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Product Innovation and Product Innovation Marketing: Theory and Microeconometric Evidence

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Abstract: This paper derives a three stage Cournot–oligopoly game for product innovation, expenditure on introducing the product and competition on the product market. Product innovation is assumed to increase consumer utility but is effective only if the innovating firm invests in marketing, so that consumers become aware of the newly developed product. Firms first decide whether or not to conduct product innovation and then determine their expenditure for bringing the new product to the market. In the final stage of the game, they are involved in competition on the product market .

Key findings of the theoretical model are that both the marketing of a product innovation and a firm's propensity to introduce an innovation decrease with an increase in the number of competitors and the degree of product substitutability. An increase in market demand has a positive effect on product innovation and marketing effort.

These findings are tested empirically using survey data from 519 German service sector firms which mainly produce consumer goods. A simultaneous sequential Tobit model is applied in the empirical part of this paper. It turns out that the predictions of the theoretical model are supported by the empirical findings.

Keywords: econometric models, game theory, new product research

JEL classification: L2, C34

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Non–technical summary
Product innovation and marketing an innovation are usually regarded as two distinct issues: marketing scientists tend to take product innovation as given and do not worry about the decision on investing in product innovation at all while economists assume that any product innovation is successful, independent of the effort which is used to bring it to consumers.
In this paper, firms' decisions concerning the marketing of product innovations and the introduction of a product innovation are treated as sequential steps of a firm's effort to maximize profit: after having decided to introduce a new or markedly developed product in a first stage, they determine their level of effort used to market the product innovation.
Several factors influence firms' decisions concerning product innovation and marketing innovations: the degree of substitutability, the number of competitors and market size. A three stage game–theoretical model for product innovation, effort used to market the innovation and product market competition is derived. It is found that the marketing of product innovation decreases with both the degree of product substitutability and the number of competitors while it increases with increasing market size.
Using firm–level data from an innovation survey in the German service sector, these results of the theoretical model are empirically tested. The estimation results of a simultaneous sequential Tobit model indicate that market concentration increases the effort used to market the innovation while the reverse holds for the service sector. It is also found that an increase in market demand leads to an increase in effort used to market the product innovation. Sectoral affiliation, the empirical proxy variable for the degree of product substitution, turns out to significantly influence both product innovation and effort used to market the product innovation.

1 Introduction

Game–theoretical models of product innovation are based upon the idea that a product innovation increases consumer utility. In reality, however, it seems unlikely that consumer utility actually increases if a product innovation is introduced to the market: if the new product is not marketed at all, consumers may not even notice that a new product has been developed.

Theoretical and empirical work which treats product innovation and new product marketing as the two sides of the same coin is scarce. This paper aims to combine both issues by developing a game–theoretical model for product innovation and the effort to market the new product. The hypotheses derived from this model are tested empirically using firm–level data taken from an innovation survey in the German service sector. Both the theoretical and the empirical model are concerned with firms which produce consumer goods since customers of investment goods are likely to become aware of innovative products even in the absence of marketing effort. Purchasers of investment goods are typically firms which, in contrast to private households as purchasers of consumer goods, employ qualified personnel to monitor the input market.

Earlier studies which look at product innovation and the marketing of innovation simultaneously include Berndt et al. (1997), who empirically analyze the effect of product quality and marketing on market shares in U.S. pharmaceutical industries. Another empirical contribution in this context comes from Smith (1994) who studies the impact of innovation and marketing on the performance of Italian industrial cooperatives.

By contrast, marketing scientists usually tend to treat the occurrence of product innovation as given. Examples of such a view include Manu and Sriram (1996) who provide descriptive evidence on the typologies of innovative firms' marketing strategies based on a small sample of U.S. manufacturing firms; Meyer et al. (1999) describe key factors for a successful product introduction from a review of existing case and small–sample studies; Edgett (1996) conducts case studies in the U.S. financial services sector to trace the interaction between the development and the sales unit of the firm involved in the study; Lynn et al. (1996) show on the basis of case studies that conventional marketing strategies may lead to unsatisfactory results if drastic innovations occur and Beard and Easingwood

(1996) describe effective strategies for successful product introduction. Wieandt (1994) refers to product innovation marketing in general, and Mattmüller and Susen (1995) study the marketing deficits of German medium–sized enterprises. The comprehensive textbook by Urban and Hauser (1993) implicitly combines innovation economics and marketing sciences by taking a normative perspective on the interaction between new product development and the marketing of new products.

