DEPARTMENT OF ECONOMICS
UNIVERSITY OF CYPRUS

THE ADOPTION OF AN EXPORTING STRATEGY AS A DIFFUSION PROCESS

Sofronis K. Clerides and
George I. Kassinis

Discussion Paper 2000-02

P.O. Box 20537, 1678 Nicosia, CYPRUS Tel.: ++357-2-892101, Fax: ++357-2-750310
Web site: http://www.econ.ucy.ac.cy

The Adoption of an Exporting Strategy as a Diffusion Process

Sofronis K. Clerides
Department of Economics
University of Cyprus
P.O.Box 20537
CY-1678 Nicosia, Cyprus
sofronis@ucy.ac.cy

George I. Kassinis*
Department of Public and Business Administration
University of Cyprus
P.O.Box 20537
CY-1678 Nicosia, Cyprus
kassinis@ucy.ac.cy

February 2000

*Corresponding author.

The Adoption of an Exporting Strategy as a Diffusion Process

Abstract

We use a detailed plant-level dataset of Colombian manufacturing firms to examine whether the spread of exporting activity can be characterized as a diffusion process. Our model generalizes standard diffusion models to allow for a changing pool of potential adopters and to include firms that abandon the strategy under study. We find that the pattern of adoption of the exporting strategy is consistent only with the external model of diffusion, and that the rate of adoption increases over time. This increase in the adoption rate is entirely exogenous; in particular, it is unrelated to evidence of improved performance by past adopters.

Keywords: diffusion models, diffusion of strategies, exporting strategy.

1 Introduction

The diffusion of technological innovations has attracted the attention of researchers for many years.[1] More recently, attention has also been given to the diffusion of corporate governance mechanisms and strategies across organizations.[2] In this paper we examine whether the adoption of an exporting strategy by firms can be characterized as a diffusion process. The central question is whether the spread of exporting is a result of imitation or of exogenous factors (which could be either global or firm-specific). If the latter is the case, it is also important to identify those factors and assess their effect on the rate of diffusion of exporting activity. Our approach is motivated by work that points out the similarity of innovations to strategic choices (O'Neill, Powder and Buchholtz 1998) and by studies that treat the decision of firms to engage in exporting as an innovation (Lim, Sharkey and Kim 1991).

The statistical appraisal of diffusion processes has traditionally been based on the diffusion models originally developed in the 1960s and some of their more recent variants.[3] We follow the literature in this regard and extend it by setting up a general framework that is unique in three important ways. First, it allows the pool of potential adopters to change over time, as it often does in practice. Second, it incorporates information on both firms

[1] Rogers (1983) reviews the extensive literature on this topic.

[2] Teece (1980) started the literature on governance mechanisms; Abrahamson (1991) is an example of early work on the diffusion of strategies.

[3] The original models are due to Mansfield (1961), Coleman, Katz and Menzel (1966), and Bass (1969). Mahajan and Peterson (1985) and Mahajan and Wind (1986) provide comprehensive reviews of the mathematical models used to represent the diffusion of an innovation.

that adopt the strategy under examination (*adopters*) *and* firms that abandon it (*quitters*). And third, it proceeds with a parameterization of the rate of diffusion, allowing us to test how the latter is affected by changes in external factors. All commonly used diffusion models can be obtained as special cases of this general framework.

A firm's decision to adopt an exporting strategy has been studied extensively in the literature. Issues relevant to this study mostly concern the factors that stimulate the initial adoption of the strategy. The literature suggests that both economic and non-economic considerations may motivate the adoption of a strategy. The notion of imitation captures the effect of both of these factors. In other words, competitive pressures push firms to copy strategies of others in hopes of realizing gains in performance or reputation. In both instances the resulting diffusion process should be consistent with the imitation model.

In addition to imitation, the adoption of a strategy may be precipitated by conducive external factors that may affect performance. Our rich, firm-level dataset of Colombian manufacturing firms allows us to test for the effects of several such factors. Exchange rate fluctuations are an obvious candidate: as the local currency depreciates, exports become more profitable. Moreover, one expects the rate of diffusion to be higher when the adopting firms are performing better than their non-exporting counterparts. We use two different measures of performance to test whether the rate of diffusion is affected by this type of "informed imitation".

One final modeling issue pertains to the definition of the system within which diffusion patterns will be analyzed. Two definitions are reasonable candidates: we can think of the system as being an industrial sector or a geographical region. Both definitions find support in work that looks for (and often finds[4]) evidence that firms are more likely to become exporters when they are in an export intensive industry or region. We try both approaches with similar qualitative results.

Our results are quite striking. When we do not take into account the presence of quitters, the imitation model seems to describe the spread of exporting activity very well. But when we do include quitters this result is reversed: the imitation model is inconsistent with the observed process while the external influence model describes the process well. We find that quitters are much more likely to re-adopt an exporting strategy than potential first-timers. This result is consistent with the sunk cost story in the economic literature. We further find that the rate of adoption increases over time, and this increase appears to be exogenous. We experimented with several possible explanations (exchange rate fluctuations, performance of past adopters), but none of them could explain this increase in the diffusion rate. In hindsight, this should not be surprising given the poor performance of the imitation model.

The paper is organized as follows. In section 2 we review the relevant literature; in section 3 we specify our model and derive the regression equations to be estimated. In section 4 we present and discuss the results. Section 5 concludes.

[4]See Clerides, Lach and Tybout (1998) for a recent example.

2 Literature Review

Given that related literature spans several disciplines, we chose to break this section into three segments. In the first, we briefly review relevant aspects of the literature on diffusion models; in the second we look at the treatment of the diffusion of strategies across organizations in the management literature; and in the third we look at the export development process in the context of the international business literature and examine the relationship between exporting and firm performance in the economics literature.

2.1 Diffusion Models

The diffusion process has generally been described using three modeling specifications: internal influence (imitation), external influence, and mixed influence.

