Portuguese Financial Corporations' Information Technology Adoption Patterns

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A survey of Portuguese financial corporations showed that their adoption of information technologies (IT) depends on strategic variables, such as competitive strategies, competitive aspects, business environment, and geographic strategies. The survey also revealed that firms adopting one information technology are likely to adopt others and that they follow a sequence in adopting information technologies. We identified the IT adoption sequence by estimating, through the Bayes theorem, the likelihood of a firm's adopting a specific technology after having adopted a set of more basic technologies. We propose a classification for information technologies according to their place in the adoption sequence: infrastructure technologies, intermediate technologies, and advanced technologies.

A deregulation in the early 1990s of the Portuguese financial sector has forced banks and insurance companies to pay more attention to competitiveness and to search for sources of competitive advantage. Because information technology (IT) is thought to provide competitive advantage, they must evaluate the information technologies available and decide whether to adopt them.

Although we couldn't find a study on the adoption of each of the information technologies by Portuguese financial corporations, we found some publications concerning the adoption of technology [Cohen and Levinthal 1989; Fichman 1992;

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Pennings and Harianto 1992].

To understand the adoption of information technologies by Portuguese financial firms, we looked at what factors might influence adoption of specific information technologies by raising and testing a set of hypotheses. We wanted to answer the following questions:

(1) What strategic profile (situation and actions) is associated with the adoption of each of the information technologies?

(2) Does a firm's adoption of an information technology increase its likelihood of adopting another information technology?

(3) Is there a sequence in which firms adopt information technologies?

Strategic Profiling and IT Adoption

Competitive businesses must use their resources effectively. Although there are many calls on these resources, IT's reputation for enhancing competitiveness makes it a sound candidate for investment.

However, for firms to adopt new technologies, they must perceive their benefits and believe that they can successfully adopt them. To understand and realize the benefits of the new technology, the firm must align its adoption plans with its corporate strategy [Kovacevic and Majluf 1993; Robson 1994]. Furthermore, it must possess technical, strategic, and administrative skills [Pennings and Harianto 1992].

In the Portuguese financial sector, the early '90s deregulation generated a new breed of banks and insurance companies and increased competitiveness. Simultaneously the rapid development of information technologies highlighted their importance for achieving or maintaining competitiveness.

Gonçalves and Grigsby [1997] surveyed the Portuguese financial sector and found that the adoption of information technologies could be explained by such strategic variables as market share, investment leverage, market segment coverage, the range of products and services, and expansion of business into other Portuguese-speaking countries. We hypothesized that the adoption of specific information technologies would depend on specific strategic variables (H1). To test this hypothesis, we categorized information technologies and strategic variables. We adopted Gonçalves and Grigsby's [1997] segmentation of information technologies into the following categories: communications technology, decision-support-systems technology, multimedia technology, end-user interfaces, and systems design and implementation methodologies.

Is there a sequence in which firms adopt information technologies?

Communications technology includes electronic data interchange (EDI), teleconferencing, videoconferencing, electronic mail within the company, electronic mail outside the company, wireless communications, telecommuting, local area networking, wide area networking, telemarketing, and home banking. Decision-support-systems technology includes decision-support systems, group-decision-support systems, executive information systems, groupware, expert systems, and other artificial intelligence applications. Multimedia technology includes multimedia for business presentations,

computer-assisted instruction, multimedia for marketing, and electronic document storage and retrieval using images or sound. End-user interfaces include notebook computers, desktop publishing, analytic tools, presentation graphic tools, end-user database access tools, and surveys or other assessments of end-user satisfaction. Systems-design and implementation methodologies include joint-application development, nonprocedural application development, application prototyping and iterative development, computer-aided software engineering, and process innovation or reengineering.

Gonçalves and Grigsby [1997] grouped strategic variables into the following categories: competitive strategies, competitive aspects, and business environment. By competitive strategies they mean the strategic actions the firm considered important during the last five years. Competitive strategies include strategic alliances and geographic strategies. Strategic alliances include the acquisition of interest in another company, joint ventures with other companies, licensing arrangements, joint research and development with another company, and so on. Geographic strategies are those concerning expansion of business to new regions, within Portugal, within Portuguese-speaking countries, within Spain, or within other European countries. Competitive aspects are the aspects of doing business that influence competitiveness, such as cost of operations, volume of business, market share, speed of operations, ability to compete on price, service, customer satisfaction, range of products or services, investment in new-product development, technological know-how, commercial or competitive know-how, geographic coverage, market segment coverage, and investment leverage. Business environment includes such elements as the number of firms competing, the degree of concentration, the competitive pressure, government regulations, the power of customers, the power of suppliers, the available substitutes for products or services, technological change, and the barriers to entering the market.

