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The dynamics of factors affecting the adoption of innovations

Eric Waarts[a,*], Yvonne M. van Everdingen[a], Jos van Hillegersberg[b]

[a]*Department of Marketing Management, Rotterdam School of Management, Erasmus University, Rotterdam, The Netherlands*
[b]*Department of Information and Decision Sciences, Rotterdam School of Management, Erasmus University, Rotterdam, The Netherlands*

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Abstract

An abundance of IT innovations are constantly struggling for market acceptance. Various models have been proposed in the literature in order to aid understanding of the principles behind the adoption of IT innovations, but most of them implicitly assume that the factors explaining adoption decisions do not change over time. This study challenges that assumption and adds to the existing literature by investigating the dynamics of the factors influencing adoption. Our general proposition is that the driving factors in adopting innovations will change as the diffusion of the innovation in the market progresses. A large-scale empirical study was carried out among medium-sized companies in a variety of European countries and industries concerning the adoption of enterprise resource planning (ERP) software. The findings strongly indicate that the factors affecting late adoption of ERP differ significantly from the factors explaining early adoption. At early stages of the diffusion process adoption tends to be especially driven by a combination of internal strategic drives and attitudes of the firm together with external forces like industry competition and supplier activities. Later on, the mix of adoption stimulating factors seems to be focusing more on implementation issues such as the scalability of the system, the number of seats and the yearly available budget. The study leads to both new methodological insights and substantive conclusions that also have practical implications.

Keywords: Adoption; Innovation; Information systems; Enterprise resource planning

1. Introduction

Given the staggering speed at which new information technologies currently jostle each other in the marketplace, it is understandable that many contemporary studies choose to investigate the factors that influence the acceptance or the rejection of IT innovations [2,5,6,36,37]. Frequently the focus of these studies is on building and testing adoption models that are inspired by the work of Rogers [33]. Since the original publication by Ryan and Gross [34], and Rogers' book "Diffusion of Innovations," written in 1962 and last updated in 1995, many adoption models have tried to establish relationships between various blocks of explanatory variables and the decision of organizations to accept or reject an innovation [6,8,11,37,39,43].

All these studies have found particular discriminatory factors between adopters and nonadopters at a certain point in time. However, they all take a different point in time to do so. For instance, some studies explain adoption decisions at a very early stage of the diffusion process [11] while others explain late adoption [8]. The factors revealed by a one-shot study of a particular group of, say early adopters, may, however, not be very appropriate for describing and predicting the acceptance of the innovation by another adopting group, say the late majority. It is well known that different groups of adopters have different characteristics concerning the adoption of innovations [33]. Moore and McKenna state that these differences form the basis of the dynamics of the diffusion of innovations [28]. The implication of this is that the factors explaining the adoption of innovations will change over time as the diffusion process continues. However, remarkably little systematic research has been done focusing on the substance of these changes.

A few empirical studies have been published on this subject. For example, a recent study on the adoption of personal computers by consumers found that early purchase decisions were primarily influenced by status gains and the applications for fun, while later purchase decisions was primarily driven by the possible applications for personal use and the social influence by friends and family [40].

* Corresponding author. Tel.: +31-10-408-1970; fax: +31-10-408-9011.

E-mail address: ewaarts@fbk.eur.nl (E. Waarts).

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Within the organizational context, only two studies focusing on organizational adoption pay explicit attention to the dynamics of adoption factors [26,38]. Tolbert and Zucker investigated the adoption of civil service reforms by cities and found that adoption decisions early at the diffusion curve were stimulated by other factors than later adoption [38]. Levin, Levin, and Meisel studied the adoption of optical scanners by food stores, and found that in the early stages firms with large average store size operating in less concentrated markets tend to adopt scanners sooner [26]. Later on, differences in size and concentration become less important as other firms follow early adopters.

To summarize, on the basis of adoption theory we expect that the factors explaining the adoption of innovations will not be stable over the diffusion process but will change as subsequent groups of firms adopt the innovation. The few empirical studies up to now seem to support this proposition, but the substantive evidence is very limited. Importantly, if factors do change substantially, there are serious implications for the strategies and tactics of suppliers. Strategies must change to leverage the specific requirements and behaviors of different groups along the diffusion curve. Product offerings may have to be adjusted over time and different adopter groups have to be told different stories about the benefits of the innovation. Given this perspective, the objective of this research is (i) to demonstrate that the factors influencing adoption indeed shift significantly along the adoption life cycle, (ii) to investigate the substance of these changes for a number of commonly specified driving factors in the field of adoption of innovations, and (iii) to more specifically gain insight into the nature of adoption factor changes for a complex IT-based innovation (i.e., Enterprise Resource Planning, ERP).

To achieve these goals we develop a research framework of adoption by different adoption categories. We formulate specific hypotheses regarding the expected changes in the driving factors as the level of diffusion increases. To test the model and the hypotheses, we make use of data obtained from a large study that was carried out in cooperation with one of the major ERP vendors. The data describe the adoption and planned adoption of ERP software by medium-sized companies in various European countries and industries. The data enable us to explicitly test the shifts in driving factors explaining complex adoption between two points in time.

ERP software emerged over the past decade, and is considered to be a new generation of packaged application software, in succession to packages such as material requirements planning (MRP) and manufacturing resource planning (MRPII) [23]. It does not only calculate the materials needed as MRP does, but it seeks to integrate the complete range of business processes and functions by means of a single information and IT architecture. Although most very large organizations have already adopted ERP, most of the small- and medium-sized companies still have to make the decision whether or not they want to deploy ERP [20]. Adopting ERP can be considered a major business decision affecting many aspects of a firm's business functions.

