A Microeconometric Note on Product Innovation and Product Innovation Advertising[§]

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May 4, 2004

[§]**Acknowledgements:** This paper greatly benefited from two excellent referee reports. One of them in fact lead to a complete revision of this paper. I also gratefully acknowledge helpful comments from Anette Boom, Stefan Böters, François Laisney, Georg Licht, Armin Schmutzler, Thomas Rønde and Birgitte Sloth as well as from workshop participants at a the University of Maastricht and the annual meeting of the German Economic Association in Zurich. I am indebted to the German Science Foundation (Deutsche Forschungsgemeinschaft, DFG) for partially funding this research within the 'Industrial Economics and Input Markets' program under grants PF331/1–1,1–2,1–3 and PO 375/3–1,3–2,3–3. Lastly, I wish to thank the Centre for European Economic Research for its hospitality during the time I worked out this paper.

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Abstract: This paper seeks to explain while more than half of the German service sector firms that introduce a product innovations do not advertise their new or markedly improved product. One part of the explanation is that they do not need to because they are closely related to their customers anyway, another part of the explanation is that product innovation and product innovation are strategic substitutes.

Keywords: strategic substitutes, product innovation, product innovation advertising, service sector, bivariate probit model with selectivity

JEL classification: L2, C34

1 Introduction

The two traditional roles of advertising are to provide information and to serve as a means of product differentiation.[1] One would expect a priori that informational advertising (Dorfman and Steiner 1956; Nelson 1974) is particularly important for new or markedly improved products — i.e. for product innovations — since advertising of innovative products helps innovators to reap the benefits of their efforts (Scherer 1967).

Quite surprisingly, however, the innovation survey data that I use in this study show that a total of 60 percent of firms that introduced a product innovation do not spend anything at all on product innovation advertising.[2] The question that this paper hence seeks to answer is: why do firms that introduce product innovations do not invest in advertising their innovation?

One reason could of course be that there is no need to market the product because

[1] See Scherer and Ross (1990, Ch. 16); Schmalensee (1986) and Martin (1999, Ch. 6) for textbook discussions of the role of advertising in industrial economics.

[2] More precisely: 60 percent of the firm in my data report that they have zero expenses on the market introduction for new or markedly developed products. Note that these expenses should be termed marketing expenses rather than advertising expenses. I prefer to refer to them as advertising cost to be consistent with the literature I cite. From an industrial economics point of view, the difference is negligible anyway since advertising and marketing shift do the very same: they shift out the product demand curve.

it the innovator is very closely connected to its well–informed customers — an issue that is even more important in services where customization is a key product feature. A second, merely academic, explanation is that the innovator does not possess market power so that she has no incentives to market the product (Dorfman and Steiner 1954). A third explanation is that product innovation and product innovation advertising are strategic substitutes meaning that doing more product innovation goes along with less product innovation advertising and vice. This could be so for example since firms foresee that if they pursue a particular R&D project they need to invest both in R&D and in advertising. In some cases they may find the advertising cost too high relative to the total return on R&D and advertising so that they do not start the research project at all.[3]

In this paper I empirically test for the existence of strategic substitutability between product innovation and product innovation advertising. The econometric analysis is performed on innovation survey data for a total of 1,743 firms from the German service sector, consisting of firms from retail and wholesale trade, transport, technical services (e.g. architectural services) and "other" business–related services (e.g. business consultancy).

Both test approaches that I apply provide highly significant econometric evi-

[3]Another issue is that non–advertising of product innovations might just reflect that a firm considers advertising in general as a substitute to product innovation: both advertising and product innovations are means of product differentiation and they both shift out the product demand curve.

dence for the existence of strategic substitutability between product innovation and product innovation advertising. Other results of this paper are that product innovation advertising is the more likely (i) the lower the general acceptance of innovations at the sector level, (ii) the larger market size, (iii) if firms a part of a conglomerate and (iv) if meeting governmental regulations is an unimportant motivation for innovation.

The probability of product innovation increases with (i) a decrease in product substitution, (ii) research productivity, (iii) workers' skills and (iv) an increase in firm size.

