# MULTI-MARKET AND GLOBAL DIFFUSION

by

M.G. DEKIMPE *
P.M. PARKER **
and
M. SARVARY †

98/73/MKT

* Associate Professor at Catholic University Leuven, Naamsestraat 69, 3000 Leuven, Belgium.

** Professor of Marketing at INSEAD, Boulevard de Constance, 77305 Fontainebleau Cedex, France.

† Assistant Professor of Marketing at Graduate School of Business, Stanford University, Stanford, CA 94305-5015, USA.

# MULTI-MARKET AND GLOBAL DIFFUSION

Marnik G. Dekimpe

Philip M. Parker

Miklos Sarvary[1]

August 26, 1998

[1] Marnik G. Dekimpe is Associate Professor, Catholic University Leuven, Naamsestraat 69, 3000 Leuven, Belgium (Tel. 32-16-326 944; E-mail: marnik.dekimpe@econ.kuleuven.ac.be); Philip M. Parker is Professor, INSEAD, Boulevard de Constance, 77305 Fontainebleau, Cedex, France (Tel. 33-1-6072 4000; E-mail: parker@insead.fr); Miklos Sarvary is Assistant Professor, Stanford University, Graduate School of Business, Stanford CA 94305-5015, USA (Tel. 650-725 9206; E-mail: sarvary@gsb.stanford.edu). The authors are listed alphabetically.

# 1. INTRODUCTION

This book shows that diffusion research has been very popular in the marketing literature, resulting in many managerially useful insights. However, the large majority of this research has focused on one market (one country or geographic area), with only limited attention being paid to multi-region or international diffusion issues. Hence, even though diffusion (as any other social or economic phenomenon) must take place simultaneously in time and space (Mahajan, Muller and Bass 1990; Mahajan and Peterson 1979), previous research has had a pre-occupation with only the time dimension.

Because of recent economic trends (e.g. political and trade barriers falling, saturating home markets, etc.), and in response to the rapid globalization of world markets, more and more firms are interested in launching products in multiple countries or even on a global basis. Multinational or global firms face the problem of optimal budget allocation across markets (e.g. countries), which calls for a rigorous estimation and comparison of these individual markets' economic value. In particular, one needs to know each market's potential as well as the time horizon over which this potential is likely to be realized. However, comparing individual markets based on independent analyses of each may not be enough for designing a global marketing strategy. While firms have long recognized that there are clear differences between individual countries, international markets do not develop independently,[2] but rather countries tend to influence each other (see e.g. the notion of international product life cycles – Ayal 1981; Vernon 1981). These cross-country influences are becoming even more prevalent with the globalization of the world economy. In view of these trends, marketing managers of multi-national or global firms face the following questions:

- What is the global market potential of a given innovation? Specifically, are there countries (and which ones) that will not adopt the innovation at all, and what market potential will be realized within each of the individual countries.

[2] This dependence was clearly illustrated in Putsis et al. (1997), who found significant cross-country correlations between the residuals of Bass models estimated separately for each country.

- What is the likely path for the realization of this market potential? In particular, when will countries start using the innovation, and how fast will it diffuse within their societies?
- How can we forecast the likely within-country diffusion pattern? That is, what *exogenous* market characteristics does the market potential and the likely path of diffusion depend on?
- Do markets develop independently or do (some) countries influence one another? Asked differently, which *endogenous* characteristics will determine cross-country influence?

Diffusion theory is well suited to address the above managerial problems and, as a result, international marketing may provide a renewed impetus to diffusion research. This raises the following two questions: (i) what do we already know in terms of international diffusion and (ii) what are the issues which deserve special attention when using diffusion models in a multi-market or international context?[3]

## 2. INTERNATIONAL OR MULTI-REGION DIFFUSION: THE STATE OF KNOWLEDGE

In recent years, a number of papers have appeared which (started to) address many of the managerial questions outlined above. Tables 1 and 2 summarize, respectively, the major take-aways and methodological features from these studies. As can be seen from the tables, the literature on international diffusion is quite fragmented. In particular, from a substantive point of view, there is little overlap between the covariates used across studies, and most work has concentrated on a limited subset of product categories and geographic regions. Even so, some generalizations begin to emerge from the literature. In

[3] Within the area of multi-market diffusion, our focus is on international or global diffusion because of the special challenges arising from this context. Many of the issues (especially the technical ones) mentioned here should also be considered in other contexts (e.g. multi-region diffusion within a given country, inter and intra-organizational diffusion, etc.).

what follows, we first identify a number of unfortunate "biases" in international diffusion research, after which we summarize the recurring or generalizable substantive findings.

------------------------------------

Insert Tables 1and 2 about here

------------------------------------

**2.1 Limited Geographic Scope**

Previous research on international diffusion has mainly dealt with a comparison of the diffusion rates across a *limited* set of industrialized countries. As a consequence, over 90% of the world's nations are ignored, and key countries like Brazil, Indonesia, China, India and Russia, which together represent over 40 percent of the world's population are mostly excluded. This tendency to focus on only a few of the richer countries is mirrored both in marketing practice (Mahajan, Pratini de Morales & Wind 1998) and in a broader survey of the international marketing literature reported in Dekimpe, Parker and Sarvary (1998a, Table 3). The inclusion of a larger number of countries in international diffusion studies is extremely important, however, if one is interested in generating empirical generalizations and normative insights for practitioners. From a statistical point of view, a more global scope is important to ensure the largest possible variation in terms of the variables across countries.

The set of countries considered in most international diffusion research is not only limited in scope, but also severely biased towards the study of *industrialized* countries. Given the improving economic status of many developing countries, marketers should no longer ignore this as-yet untapped market potential (Glenn and Gordon 1997). Moreover, even when making abstraction of the future growth potential of these markets, marketers should keep in mind that many already contain wealthy and attractive segments whose size may actually exceed the population of many industrialized countries (Mahajan et al. 1998).

Little is known, however, about the nature of the diffusion process in developing countries. First, it is unclear whether reported empirical generalizations on the sizes of the Bass parameters (as reported e.g. in Sultan, Farley and Lehmann 1990) still hold when also considering these countries. In their study on the global diffusion of cellular services, Dekimpe et al. (1998a), e.g., found smaller average coefficients of internal and external influence than typically reported, and attributed this in part to the inclusion of non-industrialized countries in their sample. Second, more research is needed on the extent of an international learning effect (cf. infra) both among developing countries, and between developed and developing countries.

### 2.2 Focus On a Small Set of Product Contexts

Table 1 also reveals a severe limitation in the product contexts explored in the literature. The large majority of studies have concentrated on consumer durables. Only 2 studies consider a service (cellular telephone services), 1 study considers a new drug, and 2 studies model the diffusion of an industrial product (digital telecommunication switches and retail point-of-sales scanners). A large number of product contexts has therefore been ignored by the international diffusion literature, and it is not clear to what extent the international diffusion process of consumer durables is (or should be) similar to that of industrial innovations (see e.g. Ganesh and Kumar 1996 or Parker 1994 for a more elaborate discussion).