Competitive markets make effective decision making essential.

Given these categories of information technologies and strategic variables, we reviewed the literature on the factors that influenced the adoption of each of the information technologies, that is, the reasons why and the circumstances in which firms adopted these technologies. We also classified those factors according to the categories of strategic variables.

What Drives Companies to Adopt Specific Information Technologies?

Firms follow different reasoning processes in adopting each of the information technologies. The forces driving firms to adopt communications technology have been identified as competitive aspects, such as the desire to stay ahead or explore new channels, and the need to catch up with the competition [Gonçalves and Grigsby 1997]. According to Gordon [1996], more and more corporations are investing money in the Internet, CD-ROM, and online services as new marketing channels for delivering key messages to a

targeted population. These expenditures depend on the corporation's competitive strategies.

The banking industry can surely benefit from these marketing technologies. According to Bers [1996], the combination of electronic banking with telephone support results in true banking without boundaries. Furthermore, a survey of 256 chief information officers (CIOs) from firms in a variety of industries showed that organizations viewed telecommunications as an integral part of the IT infrastructure that supports the organization's overall strategic goals [Health Management Technology 1996]. We hypothesized that a firm's adoption of communication technologies depends on its competitive strategies, competitive aspects, and business environment. (H1.1)

Decision support systems are recommended for supporting decision makers in unstructured decisions [Turban 1995]. The most important corporate decisions typically result from unstructured processes, since there is no universal approach, framework, or algorithm to solve them. Examples of such decisions are defining the corporate mission, goals, and objectives; positioning the firm's products in the market; and determining the firm's interface with customers. Firms facing strong competition must seek optimal solutions to these problems. In such situations, decision-support tools may deliver major advantages over aggressive competitors.

Competitive markets make effective decision making essential—unstructured or structured. According to Eom [1996], many expert systems reduce the time required to carry out tasks and provide such benefits as improved customer satisfaction, improved quality of products and services, and accurate and consistent decision making. These benefits give the firms using expert systems for structured decisions an edge over their competitors. So, we hypothesized that a firm's adoption of decision-support-system technology depends on competitive aspects. (H1.2)

Davis [1989] found a strong correlation between a firm's expectations of using software in the future and its perception that the software was easy to use. Assuming that multimedia are most useful to firms whose divisions are spatially dispersed, firms' adoption of multimedia technology should depend on their geographical dispersion.

People's perception of how easy software is to use depends on their level of computer literacy. In information-intensive businesses, such as banking or insurance, computer literacy is a major competitive factor. Therefore, computer literacy, which we included in our survey as the technological know-how component of competitive aspects, is also likely to affect the adoption of multimedia technology. Based on this reasoning, we developed the hypothesis that a firm's adoption of multimedia technology depends on its geographical strategies and competitive aspects. (H1.3)

We would expect that a firm's adoption of end-user interfaces would depend on the extent to which its employees were responsible for developing, maintaining, and using its systems and interfaces, including databases and spreadsheet models. A firm's need for these systems depends on

the competitiveness of its market and the firm's strategy. Our expectations regarding firms' adoption of employee access to databases were supported by Bers [1996], who reported that banks and their technology providers are pouring investment dollars into call-center systems that pull customer data from information silos across the enterprise and make them available on customer-service representatives' desktops. We hypothesized that firms' adoption of end-user interfaces depends on their competitive aspects and competitive strategies. (H1.4)

Some technologies rarely precede others.

Leonard-Barton [1987] found that client preferences, adopter attitudes, and training in structured systems analysis (SSA) strongly discriminates SSA adopters from nonadopters, while years of experience, perceived accessibility of consulting, supervisor desires, and acquaintance with an advocate are moderately discriminating. That client preferences and adopter attitudes strongly influence a firm's adoption of SSA supports the notion that the business environment is a relevant variable explaining the adoption of SSA, which is the most common of the existing systems-design and implementation methodologies. The importance of training (a component of technical know-how, which is considered a competitive aspect) to the adoption of SSA supports the relevance of the competitive aspects for the adoption of systems design and implementation methodologies. Based on this information, we developed the hypothesis that a firm's adoption of systems-design and implementation methodologies depends on competitive aspects and business environment. (H1.5)

Are Some Strategies More Likely Than Others to Lead to Technology Adoption?