While marketing scientists do often not consider the innovation decision, industrial economists assume that consumer utility always increases if product innovation takes place, irrespective of whether any attempt is made to market the product. This view of the world of innovation is shared by virtually every study of product innovation. Examples are Motta (1992), De Bondt and Kesteloot (1993), Cohen and Klepper (1996), Beath et al. (1997), Bonano and Haworth (1998), Fishman and Rob (2000), Kaiser and Licht (2000), Levin and Reiss (1998).

This paper tries to integrate marketing sciences and industrial economics by setting up a three stage Cournot oligopoly game for product innovation and effort used to market the innovation. Key findings of the theoretical model are that an increase in either (i) product market concentration, (ii) product complementarity or (iii) market size leads to increases in both the effort used to market the innovation and in firms' propensity to conduct product innovation.

An empirical test of this model on the basis of a sample of 519 German firms from the service sector quite broadly supports these findings. Since new product introduction costs are only observed if product innovation takes place, these costs constitute a left–censored variable (a number of firms do not invest in new product marketing at all). Moreover, the desired level of marketing effort is a determinant of the probability of product innovation. Thus, the theoretical model is tested using a simultaneous sequential Tobit model. This model captures the endogeneity of effort used to market the innovation on the decision to introduce a product innovation and also takes into account the fact that effort used to market the innovation is only observed if a firm introduces a new or markedly improved product to the market.

The empirical analysis shows that market size has a positive and highly significant effect on firms' propensity to introduce product innovation and also their effort in marketing the innovation. Market concentration has a significantly positive effect on product innovation only and does not significantly affect effort used to market the product innovation. Sectoral affiliation, the empirical proxy variable for product substitution, turns out to be jointly significant in both the innovation equation and in the determination of the effort to market the new product. Market introduction effort has an insignificant effect on product innovation, indicating that sales increases balance out a rise in costs due to market introduction spending. Other findings are that (i) firm size has a linear an positive effect on product innovation and a U–shaped effect on the effort used to market the product, with a minimum reached at 74.2 employees and (ii) east German firms spend less on new product marketing than their west German competitors.

2 Theoretical model

2.1 Household utility

The theoretical model is based on a common utility function which is borrowed from Sutton (1998) and can essentially be traced back to Bowley (1924). Let N single product firms compete for Z identical consumers and let σ denote the degree of substitution between the products with $\sigma \in [0,1]$. If $\sigma = 1$, the goods are perfect substitutes and if $\sigma = 0$, the extreme case of monopoly is present. The consumers are endowed with an exogeneously given income Y which they spend on the consumption of the N 'inside goods' and also on the consumption of 'outside goods', i.e. goods that are not affected by cross–quality effects due to quality improvements. The latter fraction of household income is denoted by $B = Y - \sum_{i=1}^{N} p_i \, q_i$, where p_i denotes the price of product quantity q_i. The utility function maximized by each household is:

$$U(q; u, \sigma, B) = \sum_{i=1}^{N} (q_i - \frac{q_i^2}{u_i^2}) - 2\,\sigma \sum_{i=1}^{N} \sum_{j \neq i}^{N} \frac{q_i}{u_i} \frac{q_j}{u_j} + B, \tag{1}$$

The utility parameter index u_i increases if firms engage in product innovation *and* invest in bringing the new product to the market. For simplicity, $u_i > 1$ is assumed. If firm i has a product innovation and does not invest in marketing, there is no utility gain. The idea behind this is simple: how could consumers possibly buy a product they know nothing about? Inversely, if there is no product innovation, there also is no increase in consumer utility. The utility parameter index is hence a function of product introduction effort, M, which is zero if there is no product innovation and which is measured in monetary terms. It is important to note that the model developed here is suited to producing consumer goods producing firms since the kind of information problems as described above are not likely to exist for producers of investment goods. Purchasers of investment goods are typically well informed about product quality, innovation and prices, so the model is inadequate in these cases. The empirical model takes these differences into account by restricting attention to those firms with an over–proportional share of private households customers.

Let PD denote a dummy variable which is coded 1 if product innovation takes place. The utility parameter index then takes the form $u_i = f(M_i \cdot PD)$ and has the following properties: (i) $f(0) = 1$ (no utility gains without innovation and marketing), (ii) $f' > 0,\ f'' < 0$ (concavity of the utility index in M_i) and (iii) $f\ f'' + f' < 0$. The latter property guarantees that marketing costs increase more steeply than their returns so that firms do not boundlessly invest in marketing.

