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Published in:
Small Business Economics

Publication date:
1996

Firm Size, Small Business Presence and Sales of Innovative Products: A Micro-econometric Analysis

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ABSTRACT. In our generalized TOBIT analysis we identify a number of variables which have an impact on a firm's innovation "output". Among others we find that larger firms generally have a higher probability of selling some innovative products, although this probability increases less than proportionately with firm size. Given that a firm has some sales of innovative products, the share of such products in a firm's total sales tends to be higher in smaller firms. Moreover, a strong small business presence in a sector seems to enhance imitative innovation but has no influence on "true" innovations, whereas market concentration has no influence on innovation "output" in whatever definition. We also find evidence of regional knowledge spill-overs. Furthermore, our results are consistent with Schmookler's hypothesis that the growth of demand enhances innovation. The outcomes about the impact of R&D collaboration and technology transfer on innovation remain ambiguous.

I. Introduction

In the past, empirical research on determinants of innovation concentrated on data on R&D and patents. Both indicators have some well-known shortcomings. For example, not all innovations are protected by patents and many patents are never translated into commercially viable products. Moreover, the propensity to patent may vary across sectors or firm size classes. Also data on R&D have several disadvantages. First, there is evidence that small-scale and often informal R&D tends to be undercounted in R&D surveys and that the quantity of R&D measured in small firms may be quite sensitive to questionnaire design (Kleinknecht *et al.*, 1991); second, R&D covers a wide variety of activities, ranging from – far from the market – basic research, via applied research up to development. Third, firms can use their innovative resources with varying degrees of efficiency.

Such arguments suggest that more direct measures of innovation behaviour, i.e., indicators of the output side of the innovation process are desirable. Once a direct measure of innovations (introduced into the market) is available, one can also study factors which influence the relationship of innovation input and output. In other words, it becomes interesting to see which factors cause differences between firms' innovation output, given a certain R&D input. Obvious candidate variables are factors such as firm size, market structure, regional location, the growth of demand, technology transfer, R&D collaboration and others.

In recent years, direct measures of innovation output have been developed in two ways. First by recording new product announcements in a larger number of trade journals; second, by means of postal surveys, asking firms about sales due to innovative products. In 1984 the U.S. Small Business Administration commissioned the collection of more than 8,000 new product announcements from U.S. trade journals. These new data enabled a wave of fruitful research about the impact of firm size on innovation which has recently been summarized by Acs and Audretsch (1993). In their survey, these authors claim that there is indeed a "new learning" about this issue. Perhaps the most important message from this new research is that, according to these new indicators, small and medium-sized firms have a more favourable innovation record than when judged from conventional R&D (input) data. Research

Final version accepted on August 18, 1995

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Small Business Economics 8: 189–201, 1996.

from similar data collected in European countries seems to confirm this (see various contributions in Kleinknecht and Bain, 1993).

Quite recently, in the framework of the Community Innovation Survey (CIS) project of the European Commission, data have been collected on the second type of output indicator: sales of innovative products. This new indicator was obtained by asking innovative firms to subdivide their total product range into three types, i.e.:

- products essentially unchanged during 1990–92;
- products incrementally improved during 1990–92; and
- products radically changed or newly introduced during 1990–92.

Firms were then asked to report the percentages of their 1992 sales that were due to each of the three categories of product named.

Obviously, this new indicator differs from R&D input data in that we look directly at the results of the innovation process in terms of cash flow. In so far, this indicator comes very close to the original Schumpeterian definition of innovation as being the successful market introduction of a new item. Moreover, the new indicator allows to differentiate by degree of innovation: products "new to the firm" versus products "new to the industry" (i.e., not earlier introduced by a direct competitor). Whereas products "new to the firm" are often based on some degree of imitation of innovations introduced earlier by competitors, products "new to the industry" may be considered as "true" innovations.

The CIS indicator differs from patents in that it can include non-patented (or even non-patentable) innovations. There is also a major difference with respect to indicators based on the announcement of new products in trade and technical journals. The latter captures announcements of new products many of which may fail or even may never result in a positive cash-flow, whereas the CIS indicator is confined to innovations which were successful, leading to sales.

In the following, we report the outcomes of this indicator, obtained in a national innovation survey among some 8,000 firms with 10 and more employees in the Netherlands. In Section II, we give some descriptive statistics, and in Section III we estimate a generalized TOBIT model on the new data. With the help of that model we analyze which variables have a systematic impact on the probability that a firm will have some sales of innovative products and, given that a firm has such sales, which factors have a systematic influence on the percentage of its total sales due to innovative products.

While special attention is given to the firm size issue, the model provides insights into a larger number of factors behind innovation. Among others we find that innovation output is influenced by a firm's location in a certain type of region, by the growth of demand (supporting Schmookler's demand-pull hypothesis) and by the degree of small business presence in a sector. One of the most surprising outcomes is that we find little evidence that firms which engage in R&D collaboration or acquire technological knowledge via external channels have a higher innovation output. Moreover, market concentration is found to have no influence on innovation output.