Since the prerequisites or stimulae for the adoption of information technologies overlap, we would expect that firms' adoption of the various information technologies would be correlated, showing that firms that adopt one information technology are likely to adopt others. The literature provides plenty of evidence to support this hypothesis. Cohen and Levinthal [1989, 1990] and Levinthal and Myatt [1994] think that organizations with expertise in a particular domain will readily acquire additional knowledge in that domain. According to Pennings and Harianto [1992], the more a firm commits itself to technological networking, the greater its propensity to innovate. We formed the hypothesis that firms adopting one information technology are likely to adopt other information technologies. (H2)

Is There a Sequence Pattern in the Adoption of Information Technologies?

Once we found support for our second hypothesis, that a correlation existed between the adoption of the different information technologies, we questioned whether technology adoptions showed a pattern or sequence. Pennings and Harianto [1992] think that when a firm's adoption of a new technology depends on the firm owning a prior technology, competitors cannot follow the adoption of the second technology unless they already own the first one. Therefore, first mover advantages occur for innovative firms. The

prior-technology requirement causes a correlation between the adoption of the prior technology and the adoption of the subsequent technology, since all firms that adopted the subsequent technology must have adopted the prior technology. Kendall [1997] identified three chief barriers technologies face as they advance through their phases: buyers' uncertainty concerning the value of the emerging information technology; resistance to using it or difficulty using it; and the complexities of implementation. Organizations may prepare to face these barriers by encouraging organizational learning and by building a technological infrastructure. On the other hand, market requirements may force the organization to move forward and adopt some technologies.

The high cost of some technologies limits their adoption.

The need for organizational learning supports the existence of a technological sequence when users must have experience with basic technologies to successfully use more complex ones. According to Pennings and Harianto [1992], technological experience and linkages with other firms are crucial conditions for innovation. For example, the technological investments and skills banks needed to introduce video banking and videotext services included back-office automation and transaction-oriented technology.

A firm may have to build a technological infrastructure prior to installing and using a new technology. For example, Chiang [1996] identifies the criteria for selecting the next local area network (LAN) as availability, risk, cost, broad vendor support, leveraging of existing equipment, and painless migration.

Market conditions may force an organization to adopt certain technologies to remain competitive. For example, one firm introducing a major innovation may drive customers to require the same quality of product or service the innovation produces from the whole industry [Applegate 1996].

The adoption barriers described above may postpone a firm's adoption of the technologies they affect, creating a sequence of adoption, since firms are likely to adopt the technologies that are not postponed by the barriers before those that must overcome one or more adoption barriers. We hypothesized that there is a sequence in the adoption of new information technologies (H3) (Figure 1).

Methodology

To evaluate our research hypotheses, we prepared a questionnaire asking firms to evaluate their technological-innovation behavior and their competitive strategies, competitive aspects, and business environment. Each item was rated according to a five-point Likert scale.

We sent the questionnaire, by December 1996, to the whole banking and insurance industry in Portugal: 73 insurance companies and 45 banks. We reinforced the mailing with a follow-up call to increase response rate three months after sending the questionnaire. We received 18 answered questionnaires from insurance companies and 14 from banks. Although the number of data points collected is moderate, the data collected are representative for the in-