The remainder of the article is organized as follows. The following section presents the research framework, and specific hypotheses are proposed in relation to the adoption of ERP software. Then we explain the methods used for the empirical study, followed by the analysis and the results. Theoretical and practical implications are discussed in the final part of the article.

2. Research framework and hypotheses

Fig. 1 shows our research framework. At any point in time, a group of potential adopters of an innovation can be split into adopters and nonadopters, but not all nonadopting firms will necessarily have the same state of mind about accepting the innovation. For instance, it can be assumed that among the current nonadopters of a certain innovation a group of companies can be found that intend to invest in the innovation in the near future, while other nonadopting companies do not (yet) have such intentions. Therefore, we include two dependent variables in our model: 1) the likelihood of early adoption of ERP software in 1998—when ERP was relatively new on the midsize market—, and 2) the likelihood of later adoption in 2000 among the firms that did not adopt at the earlier stage. ERP purports to support all business functions of an enterprise, especially procurement, material management, production, logistics, maintenance, sales, distribution, financial accounting, asset management, cash management, controlling, strategic planning, and quality management [23]. In our study, a firm is said to be an adopter if the innovation (in this study ERP software) is installed at least in one of these functional areas of the organization.

With respect to the explanatory variables, the literature suggests several general categories of variables that may influence the adoption and diffusion of an innovation by organizations. These are *innovation characteristics, adopter characteristics, internal environment characteristics, and external environment characteristics* [11,31]. Within these generic categories specific factors must be specified that are assumed to be applicable to the particular innovation under study. For this study, we selected a parsimonious set of variables for each category on the basis of a review of the literature on acceptance of IT innovations. While there may be a wide range of specific variables imaginable, we only use a relatively small set of variables because our aim is to demonstrate changes in the effects of variables rather than to provide an exhaustive set of variables that might influence adoption decisions. Below we will briefly state the selected variables, and thereafter elaborate on each variable when formulating specific hypotheses about the effects of the variables on early and later adoption.

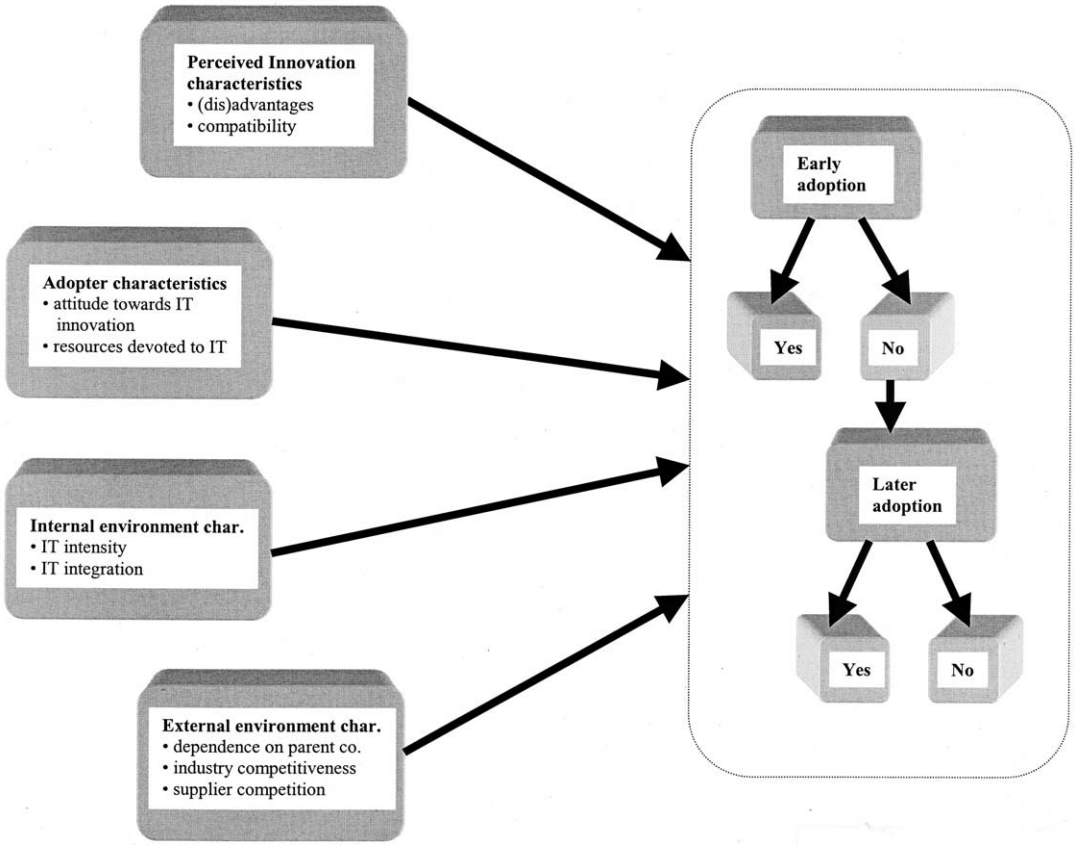

Fig. 1. A framework for explaining the likelihood of early and later adoption of information systems.

- *Perceived innovation characteristics*, that is, the firms' ideas about value of the innovation (ERP) in terms of the advantages and disadvantages compared to existing solutions, and its compatibility with current (IT) infrastructure.
- *Adopter characteristics*, referring to the company's general attitude towards the type of innovation (IT), nd the financial resources it devotes to IT technologies.
- *Internal environment characteristics*, concerning the way IT is implemented in the total organization, that is, its level of automation, and the level of integration between functional areas of the company.
- *External environment characteristics*, referring to influences exercised by parties outside the firm, such as the influence of the parent company, the level of competition in the firm's operating environment, and the competition among the (IT) suppliers.