### 2.3 Idiosyncrasy of the Included Covariates

A third observation from Table 1 is that the covariates used by each study differ a great deal both in nature and in terms of the adopted operationalizations. To some exent, this is not surprising, especially in view of the fact that (i) international research requires the availability of proxies across all countries included in the analysis, and some of these proxies may no longer be available when the sample is modified or extended, and (ii) different product contexts intrinsically require the inclusion of different covariates. In their study on the diffusion of consumer durables across European countries, for example, Gatignon et. al. (1989), use "sex roles", "mobility" and "cosmopolitanism" to explain cross-country variations in diffusion patterns. Clearly, while these variables provide useful insights in the context of time-saving consumer durables, they have limited use in other product contexts (e.g. industrial products). The idiosyncratic nature of the covariates across studies makes it harder to draw empirical generalizations, which in turns limits the scope of the theoretical take-aways from this resaerch.

Another problem with the covariates used in the literature is related to differences in operationalizations across studies. Social system heterogeneity, for instance, is measured through the number of ethnic groups in the country in Dekimpe et al. (1998a,b), while it is operationalized by means of a qualitative variable (high vs. low-context culture) in Takada and Jain (1991). Furthermore, while some covariates are meant to describe different constructs, they are often highly correlated. Gatignon et al. (1989), for example, operationalize "mobility" with three items, each related to the ownership and usage level of automobiles. While this operationalization shows face validity, it is strongly related to GNP/capita, which is used in a number of other studies to describe the wealth of a country (e.g. Helsen et al. 1993; Ganesh et al. 1997). Finally, most studies, especially those including a larger number of countries, use single-item measures, which is clearly a limitation. Notable exceptions are the work by Helsen et al. (1993), in which 23 country traits (measured on 12 countries) were factor-analyzed to derive five interpretable factors (mobility, health situation of the country, foreign trade activities, the country's standard of living and cosmopolitanism), and Ganesh et al. (1997) who measure economic similarity through the sum of three items.

In sum, currently there is little agreement among researchers on the nature and operationalization of the covariates used in international diffusion studies. While the idiosyncratic product context will always modify to some extent the set of covariates included, in order to generate empirical generalizations it would be useful to agree upon a set of constructs (along with their measurement instruments) that should be included in any global diffusion study (e.g. the wealth of the country). As an illustration, and to encourage the development of such measures, we have run a preliminary analysis on 60 variables describing over 200 countries along a number of important dimensions such as socio-economic development, political structure, demographics, culture, climate and geography. The data originate from multiple sources, including Euromonitor, The World Fact Book (CIA), International Telecommunications Union (ITU), "Investing, Licensing and Trade" (The Economist) and Parker (1997a). Exploratory factor analysis (PCA with varimax rotation) was used to explore what constructs might describe the community of nations along these dimensions. As all 60 variables could not be simultaneously included in the analysis, they were analyzed by conceptually separate subsets. The results are reported in Table 3, and reveal that most countries can be described through 18 factors. Correlations among the factors resulting from the procedure were not found to be severe (the highest correlation between any factor is 0.6 with only 6 significant correlation coefficients above 0.3, for 162 possible coefficients). Most factors show strong face validity and many relate to constructs used in previous research (but then measured mainly through single-item scales). While these results are definitely preliminary, they constitute a first step towards the development of more rigorous measures which can be shared across international diffusion researchers.

------------------------------

Insert Table 3 about here

------------------------------

**2.4 Focus on Descriptive Uses**

Mahajan, Muller and Bass (1990) identify three different uses for diffusion models: forecasting, hypothesis testing (descriptive use) and the formulation of normative guidelines. While some of the earlier studies had a clear forecasting focus (e.g. Heeler and Hustad 1980; Lindberg 1982), most of the currently-available international diffusion studies are of the descriptive or *hypothesis-testing* type, focusing on differences in the coefficients of innovation *(p)* and imitation *(q)* between countries varying in terms of their time of adoption, wealth, social homogeneity, population mobility and cosmopolitanism, etc... As already indicated, many of these hypotheses are study- and/or product-category specific, and few empirical generalizations have emerged from them (see Section 2.6 for a more detailed discussion on some tentative generalizations).

Two potential *forecasting* uses of these models can be considered. First, the identified relationships can be used to forecast the *p*- and *q*-values for countries which have not yet started the adoption process (or for which not enough observations are available yet); see e.g. Dekimpe et al. 1998a or Gatignon et al. 1989. By exploiting this cross-sectional variation, one overcomes a basic criticism on single-country diffusion models that "parameter estimation for diffusion models is basically of historical interest; by the time sufficient observations have developed for reliable estimation, it is too late to use the estimates for forecasting purposes" (Mahajan et al. 1990, p. 9). Second, one may consider whether the nesting of country-specific covariates into Bass-type diffusion models would improve these models' (long-run) forecasting performance. We are not aware, however, of any systematic attempts in this direction. Both Dekimpe et al. (1998a) and Putsis et al. (1997), for example, indicate that this would involve the prediction of the future time path of the covariates, but leave the issue as an important area for future research.

Finally, *normative* international diffusion has been under-researched. A notable exception is the work by Kalish, Mahajan and Muller (1995), who derive conditions under which, respectively, waterfall (where all markets are entered sequentially) and sprinkler (where markets are entered simultaneously) strategies should be selected. The choice between both strategies is shown to be related to the length of the product life cycle, the attractiveness (e.g. size, growth rate, innovativeness) of the foreign markets, and the strength of the competitors in the foreign market. More work is needed, however, to extend single-country normative research findings on, e.g., the optimal time path for advertising, price and distribution, to a multiple-region context.

## 2.5 Modeling Approaches Adopted in International Diffusion Research

Table 2 compares the models used in cross-national diffusion research. Most international diffusion studies use the Bass model (1969) or some modified version to generate substantive insights. This is not surprising, given the nature of the data which most of the time consists of aggregate sales or penetration levels. The Bass model is well-suited to analyze such data and perform cross-country comparisons. The only two studies using a different (hazard modeling) approach investigate the timing when countries try (or allow the distribution of) an innovation. They analyze dis-aggregate data for which micro-level models are more appropriate (see also Section 3.3 and Chapter 8 in this book).

When focusing on the type of *aggregate* diffusion model used, we note that many studies have used the standard Bass model. While extensions to this model have been implemented in some of the studies (e.g. the nesting of covariates into the model to explain differences in $p$ and $q$ in Dekimpe et al. 1998a or Gatignon et al. 1989, or the explicit modeling of the peer pressure emanating from previous adopters in other countries in Mahajan and Muller 1994), it is fair to say that many of the refinements to the standard Bass model (documented in Mahajan et al. 1990) have not yet been implemented in an international context. Given that these extended models have been shown to improve upon the basic Bass model in a one-region setting, it would be advisable to also apply them in a multi-region diffuison context.

**2.6 Emerging Empirical Generalizations**

Despite the fragmented nature of the literature and the frequent contradictions across studies, a few empirical generalizations seem to emerge from the literature. A first insight is that the wealth of a country (often operationalized through GNP/ capita) has a positive effect on the diffusion process both in terms of reducing the time before a country tries the innovation and in terms of the subsequent speed of diffusion within the country. This general insight is intuitive and consistent with diffusion theory (see e.g. Gatignon and Robertson 1985; Rogers 1983).