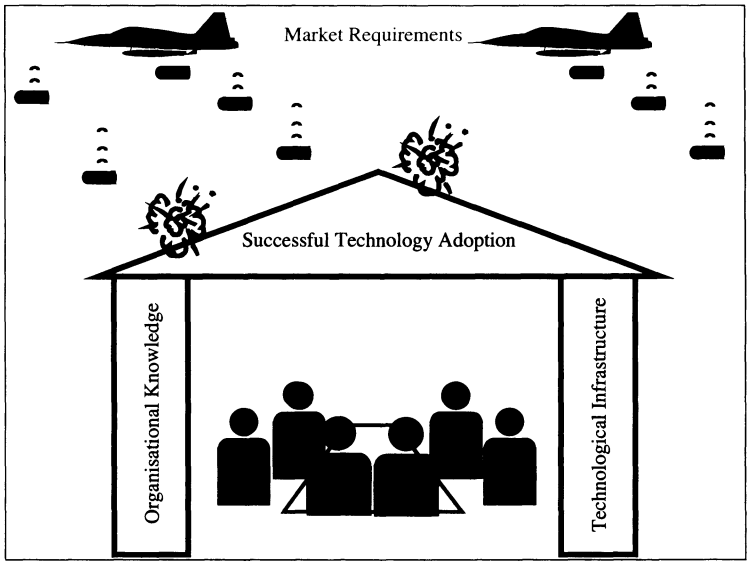

Figure 1: Our third hypothesis, that there is a sequence in the adoption of new information techniques, is graphed as a shelter to protect the company from the demanding market requirements. This shelter uses technology adoption as the roof and organizational knowledge and technological infrastructure as the main pillars. These pillars must satisfy the roof's support requirements. "Heavier" roofs (technologies) demand "stronger" pillars and, therefore, may need to wait to be built (adopted).

dustry in Portugal, since the banks and insurance companies that answered our survey hold 60 percent of the industry's assets and process 58 percent of the industry's transactions, as of 1993. So, this study is based on 60 percent of the Portuguese banking and insurance industries.

We evaluated hypothesis 1.1 through 1.5 and hypothesis 2 using Pearson's correlation coefficients among average Likert-scale scores for each of the hypotheses components. We evaluated hypothesis 3 by computing precedence numbers and preceding probabilities.

Discussion

We tested the components of the first and second hypotheses through the correlation matrixes shown in Tables 1 and 2. We used the Pearson correlation coefficients with pairwise case deletion to maximize the number of observations taken into account in each coefficient.

We expected the adoption of communication technologies to depend on competitive strategies, competitive aspects, and business environment (H1.1). The correlation matrix shows significant correlations between the adoption of communication technologies and both competitive strategies and competitive aspects. However, the correlation between adoption of communication technologies and business environment is far from significant.

We expected the adoption of decision-support-systems technology to be correlated with competitive aspects (H1.2). This correlation was significant.

Our hypothesis that the adoption of multimedia technology is correlated with geographical strategies and competitive

aspects (H1.3) was supported with significant correlation coefficients.

Our hypothesis that the adoption of end-user interfaces depends on competitive aspects and competitive strategies (H1.4) was supported by the data. However, we also found a significant correlation between the adoption of end-user interfaces and geographical strategies.

Our hypothesis that the adoption of systems design and implementation methodologies depends on competitive aspects and business environment (H1.5) was not fully supported. The correlation between adoption of systems design and implementation methodologies and competitive aspects was significant. However, we found no significant correlation between adoption of systems design and implementation methodologies and business environment.

Our second hypothesis, that firms adopting one information technology are more likely to adopt other information technologies (H2), found very strong support. All correlation coefficients between adoption of different types of technology are significant for $p = .01$ (Table 2).

Our third hypothesis was that a sequence exists in the adoption of information technologies. To search for such a pattern, we added, for each pair of technologies, the times that a technology (second) was adopted after the adoption of the other technology (first). We labeled this result the precedence number. We computed the precedence number for all possible pairs of technologies:

$$\text{Precedence number } (SF) = \sum_{c=1}^{32} \sum_{t=2}^{3} \sum_{i=1}^{t-1} \text{Integer } [(\text{Adoption of } S_t) \wedge (\text{Adoption of } F_{t-1})], \quad (1)$$

	Technology adoption				
Strategic variables	Communications	Decision-support systems	Multimedia	End-user interfaces	Design and implementation methodologies
Competitive strategies	.3773	.3189	.1460	.4261	.3937
	(32)	(32)	(30)	(32)	(31)
	$p = .033$	$p = .075$	$p = .442$	$p = .015$	$p = .028$
Competitive aspects	.4948	.3267	.4478	.4286	.3714
	(31)	(31)	(29)	(31)	(30)
	$p = .005$	$p = .073$	$p = .015$	$p = .016$	$p = .043$
Business environment	.1482	.1686	.2945	.0860	.3410
	(32)	(32)	(30)	(32)	(31)
	$p = .418$	$p = .356$	$p = .114$	$p = .640$	$p = .061$
Geographic strategies	.5977	.4157	.3774	.5487	.4106
	(31)	(31)	(29)	(31)	(30)
	$p = .000$	$p = .020$	$p = .044$	$p = .001$	$p = .024$

Table 1: Pearson's correlation coefficients show a correlation between the adoption of types of technology and some strategic variables. For each cell, we present the Pearson's correlation coefficient, the number of observations considered in its computation (in parentheses), and its significance level.