2.1. Perceived innovation characteristics

2.1.1. Perceived advantages and disadvantages

Generally, a company's adoption decision will be made on the basis of comparing the expected situation after adoption to the current situation or available alternatives. The value of an innovation—that is the total additional functionality or performance of the innovation for the organization in terms of increased revenues—will be considered together with the costs of adoption, to make the adoption decision [3]. This may seem a simple issue, but in practice it is not that easy. Especially in case of new generation information systems—such as ERP—it has shown to be extremely difficult to formally assess its value in terms of increased revenues. There are several reasons for this (for an extensive discussion of this topic see Hirschheim and Smithson, [17]), but perhaps the major problem is that the value of adopting a new information system is hard to quantify as its (dis)advantages are often tacit [7]. Hence, in practice, organizations have to try to assess the relative (dis)advantages and cost of a new generation information system in a more qualitative way. In our research framework we address the value assessment by organizations through including a number of variables related to frequently stated (dis)advantages of adopting an ERP system. ERP suppliers commonly claim advantages in terms of flexibility in integrating business information over functional areas, the use of state-of-the-art technology, and user-friendliness of the system. Frequently reported disadvantages are the lack of fit with current business processes, the scalability of the software, and a long implementation period.

We expect that the importance organizations attach to the different (dis)advantages for assessing the value of the innovation and for making the adoption decision will change

over time as the innovation diffuses through the market. For instance, when a new generation innovation such as ERP has just been launched on the market, the specific strategic benefits and cost elements of the new technology are not evident yet [7]. Early adopting organizations are therefore likely to envision the potential strategic advantages of adopting innovations better and faster than later adopters although they know their decision has scope for risk taking. Hence, we expect them to be keener on the potential business values of having the new technology on board and to a lesser extent concerned with implementation issues such as fit with current business procedures, implementation period, user-friendliness, reliability, and scalability. We expect later adopters to pay more attention to these implementation issues in making the weigh out of value and cost. We therefore hypothesize that:

> Hypothesis 1a: Early adoption (of ERP software) is influenced more by the perceived potential value of having the new technology on board than later adoption is.

> Hypothesis 1b: Later adoption (of ERP software) is influenced more by implementation issues such as fit with current business procedures, implementation period, user-friendliness, reliability and scalability than early adoption is.

2.1.2. Compatibility

Suppliers commonly prefer to develop new technologies and products that have a good fit with important characteristics of their first target market. Typically, in the first stage of the innovation a single basic product is introduced, while in later stages product extensions and improvements are being made that fit the needs of other target groups. Hence, for the latter groups it becomes easier to switch to the new technology since compatibility problems diminish. Similarly, for software innovations it is important that they fit with the most commonly installed hardware platform and operating systems [37]. Later on, suppliers will work on variants that also work in other and new environments.

This phenomenon can also be observed in the ERP market. When ERP first became available and affordable for the midsize market, ERP packages where typically compatible with one platform only. For example, several ERP packages were tailored to the AS/400 platform that has been widely adopted by midsize companies because of its scalability and reliability [19]. A company that attempted to adopt an ERP system that was incompatible with its platform, was likely to face a delay in adoption, since it had to renew its hardware and operating system, which of course entailed high switching costs. Alternatively, these companies had to wait until more suitable ERP packages, matching their hardware, were introduced into the market. More recently, ERP vendors have introduced versions of their products for different hardware and operating systems. Also, technological developments have decreased switching costs to other, or mixed hardware platforms. Hence, we generally expect the compatibility factor to become less important in deciding on adoption as the diffusion of the innovation progresses. This leads to the following hypothesis:

> Hypothesis 2: The compatibility between the IT innovation (i.e., ERP software) and the current IT infrastructure (i.e., type of installed hardware platform and operating system) has a stronger positive influence on early adoption than on later adoption.

2.2. Adopter characteristics

2.2.1. Attitude

The formation of a favorable or unfavorable attitude towards an innovation precedes the decision to adopt [33]. This is not only the case for consumers, but companies also pass through a number of stages, such as awareness and interest, before adopting the innovation [10,30]. The attitude of a company towards the adoption of new products, or in other words the receptiveness of an organization towards new ideas, appear to influence a company's decision to adopt an innovation [4]. A company's attitude toward a frontier technology such as ERP is likely to correspond to that company's general attitude toward using information technology. IT-savvy organizations, frequently pioneering and trying new information technologies, are likely to early adopt or invest in ERP.

Hence, we expect that:

> Hypothesis 3: Having a positive IT attitude—being IT-savvy—has a stronger positive effect on early adoption (of ERP software) than on later adoption.

2.2.2. Company IT resources

Schumpeter [35] and Galbraith [12] have argued that larger firms have the resources necessary to be engaged in research and development and thus for the adoption of innovations. Various adoption studies confirm a positive relationship between absolute firm size and the speed of adoption of innovations [9,11,21,22,37]. Early adopters in particular run a higher risk by adopting an innovation, since the new product has not yet proven its value within the market. Webster claims that early adopters are generally those firms that can best bear the risk involved in adoption, where the ability to bear risk is a function of the size and the financial strength of a company [41]. As the risk of adopting and implementing ERP systems diminishes over the life cycle, the effect of the size of resources can be expected to diminish. Levin, Levin, and Meisel have empirically confirmed this effect [26]. Accordingly,

> Hypothesis 4: Having larger company (IT) resources has a stronger effect on early adoption (of ERP software) than on later adoption.

