Commercialization of Innovations

and

Firm Performance

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Abstract:
The decision on investment in R&D is very important and highly risky for firms' performance and survival in their business. This paper focuses on the commercialization of firms' investment in innovation and how these decisions affect their performance. The study uses a large innovation survey of Danish firms holding information on their F&U investment as well as their patent strategies. The survey also contains information on product and process innovation and the firms' expenses on marketing which gives knowledge of the commercialization of their innovations. The survey has been merged with a longitudinal database of account information making it possible to track firms' performance over a longer period.

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1. Introduction

Product innovation and the succeeding introduction of these products to the market is often crucial for the development of the competitive advantage of a firm. Thus, successful product development is critical to long term profitability of firms and often it makes up the difference between survivors and those going bankrupt. More generally, Schumpeter (1975) refers to this process as "creative destructions", where the large incumbent corporations lack the incentive to innovate and therefore lose out to new entrants in the long run.

Innovation of new products is crucial in the first place, but commercialization of these products is important as well for the performance of the firms. In a survey of 197 research projects in large American companies Mansfield (1971) found that 57% of the projects turned out to be a technical success. However, only 48% of these projects also turned out to be a commercial success at the end of the day. This result stresses the marketing aspect for the financial success of an innovation process. The commercialization question includes not least the feedback of the customers' need from the Marketing Department so resources invested in development of new products could be used most efficiently on useful products. Consequently user-driven product development has recently been on the agenda in the formulation of many firms' market strategies.

Therefore the commercialization of innovation is essential for the overall performance of an innovative firm. However, the empirical research on this topic has been relatively sparse as most studies on firm performance have focused on the influence from either R&D or marketing, but not both at the same time. First recently a few studies have emerged focusing on the mutual interaction of R&D, innovation, advertising and the effect on firm performance. Griffin and Hauser (1996) and Hauser, Tellis and Griffin (2006) gives a survey of the interaction of innovation and advertising, while Lin, Lee and Hung (2006) estimate the effects on firm performance of a higher effort in commercialization of innovations.

The purpose of this study is to further develop the empirical evidence on this interaction by using a rich and large survey of Danish firms. The next part lists the key arguments from the theoretical literature on the influence of innovation and marketing on firm performance. The third part includes a presentation of the data set used in the empirical analysis and the empirical results of the study are presented in part 4 and 5. The final part concludes the paper.

2. Commercialization of innovation

It is well known that firms' investment in marketing is related to the market structure they operate within. Originally the profit-maximizing level of advertising was developed by Dorfman and Steiner (1954) and for the individual firm this condition is:

$$\frac{A_i}{S_i} = \frac{P - C_i}{P}\varepsilon_{qA} = \frac{s_i}{\varepsilon_{qP}}\varepsilon_{qA} \qquad (1)$$

where A_i is the firms' expenditure on advertising, S_i is firm sales and P minus C_i is the absolute mark-up. The main implication from this condition is that the optimal advertising to sales ratio for a firm depends positively on the price-cost margin ($(P\text{-}C_i)/P$) and the elasticity of demand with respect to advertising outlays (ε_{qA}). The price-cost margin depends on the market structure and is expected to increase in more concentrated industries with less competition and increasing collusion among the fewer firms. Also firm's cost efficiency is important for the price-cost margin and more efficient firms with a lower C_i are therefore expected to have a higher advertising to sales ratio. Further, the price-cost margin for the individual firm can also be expressed by the market share (s_i) and the elasticity of demand (ε_{qP}) as shown in the second term of equation (1)[1]. Advertising is therefore positively related to the firm's market share and negatively to the elasticity of demand. In industries with differentiated products the firm's elasticity of demand is expected to be low and therefore the advertising to sales ratio is expected to be high.

[1] The original Dorfman-Steiner condition was developed for a monopoly. This is an extended version for a firm operating in an oligopolistic market with Cournot competitions.

Market structure may also affect the efficiency of advertising measured by the elasticity of demand with respect to advertising. In industries with many competitors the spill-over from the firms' advertising campaign to the competitors' sales may be high and reduce the effect of and then the profitability of advertising. On the other hand, in highly monopolistic industries firms may therefore collude and reduce the outlay for advertising to eliminate the cannibalistic effect of advertising on each others demand and thereby increase profit. As a result an inverted-U relationship between the advertising to sales ratio and market concentration is expected.