2 Empirical analysis

2.1 Test strategy

I follow earlier work by Cassiman and Veugelers (2002) and use both an indirect as well as a direct test of the existence of substitutability between product innovation and product innovation advertising that builds on seminal work by Milgrom and Roberts (1990) on strategic complememtarity between firm strategies. The indirect test is based on a result in Holmström and Milgrom (1994, part B) that states that a condition for activities to be complements (substitutes) to one another is that the activity levels are positively (negatively) correlated,

provided that agents act rationally. They also must remain being correlated if it is controlled for firm heterogeneity. The practical difficulty here is that even if we want to believe that agents act rationally, the econometrician can only control for *observed* firm heterogeneity.[4] This is why I apply a direct test for substitutability as well.

The direct test is based on a binary probit regression that models the instance of product innovation as a function of the event of not advertising the product innovation (and other factors that may determine product innovation). If the coefficient on the non–advertising variable is significantly positive, additional evidence in favor of substitutability between product innovation and product innovation advertising is provided.

2.2 Econometric issues

There are two main econometric issues at stake here: first, expenditures to market a product innovation are only observed if product innovation has taken place. Second, product innovation advertising is potentially endogenous to product innovation. An adequate econometric model for such a problem of partially observed potentially endogenous variables is a "reduced form" binary probit model with partial observability. It compares best to the classical Heckman–type (Heckman

[4]This is even more so if only cross–sectional data is available as in the present case. Note, however, that including fixed firm effects do not solve this problem since they do not pick up unobserved firm characteristics that vary over time, for example changes in management.

1979) selection model with the difference that the selection model is binary and not continuous as in the classical case and where the error terms of the two equations are bivariate normal distributed with correlation coefficient ρ.

The potential endogeneity of product innovation advertising on product innovation requires to estimate the product innovation equation in "reduced form" where all variables of the product innovation advertising equation are also contained in the product innovation equation.

In order for this model to be identified, the product innovation equation (the selection equation) needs to contain variables that are not part of the product innovation advertising equation. These are the so–called "exclusion restrictions". These exclusion restrictions must be orthogonal ("unrelated") to the product innovation advertising decision.

In addition to the exclusion restrictions, the model for product innovation contains a set of variables that appear in both the product innovation and the product innovation advertising equation.

Apart from those joint variables, the product innovation advertising equation must also consist of variables that appears in the advertising equation only. These again are exclusion restrictions, this time variables that affect product innovation advertising but not product innovation.

The product innovation advertising equation cannot be directly be estimated because product innovation advertising is only observed if product innovation took place so that a sample selection problem potentially arises. Likewise, the prod-

uct innovation advertising equation cannot be directly be estimated with product innovation advertising as an explanatory variable since this variable perfectly predicts product innovation. I therefore first estimate a joint model, a Heckman–type model for product innovation advertising and product innovation. This model does not identify the effect of product innovation advertising on product innovation so that I then back out the fitted values for (latent) product innovation advertising and insert it as an explanatory variable in a simple binary probit model for the probability of product innovation.

The parameter vector corresponding that structural form estimation (the model contains both the "ordinary" explanatory variables for product innovation *and* latent product innovation advertising) is consistently estimated. Its variance–covariance matrix is, however, inconsistent (compare Maddala 183, Ch. 8), which is a problem common to all two–stage discrete choice models. I therefore obtain consistent and efficient estimates of the standard errors by block–bootstrapping (Efron and Tibshirani 1986).[5]

Appendix A describes the estimation procedure in further detail.[6]

[5] I use 10,000 replications in the bootstrapping.

[6] All Appendices are available for download from the internet at http://www.ulrichkaiser.com/papers/prodinno.html.

2.3 Data

The data set I use the second wave of the Mannheim Innovation Panel (MIP–S) in the service sector that corresponds to 1997. This data is representative for the German service sector and collected by the Centre for European Economic Research. It has been widely applied for empirical studies of firms' innovation activities. A thorough discussion of this data is omitted here. Appendix B describes the data in more detail, an additional reference is Janz et al. (2002).