The inverse–demand market schedule corresponding to the household utility function is:

$$p_i \ = \ 1 \ - \frac{b\ q_i}{u_i} - \frac{\sigma\ b}{u_i} \sum_{i \neq j}^{N} \frac{q_j}{u_j}, \tag{2}$$

where q_i and q_j now denote market instead of individual demand and $b = \frac{2}{Z}$. Except for the utility parameter index, a system of linear market demand equations is obtained.

2.2 Stage 3: Product market competition when product innovation and marketing expenditure are given

Following earlier models of innovation (e.g. Kamien et al., 1992), a Cournot–oligopoly model for the production stage of the game is considered.

The N firms choose the optimal output level given parametrically sunk product introduction and product innovation costs and they incur fixed and symmetric per–unit production costs, k:

$$max_{q_i}\ \Gamma_i \ = \ (p_i - k)q_i - x_i - M_i \tag{3}$$

Optimal output is given by the following expression:

$$q_i^* \ = \ \frac{(1-k)\ u_i^2 + \frac{\sigma}{2-\sigma}\ u_i \sum_{j \neq i}^{N} \Big((1-k)u_i - (1-k)u_j\Big)}{b\ (2 + \sigma(N-1)).} \tag{4}$$

If firm i introduces a product innovation and invests in marketing the new product, an increase in these marketing efforts increases firm i's output. The comparative–analysis properties of equation (4) in a symmetric equilibrium indicate that firm i's output decreases with an increase in (i) the number of competitors, (ii) the degree of product substitution and (iii) fixed production cost. Output increases with increasing market demand.

2.3 Stage 2: Determination of effort used to market innovative products when the innovation decision is given

In the second stage of the game, firms determine their level of product marketing effort given that they have decided to conduct product innovation in the first stage of the game. Firms then maximize profits by choosing optimal marketing effort:

$$max_{M_i}\ \Gamma_i \ = \ b\ \frac{q_i^{2^*}}{u_i^2} \ - \ M_i \tag{5}$$

The structural form of the optimality conditions for product marketing effort in a symmetric equilibrium is:

$$\frac{2\ f\ f'\ (1-k)^2\ (2+\sigma(N-2))}{b(2-\sigma)\ (2+\sigma(N-1))^2}\ ) = \ 1. \tag{6}$$

Implicit differentiation of equation (6) reveals the comparative–static properties of optimal marketing effort: an increase in (i) the number of competitors and (ii) the degree of product substitution both lead to a decrease in marketing effort. The intuition behind these results is that the more competitive the market is, the smaller the increase in consumer utility arising from the marketing investment. The third comparative–static result with respect to optimal marketing effort is that an increase in market size leads to an increase in effort used to market the product, which indicates a higher return on the marketing effort when market size increases.

Details on the comparative–static properties of equation (6) are provided in Appendix A.

2.4 Stage 1: Product innovation choice

In the first stage of the game, firms decide whether or not to conduct product innovation. This implies a deterministic underlying R&D process: once firms start to invest in product R&D, they will come up with a completely new or markedly improved product. The assumption of a deterministic R&D process might not always match reality well, where R&D processes are usually driven by risk and irreversibilities, but still appears to be adequate here especially with regard to the notion of 'markedly improved' products.

Firms conduct product innovation if the difference of profits, Δ, with and without product innovation is positive:[1]

$$\Delta = \Gamma_{PD} \ - \ \Gamma_{no\ PD} = \underbrace{c\ (f^2 - 1)}_{increase\ in\ profit} \ - \ \underbrace{(M\ +\ X)}_{cost\ increase}, \tag{7}$$

where X denotes product innovation costs, measured in monetary terms and $c = \frac{(1-k)^2}{b\ (2+(N-1)\sigma)^2}$. Since $f(0) = 1$, the term $(f^2 - 1)$ is positive as long as there no effort used to market the product innovation — and zero if there is none — so that the critical value of product innovation depends on the difference between the increase in total sales and the increase in product innovation and marketing costs due to product innovation. An increase in the effort used to market the product leads to an increase (decrease) in the probability of product innovation if $2\ c\ f_M > 1$ $(2\ c\ f_M < 0)$.

Neglecting second–order effects of the number of competitors, product substitution and market size through changes in product marketing investment, comparative statics indicate, as derived in Appendix B, that the probability of conducting product innovation (i) decreases with an increase in the number of competitors, (ii) increases with an increase in market size and (iii) decreases with an increase in product substitutability. The intuition behind these results is the same as for effort used to market the product: if competition is high, it does not pay for firms to invest in innovation to the same extent as when competition is low.