2.3. Internal environment characteristics

2.3.1. IT intensity

Different companies have different processing needs and different IT infrastructures [44]. It can be expected that the likelihood of adopting new information systems depends on the IT dependency or intensity of a company. For example, the more a business depends on computerized information processes, the more likely the company is to be interested in a new type of software like ERP in order to manage these information resources effectively. However, early adoption of ERP software will also entail a high level of risk especially for IT-intense companies. Their business may be hurt severely if the switch to the new technology fails and the total cost of failure may drive the IT-intense companies to postpone adoption until the product has been proven in the market [24]. Given the high total cost of failure of fast ERP adoption, we expect that:

> Hypothesis 5: Having a high level of IT intensity has a negative effect on early adoption (of ERP software) and a positive effect on later adoption.

2.3.2. IT integration

Another characteristic of the internal IT environment concerns the level at which information processes and systems are integrated across various functional areas within the organization. This aspect is particularly relevant for ERP software, since this type of software claims to be especially appropriate for integrating business process information. ERP encompasses much new functionality compared to its predecessor MRPII [23]. Hence, if integration of IT functions over different functional areas is really a serious, strategic issue within a firm, we expect that ERP software is more likely to be adopted at an early stage to enhance the current level of integration. This is consistent from a strategic capability perspective. If firms are less concerned with the integration issue, adopting ERP software is less beneficial and can easily be postponed to later stages. We therefore expect the level of integration to have a positive effect on the likelihood of ERP adoption, but especially for early adopters:

> Hypothesis 6: Having a higher level of IT integration has a stronger positive effect on early adoption (of ERP software) than on later adoption.

2.4. External environment characteristics

2.4.1. Parent company

Early adopters are more cosmopolitan, that is, are more oriented outside than within their own social system, as compared to later adopters. Being cosmopolite increases access to new information, which encourage a more rapid diffusion process. This has been found not only at the individual consumer level [13,33]. This implies that, especially in explaining early adoption of organizations, the external network of the organization will play a substantial role. Several studies have shown that higher levels of network participation are associated with a higher chance of becoming aware of an innovation, and thus with a higher likelihood of adopting it [1,16]. One very important way for a company to be connected with outside parties is through a parent company. According to Westphal, Gulati, and Shortell external conformity pressures from parent organizations drive organizational action, and may influence subsidiaries in deciding to adopt or not [42]. We therefore expect a connection with a parent company to increase the likelihood of adoption, but especially for early groups of the adoption life cycle.

> Hypothesis 7: Being connected with a parent company has a stronger positive effect on early adoption (of ERP software) than on later adoption.

2.4.2. Industry competitiveness

Apart from parent companies, competitors can also be important drivers in adopting an innovation. It is known that competition generally increases the likelihood of innovation adoption [14,22,26,27]. According to Gatignon & Robertson, intense rivalry between firms prompts them to pay close attention to each other's competitive moves, and therefore accept technological innovations relatively fast [14]. It can therefore be expected that a firm is more likely to invest in an ERP system if its business is located in a market where IT is a major competitive driving force and where IT budgets are strongly accelerating. Market competitiveness will play an important role especially in the adoption decision of the first group of potential adopters, who either seek to gain new competitive advantage in the market or want to avoid falling behind. In line with this reasoning we hypothesize:

> Hypothesis 8: Industry (IT) competitiveness has a stronger positive effect on early adoption (of ERP software) than on later adoption.

2.4.3. Supply-side competition

So far, we have looked at the 'demand' side of the innovation: factors concerning the firm's internal and external environment and their perception about the innovation. However, it can be expected that suppliers of the innovation will also have an impact on the likelihood of acceptance in the market. After all, if suppliers do not put an effort into convincing medium-sized companies to implement an ERP system, the odds are that few firms will actually adopt it. According to Robertson and Gatignon the industry competitiveness on the supplier side does affect the probability that firms will adopt a particular innovation [31]. Simply put, the more active firms are on a market, the more customers will be aware of their products and the more likely they are to consider buying it [11]. Since competition among suppliers of IT innovations is generally rather tough we explicitly take this supply-side variable into account in this study.

Table 1
Variables and measures

H	Variables	Measures
	Early adoption of ERP	ERP softwave present in one or more functional areas of the firm (no/yes)
	Later adoption of ERP	Plans to invest in ERP software in one or more functional areas within two years (no/yes for current non-adopters)
	Innovation characteristics	
1	Advantages and disadvantages of ERP	Importance-ranking of flexibility, scalability, user-friendliness, best new technology, reliability, total cost, fit with current procedures, implementation period (0 not mentioned; 3 most important).
2	Compatibility of ERP	Installed hardware platform and operating system
	Adopter characteristics	
3	Attitude towards IT innovation	IT conservative (1), IT mainstream (2), or IT pioneer (3)
4	Yearly resources devoted to IT	Yearly IT budget ($\$10^6$)
	Internal enviornment characteristics	
5	IT intensity	Number of computerized workplaces/number of employees
6	IT integration	Extent to which information processes are optimally tuned to each other (1 low integration; 5 high integration)
	External environment characteristics	
7	Dependence on parent company	Independent (0) or dependent (1) on parent when deciding on a new business info system
8	Industry IT competitiveness	Average increase/decrease in budgets devoted to information systems across all companies in the country/industry
9	Supply-side activity (of ERP suppliers)	Spontaneous awareness of ERP suppliers in the country/industry (recalled one or more = 1; recalled none = 0)

Given their external orientation, early adopters have greater exposure to both mass media and interpersonal channels of communication, and seek information more actively than later adopters [6]. In line with this we expect the first group of adopters to experience the effect of supply-side communication activities much more strongly than the potential future adopters. Consequently, we expect the supplier marketing activities to have a stronger, more positive influence on the likelihood of early adoption than on the likelihood of later adoption decisions. Correspondingly, we hypothesize:

> Hypothesis 9: The quality and intensity of the supply-side marketing activities will have a strong effect on adoption (of ERP software), but this effect is expected to be stronger for early adoption than for later adoption.