2.4 Specification

Variables that appear in both equations

Market structure variables

There is a rich and inconclusive literature on the effects of market structure and market size on innovation (Baldwin and Scott 1987; Kamien and Schwartz 1982). My specifications include (i) a proxy variable for market concentration, (ii) a proxy variable for market size and (iii) a proxy variable for product substitutability. The first two variables are constructed from a large data base provided to the Centre for European Economic Research by Germany's leading credit rating agency Creditreform. It is the most comprehensive firm data base for Germany. This data also served as the sampling frame for the MIP–S data. Market concentration is measured as the Hirshman–Herfindahl index of total sales in a sector.[7]

[7]Here and throughout the rest of this paper sectors are defined at a three–digit industry classification level, the European NACE–Rev. 1 classification.

Market size is measured by total sales in a sector. Since both variables are heavily skewed, I take natural logarithms to make their distributions more symmetric.

My measure of product substitutability is directly constructed from information on firms' customer structure that is provided by the MIP–S. The MIP–S asks for the total sales share of the four customer group private households, manufacturing industries, services and public administration. I use the Hirshman–Herfindahl index of customer concentration as my proxy for product substitutability. My rationale for proceeding this way is that a firm that serves only one customer group might in fact be a niche player while a firm that serves all four customer groups equally might be quite diversified.[8] This might be even more so in services where customization is likely to be more important than in manufacturing industries.

Firm heterogeneity variables

Both equations also include a set of dummy variables for sectoral affiliation and a dummy variable for East German firms. They also contain the natural logarithm of the total number of employees as a measure of firm size.

Both equations also include a variable that measures the importance of customers in the generation of innovations. It is defined as the share of firms in a sector that report that customers play an important role in the innovation process.[9] Since

[8]I have also used interaction of my market structure variable. These interactions turned out to be statistically insignificant so that they are left out in the specifications I present in this paper.

[9]The question had to be answered on a three point ordinal scale with "important role" being the highest score.

this question is only answered by firms that innovated, this variable is generated on a sectoral level. It would otherwise be a perfect predictor of innovative activity.

The variable was originally meant to serve as an exclusion restriction in the product innovation advertising equation (firms that intensely communicate with their customers in order to generate an innovation might have to less worry about innovation advertising). Specification checks have, however, shown that it also has a significantly positive effect on product innovation.

My equations also include a measure for research spillovers. This variable was initially indended as an exclusion restriction in the product innovation equation but turned out to affect product innovation advertising as well. This measure is constructed from firms' responses to a five–point ordinal scale question on factors hampering innovation. One of factors potentially hampering innovation is firms' fear of imitation, and I generated a set of four variables for the share of firms in a sector that report that imitation hazard indeed was a (i) minor factor, (ii) somewhat a factor, (iii) important factor or (iv) a very important factor that hampered innovation.[10]

Variables that appear in the product innovation equation only

Four variables serve as my exclusion restrictions in the product innovation: (i) the share of firms in a sector that cooperate in innovation with universities and/or

[10]This information was unavailable in the 1997 MIP–S so that I used information from the 1995 wave instead.

public research institutions, (ii) the share of university graduates in the workforce, (iii) the share of workers with completed vocational and/or additional technical training and (iv) a dummy variable for expected foreign competition (which is thought to capture firms' strategic reaction to market entry — it presumably has a positive effect).

The inclusion of the cooperation variable follows Levin and Reiss (1988) who argue that sectors closely related to science stay at the beginning of their development so that they find themselves in areas of R&D production with high marginal returns to R&D and hence in areas with high research productivity. Sectors closely related to science will therefore be considered as sectors with high R&D productivity. Higher R&D productivity creates incentives to perform R&D and hence increases the probability of product innovation which is which I expect this variable to have a positive effect on product innovation.[11]

The share of high skilled and medium skilled workers (comparison group: workers with no formal qualification) is considered as an input factor to innovation. Firms with a workforce with high formal qualifications are more likely to generate

[11]This variable might potentially also affect product innovation advertising because very innovative products might less likely advertising since the product "speaks for itself". The argument could also go the other way around: products developed in cooperation with research institutions might be so advanced that advertising is needed to explain the benefits of this product to new consumers. Both factors might just balance out each other, and in fact, specification checks (see Subsection **??** for more details) show that cooperation with research institutions does not have a significant effect on product innovation advertising.

product innovations than firms with less with no formal qualifications.