[1]Note that neither product innovation nor marketing costs occur if firms do not engage in product innovation.

3 Empirical implementation

The hypotheses derived from the stylized theoretical model are empirically tested using the second wave of Mannheim Innovation Panel in manufacturing for the service sector (MIP–S) which was collected in 1997. Later and earlier waves of the MIP–S cannot be used here since they do not contain information on the effort used to market product innovations. The MIP–S is compiled by the ZEW on behalf of the German Ministry for Education, Research, Science and Technology. A detailed description of the data material is not presented here since Janz et al. (2000) thoroughly describe the data set. The MIP–S data is part of the European Commission's Community Innovation Surveys (CIS) program. Basic methodological remarks and implementation issues for innovation surveys are described in the OSLO–manual (OECD, 1994). The description presented here thus concentrates on the variables used in the estimations and omits any further details on the data set.

Definition of consumer goods producing firms

The theoretical model developed in Section 2 is a consumer demand model and does not readily apply to innovation and innovation marketing in investment goods producing firms. This is taken into account in the empirical investigation by only considering those firms which sell more than 50 per cent of their total output to private households. The MIP–S distinguishes four customer groups: (i) customers from the producing sector, (ii) customers from the service sector, (iii) the state and (iv) private households. The means (medians) corresponding to the share of these customer groups in total sales are 33.6 (20) per cent for customers from the producing sector, 29.5 (15) per cent for customers from the service sector, 12.1 (0) per cent for the state and 24.7 (5) per cent for private households. 615 firms out of an initial 2,301 are retained in the sample.

Decision to innovate

The MIP–S does not contain information on the amount of money a firm spends on product innovation activity but provides information on the firm's introduction of a product innovation. In accordance with the theoretical model which also describes a zero/one decision, this binary information on product innovation activity is used in the empirical investigation.

Effort used to market the innovation

The MIP–S questionnaire asks about the components of total innovation expenditures in great detail. In that respect, it provides data on the fraction of market introduction costs for new or markedly improved products relative to total innovation expenditures. This is the empirical proxy variable for M used in the empirical part of this paper. The scaling by total innovation expenditure already introduced by the MIP–questionnaire is retained in order to reduce potential problems of heteroscedasticity. Expenditure on the introduction of new or markedly improved products is of course only observed if firms have introduced product innovation. A further econometric issue is that the effort used to market the product innovation is left–censored at zero. Of the 519 firms involved in the estimation, 178 (34.3 per cent) introduced a new or markedly improved product to the market. A total of 95 of these firms (53.4 per cent), also invested in the marketing of the product innovation with a mean (median) investment of 0.3617 (0.0136) per cent of total innovation expenditures.

An adequate econometric approach to estimate such a simultaneous system of binary and partially observed left–censored dependent variables is derived in Section 4.

Proxy for market demand

Market demand is implemented empirically by the share of firms which are not yet involved in export activity but which expect to export a fraction of their total sales within the next two years. This variable is a measure of market potential and is calculated on a three–digit sectoral level since it is potentially endogeneous to product innovation and the effort used to to market the product innovation.

Number of competitors

The effect of the number of competitors is empirically implemented by a Hirshman–Herfindahl market concentration index, denoted by *CONCENTRATION*. This index is constructed on the basis of a large data base provided to the ZEW by Germany's leading credit rating agency Creditreform. This data set also served as the sampling frame for the MIP–S data. Creditreform aims at collecting data on each and every firm in Germany, including information on total sales. The Hirshman–Herfindahl index is calculated on the three–digit sector level as the sum of firms' squared total sales share in each sector.

Degree of product substitutability

The degree of product substitutability, the empirical proxy variable of σ is indirectly considered by the inclusion of a set of three sector dummy variables for trade, transport and 'other' business–related services (consisting of renting of machinery and equipment, real estate activities, business and tax consultancy, advertising and labor recruitment) with computer activities and technical services serving as the comparison group. The set of dummy variables should have jointly significant effects on both the product innovation decision and on effort used to market the product innovation.

Control variables for observed firm heterogeneity

Several control variables for observable firm heterogeneity are included in the estimation equations for product innovation and the effort to market the product innovation: (i) a dummy variable for east German firms and (ii) the natural logarithm of the total number of employees as a control variable for firm size and its square.

These variables which affect both the product innovation decision and the marketing of product innovation are summarized in row vector $\boldsymbol{z_i}$.

Control variables in the product innovation decision

Additional control variables for the product innovation decision include the share of high skilled labor in total employment and a variable reflecting the extent to which firms follow a quality differentiation strategy, with quality being a measure of 'pure' service quality and not of 'perceived' consumer quality. These variables are summarized in row vector $\boldsymbol{w_i}$.