3. Method

To test the hypotheses we make use of data collected via a survey performed at the request of a large ERP software supplier.[1] The study included a large sample of 2647 medium-sized firms from ten European countries (Finland, Norway, Sweden, Denmark, the Netherlands, Belgium, UK, France, Italy, Spain), in six industry sectors (discrete & automotive, project, electronics, process, food & beverage, wholesale). The sponsoring ERP-supplier selected the countries and industries. This ERP supplier selected those countries and industries that were most interesting to her covering most important industries and countries. A questionnaire was developed covering the current (mid-1998) adoption and later adoption, that is, firms that had decided to invest in ERP software before mid-2000, the installed and preferred hardware and operating system, business areas currently automated, annual IT budgets, level of IT intensity and integration, perceived importance of several IT aspects, general firm attitude towards IT, dependence on a parent company, and awareness and short list positions of suppliers. Precise measures of the variables used in our research model are given in Table 1.

The questionnaire was developed in English and subsequently translated into the local languages by official translation agencies. For each country one trained native and English speaking research assistant was involved. Each checked the translation of the questionnaire, and discussed it with a local ERP vendor representative. Together they examined the questionnaire on possible flaws in interpretation and errors in the phrasing. Problems were solved after mutual consultations of all research assistants during a special meeting. This procedure ensures that the questionnaires were not suffering from translation biases.

The sample procedure was the following. The sample consisted of 60 segments (or strata) derived from the ten European countries and six industries. These segments vary in size, as particular industries are more or less present in specific countries. Because random sampling across the segments (countries/industries) would yield low numbers for specific segments, it was decided to take a random sample of 45 observations for each segment. A professional call center performed the actual sampling and telephone interviews. Random samples were drawn from local chamber of commerce databases containing addresses and names of responsible persons. The respondents were either IT managers or financial managers involved in IT purchase decisions. After the first cold call to the company, the call

center used a maximum of 6 call-backs to reach the target person. This procedure yielded a reach percentage of 90% of the target persons, of which 44% was willing to take the interview. All interviews in our sample were completed, although of course there are missing values for some of the variables. The respondents were not informed about the name of the sponsor until the final part of the interview in order to avoid response bias.

This procedure yielded a total of 2647 usable observations (10 countries times 6 industries times 45 observations minus a few missing observations due to segment size limitations in some of the countries). Since in reality the country/industry segments are not equal in size, the total sample is in fact disproportional stratified. Hence, in the statistical analysis the strata are weighted by the relative sizes of the segments in order to get meaningful aggregate results [25]. We checked on possible differences between the various countries and industries. Although there are differences on the variable level, post hoc Duncan tests revealed that the industries and countries do not behave systematically different from each other over all variables.

4. Findings

4.1. ERP adoption

As mentioned before, in this study a firm is said to be an adopter if it has standardized ERP software installed in one or more functional areas of the organization. At the time of the survey (mid-1998) 27% of the companies had ERP software installed in one or more functional areas. Among the firms that did *not* have ERP on board many of them (overall 40%) had decided to invest in it within the next two years. In terms of Rogers' adoption categories, we observe that the innovators and early adopters have already adopted ERP software, whereas the early majority are planning to follow soon. Before the year 2001, more than half (57%) of the medium-sized firms in Europe are expected to have ERP software installed in one or more functional areas.

4.2. Estimations and testing

Our data enable us to test the hypotheses by comparing the effects of the independent variables on (i) the likelihood of early adoption and (ii) the likelihood of later adoption. In other words, we check the influence of the four blocks of explanatory variables in our research framework at two different points of time. The first point in time reflects a split between actual adoption and nonadoption of ERP at the time of the survey, where 27% of the sample are adopters against 73% who are (currently) nonadopters. The second split is restricted to the latter group and reflects the distinction between firms that had decided to invest in ERP software within two years (later adopters, 40%) and firms that did not intend to invest in ERP software within two years (nonadopters, 60%). Although in some cases actual buying behavior may still be different from buying intentions, we believe that the indicated decision to adopt ERP in the near future is an acceptable proxy for adoption behavior for our research purposes. In fact, the indications by firms to adopt ERP reflected very serious intentions of buying ERP software, where the short list of vendors was already known. Moreover, research on technology adoption provides evidence to suggest that intention is a fairly good predictor of self-reported usage behavior [36] and actual usage behavior [29,40]. This procedure implies that for the first split we make use of the total sample ($N = 2647$), whereas for the second split we base the analysis on the 73% current nonadopters of the total sample ($N = 1932$).