A second consistent finding is that there are cross-national learning effects (Dekimpe et al. 1996, 1998a,b; Mahajan and Muller 1994; Takada and Jain 1991; Kumar et al. 1998). Countries which introduce the innovation at a later point in time seem to have faster within-country diffusion patterns. This suggests that later adopters benefit from the experience of other countries with the innovation. Moroever, this experience effect has been shown to exist for different decision-making units: at the level of the individual consumers (e.g. Ganesh et al. 1997; Mahajan and Muller 1994; Putsis et al. 1997), at the firm level (Ganesh and Kumar 1996) and the level of government agencies (Dekimpe et al. 1996, 1998b). The existence of a learning effect has also been found by means of a variety of modeling approaches, i.e. through independent Bass models (Takada and Jain 1991; Ganesh and Kumar 1996), extended Bass models (i.e. which directly model the cross-effect of one country's adoptions on another country's diffusion rate – Mahajan and Muller 1994), individual-level hazard models (Dekimpe et al. 1996, 1998b) and with the Bernouilli mixing model of Putsis et al. (1997).[4]

Third, several studies have found that the size of this cross-region experience effect is not homogenous. Mahajan and Peterson (1979) postulate the existence of a neigborhood effect (i.e. the smaller the geographic distance the larger the influence). Ganesh et al. (1997), on the other hand, find that geographic proximity was not a significant determinant of the size of the learning effect in three of their four product categories. Stronger learning effects were, however, found between countries which are culturally and economically similar. In a similar vein, Dekimpe et al. (1996, 1998a) clustered over 150 countries into 9 World Bank groups (reflecting economic similarity), and investigated the impact of previous adoptions by other group members on both the timing of the first adoption in each country and the subsequent within-country diffusion. A sizable effect was found on the timing decision, but not on any aspect of the within-country speed of diffusion. Finally, Putsis et al. (1997) demonstrated that the number of cross-country communications are not uniformly spread across all countries, and need not be symmetrical.

Fourth, it is found across a number of studies that social system heterogeneity has a negative effect on diffusion (Dekimpe et al. 1996, 1998a,b: Takada and Jain 1991). Again, this effect is true for both the timing of trial by a country as well as the speed of within-country diffusion. While in the context of within-country diffusion, this finding is intuitive and generally consistent with diffusion theory (e.g. Gatignon and Robertson 1985), it is new in the context of countries' trial of the innovation. It suggests that there is a link between the overall heterogeneity of the social system and the speed with which decision makers involved in the trial decision reach a consensus (see below). A similar observation was made by Robertson and Wind (1980) with respect to the innovativeness of organizations.

---

[4] One notable exception is the study by Helsen et al. (1993),who find for a number of product categories that the diffusion parameters in the lag country are negatively (rather than positively) related to the lag time.

## 3. IMMEDIATE RESEARCH NEEDS

In the previous section, several areas for future research were already identified while discussing the current state of knowledge in international diffusion modelling. In this section, we identify seven more issues which deserve special attention when diffusion models are used in a multi-market (global) context. For each of these issues, we address the following questions: (a) why is this an important issue, (b) how has the relevant literature dealt with it, and (c) what are the most important areas for future research?

### 3.1 The Two-Staged Nature of the Diffusion Process

The mere fact that one talks about multiple markets in a diffusion context recognizes that diffusion *across* markets is somewhat different from the diffusion process *within* a particular market. In other words, talking about multi-market diffusion only makes sense if market boundaries are relevant for the diffusion process (see e.g. Mahajan and Muller 1994 for a discussion on the role of national boundaries on the overall speed of diffusion). Accordingly, we propose that the international diffusion process (and multi-market diffusion processes in general) for most products is composed of two conceptually different but potentially inter-linked sub-processes:

- one that determines the adoption time *across* markets, i.e. when will the innovation first appear in an individual country, and
- one that determines the pattern of adoption *within* markets, i.e. how fast will the innovation reach its market potential.

We label these two processes the "breadth" and "depth" of adoption, respectively.[5] While this distinction is often made in other disciplines, such as development economics,

[5] Conceptually, these two processes resemble the inter- and intra-organizational diffusion processes identified by Mansfield (1968): once a firm has put an innovation into use, a second part of the diffusion process is started, described by the number of units that firm is adopting over time.

political science and/or industrial economics,[6] it has been ignored in marketing, where the international diffusion literature has focused almost exclusively on the depth dimension (see Table 2).

There are a number of reasons why breadth and depth should be distinguished, even though the processes may not be independent from one another (e.g. because of the learning effect from which lagging countries can benefit). First, it is important to realize that the adoption processes on which breadth and depth are based are *conceptually* different. While the timing of initial adoption (or trial) by a market (either a country or a company) often depends on the most innovative members of the market, within-market diffusion depends on the entire distribution of innovativeness in the social system. Moreover, the two processes often involve different decision-making units (see Section 3.2 for a detailed discussion) and word of mouth for cross-market and within-market diffusion processes may be fundamentally different. While in the first case, communication happens across market boundaries (e.g. across different cultures, with different languages etc.), in the second case communication mostly occurs within a relatively homogeneous population. The latter distinction, however, is seldom made in multi-market diffusion models. For example, Mahajan and Muller (1994) use the same coefficient of external influence in both instances, as do Putsis et al. (1997).

Beyond the above mentioned theoretical reasons, there are also practical reasons why one would like to distinguish between breadth and depth. First, these two processes represent different managerial problems. How does one allocate marketing resources across countries (markets) versus how should one want to spend the marketing budget allocated to a country? These questions are related, but clearly separate managerial problems. Second, and more importantly, the type of data available to study international diffusion is often very different for breadth and depth processes. While the researcher typically faces dis-aggregate data for the breadth process, s/he needs to analyze aggregate data for the depth process. This in turn asks for different methodologies and analytic models (e.g. aggregate Bass-type models versus individual-level logit or hazard-rate models).

---

[6] See Dekimpe et al. (1996) for a more elaborate discussion on applications in other social-science

Finally, when assessing the market potential of a technological innovation, incomplete diffusion may occur when some fraction of the potential adopters in a given country has no (or not large enough) perceived utility from the innovation, *or* when some countries fail to allow the innovation, and therefore preclude its entire population from adopting the innovation (Mascarenhas 1992). Clearly, the latter scenario has much more drastic managerial implications, and may require different marketing strategies to overcome the barrier to adoption.

While previous research has naturally made the distinction between breadth and depth, in the sense that most studies have dealt with the depth issue, there is very little research which considers both sub-processes in a single modeling framework. Dekimpe et al. (1998a) link the two processes by simply including country adoption timing as an exogenous covariate in the within-country Bass model. A conceptually similar approach was used in Takada and Jain's two-step procedure (see also Ganesh and Kumar 1996 or Gaensh et al. 1997). While this simple approach is intuitive and easy to implement, a more appealing approach would be to simultaneously estimate both processes/dimensions in a single integrated model. Putsis et al. (1997) do model cross-country influences directly, but since they do not make a distinction between breadth and depth, their approach cannot offer insight into understanding which aspect of the global diffusion process is affected most by cross-country learning. Moreover, their approach may be hard to implement on a global basis, when more than 150 countries need to be taken into account. Dekimpe et al. (1998b) propose a coupled-hazard approach to simultaneously estimate the impact of international experience on both the time until trial of the new technology (breadth) and the time until full substitution of the old technology (depth), but their approach is only applicable when both dimensions can be described through individual-level models. More research is needed on how to jointly estimate both dimensions when they involve different decision-making units and/or involve a different level of data aggregation.