Human capital is a very important input factor in the production of an innovation, so that an inclusion of these variables is straightforward. By contrast, it is unlikely that human capital variables influence new product marketing costs since the decision concerning the effort to introduce the product introduction is usually reached by firms' management or the respective marketing department, i.e. the human capital of the entire workforce does not matter here.

The variable reflecting the extent to which firms follow a quality differentiation strategy is derived from an MIP–S question on firms' aims of innovation which is answered on a three–point ordinal scale. The list of aims includes (i) replacement of existing services, (ii) broadening of current business segment, (iii) improvement of service quality, (iv) entering of new markets and (v) increasing market shares. I run a canonical correlation to reduce dimensions, under the assumption that the first three and the last two items can be combined. The reported linear combinations for the first factor which I term 'Quality differentiation' — since firms aiming at replacing, broadening and improving current products effectively wish to improve service quality — are enclosed in the estimations on a three–digit sector level. The other factor is a measure of 'Market orientation' and is omitted from the estimation since it is highly positively correlated with 'Quality differentiation', indicating that the two strategies are complementary. The results of the canonical correlation analysis are displayed in Appendix C.

Control variable in the product introduction expenditures equation

The share of firms, calculated on a three–digit sector level, which are involved in a research cooperation with consultancy firms, is enclosed in the equation for the effort used to market the product innovation. This variable is denoted by *CO-OPERATION* ($\boldsymbol{v_i}$). The argument behind the inclusion of this variable is that firms which cooperate with consultants are closely oriented towards the product market and may therefore have a strong desire to effectively market the product novelty.

Descriptive statistics of the variables involved in the estimation are displayed in Appendix D.

4 Econometric model

Product innovation, PD, is observed as a binary variable only and product introduction effort, M, is left–censored at zero and only observed if a firm successfully introduced a product innovation. Let the difference in profits with and without product innovation be a linear function of the explanatory variables $\boldsymbol{z_i}$ and $\boldsymbol{w_i}$. The structural model for the product innovation decision then is:

$$PD_i \ = \ \begin{cases} 1 & \text{if} \qquad \Delta_i = \boldsymbol{z_i \gamma_{PD}} + \boldsymbol{w_i \alpha} + a \ M_i^* + \epsilon_{PD \ i} > 0 \\ 0 & \text{otherwise,} \end{cases} \tag{8}$$

where M_i^* denotes latent, or 'desired', effort used to market the product is assumed to depend upon the variables summarized in $\boldsymbol{z_i}$ and $\boldsymbol{w_i}$. The structural model is:

$$M_i \ = \ \begin{cases} M_i^* & \text{if} \qquad M_i^* = \boldsymbol{z_i \gamma_M} + \boldsymbol{v_i \beta} + \epsilon_{Mi} = \boldsymbol{\Pi_{Mi} \theta_M} + \epsilon_{Mi} > 0 \text{ and if } \Delta_i > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{9}$$

The error terms ϵ_x and ϵ_M are assumed to be bivariate normally distributed.

The reduced form of equations (8) and (9) is

$$\Delta = \boldsymbol{z_i}(\boldsymbol{\gamma_{PD}} + a \ \boldsymbol{\gamma_M}) + \boldsymbol{w_i \alpha} + \boldsymbol{v_i} \ a \ \boldsymbol{\beta} + a \ \epsilon_{Mi} + \epsilon_{PDi} \ = \ \boldsymbol{\Pi_{PDi} \theta_{PD}} + \eta_i, \tag{10}$$

where the error terms ϵ_{Mi} and $\eta_{PDi} = \epsilon_{PDi} \ + \ \epsilon_{Mi}$ are bivariate normally distributed with means $\boldsymbol{\Pi_{PDi} \theta_{PD}}$ and $\boldsymbol{\Pi_{Mi} \theta_M}$, respectively, and variance–covariance matrix $(\sigma^2_{PD} \ \ \rho, \rho \ \ \sigma^2_M)$.

Consistent parameter estimates for equation (8) can be obtained by (i) running a Tobit model with partial observability — as described below — on equation (9), (ii) substituting the fitted values $\hat{M}^*_i$ ($\hat{M}^*_i = \mathbf{\Pi_{Mi}}\hat{\boldsymbol{\theta}}_{\boldsymbol{M}}$) into equation (8) and (iii) estimating equation (8) using a binary probit model. The estimated variance matrix corresponding to the second–step parameter estimates is, however, inconsistent if the error terms of the two equations are significantly correlated with one another, i.e. $\rho \neq 0$.