Focusing now on the innovative firms, they are expected to invest more in marketing for several reasons. First of all, new products have to be known by the customers so the information aspect of advertising is more prominent in innovative industries and especially for firms making product innovations. Often firms have to launch an expensive advertising campaign to bring a new product well on the market.

Next, knowledge-based firms often face the problem of imitation by their competitors, see Arrow (1962) and Levin et al. (1987) who describes this as the appropriability problem as innovating firms in competitive industries may be unable to fully appropriate the total value of their innovation. Investing in marketing to build brand loyalty will therefore increase the cost for imitators of bringing a copy of their product on the market. Therefore innovating firms can overcome this market failure and appropriate more value from their first mover advantages by investing in marketing and for this reason investment in R&D and marketing is expected to be complements. Of cause, for large innovations the patent system may reduce the problem, but patenting is not a perfect solution to imitation as it may still be possible to innovate around the patent in many industries. Further, patenting is a costly solution. Therefore for many smaller innovations the commercialization of innovation may be the only solution.

In addition marketing is an important part of the product development process itself by providing information on customers' need and identifying opportunities for product improvement. This is especially through in industries with a lot of user driven

innovations. As the firm grows larger, the marketing and R&D functions often becomes specialized within the firm. As a result of this development it is crucial that the two departments of the firm cooperate in resolving the tradeoffs between the customers-need and the engineering design. There is a lot of empirical evidence that stresses the usefulness of cooperation between marketing and R&D in the process of product development. The cooperation increases the success rate of new product, see Griffin and Hauser (1996) and Hauser, Tellis and Griffin (2006) for a survey of this literature. As cooperation with the marketing department is necessary for a successful product development it is expected that firms with a significant development of new product also invest heavily in marketing.

Still, it is well known that investment in marketing and R&D can be viewed as substitutes too. In periods when firms are going through a downsizing and the resources therefore are becoming more scarce a rivalry between marketing and R&D can emerge and this will reduce the quality of information and the performance of the firm, see Maltz, Souder and Kumar (2001) for empirical evidence. Furthermore, in their competitive strategies firms may want to reduce the potential competitions by creating barriers to entry and in order to pursue this strategy they can either invest in brand reputation, product development or production process advantages.

Firm performance

There is a wide variety of success measure for firm performance varying from their productivity gains and financial returns to growth of market share or even the survival rate as mentioned in the introduction. The approach in this study will bee to examine where the commercialization of innovations affect the factor productivity of the firms. In line with other studies gross value added (VA_i) is used as an output measure and the production function for the value creation process is given as:

$$VA_i = C_i^{\alpha} L_i^{\beta} K_i^{\delta} B_i^{\gamma} X_i \qquad (2)$$

The firm is assumed to have 4 production factors, physical capital (C_i), labour (L_i), a stock of knowledge (K_i) and a 'stock of brand reputations'(B_i). The output elasticities ($\alpha,\beta,\delta,\gamma$) are all expected to be positive but not necessarily summing to one. As labour is measured by the number of employed the stock of knowledge includes education, patent right, product and process innovation and other knowledge accumulated in the organization. The stock of knowledge and brand reputation is difficult to measure directly and often the different methods are data demanding and therefore gives incorrect measures, see Smith et al (2004). Therefore our survey uses some indirect measure from the process of creating these stocks either from the output or input side of the process

The total factor productivity (X_i) in equation (2) is expected to depend positively of the commercialization of innovation and an interaction term of marketing and innovation will capture this effect in the estimations (not shown in equation 2). However, factor productivity also depends on other firm characteristics and the product market competition and variables are introduced in the regression to control for these effects.

Other empirical studies

Until now only a few studies have examined the interaction between innovation and marketing at the firm level. Vinrod and Rao (2000) give a short survey of 4 earlier studies and in general a positive relationship between firm's promotional expenditures and their innovative effort is found. In their own study of 53 firms from the pharmaceutical industry they find that the R&D to sales ratio explains above 90% of the variation in the promotional intensity.

Whether commercialization of innovation is important for the performance of firms has to our knowledge only been examined by Lin, Lee and Hung (2006). In a sample of 143 firms from the pharmaceutical industry they found a significant positive effect on firm value at the stock exchange of an interaction effect between R&D intensity and commercialization measured by expenditure on marketing.