---

disciplines.

### 3.2 The Importance of a Central Decision-Making Unit

One of the reasons why breadth and depth are conceptually different processes is that they might involve different decision makers. In the context of global diffusion, the initial adoption of most products is likely to be regulated or administered by a bureaucracy or the government. In the case of telecommunication products, the local PTTs (for most European countries) or other agencies (e.g. the FCC in the US) decide on standards and regulations before any service is offered. A similar situation holds for most medical products, and even for common commodities such as food. Once the admission to distribute the product/technology in a given country has been granted, the depth or within-country diffusion process starts, which normally involves individual consumers (in case of consumer durables) or firms (e.g. for retail point-of-sales scanners – Ganesh and Kumar 1996). A similar distinction with respect to the relevant decision-making unit is observed in the context of inter- versus intra-firm diffusion. While trial is typically the decision of management (or a centralized buying unit), subsequent intra-firm diffusion is largely a function of the employees who are supposed to use the innovation on a daily basis (Kim and Srivastava 1994; van Everdingen 1995).

In some instances, the central decision-making unit may drive not only the breadth dimension, but also the subsequent speed of within-country diffusion. Dekimpe et al. (1998b), for example, consider the global diffusion of digital telephone lines. Both the initial trial decision (the first set of analog lines replaced by digitial lines) and the subsequent speed of substitution are not made by individual consumers, but by a central decision-making unit in each country.

The presence/absence of a central decision-making unit may have profound implications on both the observed diffusion patterns and the modeling approaches used to describe them. First, when the individual consumer is the decision maker (as is the case when dealing with consumer durables), individual-level information on each consumer's adoption timing is typically not available, and only aggregate-level diffusion models can be estimated (see also Section 3.1). On the other hand, when the decision-making unit is an organization or a bureaucracy, it might be possible to collect data on its characteristics and estimate a disaggregate model. Second, the presence of a central decision making unit may introduce discontinuities in the within-country diffusion pattern. Countries like Gabon, Gambia and Jamaica, for example, implemented digital telecommunications systems on an ubiquitous basis within their first year of adoption (Dekimpe et al. 1998b). This type of adoption runs counter to the notion that adoption patterns within a social system follow an S-shaped penetration curve in every single country, and invalidates the use of traditional diffusion models to compare the substitution speed across countries. Finally, observed differences in the countries' diffusion pattern may not be due to differences in their population's innovativeness, but may be driven by the differing influence (e.g. more or less restrictive) of the respective central decision-making units. Moreover, as their influence may vary across product categories (e.g. very high for military applications but low for sportswear), the derivation of empirical generalizations will, once more, be difficult. We therefore feel that more research is needed on how to best capture or control for the moderating influence of this central decision-making unit on international diffusion patterns (as Robertson and Wind 1980 did for organizational innovativeness). We are not aware of any studies that have already taken up this challenge. The obvious reason is that relatively little data exists on the actual decision making process across markets.

### 3.3 Centralized Versus Decentralized Diffusion Processes

A related issue, which has been largely neglected in the context of multi-market diffusion, is the distinction between *centralized* and *decentralized* processes (Rogers 1983). Centralized processes are the ones where the firm (or the change agent) controls and actively initiates the diffusion of the innovation, while decentralized processes are the ones where there is no single agent controlling the process. In the context of global diffusion, for example, we might talk about the diffusion of an individual brand. This is a centralized diffusion process where the firm controls, to the extent it can, the diffusion of the innovation. Kalish et al. (1995) explicitly deal with a centralized diffusion process in their normative model on whether firms should use a waterfall or sprinkler strategy when introducing a new product in the global market place.

A decentralized diffusion process, on the other hand, often governs the diffusion of a product category (e.g. mobile telecommunication services), where several firms drive the process and where large-scale coordination between these firms is not present. It should be noted, however, that even in the case of individual brands, interventions from local governments may render an intrinsically centralized process de-centralized. Indeed, as indicated before, governmental permission is often needed before the actual distribution of a new product in a given country can start, in which case the realized (i.e. observed) global diffusion process will no longer be driven predominantly by the brands' management. Almost all descriptive international diffusion studies have been of a decentralized nature, and little empirical evidence is available on the diffusion path emerging from centralized processes. An exception is the work by Gielens et al. (1998), who model the internationalization decision of European food retailers as a centralized diffusion process. Still, more empirical work is needed on the latter, as there is no a priori reason to believe that both types of processes would be qualititatively similar.

From a modeling point of view, the distinction between centralized and decentralized diffusion can be achieved at two separate levels. Pragmatically, one can just adjust the nature of the included variables, and add variables describing the various change agents involved, rather than just aggregate market descriptors. Alternatively, one could model decentralized international diffusion processes as the sum of a set of interacting, centralized processes. For example, the global diffusion of a product category could be modeled as the sum of the international diffusion paths of the different brands in that category. The latter approach is likely to provide better insights into the impact of the competitive structure and activities on international diffusion decisions (see Gielens et al. 1988 for a more detailed discussion), and offers a promising avenue for future research.

### 3.4 Sample Matching Requirement

Sample matching is a requirement in situations where the researcher compares two or more different samples or populations. Broadly speaking, sample matching requires the units of observation to be comparable across samples. The concept is wellaccepted, and regularly used, in behavioral cross-cultural research (see Dawar and Parker 1994; Douglas S.P. and C.S. Craig 1983; Kale and Sudharshan 1987; Levitt 1983; Seth 1986 and Simmonds 1985). In the context of international diffusion, sample matching essentially forces the diffusion researcher to make comparisons among comparable social networks. Thus, in order to make meaningful cross-country comparisons, penetration levels and market potential should be calculated using the *relevant* population instead of simple industry standards based on the *total* population in a given region. For example, to explain the diffusion of farm equipment across countries, one has to use penetration levels among farmers (who are the only potential users of such products), not the entire population. From a methodological point of view, this means that "the market potential" within each country (or market) has to be determined with *separate* (analytic) models and *prior* to the use of any diffusion model (see Dekimpe et al. 1998a for a detailed description of such staged estimation procedures). The idea is not entirely new to diffusion researchers. Many studies have argued that the market potential in diffusion models should not be estimated with diffusion data but determined in advance, and subsequently included in the diffusion model as an exogenous parameter (see e.g. Van den Bulte and Lilien 1997 for a recent review). While the basic arguments in those studies were of a statistical nature (namely that diffusion data provide unreliable estimates of the market potential), our sample matching argument is conceptual in nature.