Consistent parameter estimates and a consistent variance–covariance matrix are obtained by estimating the product innovation equation and the equation for marketing effort in a reduced form. The parameter corresponding to latent marketing effort, a, can, however, not be recovered from the structural form due to the scaling of the binary choice equation by the standard error of the disturbance term ϵ_{PD}. The appropriate econometric approach is a Tobit model with partial observability since efforts to market the product innovation are left–censored at zero and only observed if product innovation takes place. The reduced form of the product innovation equation (10) serves as the separation equation.

The contributions to the log–likelihood function corresponding to such a model are of the types: (i) $P[\Delta_i \leq 0]$, (ii) $P[\Delta > 0 \wedge M_i = 0]$ and (iii) $P[\Delta > 0 \wedge M^*_i = M]$. Let $D_{x=0}$, $D_{x=1,M=0}$ and $D_{x=1,M^*=M}$ denote dummy variables which are coded 1 if firm i does not conduct product innovation ($PD_i = 0$), if a product innovation takes place but the firm does not invest in innovation marketing ($PD_i = 1$ and $M_i = 0$) and if firm i conducts product innovation and also invested in marketing ($PD_i = 1$ and $M^*_i = M_i$) respectively. After imposing $\sigma_{PD} = 1$ for identification, the log–likelihood function for observation i is

$$\begin{aligned}
\ell_i &= D_{x=0} ln\big(\Phi(-\mathbf{\Pi_{PDi}}\boldsymbol{\theta_{PD}})\big) + D_{PD=1,M=0} ln\bigg(\Phi_2\Big(\mathbf{\Pi_{PDi}}\boldsymbol{\theta_{PD}}, -\frac{\mathbf{\Pi_{Mi}}\boldsymbol{\theta_M}}{\sigma_M}, -\rho\Big)\bigg) \\
&+ D_{PD=1,M^*=M}\bigg\{ ln\bigg(\Phi\Big(\frac{\mathbf{\Pi_{PDi}}\boldsymbol{\theta_{PD}} + (M_i - \mathbf{\Pi_{Mi}}\boldsymbol{\theta_M})\rho/\sigma_M}{\sqrt{1-\rho^2}}\Big)\bigg) \\
&- \frac{1}{2}\bigg(\frac{M_i - \mathbf{\Pi_{Mi}}\boldsymbol{\theta_M}}{\sigma_M}\bigg)^2 - ln(\sqrt{2\pi\sigma^2_M})\bigg\},
\end{aligned}$$

where Φ and Φ_2 denote the univariate and the bivariate cumulative distribution functions of the standard normal distribution respectively.[2]

[2] A GAUSS code for the Tobit model with partial observability can be downloaded from my website at the ZEW.

5 Estimation results

Table 1 presents the Full Information Maximum Likelihood estimation results for the Tobit model with partial observability. The estimation results do not provide evidence that the effort used to market the product is endogenous to the decision to conduct product innovation, i.e. firms simultaneously decide upon product innovation and the effort used to market new products. This is indicated by the insignificant correlation coefficient between the error terms of the product innovation equation and the product marketing equation. Due to the insignificance of the correlation coefficients, running a two–step procedure to identify the parameter a leads to consistent estimates of the variance–covariance matrix. The point estimates of a from the two–step procedure is -0.0422 with a standard error of 0.2361 (p–value: 0.429), indicating that that there is no significant relationship between *latent* marketing expenditures and product innovation.[3] This implies that the cost increase due to marketing effort balances out the gains in profits arising from effort used to market the product.

Although the two–step procedure produce both consistent and efficient parameter estimates here, I present the estimation results corresponding to the reduced form equations since they are more robust against misspecification of the set of identifying variables than the two–step estimation results (Heckman and Smith, 2000).

Product innovation equation

Estimation results for the estimation of product innovation are that (i) as predicted by the theoretical model, an increase in market potential leads to an increase in the propensity to innovate, (ii) an increase in market concentration induces an increase in firms' propensity to innovate, (iii) the more highly skilled the workforce, the more likely it is that a firm introduces a product innovation and (iv) quality differentiation leads to an increase in product innovation propensity.

The set of sector dummy variables, the empirical proxy variable for product substitutability, turns out to be jointly significant in the specification for manufacturing industries only, consistent with the theoretical model.

[3]Note that the explanatory variable in the level equation is observed even if the respective firm did not introduce a product innovation.