The imitation model. According to the imitation model (Mansfield 1961), the diffusion of an innovation is a result of communication, contact or interaction between prior adopters and potential adopters within a specific system (be it an industrial sector, an organizational field, a country, a region etc.). Imitative behavior within this system drives the diffusion process. This model, where the rate of diffusion is a function of the number that has already adopted and the remaining potential adopters, can be represented by:

$$\frac{dN(t)}{dt} = qN(t)[m - N(t)]$$

where $N(t)$ is the cumulative number of adopters at time (t), q is the coefficient of imitation, and m is the number of potential adopters in the system (or the market potential). As

Mahajan and Muller (1994, p. 224) indicate, the term $qN(t)[m - N(t)]$ captures the "word of mouth interaction" in a system.

The external influence model. In this model (Coleman et al. 1966), the diffusion process is driven exclusively by factors external to the system and there is no imitation behavior. The rate of diffusion or adoption of an innovation thus depends only on the number of adopters present in the system at time (t). The model can be represented by:

$$\frac{dN(t)}{dt} = p[m - N(t)]$$

where p is a non-negative constant usually defined as the coefficient of external influence or coefficient of innovation. According to Mahajan and Muller (1994), it represents the impact of external communication sources.

The mixed influence model. Lastly, the more general functional form, the mixed influence model (Bass 1969) subsumes both the imitation and external influence models. It is represented by:

$$\frac{dN(t)}{dt} = p[m - N(t)] + qN(t)[m - N(t)]$$

Applications of diffusion models. Diffusion modeling has been used to analyze the spread of not only technological innovations but that of administrative and managerial innovations as well. Teece (1980), for example, used a "simple deterministic model commonly used to represent the diffusion of technological innovations...to explain the diffusion of the [multi-divisional administrative structure] M-Form in large industrial firms." Teece found that the M-form innovation is subject to a diffusion process and follows a logistic function similar to that which describes the diffusion of a technological innovation. The satisfactory performance of his model as well as the "similarities between the diffusion processes affecting technological and administrative innovations" revealed by his findings indicate that "other insights from the study of the economics of technological innovation may be fruitfully applied to the domain of administrative and organizational innovation" (Teece 1980, p. 470).

Mahajan, Sharma and Bettis (1988) went a step further and used diffusion modeling to examine whether the adoption of an administrative innovation (again the M-form) is due to imitation behavior. They concluded that the adoption is a random walk process and suggested that the spread of complex administrative innovations may not be a result of imitation. The authors present a series of reasons why this may be so that include: organizational inertia (i.e., relative to that of a technological innovation, the adoption of an administrative innovation may suffer from organizational momentum); inability to partially adopt the innovation; the existence of unique implementation risks associated with adoption (i.e., organizational innovations have unique structures that may not be amenable to imitation); and, lastly, the fact that imitation may be industry specific (Mahajan et al. 1988).

Mahajan et al.'s results were refined and partly reversed by the work of Venkatraman, Loh and Koh (1994). Their work applies the diffusion of innovation perspective to examine the influences on the adoption of two corporate governance mechanisms–joint ventures and the M-form. Their results support their theory of imitative behavior in the diffusion of joint ventures. Their models were tested using both multi-sector data as well as data from the information technology sector with the imitation model outperforming all other specifications. Regarding the diffusion of the M-form structure, they reanalyzed Mahajan et al.'s data using NLS estimation methods (Mahajan et al. used only OLS) and contrary to the earlier findings' support of a random walk process, they found both the external and mixed influence models to be statistically significant.

2.2 The diffusion of strategies in the management literature

Building on earlier work,[5] O'Neill et al. (1998) argue that research on the diffusion of innovations may provide insights into why and how strategies (both efficient and inefficient) diffuse across organizations given the similarity of strategic choices to innovations. The adoption of a strategy remains, however, "more encompassing than [the adoption of] an administrative innovation" since a strategy alters the number and mix of products an organization produces and the population it serves. In addition, "most strategic choices will tend to have a greater economic impact on an organization than administrative innovations" and may cause significant shifts in performance (O'Neill et al. 1998, p. 98). Institutional explanations of the diffusion of innovation argue that although "early adopters of organizational innovation are driven by a desire to improve performance" as innovation spreads "a threshold is reached beyond which adoption provides legitimacy rather than improve performance" (DiMaggio and Powell 1983, p. 148, cited in O'Neill et al. 1998, p. 98). Specifically, Abrahamson and Rosenkopf (1993, p. 487) indicate that "the sheer number of organizations adopting an innovation can cause a bandwagon pressure, prompting other organizations to adopt this

[5] Abrahamson (1991), Abrahamson and Rosenkopf (1993), Abrahamson (1996), Abrahamson and Fombrun (1994).

innovation." Such bandwagons are, in other words, "diffusion processes wherein adopters choose an innovation not because of its technical merits [or success] but because of the numbers of adoptions that have already taken place" (O'Neill et al. 1998, p. 100). Institutional bandwagon pressures may be seen as a result of fears of non-adopters of appearing different from the numerous adopters (Abrahamson and Rosenkopf 1993). Moreover, "competitive bandwagon pressures occur because non-adopters fear below-average performance if many competitors profit from adopting" (Abrahamson and Rosenkopf 1993, p. 487). Contrary to such descriptions of bandwagon effects, Oliver's work (1991) describes how some firms may resist institutional pressures to conform to the adoption of popular strategies–with some organizations adopting a change and others resisting it. She shows that the diffusion process is time dependent and that this dependence is partly affected by the relationship between the characteristics of the strategy or innovation and those of the organizations that may consider it for adoption (O'Neill et al. 1998).

Despite the differing views outlined above, competitive pressures seem to push (at least some) firms to copy the innovative strategies of others in hopes of realizing the gains (in performance or reputation) of earlier adopters (O'Neill et al. 1998). Imitation, then, emerges as a factor in the diffusion of a strategy or a managerial innovation. In fact, as Kimberly (1981, p. 87) notes, "imitation is likely to play a more significant role in the diffusion and adoption of managerial innovation than technological innovation" while O'Neill et al. (1998, p. 101) indicate that successful strategic actions are imitated by other organizations because such actions are "rarely patentable and often portable". However, MacMillan, McCaffery and Van Wijk (1985) and Dewar and Dutton (1986) found that organizational inertia and the properties of an innovation, such as its complexity, may delay or even prevent its imitation by competing organizations. Moreover, environmental uncertainty may influence both the adoption and the diffusion rate of strategic changes (Jarvidan 1984, Smith and Grimm 1987, Zajac and Shortell 1989).