3. The data

The data used in the empirical analysis consists of a rich survey of Danish firms including information on firms' innovation and marketing behavior. The information was collected in the 2002 by sending a questionnaire to 2410 firms, out of which 760 answered the questionnaire giving a response rate of 32%, which are considered quite high in firm surveys. Half the sample population includes firms known to have a patent application considered at the European Patent Office in the period from 1960 to 1999. These patent-active firms have been supplemented by a randomly draw sample among the rest of the firms. However, this sample has been stratified to include all the largest firms in order to match patent active firms which are relatively large. Furthermore a few industries like public institution, agriculture, fishing and raw materials has been left out.

Finally the survey data was merged with a longitudinal firm database containing information of standard account variables, employment, gross value added and some measure of the competitive environment in the industries[2]. Table 1 gives the descriptive statistics for the variables used in the analysis below.

To increase the response rate and enhance the quality of the survey some of the variables have been formulated as categorical variables with 7 intervals to ease the information search by respondents in answering the questionnaire. This is the case for the advertising to sales ratio, the export share, the home market share, the world market share and the degree of product differentiation, while the total amount invested in R&D and the turnover has been asked for the calculation of the R&D to sales ratio. Advertising is defined in the questionnaire to include personal sales effort, administration of promotion etc. and is equal the total expenses for marketing. Likewise, R&D has been defined to include all resources used in the development of products and processes in the firm (OECD definition).

[2] The accounting data comes from Experian, a Danish credit rating agency who carefully collects firms annual report and checks the data for each firm by e.g. personal interview at least once a year.

Table 1: Descriptive statistics of variables for 2002

Variables	Mean	Standard deviation	Number of observations
Advertising to sales ratio	0.0566	0.0601	651
R&D to sales ratio	0.0349	0.1550	651
Patent active	0.4947	0.5002	855
Product innovations	0.6110	0.4878	707
Process innovations	0.5466	0.4982	697
Export share	0.3318	0.3331	641
Home market share	0.2717	0.2851	624
World market share	0.0530	0.0832	609
Product differentiation	4.1232	1.8085	641
Number of employed	229	1145.9	768
Value added per employed (1000)	534.2	729.6	712
Herfindahl index	0.2584	0.2518	851
Minimum efficient scale	8.084	1.263	851

Half of the firms were patent active in the past (1960 to 1999). However, 61% of the firms have developed one or more product innovations in the period 1990-2000 and 55% have developed one or more process innovation in the period, thus not all innovation ends up in a patent application. Table 2 lists the variable means for product innovative and non-product innovative firms and it clearly shows that the product innovative firm invests a much higher share of the turnover in R&D and marketing. These firms also have a significantly higher share of the process innovation and a higher export share, home market share, world market share and they of cause have a higher degree of product differentiation. On average they have the double size of non-product innovative firms and they create 20% more value added per employed. This may partly be due to the competitive environment as on average they operate in more concentrated industries with a higher minimum efficient scale. The following part will make a more thorough analysis of these aspects.

Table 2: Means for product innovative and non-product innovative firms

Variables	All firms	Product innovative	Non-product innovative
Advertising to sales ratio	0.0566	0.0677	0.0366
R&D to sales ratio	0.0349	0.0508	0.0097
Patent active	0.4947	0.6528	0.2800
Product innovations	0.6110	1	0
Process innovations	0.5466	0.7780	0.1791
Export share	0.3318	04104	0.1858
Home market share	0.2717	0.3298	0.1646
World market share	0.0530	0.0695	0.0213
Product differentiation	4.1232	4.5588	3.3410
Number of employed	229	316	132
Value added per employed (1000)	534.2	564.9	471
Herfindahl index	0.2584	0.2921	0.2396
Minimum efficient scale	8.084	8.364	7.8728

4. Commercialization of innovations

To analyze the commercialization of innovation a linearization of the Dorfman-Steiner condition in equation (1) has been used as the basic estimation equation and table 3 presents the coefficients from four different models. The data has not been trimmed to a balanced dataset therefore the number of observations drop as more variables are introduced in the estimations models due to missing answers in the questionnaires.

In all 4 models the R&D intensity has a highly significant effect on advertising intensity with a negative coefficient for the squared term. The implication is an inverted-U relationship between advertising and R&D with the highest commercialization level of innovations in firms with a R&D-share between 45 % (model 4) and 66 % (models 1, 2 and 3). This result verifies that firms investing in R&D also focus on the commercialization of their innovations.