II. Descriptive data on sales of innovative products

The European Community Innovation Survey (CIS) was constructed as follows. In the first part of the questionnaire, all sample firms were asked to report basic information on the firm, including details about the branch of principal activity, sales, exports, employment, etc. Thereafter, three "filtering" questions followed:

1. Did your firm develop any technologically changed products during 1990–92?
2. Did your firm develop any technologically changed processes during 1990–92?
3. Does your firm have plans to develop any technologically changed products or processes in the years 1993–95?

If at least one of these questions was answered in the affirmative, the firm was asked to complete the remainder of the questionnaire; if all answers were negative, the firm was asked to return the questionnaire with only the first part filled in. The intention behind this procedure was that non-innovators should not be bothered with numerous questions about innovation which they might experience as irrelevant (perhaps introducing a bias as non-innovators may have a higher probability of becoming non-respondents). Our analysis among non-responding firms suggests that there is no such bias problem in our survey (Brouwer and Kleinknecht, 1994).

Table I covers the percentages of firms by size class which answered "yes" to one or more of the three questions. The figures can be interpreted as national totals (for details see Brouwer and Kleinknecht, 1994). Percentages of innovators are clearly higher in manufacturing than in services, and percentages of firms that engage in innovative projects are higher among the larger firms. In the smallest size class (10–19 workers), between 6% and 28% of firms engaged in product or process innovations in 1990–92 or have plans do to so in the near future; in the largest size class (500 and more workers), the corresponding percentages are between 56% and 84%.

We have mentioned three types of product on which the new output indicator for postal surveys is based: (1) essentially unchanged products, (2) incrementally improved products, and (3) radically changed or totally new products. In this paper, we shall join the latter two categories into one: "innovative products". The survey questionnaire asked for a further subdivision of "innovative products" into the following two categories:

- products "new to the firm" (i.e., already known in the industry);
- products "new to the industry" (i.e., not introduced earlier by a competitor).

While cases of the second category can be interpreted as "true" innovations, the first category will often be based on imitation of innovations introduced earlier by competitors.

Table II gives more information about the importance of these two types of innovative product to the sales realized by the innovating firms. The first two columns of that table show the percentages of firms that had *no* sales of innovative products in 1992 in spite of reporting that they had been engaged in developing product innovations in the period 1990–92. This can occur if the firm was occupied with innovation projects that are not yet completed or which have failed. Obviously, this will be more frequent among smaller (single product) firms than among larger (multi product) firms. In the case of sales of innovations "new to the firm", on average more than 5% of firms have no such sales. It is hardly surprising that, in the case of sales of innovations "new to the industry", these percentages are considerably higher (second column).

The third and fourth columns of Table II give averages by size class of the percentage shares of

TABLE I
Percentages of firms in the Netherlands engaged in product (or service) innovations (1990–92) and/or process innovations (1990–92), or which have plans for product or process innovations (1993–95), divided by size class and sector

	Size classes (numbers of workers):						
	10–19	20–49	50–99	100–199	200–499	500	Total
Manufacturing:							
Product innov.	24%	35%	57%	64%	70%	77%	39%
Process innov.	23%	35%	53%	62%	72%	80%	38%
Plans for innov.	28%	44%	64%	73%	78%	84%	46%
Services:							
Product innov	18%	20%	35%	42%	49%	67%	22%
Process innov.	6%	15%	23%	27%	46%	56%	13%
Plans for innov.	14%	20%	32%	43%	55%	71%	21%
Total (manufacturing and services):							
Product innov.	19%	23%	41%	49%	59%	71%	26%
Process innov.	9%	20%	30%	38%	59%	65%	19%
Plans for innov.	16%	26%	39%	53%	67%	76%	26%

Source: SEO National Innovation Survey in the Netherlands (1992).

TABLE II
The importance of innovative products in total 1992 sales among firms which had some product innovation activities in 1990–92

Size class (number of employees):	Perc. of firms *without* sales of innovative products:[a]		Share in total sales of innovative products:[b]		n[c]	n[d]
	New to the firm (1)	New to the industry (2)	New to the firm (3)	New to the industry (4)		
Manufacturing:						
10–19	13.2	74.3	42.7	25.5	53	15
20–49	4.0	72.2	39.3	14.1	149	46
50–99	3.3	69.8	39.0	12.8	311	102
100–199	1.9	71.3	39.4	10.5	239	78
200–500	2.5	63.3	38.5	8.6	175	71
500 and more	0.8	56.6	40.1	12.2	109	47
Total mftg.	5.2	70.8	39.8	14.7	1036	359
Services:						
10–19	6.0	84.2	46.5	20.8	59	15
20–49	7.2	77.7	38.9	11.7	81	20
50–99	3.0	76.7	37.3	8.2	98	26
100–199	5.0	62.5	35.5	6.8	76	33
>200–499	1.8	76.9	39.0	12.5	109	34
500 and more	1.5	56.8	35.5	8.2	107	56
Total services	5.6	78.0	40.5	12.5	530	185
Total	5.4	75.6	40.2	13.4	1566	544