2.3 Exporting strategies and firm performance

Exporting and exporting strategies have been studied in a variety of literatures. For example, the international business literature deals extensively with the adoption of exporting strategies by firms. Relevant models draw from disciplines such as management and organization theory, international trade, location theory, and diffusion of innovation theory (Leonidou and Katsikeas 1996). For this paper, relevant aspects of this research include the examination of factors that facilitate and/or inhibit the adoption of an exporting strategy. These include the role of information and learning, the role of firm resources and capabilities, as well as the role of the firm's external (competitive) environment in the adoption and development of its exporting strategy (Bilkey 1978, Johanson and Wiedersheim-Paul 1975, Johanson and Vahlne 1977, 1990). Moreover, there are models – directly influenced by the work of Rogers (1983) (Andersen 1993) – that attempt to explain exporting from *an innovation adoption perspective.* They focus on the learning sequence associated with the *adoption of innovation* and *treat the decision to adopt an exporting strategy as an innovation for the firm* (Lee and Brasch 1978, Reid 1981, Lim et al. 1991). A general critique of all models in this field of research focuses on the fact that they are mostly tested in single-country contexts, on firms representing a limited number of industrial sectors, and, with few exceptions, on small- and medium-sized manufacturing firms. Lastly, the absence of longitudinal data limits their explanatory abilities (Andersen 1993, Leonidou and Katsikeas 1996).

The economics literature has also dealt with exporting. Specifically, there is an extensive literature that documents the positive relationship between exporting and firm performance.[6] Moreover, at least two papers (Clerides et al. 1998, Bernard and Jensen 1999) go a step further and examine the direction of causality, i.e., whether exporting leads to efficiency gains (firms learn to be more efficient from their interactions in world markets) or whether more efficient firms "self-select into export markets because the returns to doing so are relatively high for them" (i.e., efficient firms export because they are better equipped to face international competition).[7]

Prior work on the determinants of exporting is surprisingly limited and mostly at the aggregate level. Roberts and Tybout (1997) was one of the first papers to use plant-level data in order to examine the firm's decision to export in Colombia in the context of a dynamic model. Bernard and Jensen (1997) used the same model on U.S. data. Both papers find that exporting is related to movements in the exchange rate and to firm characteristics such as size, age, foreign ownership, and corporate status. Some papers have examined the role of

[6] A non-exhaustive list includes Aitken, Hanson and Harrison (1997), Aw and Hwang (1995), Bernard and Jensen (1999), Handoussa, Nishimizu and Page (1986), Tybout and Westbrook (1995), Clerides et al. (1998).

[7] Clerides et al. (1998, p. 904).

spillovers in the export decision. Aitken et al. (1997) estimated a static model on Mexican data and found evidence of spillovers from multinational enterprises, but not of regional or industry spillovers. Clerides et al. (1998) used a dynamic model to look for productivity spillovers due to exporting. They found such evidence for some industries in their Colombian data, while in the case of Morocco the results were mixed and inconclusive.

A number of studies also investigate the existence of positive regional or sector-specific externalities. In other words, they ask whether a firm is more likely to become an exporter if it is in an export-intensive industry or export-oriented region. Such externalities may manifest themselves as knowledge spillovers, as upgrades of transport infrastructure benefiting both exporters and non-exporters as well as export related services (Clerides et al. 1998, p. 904).

The Roberts and Tybout (1997) and Bernard and Jensen (1997) studies also find evidence of sunk costs in exporting, where sunk costs are one-time costs that are incurred when a firm enters the export market. These can be the costs of doing market research, establishing contacts and distribution networks, and so on. In our context we can think of these as the costs of adoption of the new strategy.

3 Model Specification

The diffusion models that have appeared in the literature so far are not rich enough to take full advantage of our data. Hence we generalize the models to allow for quitters, as well as adopters, and to allow for a changing pool of potential adopters. In this section we provide an outline of our modeling strategy. We refer the interested reader to the appendix for the technical details.

3.1 Incorporating quitters

We think of the process starting at some unknown time $-T_0$ in the past and continuing through time. In periods $t = 1, \ldots, T$ we observe the following variables:

$N(t)$ = the number of firms who are using the strategy at time t;

$x(t)$ = the number of new adopters at time t;

$y(t)$ = the number of quitters at time t.

We further define some new variables to assist us with our calculations:

$x^*(t) \equiv x(t) - y(t)$, net adoption: the difference between adopters and quitters at time t;

$X(t) \equiv \sum_{\tau=-T_0}^{t} x(\tau)$, the cumulative number of adopters up to time t;

$Y(t) \equiv \sum_{\tau=-T_0}^{t} y(\tau)$, the cumulative number of quitters up to time t.

Our extension is based on a simple idea: the rate of diffusion should depend not only on the number of new adopters, but also on the number of users who decide to abandon the strategy. We first illustrate this using Coleman et al.'s external influence model. Recall that the original model is

$$\frac{dN(t)}{dt} = p[m - N(t)].$$

Our generalization takes the following form:

$$\frac{dN(t)}{dt} = p_0\,[m(t) - X(t)] + p_1\,[X(t) - N(t)].$$

Note that if $p_0 = p_1$ and $m(t) = m$ for all t then our model reduces to Coleman's model. Essentially our modification allows the rate of adoption to differ among two groups: those who never adopted, $m(t) - X(t)$, and those who once adopted and then abandoned, $m(t) - N(t)$.

The regression analogue of this model can be shown to be:

$$\Delta x^*(t) = p_0 \, [\Delta m(t-1) - x(t-1)] + p_1 \, y(t-1). \tag{1}$$

The main difference between this regression equation and the one delivered by the standard model is the inclusion in this one of the number of quitters, $y(t-1)$.