While sample matching is a standard procedure in behavioral studies comparing multiple countries/populations, it is not typical in international or multi-market diffusion studies. As Table 2 shows, few international diffusion studies can claim to have matched samples. An exception is Dekimpe et al. (1998a) who perform sample matching in a study comparing the diffusion of mobile telecommunications services across over 70 countries, and who define their relevant target population as "the fraction of the literate population living in urban areas having a sufficient income to afford basic telephone service." They show (see figure 1 on page 115) that their proposed heuristic method has a dramatic impact on parameter estimates, and leads to very different conclusions on what drives the diffusion process within countries. The potential for sample matching was also touched upon by Putsis et al. (1997, footnote 11) in their discussion on the relevant market size for VCR's: the "standard" population variable, or the number of households owing a television, and implemented in Ganesh and Kumar (1996) who defined their relevant market potentials as the total number of retail outlets in each country.

How to do sample matching in a global or multi-market diffusion context is far from resolved, however, and is definitely a fruitful area for future research. While the concept does not easily lend itself to systematic methods because of its fundamentally idiosyncratic nature, guidelines on how to perform sample matching, what models to use, and how to test the robustness of alternative definitions are issues which deserve further investigation, especially given their potential impact on the results of any empirical investigation.

### 3.5 Left-Hand Truncation Bias

The problem of left-hand truncation is not unrelated to the concept of sample matching. Instead of matching markets (countries) in terms of their potential, however, taking care of left-hand truncation makes sure that markets (countries) are matched in terms of the time of origin of the within-country diffusion process. This ensures that meaningful comparisons across countries are possible because "time" reflects the same stage of the within-market diffusion process. This in turn leads to meaningful insights with respect to the impact of market characteristics on the diffusion pattern. If one ignores that country-level diffusion patterns have different origins in time, time-specific cross-sectional measures will reflect a different temporal stage of each country's penetration curve, leading to biased estimates and wrong interpretations. Indeed, assuming a fixed temporal window for all markets when markets started the diffusion process at a different points in time means that some diffusion curves are truncated to the left. This truncation inflates the intercept value of their penetration curve and, therefore, the estimates of early adoption levels (see Dekimpe et al. 1998a and Parker 1994 for further discussion). In other words, the markets in question would seem to have fast initial penetration rates (see Figure 1 in Dekimpe et al. 1998a), while those values actually represent the penetration level at a later stage of the diffusion process.

Adjusting for a comparable time of origin across markets (countries) is relatively easy if the time of origin of the within-market (country) adoption process is known. However, for the case when country adoption timing is not known, there is no standard procedure to deal with left-hand truncation bias. This might be the reason for the fact that many prior studies comparing within-country diffusion curves have failed to adjust for a comparable time of origin across countries. Table 2 shows that almost all previous research is likely to exhibit left-hand truncation bias. How serious this bias is depends on the cross-sectional variance of country adoption timing and the choice of the observation window. A clear opportunity for future research is how to deal with the left-hand truncation bias when the timing of adoption is unknown for the markets compared.

### 3.6 The Appropriate Level of Geographic Aggregation

Most papers in the international diffusion literature take the individual *country* as unit of analysis. Often, this choice will be driven by data-availability considerations. From a diffusion point of view, however, this choice may have some undesirable consequences. Indeed, this practice tends to make abstraction from any within-country heterogeneity, both in terms of adoption timing and in terms of subsequent word-of-mouth communication effects. In many instances, countries can actually be seen as "portfolios" of smaller countries or regions (Mahajan et al. 1998), each characterized by a vastly different market potential and differing rates of word-of-mouh communication (both within the region, and with members of other regions). Ignoring these regional differences may lead to sub-optimal decision making based on average estimates (ter Hofstede, Kim, Steenkamp & Wedel 1998).

The above argumentation would suggest the use of a smaller unit of analysis. On the other hand, one observes multiple attempts at dismantling geographic borders to stimulate the free flow of information, technologies and money (e.g. the European Community, NAFTA), and the question becomes whether these attempts will result in more homogenous diffusion patterns across the participating countries. Mahajan and Muller (1994) study in this respect whether the European Unification tends to accelerate the overall diffusion process, and find this only to be the case between countries which were a priori dissimilar in terms of the coefficients of internal and external influence. Interestingly, several country pairs (e.g. Belgium and The Netherlands) were found to have the same diffusion parameters prior to the unification, and hence to already form a homogenous region (at least in terms of their diffusion of video cassette recorders). More research is needed, however, to assess whether this finding is product-category specific, or a more general trait of the respective country pairs. Similarly, more research is needed on the substantive implications of Putsis et al.'s (1997) finding that their mixing parameter (describing the nature of the communication patterns in their cross-country diffusion framework) was the same for 10 European countries. Finally, Helsen et al. (1993) have used latent-class segmentation to group (fractions of) countries into broader, diffusion-based, segments, but found the results to be unstable across the three product categories studied (color TV sets, VCRs & CD players).

In sum, no consensus exists on the most appropriate unit of analysis in multi-region diffusion research. Compelling arguments can be given to not a priori restrict oneself to geographic (i.e. country-based) boundaries, but two opposite tendencies can be observed (not unlike the ones observed in politics): one focusing more on regional *differences within* a country, another emphasizing more the *similarities across* countries.

### 3.7 Supply Restrictions

The Bass model and its many extensions are intrinsically demand models. When the demand for a new product cannot be fully met (e.g. because of capacity constraints or distributional problems), the observed sales pattern will reflect the supply evolution over time, in which case the Bass model should not be applied (Jain, Mahajan and Muller 1991). While this result has been well documented in single-region applications of Bass-type diffusion models, its presence and severity may be harder to assess in a global study, especially when also incorporating less developed countries in the sample (cf. issue 2.1). As documented in Mahajan et al. (1998), companies tend to completely ignore major regions in most countries, thereby imposing implicit supply restrictions on the diffusion of the product. When countries are affected differently by these restrictions, across-country comparisons of the Bass-parameters may be misleading (Parker 1994).

## 4. LONG-RUN RESEARCH NEEDS

Thus far, we have identified a number of areas that researchers can pursue to immediately improve global diffusion modeling: (1) linking breadth and depth processes, (2) modeling the process at the central decision-making unit level, (3) formulating differences across centralized and decentralized diffusion processes, (4) developing better sample-matching methodologies, (5) collecting better data or developing techniques to control for left-hand truncation biases, (6) developing recommendations on how to aggregate across and within geographic regions, and (7) explicitly incorporating the supply-side, rather than only characterizing demand-side dynamics. In this section, we consider a number of "long-run" research agendas. Rather than build directly on the existing literature, the areas briefly outlined here may require more substantial investments in time and energy, as they will certainly require an interdisciplinary approach.