Source: SEO National Innovation Survey in the Netherlands (1992).
[a] Firms that report that they had some product innovation activities during 1990–92 are equal to 100%.
[b] Average of firms that had some sales of innovative products in 1992; shares of sales of products "new to the industry" (column 4) are excluded from percentages reported in column (3).
[c] Number of observations on which column (3) is based.
[d] Number of observations on which column (4) is based.

innovative products in the firms' total sales. The third column shows that, among firms which have some sales of innovative products, about 40% of 1992 sales were of products "new to the firm" (i.e., already known in the industry), introduced during the period 1990–92. There do not appear to be any notable differences across size classes in this category of (imitative) innovations.[1]

Column 4 covers the shares in total sales of products "new to the industry". As expected, these are considerably lower than in column 3. An interesting point in column 4 is that smaller firms appear to have on average a higher share in sales of innovative products than firms in larger size classes. In interpreting this fact, it should be noted that only a minority of smaller firms have any product innovation activities (see Table I). However, among the relatively few innovators, the share of innovative products (i.e., "truly" innovative products, "new to the industry") in total sales is higher than among larger firms. It is interesting to note that the output indicator in Table II seems to reveal a pattern similar to that found in an earlier study of R&D data: smaller firms engage less frequently in R&D, but when they do so, they are at least as R&D-intensive as larger firms (Kleinknecht *et al.*, 1991).

Our interpretation of Table II has the important limitation that data were split only by firm size classes, ignoring several other potentially relevant factors behind innovative behaviour. In the following section, we estimate a TOBIT model which allows more factors to be taken into account.

III. TOBIT analysis of factors that influence sales of innovative products

III.1. *Hypotheses*

Since R&D is a major input to the innovation process, we expect a firm's R&D intensity and, in particular, R&D related to product development, to be related directly to the share of sales due to new products. Moreover, one can argue that technological knowledge is, to a certain extent, historically accumulated in firms. In other words, experience and knowledge accumulated in past R&D work should predict innovative success in the future (Dosi, 1988). Therefore, firms that indicate that their R&D activities are a permanent (rather than occasional) activity should have a higher score on innovation output.

Following the logic of the two famous Schumpeter hypotheses, one would expect larger firms and firms that possess market power to be more innovative since they can appropriate innovation benefits more easily than smaller firms and firms in competitive markets. While this argument has often been used to explain higher R&D inputs in larger firms, it may also be extended to innovation output. Moreover, one cannot exclude the possibility that large-scale R&D benefits from economies of scale. The opposite hypothesis would be that small firms use their R&D inputs more efficiently, referring to flexibility and entrepreneurship in small firms and the small entrepreneur's ability to occupy market niches. Furthermore, a high small business presence in a sector may lead to stronger competition, which may force firms to be more alert with respect to innovation.

It has often been emphasized that, in addition to the production of technological knowledge within the firm, the acquisition of external knowledge may be an important factor behind innovative success, and the same may hold for R&D networking. The nul-hypothesis would be that firms try to keep knowledge of strategic importance within the firm, in order not to become dependent on others with respect to crucial assets (see e.g., Teece, 1988). This could lead us to expect that technology transfer and R&D collaboration are perhaps less important than is often assumed in the literature.

Schmookler (1966) suggested that strength of demand is crucial to innovation efforts. Tests provided some support for this hypothesis (Scherer, 1982; Walsh, 1984; Kleinknecht and Verspagen, 1990). In the past, however, research and testing of Schmookler's (1966) "demand-pull" hypothesis has been severely hampered by the non-availability of adequate innovation data which were often only available at sector level. Due to the recent Community Innovation Survey, we are now able to test the demand-pull hypothesis with a large micro-data base.

Another interesting hypothesis relates to the location of a firm in a regional environment which may be more or less conducive to innovation. It has often been argued that firms in agglomerations may benefit from externalities of knowledge centres and from "information density", often implying face-to-face contacts between business partners which facilitate the exchange of information and networking. Using a recently developed agglomeration index by Manshanden (1995), we can test whether firms located in agglomerated regions of the Netherlands indeed benefit from externalities and knowledge spill overs.

In addition to these factors, we can include other factors that obviously should have some influence on innovation performance, e.g., activities in certain high technological opportunity fields such as information technology or biotechnology.