The same idea is applied to Mansfield's (1961) internal influence (imitation) model. The original model is

$$\frac{dN(t)}{dt} = q(m - N(t))N(t).$$

We generalize it in a similar fashion as the external influence model:

$$\frac{dN(t)}{dt} = q_0 \, \frac{N(t)}{m(t)} \Big[m(t) - X(t)\Big] + q_1 \, \frac{N(t)}{m(t)} \Big[(X(t) - N(t)\Big].$$

The regression analogue in this case is

$$\Delta x^*(t) = q_0 \, \Big[x^*(t-1) - \Delta[L(t-1)X(t-1)]\Big] + q_1 \, \Delta[L(t-1)Y(t-1)], \tag{2}$$

where $L(t) = N(t)/m(t)$. Again, the main difference with the standard equation is the inclusion of the last term, which is a count of the cumulative number of quitters. This introduces a data problem. The term $Y(t-1)$ is the number of quitters *since the beginning of the process*. This information is not available to us; we only know the number of quitters from the time we started observing the process, time $t = 1$. This forces us to make an assumption about the number of quitters prior to time $t = 1$. We experimented with different assumptions and found that our qualitative conclusions are not affected by our choice. The results we report assume that there were zero quitters up to time $t = 0$.

3.2 Analyzing the factors that affect the rate of diffusion

We further generalize the model to allow external factors to affect the rate of diffusion of exporting. We implement this modification as a parameterization of the coefficients of influence. For example, in equation (1) we write $p_0 = \alpha_{p0} + \beta' z(t-1)$ and $p_1 = \alpha_{p1} + \beta' z(t-1)$, where $z(t-1)$ is a vector of variables that may affect the rate of diffusion, and α_{p0}, α_{p1} and β are parameters. The regression equation then becomes

$$\begin{aligned} \Delta x^*(t) &= (\alpha_{p0} + \beta' z(t-1))\,[\Delta m(t-1) - x(t-1)] + (\alpha_{p1} + \beta' z(t-1))\,y(t-1) \\ &= \alpha_{p0}\,[\Delta m(t-1) - x(t-1)] + \alpha_{p1}\,y(t-1) \\ &\quad + \beta'[\Delta m(t-1) - x(t-1) + y(t-1)]\,z(t-1). \end{aligned} \tag{3}$$

This allows us to capture the effect of any variables of interest on the rate of diffusion of exporting activity.

4 Results and implications

The data we utilize in this study come from manufacturing surveys in Colombia.[8] The dataset is quite comprehensive as it covers every plant with at least 10 workers for the years 1981-91. Our final sample includes 13,625 firms, about half of which are in the sample for the whole 11-year period, while the rest enter the market during the sample period. These firms belong to 29 different manufacturing sectors (defined at the three-digit level) and to 12 different geographical regions. This gives us a total of 261 observations when we examine industrial level diffusion and 108 observations when we look at regional level diffusion.

We estimate all three versions of the model and present the results in Table 1.[9] For comparison purposes we also present the results from the standard formulations, where the number of potential adopters is fixed and there are no quitters. The three columns correspond to the external influence, imitation, and mixed models respectively. The results are quite revealing. The first panel (without quitters) shows the imitation model to be the one describing the diffusion of exporting best. Hence if we were to stop here we would conclude that the diffusion of exporting is characterized by imitation. But we would be grossly misled because this conclusion is reversed when we introduce quitters into the model (second panel). The coefficient q_0 in the imitation model is now estimated to be strongly negative, which is inconsistent with the theoretical model. The external model, on the other hand, does quite a

[8] The same dataset has been used in other studies, including Roberts and Tybout (1997) and Clerides et al. (1998).

[9] We estimated the model using both definitions of what our cluster is (industrial sector or geographical region). The results were qualitatively the same, so we report only those at the industry level.

bit better. All coefficients are positive and strongly significant except p_0 in the variable $m(t)$ case, which is practically zero. It is interesting that both coefficients are markedly smaller with variable as opposed to fixed number of potential adopters. Nonetheless, the external model is a better descriptor of the pattern of diffusion of the exporting strategy. Note that the cumulative number of quitters $Y(t)$ does not enter the external model, so our result is not dependent on the assumption on $Y(0)$.

INSERT TABLE 1

The importance of keeping track of firms that abandon a strategy is further demonstrated by the fact that $p_1 > p_0$ in every specification. In other words, the rate of diffusion among firms that had adopted an exporting strategy in the past only to abandon it later is *higher* than the rate among firms that have never exported before. This is an important result that is consistent with the sunk cost story that comes from the economics literature. The crux of the story is that the cost of re-adopting a certain strategy is lower than the cost of adopting it for the first time.

So imitation fails to play a significant role in the diffusion of exporting strategies. A variety of factors may limit its importance. First of all the sheer complexity of the strategy may pose problems. The strategy may entail changes in the number and mix of products a firm produces as well as changes in the population it serves and, thus, cause implementation difficulties. Sunk costs, discussed above, are also relevant in this context. Adopting the strategy successfully may entail among other things increasing a firm's production capacity or upgrading the quality of its products, intimate knowledge of foreign markets and access to those markets. Such measures may be risky and may necessitate significant resource reallocation that may reduce the possibility of imitative behavior. Organizational inertia and specific industry characteristics may also prevent firms from imitating competitors. Finally, possible knowledge of the fact that adopting an exporting strategy does not appear to improve firm performance may also tame imitative behavior. The latter may be particularly relevant with respect to the effect on potential adopters of the negative experiences of quitters (which may be discounted accordingly).

Having established that the external model provides a more accurate depiction of the diffusion process of exporting, we proceed to investigate the specific factors that affect the rate of diffusion. We are interested in two main types of effects. One type includes effects that are completely exogenous to the system. The most important of those is the exchange rate. A high exchange rate (expressed as local currency per U.S. dollar) will render exported goods cheaper and thus increase exports. This should have a positive effect on the rate of adoption of an exporting strategy. The other type of effect comes from within the system. Specifically, we want to test if the performance of current exporters affects the rate of adoption of an exporting orientation by non-exporters. To that end we experiment with two measures of firm performance: value added as a percentage of total output, and rate of growth of output. Our conjecture is that if exporters perform better than non-exporters on average, then some of the latter might be induced to enter the export market.