Variables that appear in the product innovation advertising equation only

My exclusion restrictions in the product innovation advertising equation are (i) the share of firms in a sector whose main goal innovation is to meet governmental regulation, (ii) a dummy variable that is coded one (and zero otherwise) if the firm belongs to a conglomerate of firms and (iii) how large a firm's sales share is that goes to private households.

The variable for governmental regulations is thought as serving as a "no need to advertise" variable. If the innovations tend to be generated just to meet regulations, then it may to a lesser extent pay off to advertise the innovation.

Being a member of a conglomerate might also influence the decision (not to) advertise product innovations since for example affiliate firms do the advertising for the firm or since financial resources could less restricted than for independent firms.[12]

The inclusion of the share of private household customers seems to be straightforward since private households are typically less informed about new products than for example purchasers of investment goods. In the extreme case of having no private household customers, firms may not even need to market the product

[12]The financial resources issue makes this variable a potential influence factor for the product innovation equation as well. Specification checks do not, however, provide evidence for statistical significance in the product innovation equation.

innovation at all.

Appendix C shows descriptive statistics of the variables involved in the estimations.

3 Results

Table 1 displays estimation results for the bivariate probit model with sample selection as estimated in "reduced form" Table 2 shows estimation results of the "structural" product innovation equation.

In contrast to the linear regression model, the coefficients of binary choice models do not immediately translate into "marginal effects" (the effect of a one percent change in one of the explanatory variables on the dependent variable). This is why Table 1 and Table 2 contain both the coefficient estimates, the corresponding standard errors and the marginal effects.[13]

3.1 Results for the product innovation advertising equation

Primary result

The main result from Table 1 from the point of view of explaining why a large

[13]The marginal effects are evaluated at the means of the dependent variables. The marginal significance levels of the marginal effects are almost identical to those of the coefficient which is why they are omitted from the table.

share of firms does not advertise new products at all is that there is a significantly positive and quantitatively large correlation between the unobserved (to the econometrician) components of the non–advertising equation and the product innovation equation. This implies that a positive shock to the probability of non–advertising induces an increase in the probability of product innovation (and vice versa). If my specification fully controls for firm heterogeneity, then evidence is provided in favor of substitutability between product innovation advertising and product innovation.

From a purely econometric point of view it is also important to note that the exclusion restrictions appear to hold: they have jointly significant effects on product innovation advertising, with three of the four restrictions also being separately significant, and are neither jointly nor separately significant in the product innovation equations. As required for their validity, they hence appear to be highly correlated with product innovation advertising but orthogonal to product innovation.

Other results

The share of firms in the own sector that conducts innovation to meet governmental regulations has the expected significantly positive effect on the probability of non–advertising.

If a major factor that hampers innovation is the lack of acceptance by customers at the sectoral level, this significantly increases the probability of product innovation advertising.

As expected, the dummy for being part of a conglomerate has a significantly positive effect on the probability of product innovation advertising.

The other two variables that pick up the need/no need to advertise, the share of private households in total sales and customers as information source, do not have statistically significant effects on product innovation advertising.

Market size has a significantly positive effect on the probability of product innovation advertising, implying that market enlargement create incentives to advertise new products.

The imitation hazard variables have jointly highly significant effects on the probability of product innovation advertising. The qualitative effect is quite nonlinear with high imitation hazards having no effect on product innovation advertising, with "not very important" imitation hazard having highly significant negative effects and with "somewhat important" imitation hazard having a highly significantly positive effect.

Customer concentration, my measure for product substitutability, and market concentration also do not have significant impacts on product innovation advertising.

3.2 Results for structural form product innovation equation

Primary result

The estimation results for the structural form model for product innovation as shown in Table **??** provide further evidence for the existence of substitutability of product innovation and product innovation advertising since the coefficient of latent non–product innovation advertising is significantly positive: the more likely it is that there needs not to be product innovation advertising, the more likely is product innovation. Relative to the quantitative effects of the other explanatory variables, the effect of latent product innovation advertising is quite small, however.

Other results

Only one of the three market structure variables, customer concentration, has a statistically significant impact on the probability of product innovation: the more a firm depends on one one type of customer, the more unlikely it is that it creates a product innovation. Product substitution is hence negatively related to product innovation here.

