and attempting to measure a newly defined construct, IT responsiveness, and a highly complex one, IT usage. A SEM methodology allows us to hypothesize the existence of the first construct, IT responsiveness, using firms' reaction to both the millennium bug problem and the Euro adaptation as indicators. It also allows us to measure IT investment in the context of SMEs, where the lack of structured information makes it otherwise very difficult. As Chin (1998) points out, SEM provides substantial flexibility to model relationships among multiple predictor and criterion variables and to construct unobservable latent variables. In addition, the pattern of multiple associations (and, therefore, potential multi-collinearity issues) found in our data argues for such a holistic approach, over methods such as simple general regression, which assume independence of explanatory variables.

Data were analyzed using EQS for Windows 5.7b (Bentler & Wu, 1995), a package specifically developed to provide tools for SEM in the context of the Bentler-Weeks model (Bentler and Weeks, 1980). We chose EQS over LISREL in particular because several of our variables notwithstanding transformations presented skewed distributions likely to violate the assumption of multivariate normality. In such cases, EQS allows for the calculation of a scaled c^2 statistic (Satorra and Bentler, 1988) reported to be highly reliable for estimation purposes (Hu et al., 1992).

Adapting from our earlier presented theory, the model we tested appears in Figure 1. It incorporates three independent variables, number of employees, capital and age of the firm, two latent variables for IT investment and IT responsiveness, and revenues as a dependent variable. The first latent variable, IT investment, uses number of PCs, number of functional areas using IT, existence of a network and availability of Internet connection as indicators. The second one, IT responsiveness, is predicted by firms' reaction to the millennium bug and Euro issues. Each of the independent variables and latent constructs are hypothesized to have a direct influence on the dependent variable. The correlations among the independent variables are left free to be estimated.

The composite reliability of both constructs is highly satisfactory, with Cronbach's alpha values of 0.91 for IT responsiveness and 0.74 for IT investment. Both values are well above the recommended values according to Nunnally (1978). A confirmatory factor analysis (CFA) was performed to assess discriminant validity. All variables in each factor were systematically grouped together, with factor loadings regarded as very significant according to Hair et al. (1995) guidelines.

3. RESULTS

The model was estimated using the maximum likelihood method. However, since some of our variables were still non-normally distributed notwithstanding the logarithmic transformations, the value of the Mardia coefficient for multivariate normality was far away from the boundaries recommended (Mardia, 1970), indicating a violation of the multivariate normality assumption. As a result, a second set of estimates was obtained through robust maximum likelihood.

The proposed model appears to provide a satisfactory explanation of the data. For the independence model, the value of c^2 was 1,654.12 with 45 degrees of freedom ($p<0.0001$), while our model yielded a c^2 of 28.41 with 24 degrees of freedom, resulting in a p-value of 0.24. In robust estimation, the Satorra-Bentler scaled c^2 was 27.54, with a p-value of 0.28. Consequently, the hypothesis that our model satisfactory explains the relationship among our data cannot be rejected. Moreover, the iterative process converged without any special problems in 7 iterations, and all fit indices suggest a very good fit (see Table 3). The value for the Root Mean Square Error of Approximation (RMSEA) was 0.02, well below the boundaries proposed in Browne and Cudeck (1993) as a good indicator for a close fit.

Standardized parameter estimates appear also in Figure 1. Correlations among the independent variables (and factors) display high values between several variables: number of employees appears highly correlated with capital (0.59) and IT investment

(0.60), and also with age (0.30). Capital correlates strongly with IT investment (0.51) and age (0.33). However, neither number of employees nor capital display significant relationships with IT responsiveness, which appears in turn correlated with IT investment (0.17). The relationship between IT investment and age is also significant (0.19), but between IT responsiveness and age is not.