We test these hypotheses using equation (3), where for each regression the vector z includes just one of the explanatory variables: the exchange rate, a time trend, and one of the performance measures described above. The results are shown in Table 2. Interestingly, the most significant variable is the time trend. This suggests that there is a growing (over time) tendency for firms to export that is independent of short-term fluctuations in the number of adopters. It is perhaps surprising that the exchange rate does not do as well in capturing the intertemporal fluctuations in the rate of adoption: it has the expected positive sign, but it is not significant statistically. This could be due to the short panel – only 9 years – that does not enable the model to capture the effect of the exchange rate with the required precision.

INSERT TABLE 2

The fact that the performance measures have very little explanatory power may not be surprising given the poor performance of the imitation model. These variables could be important if imitation was important since imitation is at least partly driven by the desire to imitate other firms' profits or exceptional performance. Clearly there is no such evidence in our data.

5 Conclusion

In this paper we investigate the diffusion pattern of exporting activity among firms in the same industrial or regional cluster. Our prime goal is to establish whether the spread of exporting follows one or more of the patterns associated with the diffusion models that have been used heavily to model the diffusion of innovations. We embark on this analysis using a very general framework that nests all standard diffusion models. The framework allows for a changing number of potential adopters and incorporates the potential effect of firms that abandon the strategy. Moreover, we go beyond a mere assessment of the validity of the various models. Having established what the appropriate model is, we proceed to analyze the various factors – external or internal (imitation) – that may affect the rate of diffusion of the exporting strategy.

We find that imitation is not a significant determinant of the rate of adoption of an exporting strategy. Rather, the process is consistent with the external diffusion model, with the added feature that the rate of diffusion increases exogenously over time. These results suggest that the decision to adopt an exporting strategy is internal to the firm and unrelated to trends in the firm's surrounding environment. In other words, the firm bases its decision on its own assessment of the strategy's profitability and not on the success others may have had with it.

Our paper demonstrates that simple deterministic models can perform well in describing the diffusion of strategies. Thus future research can use the models to examine the diffusion of other strategies in different competitive environments and shed more light on the factors that influence such processes.

A Appendix: Derivations

A.1 Preliminaries

We start by providing some simple but useful identities that follow from the definitions given in section 3. The number of current users $N(t)$ is the difference between the cumulative number of adopters and quitters from time $-T_0$ to time t:

$$\begin{aligned} N(t) &= \sum_{\tau=-T_0}^{t} [x(\tau) - y(\tau)] \\ &= \sum_{\tau=-T_0}^{t} x^*(\tau). \end{aligned}$$

Note that

$$\begin{aligned} N(t) &= N(t-1) + x(t) - y(t) \\ &= N(t-1) + x^*(t). \end{aligned}$$

Now consider $X(t)$, the total number of adopters regardless of whether they quit or not. We define it as

$$\begin{aligned} X(t) &= \sum_{\tau=-T_0}^{t} x(\tau) \\ &= \sum_{\tau=-T_0}^{t} [x(\tau) - y(\tau)] + \sum_{\tau=-T_0}^{t} y(\tau) \\ &= N(t) + Y(t) \end{aligned}$$

Note that we know $N(t)$ but we do not know $Y(t)$ because we do not observe quitters prior to time 1. We break up $Y(t)$ into two terms:

$$Y(t) = \sum_{\tau=-T_0}^{0} y(\tau) + \sum_{\tau=1}^{t} y(\tau).$$

The second term counts the total number of quitters in our sample period. The first term is the cumulative number of quitters prior to the beginning of our sample, and is therefore unobserved. We approximate for it in our estimation.

A.2 Derivation of the external influence model

We start from

$$\frac{dN(t)}{dt} = p_0\,[m(t) - X(t)] + p_1\,[X(t) - N(t)].$$

In discrete time the above takes the following form:

$$N(t) - N(t-1) = p_0\,[m(t-1) - X(t-1)] + p_1\,[X(t-1) - N(t-1)].$$

Since $N(t) - N(t-1) = x(t) - y(t) \equiv x^*(t)$ we have

$$\begin{aligned} x^*(t) &= p_0\,[m(t-1) - X(t-1)] + p_1\,[X(t-1) - N(t-1)] \\ x^*(t-1) &= p_0\,[m(t-2) - X(t-2)] + p_1\,[X(t-2) - N(t-2)], \end{aligned}$$

which implies that

$$\begin{aligned} \Delta x^*(t) &= p_0\,[(m(t-1) - m(t-2)) - (X(t-1) - X(t-2))] \\ &\quad + p_1\;[(X(t-1) - X(t-2)) - (N(t-1) - N(t-2))] \\ &= p_0\,[\Delta m(t-1) - \Delta X(t-1)] + p_1\,[\Delta X(t-1) - \Delta N(t-1)] \end{aligned}$$

After we substitute $\Delta X(t-1) = x(t-1)$ and $\Delta N(t-1) = x^*(t-1)$ we end up with

$$\Delta x^*(t) = p_0\,[\Delta m(t-1) - x(t-1)] + p_1\,y(t-1). \tag{4}$$

Expression (4) gives the regression analogue to the external influence model in its more general form. From this we can get the model with fixed m (still with quitters),

$$x^*(t) = (1 - p_0)\, x(t-1) - (1 - p_1)\, y(t-1), \tag{5}$$

the model with variable $m(t)$ but no quitters,

$$\Delta x(t) = p\,[\Delta m(t-1) - x(t-1)], \tag{6}$$

and the model with both a fixed m and no quitters (that is, the standard external influence model):

$$x(t) = (1-p)\, x(t-1). \tag{7}$$

A.3 Derivation of the internal influence model

We start from

$$\frac{dN(t)}{dt} = q_0 \frac{N(t)}{m(t)} \Big[m(t) - X(t)\Big] + q_1 \frac{N(t)}{m(t)} \Big[(X(t) - N(t)\Big],$$

We define $L(t) \equiv N(t)/m(t)$ and discretize the above expression to get

$$N(t) - N(t-1) = q_0\, L(t-1)\, [m(t-1) - X(t-1)] + q_1\, L(t-1)\, [X(t-1) - N(t-1)],$$

which implies that

$$\begin{aligned} x^*(t) &= q_0\, L(t-1)\, [m(t-1) - X(t-1)] + q_1\, L(t-1)\, [X(t-1) - N(t-1)] \\ x^*(t-1) &= q_0\, L(t-2)\, [m(t-2) - X(t-2)] + q_1\, L(t-2)\, [X(t-2) - N(t-2)]. \end{aligned}$$