III.2. *Methodology and results*

Many of our sample firms have no sales of innovative products; for those firms that have, sales of innovative products are given on a continuous scale (as a percentage of total sales). We therefore use a generalized TOBIT model which provides double information:

1. which variables influence the probability that a firm has some sales of innovative products? (PROBIT part)
2. given that a firm has some sales of innovative products: which variables influence the percentage share of innovative products in total sales? (OLS part)

Since the percentage share of innovative products in total sales (our dependent variable) ranges by definition from 0% to 100%, we use a "double truncated" TOBIT model. Moreover, in our TOBIT estimate, some variables may have a different influence on the probability of having some sales of innovative products (the PROBIT part) and on the share of sales due to innovative products (the OLS part). We therefore use a generalized TOBIT model which does not require the exogenous variables and their coefficients to be identical for the PROBIT and OLS parts of the TOBIT estimate (Amemiya, 1986). The PROBIT and OLS parts are estimated simultaneously by means of full maximum likelihood.

The results of our TOBIT estimate are summarized in Table III (for products "new to the firm") and in Table IV (for products "new to the industry"). Before interpreting these results, some data limitations need to be mentioned. First, since the Community Innovation Survey is made for the first time, our analysis is confined to one-year cross-section data (1992). In other words, adequate time lags cannot be implemented which forces us to explain innovation output in 1992 with R&D-intensities, R&D collaboration, etc., in 1992. Clearly, time lags of some years would have been appropriate. On the other hand, one can argue that most of our explanatory variables certainly do change over time, but are not subject to dramatic fluctuations. Probably, the 1992 observations on a firm's R&D networking or on its technology transfer activities, etc., are a reasonably good proxy of its corresponding activities in previous years. An exception may be the R&D intensities that experienced a remarkable decline over the years 1988–92 (Brouwer and Kleinknecht, 1994). Therefore, the outcomes for the R&D variable need to be interpreted with particular caution.

Second, firms are not yet accustomed to answering questions about innovation output. Hence, often reporting estimates rather than exact figures, firms tend to give "round" figures (such as 10%, 25%, etc.) introducing some noise in the data. This was a problem in the OLS part of our estimates. While it was easy to estimate the PROBIT part on whether a firm had or had not some sales from innovative products, the OLS part was more difficult, notably when estimating shares of products *new to the sector*. In the latter case we had the additional problem that the number of firms having such sales was quite low. As a consequence, the simultaneous TOBIT model refused to converge when we included a larger number of exogenous variables at the same time. We had therefore to confine the estimate to a smaller group of what we considered key variables. However, we tentatively added a number of other potentially relevant variables which we later on deleted when they turned out insignificant. Therefore, a number of insignificant variables are mentioned in the text but cannot be found in our tables.

The interpretation of our TOBIT estimates can be organized around the following headings:

III.2.1. *R&D-intensity*

As expected, a firm's R&D intensity affects whether a firm will have sales of products "new to the firm" and of products "new to the industry". It also affects the actual shares of products "new to the firm", but it is doubtful whether this also applies to products "new to the industry".

III.2.2. *Historical accumulation of knowledge*

With respect to the type of R&D (does a firm consider R&D as an occasional or a permanent activity?) we find the same pattern as in the case of R&D intensity. Firms that consider R&D as a permanent activity are more likely to have sales of innovative products (according to both definitions). This supports the view that historical accumulation of knowledge is important to the innovative capacity of a firm. In enterprises where R&D only is occasional, less continuity is likely to exist in the historical accumulation of knowledge. This may be a weak point for innovating small firms which more often consider their R&D as an occasional activity (Brouwer and Kleinknecht, 1994). With respect to percentages of sales of innovative products, the difference between occasional and permanent R&D still has some significance in the case of products "new to the firm" but not for sales of products "new to the industry".

III.2.3. *Demand and innovation*

The growth of a firm's sales over the 1990–92 period exercises a positive influence on innovation output with given inputs. Both the probability that a firm will have some sales from innovative products and the actual shares of innovative

TABLE III

Factors which influence sales of products "*new to the firm*"[a]. Summary of generalized TOBIT estimates

3a) PROBIT part: Factors influencing the probability that a firm has some sales of products "*new to the firm*"

Exogenous variables	Coeff.	t-value
Intercept	–1.59	–7.25[c]
Product-R&D intensity (R&D man years as a percentage of a firm's total employment)	0.12	4.93[c]
Growth of a firm's sales (1990–92)	0.002	2.30[c]
Small business presence: share in numbers of firms taken by firms with > 50 employees in a firm's sector	0.002	0.92
Log of numbers of employees (service firms)	0.21	9.19[c]
Log of numbers of employees (manufctg. firms)	0.26	8.03[c]
Dummy: R&D is a permanent (not occasional) function	1.13	12.17[c]
Dummy: firm consulted an Innovation Centre	0.82	9.10[c]
Dummy: firm is strongly dependent on mother company when taking decisions about innovation	–0.14	–2.21[c]
Dummy: R&D focused on information technology	0.59	5.57[c]
Dummy: R&D focused on biotechnology	0.30	1.30
Dummy: firm belongs to high technological opportunity sectors	0.14	2.08[c]
Dummy: firm belongs to the service sector	–0.25	–1.45
Dummy: firm is located in a central region	0.002	0.04

[a] Excluding products "new to the sector".