If customers serve as information source for innovation, the likelihood of product innovation increases. This is consistent with customers pushing firms to introduce a product innovation that fits their own needs ("demand–pull" effects).

The imitation hazard variables, my measures for spillovers, have significant effects

on product innovation. The sign of the corresponding coefficients suggest that higher imitation hazard is associated with a higher probability of product innovation. This is somewhat in contrast to the theoretical literature on the effects of spillovers on innovation. One explanation for my finding of positive effects might be my inability to distinguish between incoming and outgoing spillovers.
As expected, a higher qualification of the workforce leads to a higher probability of product innovation. Likewise, the more universities or public research institutions are used as information sources for innovation, the more likely it is that a product innovation is generated — consistent with my use of this variable as a measure of innovation productivity.

Specification checks for validity of my exclusion restrictions and re–estimations using reduced samples (for example only Small and Medium Sized Enterprises are discussed in Appendix D. There is no evidence for misspecification of my model.

4 Conclusions

This paper seeks to explain why more than half of all German service sector firms that generated a product innovation do not spend anything at all on advertising the new or markedly improved products. An obvious way to explain non–advertising of course is that firms may not need to advertise product innovations, for example since they are closely connected to their customers in the

innovation process or since their customers are generally very open towards product innovations. My econometric analyzes in fact find evidence for the presence of these effects.

More importantly, however, I also find evidence that suggests that product innovation and product innovation advertising are strategic substitutes: a higher likelihood of product innovation advertising is associated with a decrease in the probability of product innovation. Likewise, an unanticipated shock in the probability of product innovation goes along with a decrease in the probability of product innovation advertising (and vice versa). It is not optimal for firms to do both product innovation *and* product innovation advertising.

This result might clearly only hold for services where the producer/customer interaction is more intense than in manufacturing and where an important product feature is customization.

Explanations for the phenomenon of strategic substitutability is that firms regard product innovation and advertising generally as substitutes since both lead to product differentiation and/or that firms foresee product innovation advertising expenditures before starting an innovation project and might find the additional advertising expenditures to be too high relative to the total payoff.

Lessons learned from this paper for strategic management are that it might be suboptimal for service sector firms to add advertising to product innovation. The economic policy implication is that innovation support programs for services should focus on the innovation process itself and should not be extended to prod-

uct innovation advertising as well.

Table 1: Reduced form bivariate probit model with sample selection estimation results

	Probability of non–advertising of product innovations			**Probability of product innovation**	
	Coeff.	Std. Err.	Marg. Eff.	Coeff.	Std. Err.
Exclusion restrictions in advertising equation					
Meet regulations	0.9983**	0.5115	0.2867	0.4861	0.4095
Customer acceptance lack	-4.1462*	2.2888	-1.1907	-1.7118	1.6809
Conglomerate dummy	-0.1898*	0.1089	-0.0529	0.0275	0.0777
Share private household cust.	-0.1498	0.1666	-0.0430	-0.0835	0.1166
Variables in both equations					
Information source customers	1.0008	0.8470	0.2874	1.2466*	0.6803
ln(Market size)	-0.0617*	0.0365	-0.0177	-0.0091	0.0267
Customer concentration index	0.0381	0.2124	0.0110	-0.3853***	0.1388
ln(Market concentration)	0.0827	0.0582	0.0237	0.0220	0.0446
ln(# of employees)	0.0018	0.0476	0.0005	0.1951***	0.0222
Imitation hazard...					
...not very important	2.4651***	1.0015	0.7079	0.7421	0.7134
...somewhat important	-2.5579***	0.7715	-0.7346	-0.1441	0.5643
...hazard important	-1.4763*	0.8427	-0.4240	1.2560**	0.5824
...very important	0.1410	0.8713	0.0405	1.0847*	0.6574
Dummy for East Germany	-0.0716	0.0957	-0.0204	-0.2337***	0.0714
Constant	1.5180	1.2482	—	-1.5075**	0.7688
Exclusion restrictions in product innovation equation					
Foreign competition expected	—	—	—	0.0877	0.0634
Share high skilled workers	—	—	—	1.0753***	0.2006
Share low skilled workers	—	—	—	0.3645***	0.1515
Academics as information source	—	—	—	1.0785**	0.4905
Correlation coefficient and test for independent equations					
ρ	0.7093***	0.2760			
$\chi^2(1)$ test for indep. (p–value)	0.0596				
Wald–tests for joint significance (p–values)					
Entire equation	0.0004			0.0000	
Imitation hazard	0.0003			0.1390	
Sector dummies	0.1124			0.1363	
Excl. restr. adv. eq.	0.0891			0.6868	
Excl. restr. prod. inno. eq.	—			0.0000	
Number of observations					
Number of observations	1734				
Censored observations	955				
Uncensored observations	774				

