Investigating New Product Diffusion across Products and Countries

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Appendix

In this appendix we discuss the following in greater detail than was possible in the Journal article:

1. Information about the period of data that are used in our analysis.
2. Robustness Analysis

1. Data on Product Introduction Years

The product introduction years across the 6 products and 31 countries used in our study are reported in Table 1 below. We note that there is some debate in the existing literature (e.g., Van den Bulte 2000) as to the "correct" introduction years for various consumer durable goods. It is usually hard to "pinpoint" the exact year of commercial introduction of a new product in a country, which has thus resulted in contradicting claims in some instances. That has been the case even for developed countries like the USA, which usually has a much well documented record for such events. For example, the introduction year for microwaves in the USA has differed by as many as ten years across studies (Van den Bulte 2000). Given the wide scope (both country and product wise) of our study, collection of such product introduction year data was particularly challenging, especially for the developing countries. Under the circumstances, we used what we believe is a practical and yet reasonable approach from our research perspective as follows.

We started with the assumption that the earliest year for which the data has been reported in any of our data sources – the Euromonitor publications, ITU database and the World Bank database – is the year of introduction for a given country for a given product. Wherever possible, we checked that assumption by looking through the statistical publications of respective countries available at various country and regional divisions at the World Bank, and made corrections if necessary. We also compared our data with other published studies on international diffusion. For example, we found our independently collected data to be very similar to the one used in Putsis et al. paper (1997) for the common set of products and developed countries. Finally, as a "face validity" test for our final selection of the introduction years of all the product/country combinations, we looked at the sales for that year as percentage of population. In every case, it was extremely small (0.05% or much lower). This gives us additional confidence in our selection of introduction year data across products and countries. While we recognize the possibility that the introduction years used in our analysis may not be the most accurate such data, we feel that they are likely to be reasonably accurate for the aforesaid reasons.

Table 1. Introduction years across countries across products for our data analyses

Country	VCR player (1976)*	CD player (1984)	Microwave (1975)	Camcorder (1984)	Fax machine (1979)	Cell phones (1981)
Argentina	1978	1986	1977	1989	1983	1984
Australia	1977	1984	1975	1986	1980	1984
Austria	1977	1984	1975	1986	1980	1981
Belgium	1977	1984	1975	1983	1982	1981
Brazil	1978	1986	1977	1990	1983	1987
Canada	1976	1984	1975	1986	1980	1984
Chile	1979	1986	1977	1990	1985	1985
China	1980	1987	1983	1990	1984	1989
Denmark	1977	1984	1975	1986	1980	1981
Finland	1978	1984	1975	1986	1980	1981
France	1977	1984	1975	1985	1980	1981
Germany	1976	1984	1975	1986	1980	1982
Greece	1978	1987	1980	1989	1984	1986
Hong Kong	1980	1984	1977	1986	1980	1984
India	1981	1987	1985	1990	1985	1992
Ireland	1977	1987	1975	1988	1980	1983
Italy	1977	1984	1975	1986	1980	1981
Malaysia	1979	1987	1980	1986	1984	1984
Mexico	1977	1987	1977	1986	1980	1988
Netherland	1977	1984	1975	1986	1980	1981
Norway	1977	1984	1975	1986	1980	1981
Philippines	1980	1987	1980	1990	1985	1987
Portugal	1978	1987	1980	1987	1983	1987
Singapore	1979	1984	1980	1986	1980	1987
South Korea	1979	1986	1980	1986	1982	1986
Spain	1977	1984	1975	1986	1980	1986
Sweden	1977	1984	1975	1986	1979	1981
Switzerland	1977	1984	1975	1985	1979	1984
Thailand	1980	1987	1980	1990	1984	1986
UK	1976	1984	1975	1985	1980	1984
USA	1976	1984	1975	1984	1980	1984

* Earliest introduction year for the entire set of countries is shown in parentheses for each product.

2. Robustness Analysis

In this section, we discuss in detail the robustness tests we performed. We address three data and modeling related issues:

1. Are the results sensitive to the whether we use adoption rather than sales data?
2. Is it important to account for serial correlation in a diffusion model?
3. How robust are the results to whether consumer or business products are included?

Sensitivity to Use of Sales Data

Ideally we would like to have adoption data (by separating repeat purchases from sales data) in estimating a diffusion model. In practice it is hard to get access to such information across a wide range of countries. So we have used sales data in this paper. We used only 9 periods of data in order to limit the impact of repeat purchases on the diffusion model parameters in our primary analysis. Since all products we analyze are durable goods, we assumed that there would be limited repeat purchases within 9 periods. To test the robustness of this assumption on the results, we also estimated the model with only 7 periods of data to see if our estimates for the hierarchical regressors change much between the 7 and 9 period models. The 7 period estimates are reported in column II of Table 2. For comparison, we report the same results from the basic estimation reported in the article in Column 1. We find that the estimates for the 7 period and 9 period models are quite similar and there are no significant differences between the two sets of estimates. We therefore conclude that the discrepancy between adoption and sales data (due to replacement sales) do not cause a significant impact on the estimates of interest, since we restricted our analysis to data for only 9 periods.