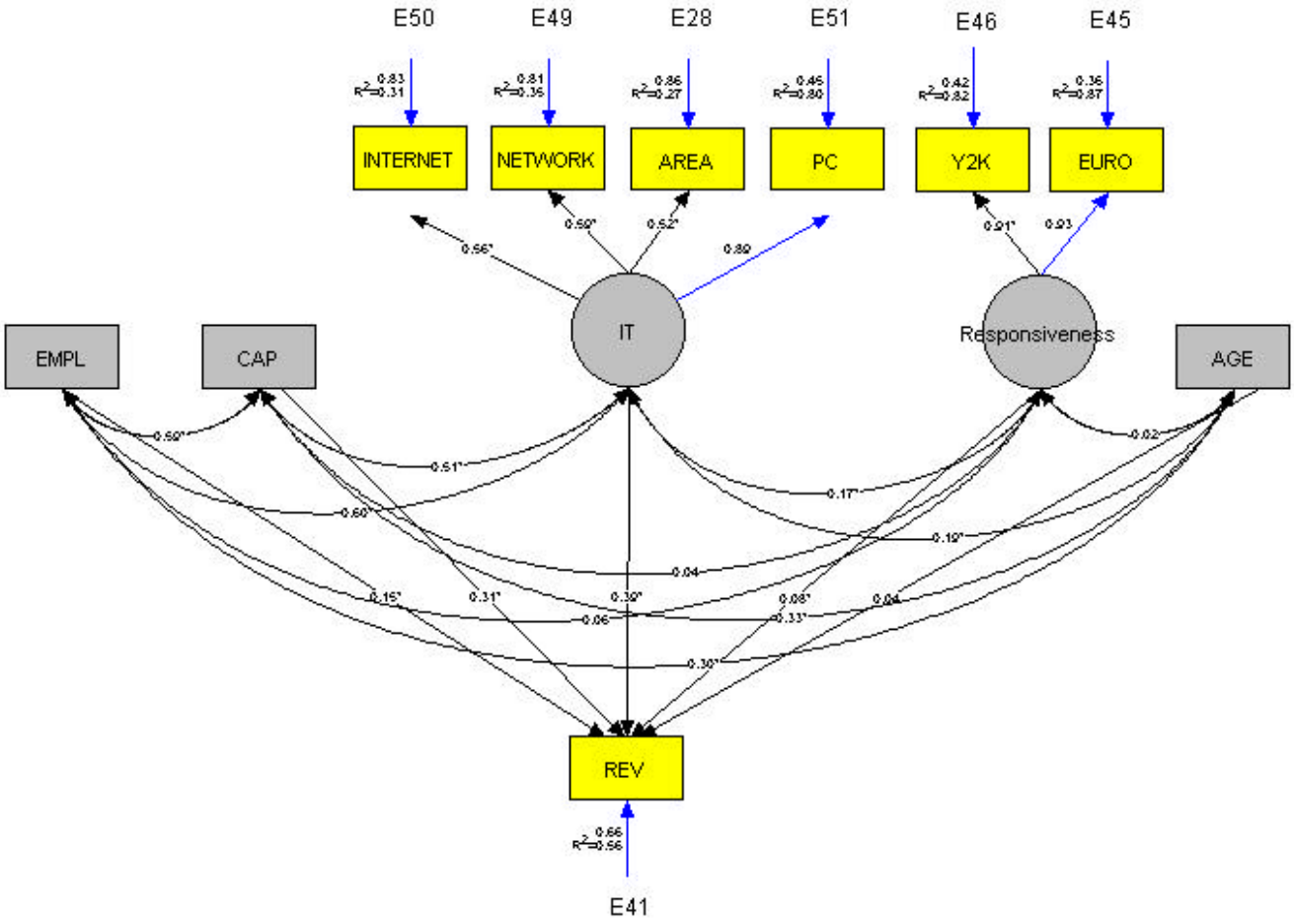

Figure 1: Research model and parameter estimates
Chi sq.=28.42 P=0.24 CFI=1.00 RMSEA=0.02

The paths between each independent variable or factor and the dependent variable, revenues, are all significant except for age. IT investment poses the highest coefficient (0.39), followed by capital (0.31), number of employees (0.15) and IT responsiveness (0.08). Finally, the total R^2 for revenues is 0.56.

The multi-sample analysis procedure used to analyze the robustness of the model to the impact of the selection process (Muthén, Kaplan and Hollis, 1987) yielded perfectly coherent results. This multiple population analysis presented a c^2 of 43.42 with 44 degrees of freedom, resulting in a p-value of 0.54. The iterative process converged without any special problem in 6 iterations, and all the fit indices indicated also a very good fit.