Table 1 displays bivariate probit model with sample selection estimation results for reduced form equations for product innovation advertising and product innovation. The asteriks ***,** and * indicate statistical significance at the one, five and ten per cent marginal significance level.

Table 2: Structural form binary probit model for product innovation

	Probability of product innovation		
	Coeff.	Std. Err.	Marg. Eff.
Variables in both equations			
Information source customers	1.0864**	0.5669	0.4289
ln(Market size)	0.0127	0.0274	0.0050
Customer concentration index	-0.3832**	0.1386	-0.1513
ln(Market concentration)	-0.0229	0.0465	-0.0090
ln(# of employees)	0.2093***	0.0211	0.0826
Imitation hazard...			
...not very important	-0.3766	0.8024	-0.1487
...somewhat important	0.8769	0.8632	0.3462
...hazard important	1.6588**	0.6951	0.6549
...very important	0.9558	0.6344	0.3774
Dummy for East Germany	-0.1994*	0.0059	-0.0782
Constant	-2.1825***	0.7643	—
Exclusion restrictions in product innovation equation			
Foreign competition expected	0.0974	0.0686	0.0384
Share high skilled workers	1.1249***	0.1971	0.4441
Share low skilled workers	0.4355***	0.1467	0.1719
Academics as information source	1.0664**	0.4876	0.4210
Effect of latent non–advertising			
Latent non–advertising	0.3946*	0.3946	0.1558
Wald–tests for joint significance (p–values)			
Entire equation	0.0000		
Imitation hazard	0.0741		
Sector dummies	0.0272		
Excl. restr. prod. inno. eq.	0.0000		
Number of observations			
Number of observations	1734		

Table 1 displays binary probit model estimation results for structural form equation for product innovation. The asteriks ***,** and * indicate statistical significance at the one, five and ten per cent marginal significance level. The standard errors are bootstrapped. 10,000 replications were used in the bootstrapping.

Appendix A: estimation method

In order for the Heckman–type selection model to be identified, the product innovation equation (the "selection equation") needs to contain variables that are not part of the product innovation advertising equation. These are the so–called "exclusion restrictions" that are summarized by the vector $\boldsymbol{z_i}$, where the subscript i denotes the ith observation. These exclusion restrictions must be orthogonal to the product innovation advertising decision.
In addition to the exclusion restrictions, the model for product innovation contains a set of variables that appear in both the product innovation and the product innovation advertising equation, vector $\boldsymbol{x_i}$.
Apart from this vector of joint variables $\boldsymbol{x_i}$, the product innovation advertising equation must also consist of a vector of variables $\boldsymbol{w_i}$ that appears in the advertising equation only. These again are exclusion restrictions, this time variables that affect product innovation advertising but not product innovation.
The *structural* equations for latent product innovation, PI_i^*, (as in all binary choice model the econometrician only observes the binary outcome but not the actual propensity of product innovation) and latent product innovation advertising, PIA_i^* respectively are hence:

$$\begin{aligned} \mathrm{PI}_i^* &= \delta \mathrm{PIA}_i^* + \boldsymbol{\alpha z_i} + \boldsymbol{\gamma}_{PI}\boldsymbol{x_i} + \mu_i \quad (1) \\ \mathrm{PIA}_i^* &= \boldsymbol{\gamma}_{PIA}\boldsymbol{x_i} + \boldsymbol{\theta w_i} + \eta_i, \quad (2) \end{aligned}$$