### 4.1 Explaining Spatial Auto-Correlation

In time-series analysis, we are accustomed to account for the interdependency of observations or the errors of regressions (which typically have positive serial auto-correlation). Once observations are collected on a geographic basis, we also need to be concerned with the interdependencies of observations. Casual observation makes clear that international data often exhibit strong spatial correlation. Countries adjacent to each other seem to exhibit more similar economic development patterns or adoption rates, than countries that are distant from each other. The tendency for geographically close observations to have similar economic, social, and cultural conditions can affect our interpretation of diffusion phenomena. Consider, for example, the degrees of freedom associated with a global diffusion study where each country is an observation. We have, then, some 200 observations to work with. Now suppose that each of the some 100 Departments in France each decide to declare "independence" and are subsequently recognized by the United Nations. Have our theoretical degrees of freedom actually increased to 300 observations, or is it somewhat less? How many truly independent observations are there across Europe's 39 countries? Would we ever expect radical differences in economic behaviors to be observed in Belgium, versus those in the

Netherlands, or the Netherlands and Germany, or Germany and Denmark, or Denmark and Sweden, etc.? The existence of strong geographic interdependence has given rise in some academic disciplines to "regional studies". While spatial diffusion processes have been considered in non-international contexts, no global diffusion study, to our knowledge, brings to bear the substantial methodological advances made by spatial econometricians; see Anselin 1988 for a complete review of spatial econometrics. If we hope to develop a detailed understanding of geographic diffusion processes, spatial economics can not be ignored.

### 4.2 Diffusion As an Outcome of an Economic Equilibrium

As mentioned earlier in our discussion of supply restrictions (Section 3.7), international diffusion models remain demand driven. As such, they describe some *reduced-form* economic process or equilibrium. Rational agents are simply not modeled. A fruitful avenue for future research would be to directly consider diffusion processes as a dynamic economic process whereby both prices and quantities are endogenous. We can easily imagine that as prices fall for a given innovation, countries with lower income will begin to adopt an innovation. Why might prices fall? In a model of temporal price discrimination, a monopolist would rationally reduce prices in the face of declining marginal costs, or elasticities. What will drive lower costs? Again, this will be a function of cross–country breadth and depth processes. Clearly, the two phenomena must be modeled in a *structural equations* framework. Fruitful methodological avenues, in this respect, have been pioneered in the literature covering new empirical industrial organization (NEIO); see Bresnahan (1989) for a review. Combining NEIO approaches with spatial diffusion modeling would represent a substantial breakthrough in both literature streams.

### 4.3 Diffusion Patterns: Cause or Consequence?

Diffusion research is at a crossroads. The field has been able to develop highly sophisticated specifications and estimation procedures to capture a rather robust pattern of demand dynamics. We have not, however, ventured far enough into asking basic questions with respect to the order of causality between the different processes of interest. For some innovations, breadth and depth of adoption closely corresponds to basic economic fundamentals whereby high income-per-capita countries adopt sooner and more so than low income countries. In the traditional economic growth literature, technological adoption and creation have been considered to be exogenous elements driving income. Recently, (see, for example, Barro 1997), economic growth and progress is endogenously driven by human capital based innovation. Our treatment of innovation adoption being driven by income begs the question: "which comes first?" If one precedes the other, then what fundamentally causes the first – be it innovation or income. Similar observations might be made of other explanatory variables in the extant diffusion literature (e.g. urbanization, political structure, ethnic mix). If causal mechanisms can be identified, these will provide a richer and more insightful explanation of innovation diffusion. Not only should we be able to describe the pattern, but also predict which product will diffuse where, and by how much – irrespective of income differences across countries. Which innovations will be bounded to poorer countries? Which will be bounded to wealthier countries? Current research on *physio-economic* explanations which draw upon biology, physiology, and economic geography may provide fruitful avenues in this regard (see, for example, Parker 1995, 1997d and Parker and Tavassoli 1998).

### 4.4 Non-Traditional Aggregation Mechanisms

Finally, the international diffusion literature has been a prisoner of data availability. The literature has generally used national boundaries as the defining characteristic of the unit of observation. In a world where political systems and economic policies are converging, we may need to consider non-national units of observations. For a number of products, the adoption unit may in fact be a religious order that dictates whether its members will have access to, or can use certain innovations. One might also see diffusion limited to ethnic, linguistic or other trans-national groups. Using countries as observations will become less meaningful for innovations sensitive to such decision-making units. Recently, Parker (1997a, 1997b, 1997c) has published adoption statistics for over 80 religious groups, 400 linguistic groups and 400 ethnic groups. The search for a single model that can explain adoption timing and depth across countries, but also across these trans-national groups, should be considered a long-run objective of global diffusion researchers.

## 5. CONCLUSION

Responding to the research needs emerging as a result of the globalization of the world economy, the diffusion literature has extended its scope to describe multi-market and/or cross-country diffusion processes. Using a variety of techniques in a variety of product contexts, the field has been able to generate a number of empirical generalizations. While these insights represent an important contribution for practitioners and academics, much remains to be done in order to fully understand how international markets evolve over time. In this chapter, we have tried to identify the most important areas that, we believe, would increase our understanding of global diffusion processes. We hope that the outlined research agenda will serve as a valuable resource for future researchers.

## REFERENCES


Anselin, L. (1988), *Spatial Econometrics: Methods and Models*, Kluwer Academic Publishers: Dordrecht.

Antonelli, C. (1993), "Investment and Adoption in Advanced Telecommunications," *Journal of Economic Behavior and Organization*, 20, 227-245.

Ayal, I. (1981), "International Product Life Cycle: A Reassessment and Product Policy Implications," *Journal of Marketing*, 45, 91-96.

Barro, Robert J. (1997), *Determinants of Economic Growth: A Cross-Country Empirical Study*, The MIT Press: Cambridge.

Bass, F.M. (1969), "A New Product Growth Model for Consumer Durables," *Management Science*, 15, 215-27.

Bresnahan, T. (1989), "Empirical Studies in Industries with Market Power," in the Handbook of Industrial Organization, Vol 2. 1011-1058.

Chatterjee, R. and J. Eliashberg (1990), "Innovation Diffusion Process: A Micro-Modeling Approach," *Management Science*, 36, 1057-1079.

Craig, C.S., S.P. Douglas and A. Grein (1992), "Patterns of Convergence and Divergence Among Industrialized Nations: 1960-1988," *Journal of International Business Studies*, 23, 773-787.

Dawar, N. & P.M. Parker (1994), "Marketing Universals: Consumers' Use of Brand Name, Price, Physical Appearance and Retailer Reputation as a Signal of Product Quality," *Journal of Marketing*, 58, 81-95.

Dekimpe, M.G., P.M. Parker and M. Sarvary (1996), "Globalization: Modeling Technology Adoption Timing Across Countries," Working Paper 96/38/MKT, INSEAD.

Dekimpe, M.G., P.M. Parker and M. Sarvary (1998a), "Forecasting the Diffusion Pattern of Cellular Telecommunications on the Country Level Using a Staged Estimation Approach," *Technological Forecasting and Social Change*, 57, 105-132.

Dekimpe, M.G., P.M. Parker and M. Sarvary (1998b), "Global Diffusion of Technological Innovations: A Coupled- Hazard Approach," Working Paper, Stanford University, #1508.

Douglas, P.S. and C.S. Craig (1983), International Marketing Research, Englewood Cliffs, NJ Prentice Hall.

Douglas, P.S. and C.S. Craig (1992), "Advances in International Marketing," *International Journal of Research in Marketing*, 9, 291-318.

Eliashberg, J. & K. Helsen (1996), "Modeling lead/lag Phenomena in Global Marketing: The case of VCRs," Working Paper, University of Pennsylvania.