3b) OLS part: Factors influencing the percentage share in total 1992 sales of products *new to the firm* (given that a firm has some sales of innovative products)

Exogenous variables	Coeff.	t-value
Intercept	31.49	3.70[c]
Product-R&D intensity	0.41	2.57[c]
A firm's sales growth 1990–92	0.05	1.99[c]
Small business presence in a firm's sector	0.14	2.29[c]
Log of number of employees (service firm)	–2.17	–2.70[c]
Log of number of employees (manufctg. firm)	-0.35	0.48
Average life cycle in a sector	–1.36	–4.16[c]
Dummy: R&D is perceived as a permanent (not occasional) function	5.96	2.45[c]
Dummy: firm is strongly dependent on mother company when taking decisions about innovation	2.28	1.34
Dummy: firm belongs to high technological opportunity sectors	5.81	3.44[c]
Dummy: firm belongs to the service sector	11.02	2.16[c]
Dummy: firm is located in a central region	–0.46	–0.32
Dummy: firm engaged in R&D collaboration with universities, institutes of higher education or public R&D institutes	2.08	1.14
Dummy: firm acquired external knowledge by means of joint ventures, by buying (parts of) other firms, by buying specialized equipment, by informal contacts, or by hiring personnel	1.82	1.34
Export share in sales (proxy for internationalization)	0.19	2.33[c]

[b] Coefficient is significant at 90% level.

[c] Coefficient is significant at 95% level.

Standard deviation of OLS estimate: 26.12.

Correlation between OLS and PROBIT estimate: –0.06 (insignificant).

Number of firms: 3784.

R-square: 0.36 (Veall and Zimmermann).

TABLE IV
Factors which influence sales of products "*new to the sector*". Summary of generalized TOBIT estimates

4a) PROBIT part: Factors influencing the probability that a firm has some sales of products "*new to the sector*"

Exogenous variables	Coeff.	t-value
Intercept	–1.70	–7.01[b]
Product-R&D intensity	0.02	2.94[b]
A firm's sales growth (1990–92)	0.002	1.88[a]
Small business presence in a firm's sector	–0.002	–0.81
Log of number of employees (service firm)	0.17	6.03[b]
Log of number of employees (manufctg. firm)	0.07	2.24[b]
R&D is a permanent (not occasional) function	0.75	10.15[b]
Firm consulted an Innovation Centre	0.39	4.93[b]
Firm is strongly dependent on mother company when taking decisions about innovation	–0.15	–1.93[a]
R&D focused on information technology	0.41	4.78[b]
R&D focused on biotechnology	0.50	3.22[b]
Firm belongs to high technological opp. sector	0.17	2.17[b]
Firm belongs to the service sector	–0.55	–2.79[b]
Firm is located in a central region	0.14	2.16[b]

4b) OLS part: Factors influencing the percentage share in total 1992 sales of products *new to the sector* (given that a firm has some sales of innovative products)

Exogenous variables	Coeff.	t-value
Intercept	16.07	1.77[a]
Product-R&D intensity	0.09	0.60
A firm's sales growth (1990–92)	0.07	2.81[b]
Small business presence in a firm's sector	0.09	1.49
Log of number of employees (service firm)	–1.78	–2.41[b]
Log of number of employees (manufctg. firm)	–1.44	–2.06[b]
A firm's export intensity (exports as a perc. of total sales)	4.15	1.61
Average life cycle in a sector	–0.49	–1.34
R&D is a permanent (not occasional) function	–1.55	0.70
Firm is strongly dependent on mother company when taking decisions on innovation	3.57	1.94[b]
Firm belongs to a high technological opportunity sector	–0.04	–0.02
Firm belongs to the service sector	–0.35	–0.07
Firm is located in a central region	–0.14	–0.09
Firm acquired external techn. knowledge via joint ventures, take-overs, etc. (see Table III)	0.84	0.64
Firm engaged in R&D collaboration with universities, institutes of higher education or public R&D institutes	–0.88	–0.56

[a] Coefficient is significant at 90% level.
[b] Coefficient is significant at 95% level.
Standard deviation of OLS estimate: 15.01.
Correlation between OLS and PROBIT estimate: 0.05 (insignificant).
Number of firms: 3718.
R-square: 0.23 (Veall and Zimmermann).

products (in both definitions) in total sales, are positively related to sales growth. Adherents of Schmookler's "demand-pull" hypothesis will take this as confirmation that demand enhances innovation, while others will argue that the opposite causation can also hold: firms that innovate successfully grow more rapidly. Certainly, the argument that innovators grow more rapidly is plausible. However, a recent Granger causality analysis of innovation time series suggests that the (main) causal link may run from demand to innovation (Geroski and Walters, 1995). An important implication of such a finding is that it can shed new light on Keynesian demand effects which, to the best of our knowledge, were never noticed by Keynesian economists: in addition to the multiplier and accelerator effects known from the textbooks, an increase of demand enhances innovation. There is therefore a perspective for a Schmooklerian re-interpretation of Keynesian demand theory.