	Communications	Decision-support systems	Multimedia	End-user interfaces	Design and implementation methodologies
Communications	—	.5764	.7905	.7740	.6346
	(32)	(32)	(30)	(32)	(31)
	—	$p = .001$	$p = .000$	$p = .000$	$p = .000$
Decision-support systems	.5764	—	.4823	.5414	.5769
	(32)	(32)	(30)	(32)	(31)
	$p = .001$	—	$p = .007$	$p = .001$	$p = .001$
Multimedia	.7905	.4823	—	.5877	.5153
	(30)	(30)	(30)	(30)	(29)
	$p = .000$	$p = .007$	—	$p = .001$	$p = .004$
End-user interfaces	.7740	.5414	.5877	—	.7847
	(32)	(32)	(30)	(32)	(31)
	$p = .000$	$p = .001$	$p = .001$	—	$p = .000$
Design and implementation methodologies	.6346	.5769	.5153	.7847	—
	(31)	(31)	(29)	(31)	(31)
	$p = .000$	$p = .001$	$p = .004$	$p = .000$	—

Table 2: Pearson's correlation coefficients between the adoption of different types of technology. For each pair of technologies, we present the Pearson's correlation coefficient, the number of observations considered in its computation (in brackets) and its significance level. This table shows that firms adopting one technology are likely to adopt other technologies.

where c stands for the identifier of the company and t stands for the time of adoption, from past to present ($t = 1$ for adoptions more than two years before the survey, $t = 2$ for adoptions one to two years before the survey, and $t = 3$ for adoptions within the year prior to the survey). Adoption of S_t stands for the adoption of the second technology in time t, and Adoption of F_{t-i} stands for the adoption of the first technology in time $t-i$, where i is the time gap between the adoption of the two technologies, such as $0>i>t$. Integer (Adoption of S_t and Adoption of F_{t-i}) yields 1 when the technology S was adopted and preceded by technology F and 0 otherwise. Afterwards, we divided the precedence number (SF) by the number of times the second technology was adopted ($\Sigma c\ \Sigma t$ Adopt S_t). The result of this division is the conditional probability of adopting the first technology before adopting the second one, given the adoption of the second technology, that is,

$$P(\text{Adopting } F \text{ before } S \mid \text{Adopted } S) = \frac{\text{Precedence Number } (SF)}{\sum_{c=1}^{32} \sum_{t=2}^{3} \text{Adopt } S_t}. \quad (2)$$

This conditional probability is labeled preceding probability since it measures the likelihood of the second technology being preceded by the first technology.

The probabilities in Table 3 show that, while some technologies rarely precede others, some are very common preceders. This fact encouraged us to propose tech-