Hence,

$$\begin{aligned}\Delta x^*(t) &= q_0 \Big[\Delta[m(t-1)L(t-1)] - \Delta[L(t-1)X(t-1)]\Big] \\ &\quad + q_1 \Big[\Delta[L(t-1)X(t-1)] - \Delta[L(t-1)N(t-1)]\Big].\end{aligned}$$

Both terms in square brackets simplify to give

$$\Delta x^*(t) = q_0 \Big[x^*(t-1) - \Delta[L(t-1)X(t-1)]\Big] + q_1\, \Delta[L(t-1)Y(t-1)]. \tag{8}$$

Again, this is the more general version of the model. In the version with fixed m the variable $L(t)$ is replace by $N(t)/m$ and the regression analogue is

$$\Delta x^*(t) = q_0 \Big[x^*(t-1) - (1/m)\, \Delta[N(t-1)X(t-1)]\Big] + q_1\, (1/m)\, \Delta[N(t-1)Y(t-1)]. \tag{9}$$

The model with variable $m(t)$ but no quitters (which means $x(t) = x^*(t)$, $N(t) = X(t)$ and $y(t) = Y(t) = 0\, \forall t$) becomes

$$\Delta x(t) = q \Big[x(t-1) - \Delta[L(t-1)N(t-1)]\Big], \tag{10}$$

and the model with both fixed m and no quitters:

$$\Delta x(t) = q\Big[x(t-1) - (1/m)\, \Delta[N^2(t-1)]\Big]. \tag{11}$$

A.4 Putting together the mixed influence model

The mixed influence model is an additive combination of the external and internal influence models (when in difference form). The derivation is thus trivial, so here we just list the equations for each version of the model.

The full version is

$$
\begin{aligned}
\Delta x^*(t) &= p_0 \Big[\Delta m(t-1) - x(t-1)\Big] + p_1\, y(t-1) \\
&\quad + q_0 \Big[x^*(t-1) - \Delta[L(t-1)X(t-1)]\Big] \\
&\quad + q_1\, \Delta[L(t-1)Y(t-1)]; \qquad (12)
\end{aligned}
$$

the version with fixed m and quitters is

$$
\begin{aligned}
x^*(t) &= (1-p_0+q_0)\, x(t-1) + (1+p_1-q_0)\, y(t-1) \\
&\quad - q_0\, (1/m)\, \Delta[N(t-1)X(t-1)] + q_1\, (1/m)\, \Delta[N(t-1)Y(t-1)], \qquad (13)
\end{aligned}
$$

the version with variable $m(t)$ and no quitters is

$$\Delta x(t) = p\,[\Delta m(t) - x(t-1)] + q\,\left[x(t-1) - \Delta[L(t-1)N(t-1)]\right], \qquad (14)$$

and the version with both fixed m and no quitters:

$$x(t) = (1-p+q)\, x(t-1) - q\,(1/m)\,\Delta N^2(t-1). \qquad (15)$$

References

Abrahamson, Eric, "Managerial Fads and Fashions: The Diffusion and Rejection of Innovations," *Academy of Management Review*, 1991, *16*, 586–612.

—— , "Management Fashion," *Academy of Management Review*, 1996, *21*, 254–285.

—— **and Charles J. Fombrun**, "Macrocultures: Determinants and Consequences," *Academy of Management Review*, 1994, *19*, 728–755.

——— **and Lori Rosenkopf**, "Institutional and Competitive Bandwagons: Using Mathematical Modeling as a Tool to Explore Innovation Diffusion," *Academy of Management Review*, 1993, *18*, 487–517.

Aitken, Brian, Gordon H. Hanson, and Ann Harrison, "Spillovers, Foreign Investment, and Export Behavior," *Journal of International Economics*, 1997, *XLIII*, 103–132.

Andersen, Otto, "On the Internationalization Process of Firms: A critical Analysis," *Journal of International Business Studies*, 1993, *24*, 209–231.

Aw, Bee-Yan and A. R. Hwang, "Productivity and the Export Market: A Firm-Level Analysis," *Journal of Development Economics*, 1995, *XLVII*, 313–332.

Bass, Frank M., "A New Product Growth Model for Consumer Durables," *Management Science*, 1969, *15*, 215–227.

Bernard, Andrew B. and J. Bradford Jensen, "Why Some Firms Export," 1997. mimeo.

——— **and** ——— , "Exceptional Exporter Performance: Cause, Effects, or Both?," *Journal of International Economics*, 1999, *47*, 1–25.

Bilkey, W. J., "An Attempted Integration of the Literature on the Export Behavior of Firms," *Journal of International Business Studies*, 1978, *9*, 33–46.

Clerides, Sofronis K., Saul Lach, and James Tybout, "Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Morocco, and Mexico," *Quarterly Journal of Economics*, August 1998, *113* (3), 903–947.

Coleman, J.S., E. Katz, and H. Menzel, *Medical Innovation: A Diffusion Study*, Indianapolis, IN: Bobbs-Merrill, 1966.

Dewar, R. D. and J. E. Dutton, "The Adoption of Radical and Incremental Innovations: An Empirical Analysis," *Management Science*, 1986, *32*, 1422–1433.

DiMaggio, P. and W. Powell, "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," *American Sociological Review*, 1983, *48*, 147–160.

Handoussa, H., Mieko Nishimizu, and John Page, "Productivity Change in Egyptian Public Sector Industries after the 'Opening'," *Journal of Development Economics*, 1986, *XX*, 53–74.

Jarvidan, M., "The Impact of Environmental Uncertainty on Long-Range Planning Practices of the U. S. Savings and Loan Industry," *Strategic Management Journal*, 1984, *5*, 381–392.

Johanson, J. and F. Wiedersheim-Paul, "The Internationalization of the Firm: Four Swedish Cases," *Journal of Management Studies*, 1975, *12*, 305–322.

——— **and J. E. Vahlne**, "The Internationalization Process of the Firm: A Model of Knowledge Development and Increasing Foreign Commitments," *Journal of International Business Studies*, 1977, *8*, 23–32.