Table 1: Reduced form simultaneous Tobit model estimation results

Selection equation: product innovation decision		
	Coeff.	**Std. err.**
CONCENTRATION	1.9651***	0.6182
Market potential	0.4052**	0.1923
Share of high skilled labor	0.6856**	0.3927
ln(# of employees)	0.0982	0.1385
ln(# of employees)^2	0.0013	0.0152
Eastern Germany	0.0724	0.1334
Quality differentiation	-0.4421	1.4439
COOPERATION	1.3269***	0.4343
Constant	-2.4632***	0.6677
Wald tests for joint significance: selection equation		
	χ^2	**d.o.f**
Selection equation	56.3729	11
Firm size	10.5464***	2
Sector dummies	4.2523	3

Level equation: product innovation marketing intensity		
	Coeff.	**Std. err.**
CONCENTRATION	-0.4909	0.7250
Market potential	0.4157**	0.2320
ln(# of employees)	-0.3316**	0.1600
ln(# of employees)^2	0.0385***	0.0172
Eastern Germany	-0.2747**	0.1473
COOPERATION	4.6375***	1.8601
Constant	0.1590	0.6974
Wald tests for joint significance: level equation		
	χ^2	**d.o.f**
Level equation	22.6546***	9
Firm size	5.0610*	2
Sector dummies	11.6130***	3
Entire specification	*79.0607****	*20*
Standard errors, correlation parameters, # of obs. and pseudo R^2		
σ	0.7588***	0.1279
ρ	-0.3299	0.5248
# of obs. full model	519	
# of obs. level equation	178	
Pseudo R^2	0.1048	

The asterisks' ***, ** and * indicate significance at the one, five and ten per cent significance levels respectively. All estimations also include a set of sector dummy variables.

Equation for the marketing of product innovation

The estimation results for effort used to market the product indicate that market potential has a significant positive effect of marketing expenditures, a finding which is consistent with the theoretical model. By contrast, significant effects of market concentration are not found.

Other findings are that market orientation has a significantly positive effect on the effort used to market the product innovation, firm size has a U–shaped impact on the effort used to market the product with a minimum reached at 74.2 employees and east German firms spend significantly less on product innovation marketing than their west German competitors. ‘Market orientation’, as measured by the share of firms cooperating with consultancy firms, has a highly significant and positive effect on the effort used to market the new product. Consistent with the theoretical model, the sector dummy variables are jointly significant from zero.

Goodness–of–fit

It turns out that the level equation is less well determined than the probit equation as indicated by lower Wald test statistics for joint significance in relation to the probit–part of the estimation equation. The relatively low precision of the estimates for the Tobit–part of the model is likely to be due to a low variation in the dependent variable and to a low number of observations in the level equation. Joint significance of the specification displayed in Table 1 cannot be rejected at the usual significance levels, and it is shown that both the probit and the Tobit–part are separately highly significant. The McFadden (1974) pseudo R^2 is 0.1048 and hence very convenient for those kinds of econometric models. Yet, joint significance of the explanatory variables except for the constant terms, cannot be rejected at the one per cent marginal significance level.

6 Conclusions

Product innovation and efforts used to introduce the product are usually treated as two separate issues. Industrial economists tend to restrict attention to incentives for firms to conduct product innovation and ignore the fact that the success of a product also depends on the effort with which it is brought to the market. In turn, marketing scientists take the invention as given and focus on product introduction costs only. Both views of the subject are likely not to meet well with reality. It seems reasonable that product innovation and expenditures on product introduction are interrelated. This paper therefore develops a stylized theoretical model for product innovation and expenditure on product marketing and empirically tests the hypotheses derived from the model.

Firms are assumed to first decide whether or not to conduct product innovation. They then determine their optimal effort used to market the product innovation and finally compete against one another in a Cournot–oligopoly on the product market. Key findings of the theoretical model are that market concentration, market size and complementarities between products enhance both product introduction spending and firms' propensity to conduct product innovation.

The empirical part of this paper attempts to verify these hypotheses on the basis of firm–level data taken from an innovation survey in the German service sector. Since expenditures on product introduction expenditure are left–censored at zero and only observed if product innovation takes place, a sequential Tobit model with partial observability that also accounts for a potential simultaneity between efforts to market product innovation and the propensity to introduce product innovation is estimated. It turns out that the prediction of the theoretical model are generally supported by the econometric findings: market potential has a significant and positive effect on both product innovation and the effort used to market the product, while market concentration has a significantly positive effect on product innovation and sector affiliation, the measure of product substitutability, is jointly significant in the innovation and the marketing equation.