Second Technology / First Technology	Adoption Count	14	9	10	12	8	14	22	26	28	17	24	7	4
		Process innovation or process reengineering	Computer-aided software engineering	Application prototyping and iterative development	Non-procedural application development	Joint application development	Surveys or other assessment of end-user satisfaction	End-user database access tools	Presentations graphic tools	Analytic tools	Desktop publishing	Notebook computers	Electronic document storage and retrieval using images or sound	Multimedia for marketing
Analytic tools		0,64	0,67	0,60	0,58	0,25	0,50	0,23	0,19	0,00	0,29	0,50	0,43	0,00
Presentations graphic tools		0,57	0,67	0,60	0,50	0,25	0,43	0,14	0,00	0,00	0,24	0,25	0,43	0,00
End-user database access tools		0,64	0,67	0,50	0,33	0,25	0,36	0,00	0,12	0,00	0,24	0,21	0,43	0,00
Local area networking		0,50	0,56	0,40	0,42	0,13	0,29	0,18	0,23	0,00	0,18	0,33	0,29	0,00
Home banking		0,50	0,44	0,30	0,33	0,13	0,36	0,09	0,15	0,04	0,24	0,25	0,43	0,00
Wide area networking		0,36	0,56	0,50	0,42	0,25	0,29	0,14	0,12	0,04	0,18	0,33	0,29	0,00
Notebook computers		0,36	0,44	0,30	0,33	0,13	0,29	0,00	0,04	0,04	0,06	0,00	0,43	0,25
Wireless communications		0,36	0,44	0,40	0,42	0,25	0,36	0,14	0,12	0,07	0,12	0,08	0,43	0,25
Electronic mail - within the company		0,43	0,56	0,30	0,17	0,13	0,21	0,05	0,04	0,00	0,18	0,08	0,14	0,00
Desktop publishing		0,29	0,44	0,40	0,33	0,25	0,21	0,05	0,00	0,04	0,00	0,08	0,14	0,25
Electronic data interchange (EDI).		0,29	0,33	0,20	0,17	0,00	0,29	0,09	0,12	0,11	0,18	0,21	0,14	0,25
Groupware		0,21	0,33	0,40	0,33	0,25	0,21	0,00	0,04	0,07	0,06	0,08	0,29	0,25
Decision support systems		0,21	0,33	0,30	0,25	0,13	0,21	0,05	0,04	0,00	0,06	0,04	0,29	0,00
Joint application development		0,21	0,33	0,40	0,33	0,00	0,14	0,00	0,00	0,00	0,00	0,04	0,29	0,00
Process innovation or process reengineering		0,00	0,11	0,00	0,00	0,13	0,14	0,09	0,08	0,04	0,12	0,08	0,14	0,00
Non-procedural application development		0,21	0,11	0,10	0,00	0,13	0,14	0,05	0,04	0,00	0,06	0,13	0,14	0,00
Computer assisted instruction for training and development		0,14	0,22	0,10	0,08	0,00	0,14	0,05	0,08	0,00	0,12	0,13	0,00	0,00
Surveys or other assessment of end-user satisfaction		0,14	0,22	0,20	0,17	0,25	0,00	0,00	0,08	0,04	0,18	0,08	0,14	0,00
Telemarketing		0,14	0,22	0,10	0,08	0,00	0,14	0,00	0,00	0,00	0,06	0,00	0,14	0,00
Executive information system		0,14	0,22	0,30	0,25	0,13	0,07	0,05	0,00	0,00	0,00	0,00	0,14	0,00
Group decision support systems		0,14	0,22	0,30	0,25	0,13	0,07	0,00	0,00	0,00	0,00	0,00	0,14	0,00
Application prototyping and iterative development		0,07	0,00	0,00	0,00	0,13	0,07	0,00	0,12	0,04	0,12	0,13	0,14	0,00
Telecommuting		0,14	0,11	0,10	0,08	0,13	0,07	0,00	0,04	0,00	0,00	0,04	0,14	0,00
Computer-aided software engineering		0,00	0,00	0,10	0,08	0,13	0,07	0,00	0,04	0,04	0,06	0,04	0,14	0,00
Multimedia for marketing		0,07	0,11	0,10	0,08	0,00	0,07	0,00	0,00	0,00	0,00	0,04	0,00	0,00
Electronic mail - outside the company		0,14	0,11	0,10	0,08	0,00	0,00	0,00	0,04	0,00	0,00	0,00	0,14	0,00
Electronic document storage and retrieval using images or sound		0,07	0,00	0,00	0,00	0,00	0,07	0,05	0,00	0,00	0,00	0,04	0,00	0,00
Multimedia for business presentations		0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00
Expert systems or other artificial intelligence applications		0,07	0,11	0,10	0,08	0,13	0,07	0,00	0,04	0,04	0,06	0,04	0,00	0,00
Teleconferencing		0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,00	0,04	0,00	0,00	0,00	0,25
Videoconferencing		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 3: Each cell in this table represents the probability of firms' having adopted the first technology (column) given the adoption of the second one (row). We computed this probability by