To estimate the effects of the independent variables we applied logistic regression analysis. Compared to, for example, multiple discriminant analysis, logistic regression analysis has several advantages in terms of assumption requirements concerning normality of the independents and equality of the variance-covariance matrices [18]. To compare the effects of the independents on the likelihood of adoption at two different points in time, we specified two logistic regression equations, one for each dichotomous dependent variable. The first (see Eq. 1 in Table 2) refers to early adoption versus nonadoption, the second (Eq. 2) refers to planned later adoption versus nonadoption. The independent variables of our research model were jointly included as predictors; the categorical variables describing the installed hardware platform and the operating system were specified as contrast variables. Table 2 exhibits the results. With respect to early adoption, the total model is significant (Chi^2 234,086 with 27 d.f. renders a significance level of 0.00), and predicts early ERP software adoption accurately in 74% of the cases. For assessing the quality of these predictions in case of unequal group size—that is the situation at hand—it is recommended to use the proportional chance criterion [15]. According to this criterion, the predictive accuracy should be at least 60% ($73.2^2 + 26.8^2$). Hence, our first model classifies adopters and nonadopters much better. The second equation model for later adoption is also significant (Chi^2 95,228; d.f. 27; sign. 0.00). This model predicts later adoption correctly in 61% of the cases. Following the same procedure, the proportional chance criterion in this case yields only 51.5%, thus also the second model predicts better as compared to the proportional chance criterion. Although both models predict better than the proportional chance criterion, one should bear in mind that there is an upward bias in the estimated predictive power for both equations, since the predictions are based on the total sample rather than using a holdout sample. Tolerance statistics were computed to investigate estimation problems due to multicollinearity among the predictors. For both equations the tolerance levels showed 0.87 or higher indicating no parameter instability problems due to multicollinearity in the data.

A first conclusion is that all blocks of factors character-

Table 2
Results (logistic regression analysis)

H		Equation 1 Early ERP adoption (0 = no adoption; 1 = adoption in 1998) (N = 2596)			Equation 2 Later ERP adoption (0 = no adoption; 1 = plans to adopt in 2000) (N = 1709)		
	Perceived innovation characteristics						
1	*Importance* (adv. and disadvantages of *ERP*)	b	S.E.	Sign	b	S.E.	Sign
	Best new technology	.30	.070	**.00**	.04	.084	.65*
	Relibility	.02	.054	.65	.06	.056	.30
	Flexibility	−.02	.046	.71	−.07	.048	.14
	Scalability	.07	.070	.29	−.16	.078	**.04***
	User-friendliness	.00	.055	.97	−.09	.057	.10
	Total cost	.07	.046	.09	.08	.048	.08
	Fit with current procedures	−.02	.036	.55	−.06	.038	.14
	Implementation period	.06	.078	.42	−.11	.088	.23*
2	*Compatibility of ERP with:*						
	Installed hardware platform (ref. cat. = other)			**.00**			**.04**
	Compaq PC server	.22	.178	.22	−.00	.174	.96
	Digital PC server	.04	.252	.87	.30	.229	.19
	HP PC server	.40	.221	.06	.37	.227	.10
	HP/9000	.94	.227	**.00**	.63	.242	**.01**
	IBM PC server	.58	.262	**.03**	.15	.271	.58
	IBM RS6000	.96	.265	**.00**	.80	.297	**.00**
	IBM AS/400	.59	.275	**.03**	.28	.299	.34
	Installed operating system (ref. cat. = other)			.66			.32
	Novell	.26	.213	.22	−.04	.216	.82
	OS/400	.21	.286	.44	.07	.307	.81
	Unix/solaris	.04	.189	.80	.17	.172	.30
	Windows NT	.26	.207	.18	.34	.186	.06
	Windows 3.1	.53	.375	.15	.54	.376	.15
	Windows 95	.29	.282	.29	.30	.265	.26
	Adopter characteristics						
3	Attitude towards IT innovation	.23	.073	**.00**	.13	.076	.08
4	Yearly resources devoted to IT($ mln)	.01	.025	.72	−.10	.031	**.00***
	Internal environment characteristics						
5	IT intensity	−.06	.064	.35	.22	.065	**.00***
6	IT integration	.04	.049	.37	−.11	.048	**.02***
	External evironment characteristics						
7	Dependence on parent company	.28	.095	**.00**	−.02	.099	.87*
8	Industry IT competitiveness	.01	.004	**.00**	−.00	.005	.93*
9	Supply-side activity	1.02	.095	**.00**	.53	.991	**.00***
		Chi^2 234,086			Chi^2 95,228		
		Sign .00			Sign. .00		
		74% correct			61% correct		

For both equations, the significant effects are shown in bold ($p < .05$).
An asterix (*) indicates a significant difference between the parameter values of equation 1 and 2.

istics of the innovation, on the firm and on its internal and external environment contain variables that significantly help to explain either early or later adoption of ERP software. These results provide support for the selection of the explanatory variables, and it enables us to compare the effects over time and to test the hypotheses. Table 2 also shows the b-parameters, standard errors and significance levels for each of the variables. For both equations the significant ($p < .05$) effects are shown in bold.

To test whether the differences between the parameters of Eq. 1 and Eq. 2 are statistically significant, we calculated the standard error of the difference between the two parameter estimates and applied a *t* test to assess the significance of the difference. An asterix (*) is printed next to the significance values of Eq. 2 if the parameter values differ significantly ($p < .05$). We will address the findings with respect to the hypotheses here.

Hypotheses 1a and 1b postulate that critical adoption factors shift from the potential value of having the best current technology to implementation issues like the best fit, implementation period, scalability, and so forth The findings indicate that the critical concerns in buying ERP software are indeed shifting along the adoption life cycle. The results show that the later group of adopters is indeed more concerned with the scalability of the systems and with the implementation period, while these factors appeared not to be significant for the group of early adopters. The latter group seems to be more concerned with the value of having

the new technology, while the total cost of investing in ERP appear to be relevant for both the early and later adopters.