Table 3: Estimates of the commercialization of innovation

	Dependent variable: Advertising share (A_i/ S_i)			
	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	0.0334* (0.0157)	0.0092 (0.0072)	-0.0040 (0.0090)	(Industry dummies)
R&D share	0.1571** (0.0370)	0.1163** (0.0369)	0.1014* (0.0409)	0.1096* (0.0464)
R&D share - squared	-0.1217** (0.0252)	-0.0961** (0.0249)	-0.0842** (0.0255)	-0.1210** (0.0300)
Minimum efficient scale	0.0014 (0.0019)			
Herfindahl index	0.0669* (0.0310)	0.0618* (0.0303)	0.0327 (0.0313)	
Herfindahl index - squared	-0.0723* (0.0349)	-0.0716* (0.0340)	-0.0450 (0.0352)	
R&D share * Herfindahl	0.1166 (0.0740)	0.1073 (0.0718)	0.0834 (0.0754)	0.2249* (0.1059)
Log of size		0.0049** (0.0014)	0.0029* (0.0014)	0.0028* (0.0015)
New product dummy		0.0157* (0.0064)	0.0034 (0.0068)	
New process dummy		-0.0051 (0.0060)	-0.0087 (0.0063)	
Patent dummy		0.0202** (0.0051)	0.0054 (0.0055)	
Home market share			0.0215* (0.0104)	0.0212* (0.0105)
World market share			0.0893* (0.0354)	0.0789* (0.0368)
Export share			0.0234** (0.0090)	0.0225* (0.0099)
Product differentiation			0.0210** (0.0047)	0.0183** (0.0047)
R^2 (Adjusted)	0.0592	0.1390	0.2193	0.2942
Observations	599	582	514	523

Notes: Numbers in brackets are standard error of the coefficient. * denotes that the estimated coefficient is significant at the 5% level and ** at the 1% level.

Also the market structure has the expected effect on advertising intensity with a significant inverted-U relationship to market concentration and a positive but not significant coefficient to the minimum efficient scale. Thus the maximum influence from market concentration is approximately 50 % or equal to 2 when interpreted as the number equivalent firms in the industry. Firm size and some indicators of the innovation activities are introduced in model (2). Larger firms have a significant higher promotion intensity, which could reflect that they are less liquidity constrained than smaller firms. Furthermore firms holding a patent or firms which have introduced a new product within the last 10 years also have a significant higher promotion share. Again, this is in accordance with the commercialization hypothesis of innovation mentioned above.

Model (3) introduces market shares and a measure of product differentiation and they are highly significant and with the expected sign. However, by introducing market shares and product differentiation the coefficients of the innovation dummies drop and become insignificant. These results underline the discussion of the Dorfman-Steiner condition. Firstly because innovation increases the price-cost margin and secondly because larger market shares increases the total payoff to the marketing effort which results in a higher optimal promotion intensity.

The need for promotion activities may vary across industries depending on e.g. the characteristics of the product, technical factors or whether the customers are final consumers or other firms. Therefore model (4) includes dummy variables for 45 different industries to control for this heterogeneity across the industries. However, controlling for this heterogeneity does not seem to affect the size of the estimated coefficients in any notably way except for the influence from the interaction between the R&D intensity and market concentration. Thus, when control is made for the unobserved differences between industries it is found that commercialization of innovation are significant stronger in more concentrated industries.

5. Firm performance

This section deals with the performance aspects of the commercialization of innovations and table 4 presents the estimated coefficient of four alternative estimation forms of a log transformed version of equation (2). Again, the number of observations is reduced due to missing value in the different variables.

Model (1) presents a basic model where R&D intensity is used as a proxy for the knowledge stock and advertising intensity is used as a proxy for the stock of brand reputation. The output elasticities are highly significant and have the right sign except for the R&D intensity. This results suggest that technology based firms which only invest in R&D may not be able to enhance the full competitive advantages and create value above the R&D expenses whereas the marketing intensity has a significant positive effect on the value created by the firm. These results are in line with the finding of Lin, Lee and Hung (2006). An obvious reason for the negative return to R&D may be the short run nature of the estimation model and that especially investment in R&D takes several years to affect the competitiveness of a firm whereas it immediately increases the costs. The leverage variable is defined as the total assets of the firm divided by the amount of equity and verifies as expected that more leveraged firms create more value to the owners and debt holders of these firms in order to compensate for the higher risk.