where PIA_i^* is only observed if product innovation took place, e.g. $\mathrm{PI}_i^* > 0$ in this binary choice setting. The terms μ_i and η_i denote are assumed to be i.i.d. bivariate normal distributed. The correlation between the two error terms is denoted by ρ.
Equation (3) cannot be directly be estimated because product innovation advertising is only observed if product innovation took place so that the information on product innovation advertising is a perfect predictor for product innovation (apart from the fact that it is also potentially endogenous). Likewise, Equation (2) cannot be directly estimated because it is conditional on product innovation. I solve this problem by proceeding in a standard way and estimate Equation (3) and (2) in *reduced form*. The estimation equation for product innovation hence is:

$$\mathrm{PI}_i^* = \delta(\boldsymbol{\gamma}_{PIA}\boldsymbol{x_i} + \boldsymbol{\theta w_i}) + \boldsymbol{\alpha z_i} + \boldsymbol{\gamma}_{PI}\boldsymbol{x_i} + \mu_i. \quad (3)$$

Equation (3) can consistently and, if the $\rho = 0$, efficiently estimated by a simple binary probit model. Apart from the possibility that there might be correlation between the error terms ($\rho \neq 0$), the interest is on the product innovation advertising as well so I estimate the equation for product innovation advertising, Equation (2), joint with the reduced form product innovation equation, Equation (3) using a Heckman–type model for two binary outcomes.

The drawback of such a reduced form estimation of the product innovation equation is that the effect of product innovation advertising on product innovation, the parameter δ, is not identified. In a second step following the estimation of the Heckman–type model I substitute these fitted values for latent product innovation advertising from the product innovation advertising equation in the Heckman–type model, $\text{PIA}_i^* = \hat{\boldsymbol{\gamma}}_{PIA}\boldsymbol{x_i} + \hat{\boldsymbol{\theta}}\boldsymbol{w_i}$, into the structural form equation for product innovation, Equation (3).

Appendix B: the Mannheim Innovation Panel in the service sector

The Centre for European Economic Research (Zentrum für Europäische Wirtschaftsforschung, ZEW) has been conducting surveys on innovative activity in the German service sector. The MIP–S is representative for the German service sector and carried out in collaboration with infas, Institute for Applied Social Studies. The project is based upon methodological and technical expertise gathered in a similar survey in manufacturing and mining (MIP), which has been carried out by the ZEW since 1993. Approximately 2,200 service sector firms take part in the survey annually. The firms belong to the sectors trade and transport (distributive services), banking and insurance as well as 'business related services' — such as software and telecommunication services, technical consulting and management consulting. The data is constructed as a panel data set, each firms are repeatedly asked to fill out the questionnaire. Every second year, newly founded firms are added to the survey population to ensure representativeness.
Every even year, a short questionnaire on core variables of innovation behavior (innovation activity, innovation expenditure and innovation success) is mailed to the firms in the sample. Every odd year, the questionnaire is enhanced by questions on special topics of innovative behavior (e.g. obstacles to innovation, innovation co–operations, targets and effects of innovation) and aspects of current policy relevance (e.g. shortage of skilled personnel).
In 1997 and 2001, the survey constituted the German contribution to the community innovation surveys (CIS) of the European Commission.
The data is available in an anonymized version (scientific use file) to external users for non–commercial basic research. Data requests may be sent the ZEW (info@zew.de).
The MIP–S is commissioned research for the German Federal Ministry of Education and Research.