Ganesh, J. and V. Kumar (1996), "Capturing the Cross-national Learning Effect: An Analysis of an Industrial Technology Diffusion," *Journal of the Academy of Marketing Science*, 24, 328-337.

Ganesh, J., V. Kumar and V. Subramaniam (1997), "Learning Effect in Multinational Diffusion of Consumer Durables: An Exploratory Investigation," *Journal of the Academy of Marketing Science*, 25, 214-228.

Gatignon, H., J. Eliashberg & T.S. Robertson (1989), "Modeling Multinational Diffusion Patterns: An Efficient Methodology," *Marketing Science*, 8, 231-247.

Gatignon, H. & T.S. Robertson (1985), "A Propositional Inventory for New Diffusion Research," *Journal of Consumer Research*, 11, 849-867.

Gielens, K., M.G. Dekimpe & K. Debackere (1998), "Global Retailing: Why the Shop around the Corner is no Longer just the Shop around the Corner," paper presented at the Marketing Science Conference, INSEAD.

Glenn, J.C. & T.J. Gordon (1997), "The Millennium Project: 1997 State of the Future – Implications for Actions Today," *Technological Forecasting and Social Change*, 56, 203-296.

Heeler, R.M. & T.P. Hustad (1980), "Problems in Predicting New Product growth for Consumer Durables," *Management Science*, 26, 1007-1-20.

Helsen, K., Jedidi, K. and W.S. DeSarbo (1993), "A New Approach to Country Segmentation Utilizing Multinational Diffusion Patterns," *Journal of Marketing*, 57, 60-71.

Jain, D.C. & S. Maesincee (1995), "Cultural Influences on Global Product Diffusion: Modeling and Empirical Analysis," Unpublished Manuscript, Nothwestern University.

Jain, D.C., V. Mahajan & E. Muller (1991), "Innovation Diffusion in the Presence of Supply Restrictions," *Marketing Science*, 10, 83-90.

Kale, S. and D. Sudharshan (1987), "Strategic Approach to International Segmentation," *International Journal of Advertising*, 2 (3), 147-57.

Kalish, S., V. Mahajan and E. Muller (1995), "Waterfall and Sprinkler New-Product Strategies in Competitive Global Markets," *International Journal of Research in Marketing*, 12, 105-119.

Kim, N. and R. Srivastava (1994), "Intra-organizational Diffusion of Technological Products: The Framework, Research Propositions and Managerial Implications," Unpublished Manuscript, Hong Kong University of Science and Technology.

Kumar, V., J. Ganesh and R. Echambadi, (1998), "Cross-National Diffusion Research: What Do We Know and How Certain Are We?," *Journal of Product Innovation Management*, 15, 255-268.

Lee, C. (1990), "Determinants of National Innovativeness and International Market Segmentation," *International Marketing Review*," 7, 39-49.

Levitt, T. (1983), "The Globalization of Markets", *Harvard Business Review*, 61, 92-102.

Lindberg, B.C. (1982), "International Comparison of Growth in Demand for a New durable Consumer Product," *Journal of Marketing Research*, 19, 364-371.

Lynn, M. & B. Gelb (1996), "Identifying Innovative National Markets for Technical Consumer Goods," *International Marketing Review*, 13, 43-57.

Mahajan, V. and E. Muller (1994), "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*, 45, 221-237.

Mahajan, V., E. Muller and F.M. Bass (1990), "New Product Diffusion Models in Marketing: A Review and Directions for Research," *Journal of Marketing*, 54, 1-26.

Mahajan, V., E. Muller and F.M. Bass (1993), "New Product Diffusion Models," in J. Eliashberg & G.L. Lilien (Eds.), *Handbooks in Operations Research and Management Science*, Vol 5, 349-408.

Mahajan, V. and R. Peterson (1979), "Integrating Time and Space in Technological Substitution Models," *Technological Forecasting and Social Change*, 14, 231-241.

Mahajan, V., M.V. Pratini de Morales & J. Wind (1998), "The Invisible Global Market: Strategies for Reaching the Forgotten 86 Percent of the World," Unpublished Manuscript.

Mansfield, E. (1968), *Industrial Research and Technological Innovation: An Econometric Analysis*, New York: W.W. Norton and Co.

Mansfield, E. (1993), "The Diffusion of Flexible Manufacturing Systems in Japan, Europe and the United States," *Management Science*, 39, 149-159.

Mascarenhas, B. (1992), "Order of Entry and Performance in International Markets," *Strategic Management Journal*, 13, 499-510.

Parker, P.M. (1994), "Aggregate Diffusion Forecasting Models in Marketing: A Critical Review," *International Journal of Forecasting*, 10, 353-380.

Parker, P.M. (1995), *Climatic Effects on Individual, Social and Economic Behavior: A Physioeconomic Review Across Disciplines*, Greenwood Press: Westport, Conn.

Parker, P.M. (1997a), *Religious Cultures of the World: A Statistical Reference*, Greenwood Press: Westport Conn.

Parker, P.M. (1997b), *Linguistic Cultures of the World: A Statistical Reference*, Greenwood Press: Westport Conn.

Parker, P.M. (1997c), *Ethnic Cultures of the World: A Statistical Reference*, Greenwood Press: Westport Conn.

Parker, P.M. (1997d), *National Cultures of the World: A Statistical Reference*, Greenwood Press: Westport Conn.

Parker, P.M. and N. Tavassoli (1998) "A Physioeconomic Explanation of Consumption Patterns Across Cultures," working paper MIT, Marketing Department, Sloan School of Management, and INSEAD.

Putsis, W.P, S. Balasubramanian, E.H. Kaplan & S. Sen (1997), "Mixing Behavior in Cross-Country Diffusion," *Marketing Science*, 16, 354-369.

Robertson, T.S. and Y. Wind (1980), "Organizational Psychographics and Innovativeness," *Journal of Consumer Research*, 7, 24-31.

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

Sheth, J. (1986), "Global Markets or Global Competition," *Journal of Consumer Marketing*, 3, 9-11.

Simmonds, K. (1985), "Global Strategy: Achieving the Geocentric Ideal," *International Marketing Review*, 2, 8-17.

Sultan, F., J.U. Farley & D.R. Lehmann (1990), "A Meta-Analysis of Applications of Diffusion Models," *Journal of Marketing Research*, 27, 70-77.

Takada, H. and D. Jain (1991), "Cross-National Analysis of Diffusion of Consumer Durable Goods in Pacific Rim Countries," *Journal of Marketing*, 55, 48-54.

Ter Hofstede, F., Y. Kim, M. Wedel & J.B.E.M. Steenkamp (1998), "A Bayesian Segmentation Model for Target Market Selection in International Retail Markets," paper presented at the Marketing Science Conference, INSEAD.

Van den Bulte, C. & G.L. Lilien (1997), "Bias and Systematic Change in the Parameter Estimates of Macro-Level Diffusion Models," *Marketing Science*, 16, 4, 338-353.

Van Everdingen, Y.M., *Adoption and Diffusion of the European Currency Unit*, Tinbergen Institute Research Series #95.

Vernon, R. (1979), "The Product Cycle Hypothesis in a New International Environment," *Oxford Bulletin of Economics and Statistics*, 41, 255-267.