III.2.4. *Market power versus small business presence*

In earlier versions of our estimates we included as a measure of market power the C-4 concentration coefficient (i.e., the market share of the four largest sellers). This proved insignificant and even had the sign in the "wrong" direction. The trifling impact of market concentration on innovation output does not necessarily contradict Schumpeter's famous hypothesis that firms in oligopolistic markets invest more in R&D, as it is likely that such firms use their R&D input less efficiently. Moreover, before drawing strong conclusions from this, it should be remembered that the Netherlands has a small and open economy. Given the importance of exports and imports, it might be asked what is the meaning of high domestic market shares.

We have defined as a counterpart of market power the variable "small business presence" earlier used by Prince (1994). This measures the share in a sector's number of firms held by firms with less than 50 workers, and can be taken as an indicator of the intensity of competition. The behaviour of this variable in our estimates suggests that a stronger presence of small firms has no impact on the probability that a firm will have sales of innovative products. Given that a firm has such sales, however, a high small business presence will have a significantly positive influence on the diffusion of imitative innovations (products "new to the firm"); in the case of "true" innovations ("new to the sector"), the coefficient just fails to be significant at 90% level.

III.2.5. *Firm size and innovation*

From the PROBIT parts of our estimates we find that firm size (i.e., the log of numbers of employees) has a significant positive impact on the probability that a firm will have sales of innovative products according to both definitions. In other words, larger firms are generally more likely to sell innovative products. However, the probability that a firm will have sales of innovative products tends not to increase proportionately with firm size.[2]

It is interesting to note that, with the exception of manufacturing firms which have products "new to the firm", we find a negative influence of firm size on the share of innovative products in total sales (given that a firm has some sales). In other words, smaller firms, particularly service firms, tend to report higher shares of innovative products in their total sales.

This outcome is similar to earlier findings about R&D and firm size in the Dutch economy: smaller firms generally have a lower probability of engaging into R&D; when they do so, however, they are certainly not less (perhaps even slightly more) R&D intensive than larger firms (Kleinknecht *et al.*, 1991).

It should be added that the differences between larger and smaller firms were more pronounced in our initial estimates than in those documented here. This has to do with our repair work for a possible measurement bias in the survey. The CIS questionnaire asked for products "new to the industry". It is conceivable that large firms with considerable international operations may interpret that term more restrictively as they tend to compare themselves with major competitors on international markets, whereas small firms are often oriented towards regional and national markets and may perceive more of their new products as "not earlier introduced by a competitor". In other words, larger firms may interpret the notion of "new to the industry" more narrowly, due to a difference in perspective.

We have corrected for this measurement bias by including in our model, as a proxy for international orientation, the firm's export intensity (i.e., the percentage share of exports in total sales). If there was no measurement bias, one would expect a positive coefficient for export intensity, due to a positive relationship between innovation and exports (Hughes, 1986; Brouwer and Kleinknecht, 1993). However, the coefficient of export-intensity just failed to be significant in the case of products "new to the industry". This can be explained by two counteracting influences: on the one hand a positive influence of export intensity on innovation; on the other hand the named bias which causes internationally-oriented firms to interpret the notion of "new to the industry" more restrictively. The highly significant positive coefficient of export intensity in the case of products "new to the firm" can be explained by two arguments: (1) export-intensive firms are more innovative, and (2) they count a larger part of their innovative products as "new to the firm" (rather than "new to the industry").

III.2.6. *R&D collaboration and technology transfer*

The CIS survey from which we draw in this paper undertook to measure in some detail various types of R&D collaboration and technology transfer. For example, the questionnaire detailed 10 different types of partners (clients, competitors, public institutions and so on), coming from seven different regional units (e.g., partners from the same region, from within the Netherlands, from inside and outside the European Union, and so on). This resulted in 70 possibilities. In the case of technology transfer, there were 66 boxes.

To test the influence of R&D collaboration and technology transfer on innovation output, we tried out dummies for various plausible alternatives. We began by including a simple dummy for firms that had ticked at least one box, and then formed dummies for numbers of boxes ticked (1–3, 4–6, 6–10, more than 10). Finally, we included dummies for various types of partners. Apart from a single significant coefficient, the outcomes were generally against our expectations. In other words, we found only very weak evidence that engaging in R&D collaboration or participating in technology transfer enhances innovation output. This is a remarkable finding, given that the R&D programmes of the European Union put strong emphasis on promoting technological co-operation among European firms. Do our findings prove that these two variables are irrelevant? Before drawing strong conclusions from our finding one should remind the above mentioned infancy problems of the new indicator, which has now been measured for the first time. Moreover, it should be repeated that our simple cross-section does not yet allow the use of adequate time lags, forcing us to explain 1992 innovation output with 1992 R&D collaboration and technology transfer.