——— **and** ——— , "The Mechanism of Internationalization," *International Marketing Review*, 1990, *7*, 11–24.

Kimberly, J. R., "Managerial Innovation," in P. Nystrom and W. H. Starbuck, eds., *Handbook of Organizational Design*, New York: OUP, 1981, pp. 84–104.

Lee, W. and J. J. Brasch, "The Adoption of Export as an Innovative Strategy," *Journal of International Business Studies*, 1978, *9*, 85–93.

Leonidou, L. C. and C. S. Katsikeas, "The Export Development Process: An Integrative Review of Empirical Models," *Journal of International Business Studies*, 1996, *27*, 517–551.

Lim, J. S., T. W. Sharkey, and K. I. Kim, "An Empirical Test of an Export Adoption Model," *Management International Review*, 1991, *31*, 51–62.

MacMillan, I., M. L. McCaffery, and G. Van Wijk, "Competitors' Responses to Easily Imitated New Products," *Strategic Management Journal*, 1985, *6*, 75–86.

Mahajan, V. and E. Muller, "Innovation Diffusion in a Borderless Global Market: Will the 1992 Unification of the European Community Accelerate Diffusion of New Ideas, Products, and Technologies?," *Technological Forecasting and Social Change*, 1994, *45*, 221–235.

—— **and R. A. Peterson**, "Models for Innovation Diffusion," *Sage University Paper No. 48*, 1985.

—— **and Y. Wind**, *Innovation Diffusion Models of New Product Acceptance*, Cambridge MA: Ballinger Publishing Co., 1986.

Mahajan, Vijay, Subhash Sharma, and Richard A. Bettis, "The Adoption of the M-Form Organizational Structure: A Test of Imitation Hypothesis," *Management Science*, 1988, *34* (10), 1188–1201.

Mansfield, E., "Technical Change and the Rate of Imitation," *Econometrica*, October 1961, *29*, 741–766.

Oliver, C., "Strategic Responses to Institutional Processes," *Academy of Management Review*, 1991, *16*, 145–179.

O'Neill, Hugh M., Richard W. Powder, and Ann K. Buchholtz, "Patterns in the Diffusion of Strategies Across Organizations: Insights from the Innovation Diffusion Literature," *Academy of Management Review*, 1998, *23*, 98–114.

Reid, S. D., "The Decision-maker and Export Entry Expansion," *Journal of International Business Studies*, 1981, *12*, 101–112.

Roberts, Mark and James R. Tybout, "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, September 1997, *XXCVII*, 545–564.

Rogers, E. M., *Diffusion of Innovations*, New York: The Free Press, 1983.

Smith, K. G. and C. M. Grimm, "Environmental Variation, Strategic Change and Firm Performance: A Study of Railroad Deregulation," *Strategic Management Journal*, 1987, *8*, 363–376.

Teece, David J., "The Diffusion of an Administrative Innovation," *Management Science*, 1980, *26*, 464–470.

Tybout, James R. and M. Daniel Westbrook, "Trade Liberalization and Dimensions of Efficiency Change in Mexican Manufacturing Industries," *Journal of International Economics*, 1995, *XXXI*, 53–78.

Venkatraman, N., Lawrence Loh, and Jeongsuk Koh, "The Adoption of Corporate Governance Mechanisms: A Test of Competing Diffusion Models," *Management Science*, 1994, *40*, 496–507.

Zajac, E. J. and S. M. Shortell, "Changing Generic Strategies: Likelihood, Direction, and Performance Implications," *Strategic Management Journal*, 1989, *10*, 413–430.

Table 1: Basic results

Without quitters

Potential adopters	Parameters	Model estimates: External	Internal	Mixed
Fixed	p	-.089***		.165
	q		.106***	.288*
	$\bar{R}^2$	.872	.046	.873
Variable	p	-.036***		-.026**
	q		.105***	.090***
	$\bar{R}^2$	.028	.047	.060

With quitters

Potential adopters	Parameters	Model estimates: External		Internal		Mixed	
Fixed	p_0, p_1	.370***	.645***			.688*	.745**
	q_0, q_1			-.796***	.758***	.139	1.68*
	$\bar{R}^2$	.376		.213		.387	
Variable	p_0, p_1	-.003	.254***			-.000	.248***
	q_0, q_1			-.676***	.842***	-.501***	-.308
	$\bar{R}^2$	.088		.176		.197	

Note: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 2: Factors affecting the rate of diffusion

Variable	Estimate	p-value	Model R^2
Exchange rate	.156	.202	.091
Time trend	.013*	.056	.098
Difference in growth rates	.028	.270	.089
Diff. in value added / unit of output	-.164	.711	.085

Note: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

SELECTED RECENT PUBLICATIONS

Bertaut C. and M. Haliassos, Precautionary Portfolio Behavior from a Life - Cycle Perspective, *Journal of Economic Dynamics and Control*, 21, 1511-1542, 1997.

Blundell R., P. Pashardes and G. Weber, What Do We Learn About Consumer Demand Patterns From Micro-Data?, *American Economic Review*, 83, 570-597, 1993.

Bougheas S., P. Demetriades and T. P. Mamouneas, Infrastructure, Specialization and Economic Growth, *Canadian Journal of Economics,* forthcoming.

Caporale W., C. Hassapis and N. Pittis, Unit Roots and Long Run Causality: Investigating the Relationship between Output, Money and Interest Rates, *Economic Modeling*, 15(1), 91-112, January 1998.

Caporale G. and N. Pittis, Efficient estimation of cointegrated vectors and testing for causality in vector autoregressions: A survey of the theoretical literature, *Journal of Economic Surveys*, forthcoming.

Caporale G. and N. Pittis, Unit root testing using covariates: Some theory and evidence, *Oxford Bulletin of Economics and Statistics*, forthcoming.

Caporale G. and N. Pittis, Causality and Forecasting in Incomplete Systems, *Journal of Forecasting*, 16, 6, 425-437, 1997.

Clerides K. S., Lach S. and J.R. Tybout, Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Morocco, and Mexico, *Quarterly Journal of Economics* 113(3), 903- 947, August 1998.