Appendix A

Comparative–static properties of the equation for optimal marketing effort (6)

Substituting $2/Z$ for b in equation (6) in order to visualize the effect of market size Z on product marketing investment leads to:

$$g \;=\; \frac{f\ f'\ (1-k)^2\ (2+\sigma(N-2))\ Z}{(2-\sigma)\ (2+\sigma(N-1))^2} \;-\; 1 \;=\; 0 \tag{11}$$

The partial derivative of equation (12) with respect to optimal product innovation marketing effort, M, is negative:

$$\frac{\partial g}{M} \;=\; \frac{(k-1)^2\ Z\ (2+(N-2)\sigma)\ (f'+f\ f'')\ f'}{(2-\sigma)\ (2+(N-1)\sigma)^2} \;<\; 0. \tag{12}$$

This implies that the signs of the partial derivatives of M with respect to the number of competitors, $N-1$, the degree of product substitution, σ, and market size, Z, are determined by the partial derivative of the optimality function g with respect to these variables. The corresponding partial derivatives are:

$$\frac{\partial g}{(N-1)} \;=\; \frac{f\ (1-k)^2\ Z\ (2+(N-2)\sigma)\ f'}{(\sigma-2)\ (2+(N-1)\sigma)^3} \;<\; 0 \;\Longrightarrow\; \frac{\partial\ M}{\partial\ (N-1)} \;<\; 0 \tag{13}$$

$$\frac{\partial g}{\sigma} \;=\; \frac{2\ f\ (k-1)^2\ (N-1)\ Z\ ((4+(N-1)(\sigma-1)-\sigma)\sigma-2)}{(\sigma-2)(2+(N-1)\sigma)^3}, \tag{14}$$

which is smaller than 0 if $N-1 > ((\sigma-2)-2)/(\sigma(\sigma-1))$ so that

$$\frac{\partial\ M}{\partial\ \sigma} \;<\; 0 \text{ if } (N-1) \text{ large.} \tag{15}$$

Lastly,

$$\frac{\partial g}{Z} \;=\; \frac{f\ (k-1)^2\ (2+(N-2)\sigma)\ f'}{(2-\sigma)\ (2+(N-1)\sigma)^2} \;>\; 0 \;\Longrightarrow\; \frac{\partial\ M}{\partial\ Z} \;<\; 0. \tag{16}$$

Appendix B

Comparative–static properties of the product innovation equation (7)

$$\frac{\partial \Delta}{(N-1)} = -\frac{(f^2-1)\,(k-1)^2\,Z\,\sigma}{(2+\sigma+(N-1)\sigma)^3} < 0 \tag{17}$$

$$\frac{\partial \Delta}{\sigma} = -\frac{(f^2-1)\,(k-1)^2}{2\,(2+(N-1)\sigma)} < 0 \tag{18}$$

$$\frac{\partial \Delta}{Z} = \frac{(f^2-1)\,(k-1)^2}{2\,(2+(N-1)\sigma)^2} > 0 \tag{19}$$

Appendix C

Linear combinations for canonical correlation

	Coeff.	Std. err.
Diversification		
Replace existing services	-0.0424033 *	0.0239815
Broaden existing business segments	0.3687592***	0.0261594
Improve service quality	0.4077296***	0.0248501
Market orientation		
Enter new markets	0.3537357***	0.0282321
Increase market shares	0.4374955***	0.0271143

The asterisks' *** and * indicate significance at the one and ten per cent significance levels respectively. The canonical correlations are 0.9149 and 0.9149. A total of 594 observations is involved in the estimation.

Appendix D

Descriptive statistics of the variables involved in the estimations

	Manufacturing		Services	
Product innovation	0.6416		0.3624	
Innovation marketing	0.0333	0.0656	0.0302	0.0614
SALES+	0.5651	0.4959	0.4372	0.4962
Eastern Germany	0.3303		0.3943	
CONSULTANCY	0.1138	0.0738	0.1122	0.0652
COOPERATION	0.0372	0.0466	0.0318	0.0438
CONCENTRATION	0.0428	0.0836	0.0418	0.0592
ln(# of employees)	4.3885	1.4474	3.7406	1.5182
ln(# of employees)^2	21.3528	13.6451	16.2952	14.1771
Share of high skilled labor	0.1023	0.1261	0.1761	0.2475
Share of low skilled labor	0.3773	0.2981	0.2309	0.2838
ln(labor cost p.c.)	-2.8210	0.5903	-2.8017	0.6827

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