Besides such technical points there is also a theoretical argument, referring to Teece (1988) who argued that firms do not want to make themselves dependent on external partners with respect to crucial assets. In other words, if an innovation is conceived to be crucial for the future of the firm, one will try to do it alone. Only innovators lacking an adequate knowledge base will search for partners. If valid, this argument would imply that our various dummies for R&D collaboration and for acquisition of external technological knowledge may capture the somewhat weaker innovators. From the fact that this dummy is not negative, one could derive that R&D collaboration and acquisition of external knowledge play a compensating role for these weaker innovators.

III.2.7. *The impact of policy instruments*

In earlier versions of our estimates, we included dummies for firms which participated in R&D programmes of the European Commission and in a national R&D programme (PBTS) in 1991 and/or 1992. It should be noted that, in an earlier study of panel data, we found evidence that firms participating in such programmes increased their R&D input more than similar firms which did not. Participants in these programs also have an increased probability of engaging in R&D collaboration and technology transfer (Brouwer and Kleinknecht, 1994). However, in the OLS part of our above estimate, we find no evidence that firms participating in those programmes have a higher share of innovative products in their total sales than firms which did not participate. It the PROBIT part it turns out that participants in the EU programs are generally more likely to have some sales of products "new to the sector". However, the same does not hold with respect to imitative products ("new to the firm"). This suggests that the EU programs tend to attract the "true" innovators rather than the imitators.

Does this prove that the EU programs do not influence innovation output? Before drawing such conclusions, the following qualification should be made. The named programs often cover longer time-spans, and in the case of the EU-programs, they concentrate on the pre-competitive stage. Hence the lag between 1991 or 1992 participation in these programs and innovation output in 1992 is likely to be too short. For a good judgement we need to have more inter-temporal data which allow to use longer time lags. All that can be derived from our present estimate is that the programs attract innovators which already have some sales from products "new to the sector", but in terms of shares of these products in total sales, they do not differ from non-participants.

Perhaps encouraging for Dutch policy makers is our finding that firms which consulted one of the newly founded regional Innovation Centres have a strongly increased probability of selling innovative products, although the share of innovative products in their total sales does not differ from those of other firms. Sceptics may of course argue that causality runs opposite to what is assumed in our model: the Innovation Centres attract innovating firms. But even if this would hold true, one could still argue that the Innovation Centres do at least reach the innovators.

III.2.8. *Regional spill overs*

A firm's location in a region has no influence on sales of products new to the firm. Compared to firms in more rural regions, however, firms in urbanized areas of the Netherlands have a significantly higher probability of selling products "new to the industry", i.e., "true" innovations. This is consistent with the hypothesis that, due to information density and spill over effects from knowledge centres, urban agglomerations are a better "breeding place" for innovations than are rural areas. Such regional effects are remarkable, as the Netherlands is a small country with a well-developed transportation and communication infrastructure. It should be noted that the result is consistent with findings from our analysis of determinants of the regional distribution of new product announcements in trade journals (Budil-Nadvornikova and Kleinknecht, 1993), which adds to the evidence on regional spill overs in the international literature (see e.g., Feldman, 1994).

III.2.9. *Sector dummies*

Experiments with a number of sector dummies showed that there is little evidence of sector-specific differences in innovation output. However, "broad" sector dummies for high versus low technological opportunity sectors[3] within manufacturing and for service firms make some difference. Compared to manufacturing firms, service firms tend to have less frequent sales of innovative products. Given that they have some such sales, however, the share of innovative products in their total sales is certainly not lower than in manufacturing. In the case of imitative products, the average share is even higher. With one exception, manufacturing firms in high technological opportunity sectors tend to have a more favourable score on innovation output, which is according to our expectations. The same holds for firms that concentrated their R&D in the fields of information technology and biotechnology.

III.2.10. *Other factors*

As expected, the share of innovative products in a firm's total sales is influenced negatively by the average length of the product life cycle in a sector. A shorter life cycle of products will necessitate firms to renew their products more quickly.

A dummy for firms that report that they are "strongly dependent on the mother company when taking decisions on new products" behaves according to our expectations: such firms (often branch plants) have a significantly lower probability of sales of innovative products. Given that they have some such sales, however, they tend to be higher than in other firms since they are likely to take over innovative products from their mother companies; as a consequence, with R&D input and other firm characteristics kept constant, these firms have a higher output.

IV. Summary and conclusions

Our summary has to begin with unavoidable caveats. The output indicator analyzed in this paper is a novel concept which, apart from a large-scale pilot study in Baden-Württemberg (Meyer-Krahmer, 1984), has now been surveyed for the first time on a large scale. Clearly, firms are not yet accustomed to answer such questions and their accounting procedures are often not (yet) adapted to producing this type of information. As a consequence, many firms report "rough estimates" rather than precise figures and, in doing so, tend to fill in "round" figures (e.g., 10%, 20%, etc).

Hence, the data from this first pilot survey are still more noisy than will probably be the case in future routine surveys.