Cukierman A., P. Kalaitzidakis, L. Summers and S. Webb, Central Bank Independence, Growth, Investment, and Real Rates", Reprinted in Sylvester Eijffinger (ed), Independent Central Banks and Economic Performance, Edward Elgar, 416-461, 1997.

Dickens R., V. Fry and P. Pashardes, Non-Linearities and Equivalence Scales, *The Economic Journal*, 103, 359-368, 1993.

Eicher Th. and P. Kalaitzidakis, The Human Capital Dimension to Foreign Direct Investment: Training, Adverse Selection and Firm Location". In Bjarne Jensen and Kar-yiu Wong (eds), Dynamics,Economic Growth, and International Trade, The University of Michigan Press, 337-364, 1997.

Fry V. and P. Pashardes, Abstention and Aggregation in Consumer Demand, *Oxford Economic Papers*, 46, 502-518, 1994.

Gatsios K., P. Hatzipanayotou and M. S. Michael, International Migration, the Provision of Public Good and Welfare, *Journal of Development Economics*, 60/2, 561-577, 1999.

Haliassos M. and C. Hassapis, Non-expected Utility, saving, and Portfolios, *The Economic Journal*, forthcoming.

Haliassos M. and J. Tobin, The Macroeconomics of Government Finance, reprinted in J.Tobin, Essays in Economics, vol. 4, Cambridge: MIT Press, 1996.

Haliassos M. and C. Bertaut, Why Do So Few Hold Stocks?, *The Economic Journal*, 105, 1110- 1129, 1995.

Haliassos M., On Perfect Foresight Models of a Stochastic World, *Economic Journal*, 104, 477-491, 1994.

Hassapis C., N. Pittis and K. Prodromidis, Unit Roots and Granger Causality in the EMS Interest Rates: The German Dominance Hypothesis Revisited, *Journal of International Money and Finance,* pp. 47-73, 1999.

Hassapis C., S. Kalyvitis and N. Pittis, Cointegration and Joint Efficiency of International Commodity Markets", *The Quarterly Review of Economics and Finance,* 39, 213-231, 1999.

Hassapis C., N. Pittis and K. Prodromides, EMS Interest Rates: The German Dominance Hypothesis or Else?" in European Union at the Crossroads: A Critical Analysis of Monetary Union and Enlargement, Aldershot, UK., Chapter 3, 32-54, 1998. Edward Elgar Publishing Limited.

Hatzipanayotou P., and M. S. Michael, General Equilibrium Effects of Import Constraints Under Variable Labor Supply, Public Goods and Income Taxes, *Economica*, 66, 389-401, 1999.

Hatzipanayotou, P. and M.S. Michael, Public Good Production, Nontraded Goods and Trade Restriction, *Southern Economic Journal*, 63, 4, 1100-1107, 1997.

Hatzipanayotou, P. and M. S. Michael, Real Exchange Rate Effects of Fiscal Expansion Under Trade Restrictions, *Canadian Journal of Economics,* 30-1, 42-56, 1997.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, A Nonlinear Sensitivity Analysis of Cross-Country Growth Regressions, *Canadian Journal of Economics,* forthcoming.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, European Economics: An Analysis Based on Publications in Core Journals, *European Economic Review*, 1999.

Kalaitzidakis P., On-the-job Training Under Firm-Specific Innovations and Worker Heterogeneity, *Industrial Relations,* 36, 371-390, July 1997.

Ludvigson S. and A. Michaelides, Does Buffer Stock Saving Explain the Smoothness and Excess Sensitivity of Consumption?, *American Economic Review*, forthcoming.

Lyssiotou Panayiota, Dynamic Analysis of British Demand for Tourism Abroad, *Empirical Economics*, forthcoming.

Lyssiotou P., P. Pashardes and Th. Stengos, Testing the Rank of Engel Curves with Endogenous Expenditure, *Economics Letters,* 64, 61-65, 1999.

Lyssiotou P., P. Pashardes and Th. Stengos, Preference Heterogeneity and the Rank of Demand Systems, *Journal of Business and Economic Statistics*, 17 (2), 248-252, April 1999.

Lyssiotou Panayiota, "Comparison of Alternative Tax and Transfer Treatment of Children using Adult Equivalence Scales", *Review of Income and Wealth*, 43 (1), 105-117, March 1997.

Demetriades P. and T. P. Mamuneas, Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economies, *Economic Journal*, forthcoming.

Mamuneas, Theofanis P., Spillovers from Publicly – Financed R&D Capital in High-Tech Industries, *International Journal of Industrial Organization*, 17(2), 215-239, 1999.

Mamuneas, T. P. and Nadiri M. I., R&D Tax Incentives and Manufacturing-Sector R&D Expenditures, in *Borderline Case: International Tax Policy, Corporate Research and Development, and Investment*, James Poterba (ed.), National Academy Press, Washington D.C., 1997. Reprinted in *Chemtech*, 28(9), 1998.

Michaelides A. and Ng, S., Estimating the Rational Expectations Model of Speculative Storage: A Monte Carlo Comparison of three Simulation Estimators, *Journal of Econometrics*, forthcoming.

Pashardes Panos, Equivalence Scales in a Rank-3 Demand System, *Journal of Public Economics*, 58, 143-158, 1995.

Pashardes Panos, Bias in Estimating Equivalence Scales from Grouped Data, *Journal of Income Distribution*, Special Issue: Symposium on Equivalence Scales, 4, 253-264,1995.

Pashardes Panos., Bias in Estimation of the Almost Ideal Demand System with the Stone Index Approximation, *Economic Journal*, 103, 908-916, 1993.

Spanos Aris, Revisiting Date Mining: ´hunting´ with or without a license", *Journal of Methodology*, July 2000.

Spanos Aris, On Normality and the Linear Regression Model, *Econometric Reviews*, 14,195-203, 1995.

Spanos Aris, On Theory Testing in Econometrics: Modeling with nonexperimental Data, *Journal of Econometrics*, 67, 189-226, 1995.

Spanos Aris, On Modeling Heteroscedasticity: The Student's t and Elliptical Linear Regression Models, *Econometric Theory*, 10, 286-315, 1994.