The second hypothesis states that the influence of compatibility becomes less strong along the adoption life cycle due to the increasing compatibility of ERP systems with all sorts of platforms and operating systems. The effects of compatibility regarding hardware platform and operating system were estimated using contrast variables. The reference category for comparing specific hardware platforms and operating system effects is the 'all other' category that includes various small platforms and systems. The results show that the most important compatibility issue concerns the installed hardware platform. More specifically, early adoption has occurred significantly more frequently among IBM and HP users than among other users. Equation 2, concerning later ERP adoption, shows that hardware compatibility is still an issue, but the compatibility advantage of having IBM (PC server and AS/400) on board is no longer significant. Although the differences between each pair of parameters are not significant, the overall results indicate that for IT innovations compatibility with the current situation seems to become less important over time and that specific advantages seem to shift. This is in line with Hypothesis 2.

H3 and H4 state, respectively, that the effects of being IT-savvy and of having larger IT resources on the likelihood of adoption can be expected to diminish over the life cycle. The results indicate only small (not significant) differences between the parameters, but the direction of the change conforms to our expectation in H3. Among early adopters being IT-savvy has a significant effect on adoption, but for later adopters the effect is somewhat smaller and only weakly significant.

With respect to IT resources, we expected a diminishing positive effect over time (H4). Eq. [1] shows that early adopters indeed seem to allocate slightly higher resources to IT than other firms do, but the effect is not significant. Eq. [2] reveals that further on in the adoption life cycle the level of yearly IT resources does become a significant variable, but those who plan to invest in ERP software have *lower* budgets than those that do not plan to invest in ERP. Hence, H4 is supported in the sense that the effects significantly change over time. However, we do not find evidence that higher IT resources increase the likelihood of early adoption.

H5 and H6 concern the effects of internal environment characteristics, IT intensity, and IT integration. H5 expected a negative effect of IT intensity for early adopters and a positive effect for later adopters. The data partly confirm this expectation. The effect for early adoption is nonsignificant, whereas we indeed find a significant positive relationship for later adoption. H6 expected a positive effect of IT integration on the likelihood of ERP adoption especially for the early adopting firms since for those firms business process integration can be considered to be of highly strategic importance. Although the data do not show a significant effect on early adoption, the sign of the effect is indeed positive. For later adoption, the effect does become significant, but the direction of the effect is negative, indicating that the likelihood of later adoption decreases if a firm has already integrated the IT functions better. One reason for this phenomenon may be that for later adopters the added value of buying ERP software decreases the more a firm has already integrated its information processes. The findings suggest that in buying ERP software both strategic and practical arguments play a role, where the trade-off strategic versus practical appears to shift from more strategic for early adopters to more practical for later adopters.

The final block of independent variables concerns the characteristics of the external environment. We expected the dependence on parent companies (H7), industry competitiveness (H8), and supply-side activities (H9) to have a larger effect on early adopters than on later adopters. Results indicate significant positive effects of all three external characteristic variables on early adoption decisions. All effects change significantly for later adopters. The effects of dependence on parent company and industry competitiveness is no longer significant, while the sign of the effects even changes from positive to negative. The influence of activities of suppliers is still significant for both early and later adoption, but the size of the effect diminishes significantly. Hence, the data support H7, H8, and H9. Interestingly, the overall findings show that the external characteristics seem to be more important for early adopters, which is in line with the general idea that early adopters are more externally oriented than later adopters.

5. Conclusions

This research presents one of the first large-scale empirical studies that aims to provide insights into the dynamics of diffusion processes among organizations. Where previous research only provide piecemeal findings predominantly based on one shot adoption studies or on anecdotic evidences, this research systematically investigates shifts in adoption stimulating factors that enables to better understand the processes behind the diffusion of innovations. Our empirical study reveals the nature of the dynamics both on the individual factor level as well as on the level of synthesizing across the factors. Below, we elaborate further on a number of methodological and substantive conclusions, but first we point out some restrictions that should be borne in mind when interpreting the findings of our study. As with any empirical research, this study has limitations. Firstly, although the sample is relatively large and includes various countries and industries, it is limited to a specific innovation (ERP software) and to these (Western European) countries and industries. Other specific factors may be at work for other innovations and for other market environments. However, while this may limit our substantive findings regarding the effects of specific variables, it does not limit our main

conclusions about the changing influence of variables over the diffusion curve. Secondly, we make use of a database provided by one of the major ERP suppliers, which limits the inclusion of specific factors in the model to those included in the database and therefore some specific factors may be missed. We do not consider that it has limited us too much, however, because in this study we are not so much interested in establishing an exhaustive set of variables explaining adoption of ERP software, but rather in investigating the dynamics of the effects. Fortunately, we were able to specify one or more variables for each of the building blocks used in general adoption models of innovations.

5.1. Methodological conclusions

In our research model we include four blocks of variables obtained from literature on adoption of innovations [11,31]. Our findings reveal that all four blocks of variables indeed seem to matter in one way or another with respect to their influence on adoption decisions. Characteristics of the innovation, the adopting firm, and the internal and external environment all show significant effects on the decision of firms to adopt an ERP system. Importantly, while supply-side characteristics are frequently somewhat neglected in adoption studies [31], our study indicates strong influence of activities by suppliers on the adoption decisions of both early and later adopters. For future research, we recommend to include and further investigate external influences such as supplier activities on the likelihood of adoption in different phases of the diffusion curve. Different effects in phases may have severe implications for the marketing strategies of suppliers.

