Running title:

Product Innovation and Product Innovation Advertising

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

Ulrich Kaiser*

University of Southern Denmark at Odense
Centre for Economic and Business Research
Centre for European Economic Research

[§]**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, Thomas Rønde, Armin Schmutzler 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.

*__Address:__ University of Southern Denmark at Odense, Dept. of Economics, Campusvej 55, 5230 Odense M, Denmark; email: uka@sam.sdu.dk, internet: www.sam.sdu.dk/staff/uka, Centre for European Economic Research, Mannheim, and Centre for Economic and Business Research, Copenhagen.

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 advertising 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 not invest in advertising their innovation?

One reason could of course be that there is no need to market the product because it the innovator is very closely connected to its

[1] See Scherer and Ross (1990, Ch. 16) and Martin (1993, 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.

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).[3] 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 versa. 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 additional 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.[4]

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

[3]There is an analogy to process innovation expenditures where an increase in product substitution goes along with reduced R&D efforts (Kamien et al. 1992).

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

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 evidence 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 less more severe a problem it is that consumers do not accept innovations, (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.[5] This is why I apply a direct test for substitutability as well.

The direct test is based on a binary probit regression that models

[5]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.

the instance of product innovation as a function of the probability to not advertise 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 1979) selection model with the difference that the equation of interest, the product innovation advertising equation, is binary and not continuous as in the classical case. In both cases two equations are estimated, a selection equation and an equation of interest with the error terms of the two equations being assumed to be bivariate normal distributed with correlation

coefficient ρ.

The potential endogeneity of product innovation advertising on product innovation requires the product innovation equation to be estimated 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 consist of 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 comes with 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.

My joint Heckman–type selection model for product innovation ad-

vertising and product innovation does not identify the effect of product innovation advertising on product innovation, however, so that I then back out the fitted values for product innovation advertising — the "latent" variable — 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 1983, 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).[6]

Appendix A describes the estimation procedure in further detail.[7]

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

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

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

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.[8] Market

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

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 be a niche player while a firm that serves all four customer groups equally might be quite diversified.[9] 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.

[9]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.

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.[10] Since 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

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

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.[11]

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 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 is therefore considered as sectors with high R&D productivity. Higher R&D productivity creates incentives to perform R&D

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

and hence increases the probability of product innovation which is why I expect this variable to have a positive effect on product innovation.[12]

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 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

[12]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 the end of Section 3 for more details) show that cooperation with research institutions does not have a significant effect on product innovation advertising.

private households.

The variable for governmental regulations is thought to serve as a "no need to advertise" variable. If innovation tends 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 be less restricted than for independent firms.[13]

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 innovation at all.

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

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

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.[14]

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 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) compo-

[14]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.

nents 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.

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.

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 adver-

tise, 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 2 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 as-

sociated 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 prod-

ucts. 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 in my sample 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.

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.

References

Baldwin, W.L. and J.T. Scott (1987) *Market Structure and Technological Change*. Harwood Academic Publishers.

Cassiman, B. and R. Veugelers (2002) *Complementarity in the Innovation Strategy: Internal R&D, External technology acquisition, and Cooperation in R&D*. CEPR discussion paper 3284.

Dorfman, R. and P.O. Steiner (1954) Optimal Advertising and Optimal Quality. *The American Economic Review*, 44(12), 826–836.

Efron, B. and R. Tibshirani (1986) Bootstrap Measures for Standard Errors, Confidence Intervals, and other Measures of Statistical Accuracy. *Statistical Science*, 1, 54–77.

Heckman (1979) Sample Selection Bias as Specification Error. *Econometrica*, 47, 153–161.

Holmström, B. and P. Milgrom (1994) The firm as an incentive system. *American Economic Review*, 84, 972–991.

Janz, N., G. Ebling, S. Gottschalk and H. Niggemann (2001) The Mannheim Innovation Panels (MIP and MIP-S) of the Centre for European Economic Research (ZEW). *Schmollers Jahrbuch — Zeitschrift für Wirtschafts- und Sozialwissenschaften*, 121, 123–129.

Kamien, M. I., E. Muller, and I. Zang (1992) Research Joint Ventures and R&D Cartels. *American Economic Review*, 82, 1293–1306.

Kamien, M.I. and N. L. Schwartz (1982) *Market Structure and Innovation*. Cambridge University Press.

Maddala, G.S. (1983) *Limited Dependent Variables and Qualitative Variables in Econometrics*. Cambridge University Press.

Martin, S. (1993) *Advanced Industrial Economics*. Basil Blackwell.

Milgrom, P. and J. Roberts (1990) The Economics of Modern Manufacturing: Technology, Strategy, and Organization. *American Economic Review*, 80, 511–528.

Nelson, P. (1974) Advertising as Information. *Journal of Political Economy*, 82(4), 729–754.

Scherer, F.M. (1967) Research and Development Resource Allocation under Rivalry. *Quarterly Journal of Economics*, 81, 265–309.

Scherer, F.M. and D. Ross (1990) *Industrial Market Structure and Economic Performance*. Houghton Mifflin.