Accounting for serial correlation

Diffusion models typically do not account for the serial correlation in errors in the sales equations between successive time periods as we do in this paper[1]. Econometric theory tells us that not accounting for serial correlation in a model will not bias, but can reduce the efficiency of the estimates (Greene 2000). Therefore as long as the α, p and q are estimated without bias, we do not expect bias on the hierarchical regressors. But the

[1] For an exception, see Van den Bulte's (2000) estimation of a logistic model of diffusion speed.

lower efficiency of α, p and q estimates may reduce the efficiency of the hierarchical regressors. We empirically evaluated the importance of accounting for autocorrelation (AR (1) errors) on the hierarchical estimates. The results of the model without autocorrelation are reported in the column III of Table 2. We do not find any significant differences in the estimates, but the standard errors of the estimates for many parameters in the model where autocorrelation is accounted for are marginally lower, but it has no impact on the substantive inferences that we make. Theoretically it is possible to dismiss important explanatory variables as insignificant by not accounting for serial correlation in the errors, but empirically we find that this issue has very little impact on the results in this paper.

Accounting for differences in products

One issue that is relevant in estimating a model across products and countries is whether the country effects are stable across all products. For example, while most of the products in our analysis are pure consumer products (VCR, Camcorder, Microwave and CD players), some are used both by businesses as well consumers (Cell phones and Fax machines). To see if these effects are different for the two types of product categories, we estimated a model with just the four pure consumer products. We found that estimates of hierarchical regressors are quite similar for both categories, except for a few variables. We discuss the differences below. The estimates are reported in column IV of Table 2.

There were hardly any differences in the estimates of penetration level. The effect of newspapers on the coefficient of external influence became insignificant once we dropped the two business & consumer products. This indicates that print media are probably more effective as an information source for business-oriented products than for marketing consumer-oriented products. In contrast the significance levels of TV increased to become very close to a p-value of 0.1, indicating that for consumer products television is relatively more important than newspapers as an advertising medium. With respect to the coefficient of internal influence, the *Gini Index* becomes significant when we consider only consumer products. This is not surprising when one recognizes that greater income disparities in the general population are likely to be less of an impediment to communication process among potential adopters for products targeted towards businesses than those aimed solely towards individual consumers.

Table 2: Robustness Checks

	I (9 Per, 6 Prod, AR)	II (7 Per, 6 Prod, AR)	III (9 Per, 6 Prod, No AR)	IV (9 Per, 4 Prod, AR)
Variables	**Estimate (P Val)[1]**	**Estimate (P Val)**	**Estimate (P Val)**	**Estimate (P Val)**
Penetration Level				
Intercept	-1.7850, (0.0)***	-2.1040, (0.0)***	-1.3070, (0.0)***	-1.5870, (0.0)***
PPP Adjusted Per Capita Income	0.3125, (0.031)**	0.8799, (0.0)***	0.4670, (0.004)***	0.2931, (0.035)**
Dependents- Working People Ratio	-0.1279, (0.189)	-0.0549, (0.363)	-0.1203, (0.205)	-0.0825, (0.26)
Gini Index	-0.0118, (0.457)	0.1372, (0.225)	-0.0121, (0.456)	-0.1411, (0.153)
Urbanization	0.1554, (0.100)*	0.1235, (0.213)	0.0615, (0.3)	0.1998, (0.042)**
International Trade	0.4882, (0.0)***	0.5296, (0.0)***	0.5161, (0.0)***	0.3869, (0.0)***
TV penetration on VCRs	0.1196, (0.175)	-0.0640, (0.296)	0.1359, (0.138)	-0.0103, (0.471)
TV penetration on Camcorders	0.1168, (0.22)	0.2161, (0.142)	0.0931, (0.257)	0.1871, (0.089)*
Telephone Wait List on Cell Phones	0.1784, (0.142)	0.0314, (0.437)	0.0672, (0.367)	-
Telephone Penetration on Fax	-0.0718, (0.35)	-0.3858, (0.143)	0.0673, (0.375)	-
External Influence				
Intercept	-10.2700, (0.0)***	-9.5640, (0.0)***	-11.7400, (0.0)***	-9.2000, (0.0)***
TV Penetration	0.1035, (0.323)	-0.2591, (0.14)	0.0058, (0.474)	0.1938, (0.112)
Newspapers	0.2523, (0.033)**	0.2545, (0.083)*	0.2499, (0.065)*	0.0853, (0.244)
Illiteracy	-0.5812, (0.004)***	-0.7329, (0.0)***	-0.6021, (0.001)***	-0.4429, (0.007)***
External Contact	-0.0465, (0.371)	-0.1684, (0.168)	-0.0532, (0.356)	0.0439, (0.361)
Introductory Lag (Years)	-1.0120, (0.0)***	-1.3100, (0.0)***	-0.9514, (0.0)***	-1.0620, (0.0)***
Internal Influence				
Intercept	-0.6607, (0.0)***	-0.2070, (0.0)***	-0.5894, (0.0)***	-0.7023, (0.0)***
Gini Index	0.0273, (0.202)	0.0173, (0.321)	0.0293, (0.164)	0.0634, (0.053)*
Number of Ethnicities	-0.0305, (0.098)*	-0.0137, (0.283)	-0.0315, (0.061)*	-0.0204, (0.216)
Women in Labor Force (%)	0.0285, (0.142)	0.0198, (0.245)	0.0243, (0.148)	0.0279, (0.168)
Introductory Lag (Years)	0.0531, (0.032)**	0.0957, (0.003)***	0.0460, (0.052)*	0.0503, (0.068)*

[1] We compute Bayesian analog of a p-statistic. A value of 0.05 means that 95% of the posterior mass lies to one side of 0, and 0.05% to the other side. The asterisks indicate the level of significance: *** 1% level; ** 5% level; and * 10% level.

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