## TABLE 1: SUMMARY OF INTERNATIONAL DIFFUSION STUDIES

| Reference | Countries included | Product category | Variables/factors included | Main conclusions with respect to the covariates |
|---|---|---|---|---|
| Dekimpe et. al. (1998a) | 74 Worldwide | 1 service | Population growth<br># of pop. centers<br>GNP/capita<br>Death rate<br>Communist dummy<br># of competitors<br># of ethnic groups<br># of adopting countries<br># of similar adopting countries | GNP has no effect and death rate has a negative effect on diffusion parameters.<br># of population centers has a positive effect on imitation but a negative effect on innovation.<br>Population growth has a positive effect on innovation.<br>Competition positively affects innovation.<br>Ethnic heterogeneity negatively affects both diffusion parameters. |
| Dekimpe et. al. (1996) | 184 Worldwide | 1 service | Population growth<br># of pop. centers<br>GNP/capita<br>Communist dummy<br># of ethnic groups<br># of similar adopting countries | GNP/cap. # of population centers and # of similar adopting countries has a negative effect while ethnic heterogeneity has a positive effect on country adoption timing.<br>Countries affect each others adoption timing. |
| Dekimpe et. al. (1998b) | 160 Worldwide | 1 industrial product | GNP/capita<br># of ethnic groups<br>Installed base of old technology | GNP has a positive effect on both country adoption timing and within country diffusion.<br>Ethnic heterogeneity and the installed base of old technology has a negative effect on the timing of full substitution.<br>Later adopters have faster within-country diffusion rates. |
| Eliashberg and Helsen (1996) | 13 Europe | 1 durable | none | Bi-country lead effects need not necessarily be positive |
| Ganesh and Kumar (1997) | 10 (Europe, Japan, US) | 1 retail scanners | Adopters in lead country (US)<br>Competition (population/outlet) | A positive lead effect exists from the lead country on the lag countries;<br>The size of the lead effect is not homogenous. |
| Ganesh et al. (1996) | 11 to 16 | 4 durables | Geographical, cultural, economic similarity<br>Time lag<br>(Dis)continous innov.<br>Technical standard present | Cross-country learning effect is function of<br>• cultural similarity<br>• economic similarity<br>• time lag<br>• type of innovation<br>• existence of technical standard<br>but not of geographic proximity. |
| Gatignon et. al. (1989) | 14 Europe | 6 durables | Cosmopolitanism<br>Mobility<br>Women in the labor force | Cosmopolitanism relates positively to the innovation coefficient.<br>The effects of mobility and women in the labor force depend on the product context. |

**Table 1 (continued)**

| | | | | |
|---|---|---|---|---|
| Heeler and Hustad (1980) | 16 Worldwide | 10 durables + a drug | none | The value of Bass-model as a predictive tool is limited in international settings. |
| Helsen et. al. (1993) | 12 Europe and U.S. | 3 durables | Mobility, Health, Trade, Lifestyle, Cosmopolitanism | Wealth and health status are positively related to innovation and imitation coefficients. |
| Jain and Maesincee (1995) | 14 Europe | 6 durables | Cultural factors: uncertainty avoidance & individuality | Cultural factors affect the diffusion parameters; This impact may vary by product category; Adjusting for cultural factors reduces size of learning effect. |
| Mahajan and Peterson (1979) | 1 (25 US states) | industrial product | Distance from the innovative region | The rate of substitution decreases with the distance from the innovative region. |
| Mahajan and Muller (1994) | 16 Europe | 1 durable | none | Diffusion parameters vary across countries. |
| Putsis et al. (1997) | 10 Europe | 4 durables | TV ownership GNP/capita | TV ownership and GNP/capita have a positive impact on the speed of diffusion. |
| Takada and Jain (1991) | 4 Pacific Rim | 8 durables | Context culture (social system homogeneity) | Imitation parameters are higher in homogenous social systems. Countries adopting later have faster diffusion rates. |

## TABLE 2: METHODOLOGY IN INTERNATIONAL DIFFUSION RESEARCH

| Reference | Model type | Diffusion stages | Sample matching | Left hand truncation bias |
|---|---|---|---|---|
| Dekimpe et. al. (1998a) | Bass | Depth | Yes | No |
| Dekimpe et. al. (1996) | Hazard | Breadth | N/A | N/A |
| Dekimpe et. al. (1998b) | Coupled-hazard | Breadth/Depth | Yes | No |
| Eliashberg and Helsen (1996) | Bass | Depth | No | No |
| Ganesh and Kumar (1996) | Bass | Depth | Yes | No |
| Ganesh et al. (1997) | Bass | Depth | No | No |
| Gatignon et. al. (1989) | Bass | Depth | No | Yes |
| Heeler and Hustad (1980) | Bass | Depth | No | Yes |
| Helsen et. al. (1993) | Bass | Depth | No | No |
| Jain and Maesincee (1995) | Modified Bass | Depth | No | Yes |
| Mahajan and Peterson (1979) | Modified Bass | Depth | Yes | Yes |
| Mahajan and Muller (1994) | Bass | Depth | No | Yes |
| Putsis et al. (1997) | Modified Bass | Depth | No | No |
| Takada and Jain (1991) | Bass | Depth | No | Partial |

## TABLE 3: MULTI-ITEM MEASURES PROPOSED FOR INTERNATIONAL DIFFUSION RESEARCH

| Dimension | Factor* | Variable** |
|---|---|---|
| Politics | Centrality of the government | Number of parties, % share of largest party in government, % share of top two parties in government. |
| | Internal tensions | Number of changes in government since 1960, Number of visas needed, Number of civil wars. |
| | International tensions | Number of border disputes, Number of international wars |
| | Year of Independence | Year of independence |
| Socio-economics | Wealth | GNP/capita, Death rate, Birth rate, Fertility, Female life expectancy, Male life expectancy, Infant mortality, Number of major diseases, Literacy rate, Electricity consumption/capita, Televisions/capita, Telephones/capita. |
| Demographics | Population density | % population in cities, Population/ Area, % population in largest city. |
| | Population dynamics | Migration/inhabitant, Population growth, |
| | Population | Population size |
| Culture | Social Heterogeneity | # of ethnic groups, % of population in largest ethnic group, Number of languages, % population in largest language group. |
| | Anglo-German | % population in largest religious group, % Anglican population, % Protestant population. |
| | Latin | % Christian population, % Islamic population (-), % of Roman Catholics, % os Spanish speakers |
| | Asian | Number of religions, % Buddhist population, % Hindu population, % English speakers. |
| Climate | Temperate | Latitude, Average temperature, Monthly high temperature, Monthly low temperature, Monthly max. rain. |
| | Humidity | Morning min-max. humidity, Afternoon max. humidity. |
| | Rain | Afternoon min. humidity, Monthly min. rain, Barometric pressure. |
| Geography | Area | Total area, Inland waterways, Number of boundaries, Length of boundary, Number of natural minerals. |
| | Sea | Length of coastline, Water area, Fish supply. |
| | Elevation | Elevation, Sea territory (-). |

* : All factors have eigenvalues higher than 1.
**: All variables have loadings higher than 0.5.