The second, important, methodological conclusion concerns our fundamental proposition that the influences of explanatory factors on the adoption of innovations change over time as the adoption life cycle proceeds from early adopters to later adopters. On the basis of our data, which constitute a large set of observations, we find solid support for that proposition. For all blocks of variables, the effects of (some of) the variables change significantly over time. Only two factors—infrastructure compatibility and supply-side activities—have significant effects for both early and later adoption, but even in these cases the sizes and specific influences are different. For some of the variables, for example, advantages and disadvantages of ERP and IT resources, the data even show different directions of the effects on the likelihood of adoption. Thus, the general finding is that, to explain the adoption of an innovation, different factors must be considered, depending on the level of diffusion of the innovation in the market. In other words, early adopters are sensitive to other factors than later adopters. An important practical implication of this finding is that single snapshot adoption studies may produce outcomes that are relevant in explaining what has happened, but the results (i.e., the parameter estimates) are not necessarily valid in predicting the likelihood of adoption for the next group of potential adopters.

5.2. Substantive conclusions

In this article, we have formulated a number of hypotheses regarding the influences of various factors on early and later adoption and found evidence in our data supporting most of the hypotheses: factors do change as the diffusion process goes proceeds. We have discussed the findings per hypothesis in the previous section. If we take a more synthesizing perspective over all our findings and findings from previous research [11,31], we conclude that overall, the findings point to a conclusion that in the first stages of adoption of innovation by organizations, the most important stimulating factors are a combination of internal drives like the firm's attitude towards the innovation and the strategic importance of the innovation for the firm, together with external forces like the parent company, industry competitiveness and supplier activities. Later on, the mix of stimulating factors seems to be focusing more around practical implementation issues like in the case of ERP the scalability of the software, the number of seats within the firm, the standard available budget. This phenomenon can also be observed in recent research on PC-adoption by consumers demonstrating that in early stages people's internal drives (status, fun, applications) are important adoption stimulating factors, whereas later or nonadopters are more concerned by the practical aspects of rapid changes in technology, costs and requisite knowledge [39].

These findings have important implications for the way suppliers act on the market. Besides the fact that their presence and marketing activities turn out to stimulate the adoption of IT innovations and its diffusion throughout the market strongly, the main implication of the results of this study is that their marketing tactics should change as the new technology moves along the adoption life cycle.

During the early market phase much attention should be given to the strategic value and the credibility of the new technology to convince innovating firms that the new technology should be adopted in order to enhance companies' competitive strengths. An interesting dilemma seems to present itself when potential early adopters have to weigh the potential strategic advantages of adopting ERP against the disadvantage of facing the risks of failure. Consequently, ERP vendors should focus on reducing the perceived switching cost and risk associated with early adoption. This can be done, for instance, by demonstrating (pilot) applications accomplished in the same sector, if needed in other countries. In addition, the compatibility of the new software with currently installed hardware platforms is an important issue especially at the beginning of the life cycle of the innovation. As time goes by, new and more flexible software makes the compatibility issue less important. Given the basic principles, by which innovations generally unfold from narrow to broad applicability, it is likely that

one will observe the phenomenon of declining importance of the compatibility issue in many markets. This implies that IT vendors may speed up adoption by increasing the compatibility of their innovation at an earlier stage in the adoption life cycle. This can be done by immediately introducing different versions of the IT innovation for multiple platforms. Later on, when targeting majority groups, attention should shift to decreasing practical problems related to the scalability of the product as well as the long implementation period. Among the group of potential later adopters, the probability to adopt ERP is higher for highly automated but less IT-integrated companies. For this group of companies, the potential advantages of ERP can also be significant, but so are the costs and risks involved. It seems that in these circumstances the most common strategy is to further postpone the adoption. ERP suppliers could increase the likelihood of adoption by these companies by offering a gradual path of implementation as an alternative to the current "big-bang" approach that encompasses high risks. Some ERP vendors are currently starting to partition their monolithic products into components that can be incrementally installed, thus lowering the risk of implementation.

Notes

1. We are grateful to this ERP supplier for its willingness to share the data with us.

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Biographical Sketches

Eric Waarts is Associate Professor of Marketing at the Rotterdam School of Management, Erasmus University Rotterdam, where he currently also acts as academic director, and dean international affairs. He holds a Ph.D. from the Erasmus University based on a study on competitive reactions to new product introductions. His interests are concentrated on product innovation, competitive behavior, and international marketing strategy. He was a visiting scholar at the Ghent University and is (guest) lecturer in many executive programs. He has published several books and articles in journals such as *the Journal of Marketing Research, Marketing Letters, Communications of the ACM,* and *Corporate Reputation Review.*

Yvonne van Everdingen is Assistant Professor of Marketing at the Rotterdam School of Management, where she teaches a course on International Marketing Management. Her research focuses on adoption and diffusion of innovations in an international context. In particular she has investigated the acceptance of the common European currency by European companies as well as European consumers, and the international adoption of ERP systems by midsize companies in Europe. She has published in journals such as: *the Journal of Economic Psychology, the Journal of Business Research, Communications of the ACM,* and *the European Management Journal* (forthcoming).

Jos van Hillegersberg is an Associate Professor of Information Management at the Rotterdam School of Management. His research interests include Enterprise Resource Planning systems, component based software development, global software projects and ICT support for e-commerce and supply chain management. He was a visiting scholar at Georgia State University. He has served on the program committee of several international conferences (e.g. ICIS, HICSS). Earlier, he worked at a large insurance company setting up a component-based development strategy. He has published in international conferences and journals such as *Information Systems* and *Communications of the ACM.*