Table 3: Output of the estimation:

Independence Chi-square	=	1,654.12
Degrees of freedom	=	45
Model Chi-square	=	28.42
Degrees of freedom	=	24
P value	=	0.24
Satorra-Bentler Chi-square	=	27.54
P value	=	0.28
Bentler-Bonnett normed fit index	=	0.983
Bentler-Bonnett nonnormed fit index	=	0.995
Comparative fit index (CFI)	=	0.997
Robust Comparative Fit Index	=	0.998
RMSEA	=	0.021
Lower bound for RMSEA CI	=	0.000
Upper bound for RMSEA CI	=	0.047
LISREL GFI	=	0.987
Number of iterations	=	7

The model was cross-validated following MacCallum et al. (1994). The sample was randomly split into two sub-samples. Then, the first half was used as the calibration set, and the estimates obtained were applied to the second sub-sample. This procedure was repeated ten times, generating twenty random sub-samples. An a priori Wald test was performed in each second sub-sample using as input the set of parameters estimated in each first sub-sample. For all ten comparisons, correlations between these a priori constants and the final estimates were higher that 0.9, further indicating the stability of the model.

The statistical power for the analysis was calculated according to MacCallum et al. (1996), and was found to be 0.89, substantial enough to ensure our ability to detect and reject a poor model.

4. DISCUSSION

In general terms, our findings substantially support the proposed research model. They provide evidence about the positive and significant relationship between IS responsiveness and generation of revenues described in Hypothesis 1. Hypothesis 2, however, is not supported. The newly identified construct, IS responsiveness, did not show significant correlations with any of the two measures of size used in the study, number of employees or capital. However, it was positive and significantly correlated with IT investment, thus validating Hypothesis 3. Interestingly, IT investment itself appears strongly correlated with both measures of size, number of employees and capital, positing that Hypothesis 2, although not validated in our original setup, might be true as an indirect effect: larger firms tend to invest more in IT, and firms that invest more in IT tend to be more responsive.

The effect of age is straightforward from a common sense perspective, and consistent with previous studies on SMEs. Age appears correlated with number of employees, capital and IT investment, as expected due to the normal growth process of a firm. In the SME arena, however, the relationship is even more obvious due to the constant struggle for survival that firms face. As illustrated by Storey and Cressy (1995), about 11% of SMEs fail to survive in any given year, and, in a period of five years, about 80% of all new firms close their activities permanently. As time goes by, firms grow, hire more employees, capitalize themselves and accumulate more IT, and such process can be considered as a kind of Darwinian process in which only the fittest survive. However, age itself is not directly related to revenue generation, and neither it is to IT responsiveness, unless mediated by size. These findings validate to some extent the central role attributed to firm size by the organizational literature (Damanpour, 1992).

Our findings also confirm the strong and positive effect of IT investment on revenue generation, along the lines of several recent studies that contradict the so-called "productivity paradox" (Lichtenberg, 1995; Brynjolfsson and Hitt, 1996; Dewan and

Kraemer, 1998; Lohr, 1999; Dans, 1999). The high value of the coefficient obtained in the IT investment path does not leave room for doubt: IT constitutes an input in the production function whose importance cannot be neglected. Our multivariate approach allows us to introduce several measures for IT investment whose monetary value would have been otherwise difficult to calculate, such as the number of areas using IT or particular technologies such as the existence of a network. However, we must caution about the interpretation of our coefficients in the following way: since our IT measures were extremely difficult to quantify, and doing so would have probably introduced a large amount of error in our study, the value of IT capital has not been discounted from total capital. Therefore, our coefficients for total capital and IT investment should not be interpreted strictly, given that, in fact, such interpretation is not one of the objectives of the present study.

5. CONCLUSION

The main finding of this study is the one posited in Hypothesis 1: firms that display a proactive and responsive attitude towards IS, that are more "on top of IT", generate more resources than those who are not, all other factors being equal. The conclusions of this finding would justify measures taken to reinforce such responsive attitude in SMEs, both from an internal or external initiative. Internally, the attitude of the owner or responsible of the firm is probably key. As Blili and Raymond (1993) previously pointed out, the link between characteristics of the firm and those of the CEO is of a great importance in SMEs, so it is likely that firms managed by a person who is responsive to IT will have a culture of being also responsive. Externally, public initiatives to increase awareness of new technologies, divulge their benefits or ease their adoption could also be worthwhile, given the potentially high impact that productivity gains in SMEs might have in the economy as a whole.

A future research agenda should include testing the IT responsiveness construct with different measures. Although we are confident that our instrumentation using the

millennium bug and the adaptation to the Euro reflects the attitude of the firms towards being responsive in IS, its characteristic of "one time opportunity" isolates it as an opportunity for further research. Additional and richer measures such as attitude and perceptions of firm owners towards IS, software versions being used, average age of the hardware portfolio or technologies being adopted would undoubtedly complement and improve our construct and conclusions.

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