Appendix C: descriptive statistics

	Product innovation advertising equation		**Product innovation equation**	
	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables				
Dummy no product advertising	0.3856	0.4870		
Dummy product innovation	0.4487	0.4975		
Exclusion restrictions in advertising equation				
Meet regulations	0.2744	0.1260	0.2556	0.1194
Customer acceptance lack	0.1829	0.0426	0.1780	0.0425
Conglomerate dummy	0.3827	0.4863	0.3118	0.4634
Share private household cust.	0.2307	0.3321	0.2522	0.3457
Variables in both equations				
Information source customers	0.3451	0.0932	0.3257	0.0952
ln(Market size)	23.8134	1.7770	23.8585	1.8213
Customer concentration index	0.6250	0.2402	0.6546	0.2446
ln(Market concentration)	-3.9096	1.1124	3.9791	1.1278
ln(# of employees)	4.3248	1.9142	3.8251	1.7935
Dummy retail trade	0.1057	0.3077	0.1473	0.3545
Dummy transport	0.0771	0.2669	0.0742	0.2622
Dummy banking and insurance	0.2226	0.4163	0.1735	0.3788
Dummy technical services	0.2289	0.4204	0.1914	0.3935
Dummy 'other' services	0.2624	0.4402	0.2868	0.4524
Imitation hazard...				
...not very important	0.1892	0.0565	0.1844	0.0591
...somewhat important	0.1724	0.0672	0.1788	0.0726
...hazard important	0.2005	0.0679	0.1941	0.0697
...very important	0.1534	0.0640	0.1536	0.0635
Dummy for East Germany	0.3097	0.4627	0.3471	0.4762
Exclusion restrictions in product innovation equation				
Foreign competition expected			0.5035	0.5001
Share high skilled workers			0.2038	0.2555
Share low skilled workers			0.5821	0.2906
Academics as information source			0.1245	0.0886

Appendix D: specification checks

The two most important criteria for model appropriateness are (i) validity of the exclusion restrictions and (ii) predictive power of the equation for product innovation advertising.
The first criterion has already been partly validated by my finding of significant effects of the exclusion restrictions in the equations to which they are associated and my finding of insignificant effects of the exclusion restrictions for product innovation advertising in the product innovation equation. What is still missing is a test for insignificance of the exclusion restriction of the product innovation equation in the product innovation advertising equation. The problem here is that product innovation advertising is conditional on product innovation so that "direct" test as described above do not apply. In order to still get an impression on how closely product innovation advertising is related to the exclusion restrictions of the product innovation equation, I use two "informal" test. First, I run a simple binary probit model for non–advertising as in Table 1 and ignore that it is conditional on product innovation. The exclusion restrictions are both jointly and separately insignificantly different from zero at the usual significance levels (the p–value for the joint test is 0.3148). Second, I regress the generalized residuals from the advertising part of the Heckman–type probit model (using the results from Table 1) on the exclusion restrictions.[14] The results from that auxiliary regression do not provide evidence in favor of non–orthogonality: the specification is jointly insignificant (p–value 0.2844) with an adjusted R^2 of 0.0004. None of the coefficients is separately significantly different from zero. Even though both procedures are not true test for orthogonality of the exclusion restrictions of the product innovation equation in the product innovation advertising equation, they both strongly suggest that they are indeed orthogonal.
The second criterion for model validity is that the predicted values from the product innovation advertising equation are reasonably well fitted so that they indeed carry information about latent product innovation advertising that is used in the structural form product innovation equation. First of all, the specification for product innovation advertising is jointly highly significant.[15] Second, 62 percent of the binary outcomes of the non–advertising outcomes are correctly predicted.

Additional specification checks involved discarding all firms with more than 250 employees, thus restricting attention to Small and Medium Sized (SMEs) firms only. The results regarding substitutability between product innovation and

[14]Residuals from an estimation equation cannot be as easily backed out from the fitted values of the dependent variable as in linear regression models so that "generalized" residuals need to be used. See Chesher and Irish (1987) for details.

[15]There is no equivalent to the usual pseudo R^2 since there is no constants–only specification. Note, however, that the pseudo R^2 is just a transformation of a test for joint parameter significance.

product innovation advertising remain the same: there is an even higher correlation between the unobserved components of the two equations (ρ=0.907, p–value 0.0135) while the magnitude and significance of latent product innovation advertising has remained about the same. Probably due to the reduction in firm heterogeneity, the specification fit (correctly predicted outcomes and tests for joint significance) improves if the large firms are discarded.
I have also re–estimated my model leaving out one or more of the main sectors that serve as controls variables in the estimations. Even though the sector dummy variables are both jointly and separately insignificantly different from zero, the effects of each of the variables might differ depending on the sector of consideration. The estimation results from these sector–level estimations also show substitutability between product innovation and product innovation advertising. Both the correlation coefficient and the coefficient on latent product innovation advertising tend to be, however, estimated quite imprecisely. My explanation for the insignificance is that the identification of my model partly stems from sector–level information. The variation in the sector–level variables is reduced if one or more sectors are left out so that less precision in the parameter estimates is a natural outcome.