10	6	8	10	16	5	9	14	7	15	25	10	20	14	16	5	4
Computer assisted instruction for training and development	Multimedia for business presentations	Expert systems or other artificial intelligence applications	Groupware	Executive information system	Group decision support systems	Decision support systems	Home banking	Telemarketing	Wide area networking	Local area networking	Telecommuting	Wireless communications	Electronic mail - outside the company	Electronic mail - within the company	Videoconferencing	Teleconferencing
0,40	0,50	0,63	0,30	0,56	0,20	0,33	0,21	0,43	0,07	0,08	0,30	0,45	0,71	0,50	1,00	0,75
0,40	0,50	0,63	0,20	0,56	0,20	0,33	0,14	0,29	0,07	0,12	0,30	0,25	0,57	0,38	1,00	0,75
0,40	0,50	0,38	0,10	0,44	0,00	0,22	0,14	0,14	0,07	0,12	0,30	0,30	0,57	0,38	1,00	0,75
0,30	0,17	0,38	0,20	0,44	0,20	0,33	0,00	0,29	0,07	0,00	0,20	0,35	0,71	0,56	1,00	0,75
0,20	0,17	0,38	0,00	0,44	0,20	0,33	0,00	0,14	0,07	0,04	0,20	0,20	0,50	0,38	1,00	0,75
0,20	0,33	0,38	0,00	0,44	0,20	0,33	0,14	0,14	0,00	0,04	0,20	0,25	0,43	0,31	0,80	0,50
0,30	0,00	0,38	0,00	0,44	0,20	0,33	0,00	0,14	0,07	0,12	0,30	0,20	0,50	0,19	1,00	0,75
0,30	0,33	0,25	0,20	0,25	0,00	0,11	0,00	0,14	0,07	0,12	0,30	0,00	0,29	0,13	0,60	0,75
0,20	0,33	0,38	0,10	0,31	0,20	0,22	0,14	0,00	0,07	0,04	0,10	0,20	0,29	0,00	0,80	0,50
0,20	0,33	0,38	0,10	0,25	0,20	0,22	0,07	0,14	0,07	0,08	0,20	0,10	0,21	0,06	0,40	0,50
0,00	0,33	0,38	0,10	0,25	0,20	0,22	0,00	0,14	0,07	0,04	0,20	0,10	0,14	0,13	0,80	0,50
0,10	0,17	0,13	0,00	0,13	0,00	0,11	0,00	0,00	0,13	0,08	0,20	0,05	0,14	0,13	0,60	0,75
0,20	0,17	0,13	0,00	0,06	0,00	0,00	0,00	0,14	0,07	0,04	0,30	0,00	0,21	0,19	0,60	0,50
0,10	0,00	0,00	0,00	0,13	0,00	0,22	0,00	0,00	0,07	0,00	0,20	0,05	0,07	0,00	0,60	0,75
0,00	0,33	0,38	0,10	0,19	0,20	0,33	0,00	0,14	0,07	0,04	0,10	0,05	0,14	0,06	0,40	0,25
0,00	0,33	0,25	0,10	0,25	0,00	0,22	0,07	0,00	0,00	0,04	0,20	0,20	0,14	0,13	0,40	0,25
0,00	0,17	0,38	0,00	0,13	0,20	0,11	0,00	0,14	0,07	0,00	0,20	0,10	0,14	0,19	0,40	0,25
0,10	0,00	0,13	0,00	0,06	0,00	0,11	0,00	0,00	0,07	0,04	0,20	0,10	0,29	0,13	0,40	0,25
0,10	0,00	0,25	0,00	0,13	0,20	0,11	0,00	0,00	0,07	0,04	0,20	0,05	0,29	0,13	0,40	0,25
0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,20	0,00	0,07	0,06	0,40	0,50
0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,20	0,00	0,07	0,06	0,40	0,50
0,00	0,00	0,13	0,00	0,19	0,00	0,22	0,00	0,00	0,07	0,04	0,20	0,15	0,14	0,13	0,20	0,25
0,10	0,00	0,13	0,00	0,13	0,20	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,13	0,20	0,25
0,10	0,00	0,00	0,00	0,13	0,00	0,22	0,00	0,00	0,07	0,04	0,20	0,05	0,07	0,00	0,20	0,25
0,00	0,00	0,25	0,00	0,13	0,20	0,11	0,00	0,00	0,07	0,00	0,10	0,05	0,00	0,06	0,20	0,25
0,00	0,00	0,13	0,00	0,13	0,20	0,11	0,00	0,00	0,00	0,00	0,00	0,05	0,00	0,00	0,40	0,25
0,10	0,17	0,38	0,10	0,19	0,20	0,11	0,00	0,00	0,00	0,00	0,00	0,05	0,07	0,13	0,00	0,00
0,00	0,00	0,25	0,00	0,13	0,20	0,22	0,00	0,00	0,00	0,00	0,00	0,05	0,21	0,06	0,20	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13	0,04	0,10	0,00	0,00	0,00	0,20	0,25
0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,04	0,10	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10	0,00	0,00	0,00	0,00	0,00

Table 3 (continued): dividing the number of times the second technology was adopted after the adoption of the first technology by the number of times the second technology was adopted.

nology levels according to their place in the precedence chain or adoption sequence. To evaluate the place of each technology in the precedence chain, we established three levels of precedence: infrastructure technologies, intermediate technologies, and advanced technologies.