We had the impression that data deficiencies caused few problems for a PROBIT estimate of whether a firm had or had not sales of innovative products. Separate PROBIT estimates on this "zero-one" problem generally looked quite satisfactory. However, some problems emerged in the OLS part of our TOBIT estimates where we tried to explain the actual share of innovative products in a firm's total sales. This applies in particular to estimates of shares in sales of products "new to the sector", where observations are relatively few in number. Hence, reservations about our results should first of all apply to the OLS estimates on products "new to the sector".

Another point of concern is that, for the purpose of this paper, we have only data for one year, which does not allow the use of adequate time lags. Moreover, in future surveys, one relevant question can be improved conceptually. The notion of products "new to the industry" should be defined less ambiguously by asking about products "new to the industry *in your country*". This would guarantee that the answers of large and small firms are more consistent.

In spite of such qualifications, we think that our analysis of the data still makes sense and provides some useful insights. Compared to earlier innovation studies, a strong point of our exercise is that our database consists of firm-level data and allows the inclusion of an entire range of control variables, thus reducing our chances of finding pseudo-correlations.

An interesting outcome relates to the positive relationship between growth of demand and a firm's innovation output. In so far as this can be interpreted as support of Schmookler's "demand-pull" hypothesis, this would shed new light on the beneficial effects of Keynesian demand policy which has hitherto been ignored by macro-economists (and by Keynesians).

Another notable outcome is that R&D as a permanent (as opposed to an occasional) activity seems to contribute to innovative success. This stresses the importance of a continuous accumulation of technological knowledge, likely to create an innovative advantage for larger firms since smaller firms more often than not engage only occasionally in R&D (see Brouwer and Kleinknecht, 1994).

With respect to the impact of firm size, our findings approximate earlier findings on R&D-intensities: generally, larger firms are more likely to innovate. Given that they innovate, however, smaller firms tend to be more innovative than larger firms, with one exception (i.e., products "new to the firm" in manufacturing). Moreover, a high small business presence in a sector tends to have a positive influence on the share in total sales taken by products "new to the firm".

A final remarkable point relates to the impact of the regional environment on innovation. With respect to "true" innovations ("new to the industry"), we find indications that, even in a small country like the Netherlands, more agglomerated regions seem to be a better "breeding place" for innovations than are rural areas. Regional economists may interpret this finding as evidence of knowledge spill overs. In this respect, our new findings are consistent with earlier findings from an alternative output indicator: cases of new product announcements in trade journals which also tend to concentrate in the more agglomerated regions of the country (Budil-Nadvornikova and Kleinknecht, 1993).

In conclusion we can note that, with respect to the regional concentration of innovations and the relative scores of small and medium-sized enterprises, the new indicator on sales of innovative products tells us essentially the same story as the previous indicator derived from new product announcements in trade and technical journals. Future research will have to work out in more detail other consistencies or inconsistencies between the two indicators.

Acknowledgements

The construction of our database and subsequent research was sponsored by the Dutch Ministry of Economic Affairs (Directorate for Technology Policy, ATB) and by DG 13 (SPRINT/EIMS programme) of the European Commission. We wish to thank Lianne Harrewijn, Wendy Smits and Jaap Westerling who assisted the survey work. When the research underlying this paper was carried out, both authors were fellows of SEO, Foundation for Economic Research, Universiteit van Amsterdam. Kleinknecht is now Professor of Industrial Economics and Director of the Economic and Social Institute (ESI) at the Vrije Universiteit Amsterdam (VU). We thank Kees Burger, Hans van Ophem and Geert Ridder for econometric advice and participants of the "Third Global Workshop on Small Business Economics" at the Tinbergen Institute, Rotterdam, as well as participants of the workshop "Determinants of Innovation and Diffusion" held on the occasion of the 40th anniversary of ESI-VU for helpful comments on earlier versions of this paper. The usual disclaimers apply.

Notes

[1] Exceptions are perhaps small service firms (10–19 employees), but this category may cover a substantial number of new firms which have, by definition, a high share of products "new to the firm" (i.e., introduced during the last three years). During the period 1988–92, the rate of new firm foundation was particularly high in Dutch service industries (see Brouwer and Kleinknecht, 1994).

[2] The so-called pseudo-elasticities from our model provide information about the effects of an increase of employment. For example, in the case of products "new to the firm", the pseudo-elasticity is 0.06 in services (0.07 in manufacturing). This means that a one percent increase in the number of workers results in an increased probability of a service firm having sales of products "new to the firm" by 0.06 percentage points. In the case of products "new to the industry", the corresponding pseudo-elasticities are 0.02 in services and in manufacturing.

[3] In analogy with Pavitt's (1984) taxonomy of sectors, high technological opportunity sectors include chemicals and plastics, the pharmaceutical industry, the electrotechnical and electronics industry, transportation equipment (automobiles and aircraft), mechanical engineering, instruments and optical industries. Low technological opportunity sectors are identical with what Pavitt called "supplier-dominated sectors" (e.g., food & beverages, textiles, clothing, wood processing and furnitures, printing & publishing, or basic metals).

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