Alternative proxies for the knowledge stock has been introduced in model (2) testing where those firms which have developed new products or new production methods within the latest decade had create more value. The two proxies take into account the long run nature of the innovation process and the sign of both parameters are positive but not significant. Variables of the competitive environment of the firm are tested in model (3) and as expected a significant inverted-U relationship exist between the value creation in firms and market concentration. Home market share and world market share have a positive effect on value creation as well, but they are not significant. Next, exporting firms create less value, which may seem surprising. However this result is in line with Bitzer, Görg and Schröeder (2008) who argues that outflows of knowledge to competitors via export may hurt the firms of the home countries.

Table 4: Estimation of firm performance and commercialization of innovation

	Dependent variable: Log of value added			
	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	4.2836** (0.2161)	4.1046** (0.1909)	3.8842** (0.3262)	4.1899** (0.2260)
Log of equity	0.3173** (0.0367)	0.3480** (0.0328)	0.3154** (0.0412)	0.3240** (0.0380)
Log of employment	0.6537** (0.0443)	0.6271** (0.0406)	0.6453** (0.0480)	0.6480** (0.0452)
Levered	0.2525** (0.0595)	0.2968** (0.0537)	0.2580** (0.0660)	0.2550** (0.0617)
R&D share	-0.4606* (0.2062)		-0.5265* (0.2223)	-1.8265** (0.7024)
R&D share - squared				0.6632* (0.3369)
Advertising share	1.8389** (0.5444)		2.0273** (0.6547)	1.9392** (0.6294)
Minimum efficient scale			0.0518 (0.0285)	
Herfindahl index			1.1495** (0.4655)	0.9704* (0.4321)
Herfindahl index - squared			-1.2200* (0.5172)	-0.9897* (0.4769)
New product dummy		0.1001 (0.0763)		
New process dummy		0.0436 (0.0755)		
Home market share			0.0105 (0.1471)	
World market share			0.4702 (0.5156)	
Export share			-0.2976* (0.1281)	-0.1826 (0.1089)
Product differentiation			-0.0407 (0.0682)	
R&D share * adv. share				5.3329 (5.0807)
R^2 (Adjusted)	0.8449	0.8549	0.8368	0.8452
Observations	496	552	435	477

Notes: Numbers in brackets are standard error of the coefficient. * denotes that the estimated coefficient is significant at the 5% level and ** at the 1% level.

Finally all insignificant variables from model (1) to model (3) were dropped and column 4 shows the resulting model specification. In addition the interaction term between R&D intensity and advertising intensity is now introduced. In accordance with the theoretical model the coefficient of the interaction term is positive but it is not significant at the 5% level. Also a non linear relationship with the R&D intensity is introduced suggesting that the influence on gross value added is U-shaped with a minimum value fro the R&D intensity equal to 1.32. Thus, it can not be verified that firms with a high rate of R&D intensity may create more value in the short run. This result is partly consistent with the literature dealing with R&D and productivity effects where several empirical studies suggests that the positive effects of R&D is present in the long run, see Smith, Eriksson, Dilling-Hansen and Madsen (2004). The advertising intensity is highly significant and this verifies, that investment in marketing in the short run seems to be more important than investment in R&D in creating value for the firm and some indication also exists that firms with a higher degree of commercialization of their innovation create more value.

The analyses do not take into account the potential mutual dependency between advertizing and firm performance. According to the Structure-Conduct-Performance paradigm conduct in terms of e.g. an advertizing strategy affect firm performance. But the causality may also be the adverse that firms performing well can afford to use a significant amount of resources on advertizing strategies, market campaigns etc. in building barriers to entry of new competitors to enlarge their dominant market position. Experiments to correct for this simultaneous bias in the estimated coefficients have been run using IV and simultaneous estimation techniques. However, the estimated parameters for some of the variables changes size in an unrealistic way and the most likely explanation for this is lack of suitable instruments.

6. Conclusion

This study focuses on the commercialization of innovations and how these strategic decisions in the firms affect their performance. The analyses use a large innovation survey containing information on firms' innovation of new products and new production processes as well as their investment in product promotion.

The empirical analysis verifies a highly significant commercialization of innovation. So firms' follow a strategy of investment both in innovation and marketing making R&D and marketing complements in their investment decision. However, there is only week evidence for the hypothesis that commercialization of innovations also creates more value for the firms in the short run.

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