Infrastructure technologies are those that precede more than two other technologies in 50 percent or more of the cases in which the second technology is adopted. *Intermediate* technologies are those that precede one or two other technologies in at least half of their occurrences, and *advanced technologies* are those that do not precede any technology in half of their occurrences or more. We applied the concepts of infrastructure, intermediate, and advanced technologies to the data collected in the survey. Note that the following technology classifications are restricted to the time and environment of the survey. The first precedence level, infrastructure technologies, included analytic tools, presentation graphic tools, end-user database-access tools, home banking, notebook computers, local-area networking, and wide-area networking. The second precedence level, intermediate technologies, included desktop publishing, wireless communications, electronic mail within the company, electronic data interchange (EDI), decision-support systems, executive information systems, group decision-support systems, groupware, and joint application development. The third precedence level, advanced technologies, included process innovation or process reengineering, nonprocedural application development, computer-aided software engineering, survey and other assessments of end-user satisfaction, application prototyping and iterative development, electronic mail outside the company, electronic document storage and retrieval, multimedia for marketing, multimedia for business presentations, computer-assisted instruction for training, expert systems and other artificial intelligence, telemarketing, telecommuting, teleconferencing, and videoconferencing.

In this categorization, we observed that the infrastructure technologies, such as networking, analysis and presentation tools, database management, and portable computers, are required for the success of a financial institution. The intermediate technologies build on the existing networking capabilities to provide more effective communication and decision support. Finally, the advanced technologies further integrate the electronic management of information, regarding both content and space. These technologies deliver voice and video integrated with data; automate the storage and retrieval of information, as well as some decision processes; and reengineer the process of developing and evaluating business processes and applications. The delay in adopting these technologies may be due to the complexity of implementing or using the technology, the high cost of the technology compared to the expected benefits, uncertainty concerning the technology's value, the need for integration beyond company borders, burdens created by company politics, and psychological barriers.

Systems that are difficult to develop or implement successfully include expert systems and other types of artificial intelligence that are complex due to difficulties

in capturing and representing knowledge. Technologies that are difficult to use effectively may have complex interfaces or concepts or benefits that are difficult to understand. Examples of technologies whose adoption may be delayed for these reasons are nonprocedural application development and application prototyping and iterative development.

The high cost of some technologies compared to their expected benefits limits their adoption. Examples of such technologies are computer-aided software engineering, multimedia for marketing and for business presentations, computer-assisted instruction for training, videoconferencing, and electronic document storage and retrieval using images or sound.

The need for integration beyond company borders may also postpone the adoption of IT. To use technologies requiring integration beyond company borders effectively, the parties outside the company must also have adopted the technology. This difficulty applies to such technologies as electronic mail, telemarketing, and telecommuting.

Company politics and psychological barriers may also delay IT adoption. Although most innovations have the potential to change the distribution of power in the organization, some have greater potential to do so. Examples of such technologies are process innovation or process reengineering tools and surveys and other assessments of end-user satisfaction. Similarly, although many organizations need to change their habits or procedures, some technologies require major changes in habits or procedures. For example, teleconferencing technology forces people to discuss issues talking to a microphone and viewing the other participants on a screen.

Conclusions

In this research, we raised and tested a set of hypotheses to explain the adoption of specific information technologies by Portuguese banks and insurance companies. Our hypotheses were that (1) The adoption of each of the information technologies is correlated with strategic variables; (2) Firms adopting one information technology are likely to adopt other information technologies; and (3) There is a sequence in which firms adopt information technologies.

Our survey supported these three hypotheses. After confirming the hypotheses, we classified each of the technologies in the survey as infrastructure, intermediate and advanced technologies and explained why the adoption of each of the advanced technologies was preceded by the adoption of other technologies.

This research provides some insight into what distinguishes technology adopters from nonadopters and gives some information on how likely a company is to adopt a specific technology, given the technologies it has already adopted.

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