INdustry and Company Analysis
Program

Katholieke Universiteit Leuven

Departement voor Toegepaste
Economische Wetenschappen

Dekenstraat 2
B-3000 Leuven ☎ 016/22.75.17

Onderzoeksrapport Nr. 8607

INNOVATION EXPENDITURES AND THE ROLE OF GOVERNMENT IN BELGIUM

By

Benni Holemans and Leo Sleuwaegen*

August 1986

Wettelijk depot: D/1986/2376/8

* Support from the research fund ("onderzoeksfonds") of the Catholic University of Leuven ("K.U. Leuven") and from the project on "Entrepreneurship and Innovations", managed by the I.C.M. ("Interuniversitair College voor Doctorale Studies in Management Wetenschappen"), Brussels, is gratefully acknowledged. The authors would like to thank Claude Carbonelle, J.F. Hoffelt and S. Janssens for kindly providing data for this research. Raymond De Bondt and other members of INCAP (Industry and Company Analysis Program), provided useful comments on an earlier draft of this paper.

INNOVATION EXPENDITURES AND THE ROLE OF GOVERNMENT IN BELGIUM

By

Benni Holemans and Leo Sleuwaegen

ABSTRACT

Unlike suggestions from earlier research on the Schumpeterian hypothesis, it is argued and shown that sales and employment are not simply substitute size measures to test the R&D size of company relationship. Empirical evidence on the R&D behaviour of foreign and domestic companies operating in Belgium further suggest that government sponsored R&D has not substituted for privately funded R&D. Foreign companies are found to behave differently and to do less R&D the more they pay for externally supplied technology.

I. INTRODUCTION

Together with the growing importance of technology, research on the determinants of R&D has gained interest in industrial economics. The basic hypothesis goes back to Schumpeter who argued that there exists a positive relationship between innovation and monopoly power and that larger firms are more innovative than small firms.

More and more the idea developed that research and development (R&D) is stimulated by the interplay of many factors. Among those factors, the role of government sponsored R&D occupies a special place. With respect to company structure, the hypothesis has been put forward that diversified firms are in better position to market inventions and to maximize on the technological spill-overs occurring between the

company's served business lines. This relates not only to the product diversification of the company, but also to its geographical diversification (multinational activity).

In connection with the multinationalization phenomenon, relatively little attention has been devoted to the finding that R&D remains a very centralized function of the company (Hirschey and Caves (1981) et al.). An important implication from this is that the behaviour of subsidiary companies in foreign countries may be seriously determined (and restricted) by the parent company's strategy.

In an effort to better understand the determinants of R&D expenditures in Belgian industry the present paper will focus both on these multinational strategy impacts and on the role of government support. More specifically, it will be analyzed how high technological dependence from outside sources causes foreign companies to deviate from local companies in their R&D spending patterns. Along the same line it will be investigated to what extent government subsidies affect R&D spending behaviour of domestic and foreign companies.

II. THE MODEL

The empirical model derives from profit maximizing firms, who are optimizing their R&D expenditures and take into account the distinctive nature of the market and industry in which they operate (see e.g. Howe and McFetridge (1976) and various contributions in Griliches (1984)). In line with Howe and McFetridge (1976), who made a similar analysis for Canada, a distinction in R&D behaviour of foreign companies (subsidiaries of multinational companies MNC) and domestic firms (DOM)

is introduced. These two groups of companies are assumed to compose two different strategic groups within the industry (see also De Bondt, Sleuwaegen and Veugelers (1986)).

The basic specification is as follows:

$$\begin{aligned} \ln R\&D_i = \sum_{f=1}^n \alpha_{0f} I_f + \alpha_1 M_1 + \alpha_2 G + \sum_{k=1}^2 \alpha_{3k} M_k * \ln S_i + \sum_{k=1}^2 \alpha_{4k} M_k * \ln GRD_i \\ &+ \sum_{k=1}^2 \alpha_{5k} M_k * \ln ROYFEE_i + \alpha_6 DIV_i + \alpha_7 H_i \end{aligned}$$

where $R\&D_i$ are the research and development expenditures of firm i excluding government supported R&D for firm i ; S_i is size which will be measured alternatively by sales ($SALES_i$) and employment ($EMPL_i$) and GRD_i are government incentive grants received by the i th firm; $ROYFEE_i$ are royalties and fees paid by the i th firm. G equals one if firms do not receive government incentive grants, and zero otherwise. DIV_i is the degree of diversification of the three-digit industry to which the i -th firm is assigned, measured by the relative number of firms that produce also in an other three-digit industry; H_i is the Herfindahl index of the corresponding three-digit industry; M_k $k=1,2$ refers to foreign-owned companies (MNC) for which $M_1=1$, and zero otherwise, and to domestic firms (DOM) for which $M_2=1-M_1$ respectively. I_f represents n NACE two digit industry dummies.

Size as determinant of innovative activity, measured by sales or employment, is one of the two major hypotheses associated with Schumpeter. Because of economies of scale in research and development large firms would have an advantage over small firms. A source of advantage is that researchers in large firms are more productive when they have more colleagues surrounding them: new insights or special

familiarity of colleagues; division of labor in a particular area or the greater ability to exploit special equipment and the increasing chance to recognize unforeseen results. A second possible reason of advantage is the superior ability for a large firm to exploit the output of the research stage, due to the greater ability to enter new markets. There may, however, also be some negative effects, of firm size on innovative activity due to the higher probability that in a large firm unexpected findings will get lost, or researchers are less motivated because their fees are not directly related to their findings. If the net effect is positive, the above logarithmic specification will support the Schumpeterian hypothesis with $\alpha_{3k} > 1$ (see Kamien and Schwartz (1982) for a more detailed discussion).

The interpretation of α_{3k} is dependent upon the particularly chosen size measure. This leaves us with an important specification problem. One way to tackle this is to assume that only one size measure is relevant to include in the empirical model. If sales is taken as the right measure, it becomes possible to predict what result will be obtained when an other size measure, in casu employment, is used as a substitute. This "encompassing property" of the sales measure model can be explicated as follows: assume that the two alternative size measures are related to each other by the following relationship $SALES = aEMPL^b e^{\epsilon_1}$ (1), with ϵ_1 independently and normally distributed. Abstracting from other determinants, and with R&D related to SALES by $R\&D = cSALES^d e^{\epsilon_2}$ (2), it follows that the relationship between R&D and EMPL can be predicted to corresponding to $R\&D = ca^d EMPL^{bd} e^{d\epsilon_1 + \epsilon_2}$ (3). It is not unreasonable to assume that $b > 1$, due to economies of scale in sales with respect to employment. The elasticity of R&D with respect to employment (bd) will therefore be (misleadingly) greater than the elasticity with respect to sales (d). Clearly, this encompassing proposition has to be tested.

An appropriate way to do so is to nest the two rival hypotheses, with sales and employment as alternative size measures, in the same equation and given the structure of the model, to test whether the employment coefficient is indeed insignificantly different from zero. In terms of the estimating equation $R\&D = f(EMPL) e^{\epsilon}$ this result implies the non-rejection of the hypothesis that the employment elasticity of R&D (g), in a restricted model without sales as regressor, equals the product of the sales-employment elasticity (b) with the sales elasticity of R&D (d) as explicated in equation (3) ($g = bd$) (requiring no additional testing see Hendry and Richard (1983), p40).

A further Schumpeterian hypothesis is that market imperfections related to industry concentration may also stimulate company R&D (Scherer (1965a,b), P. Finet(1975), Levin, Cohen and Mowery (1985) et al.). The more the industry is characterized by an oligopolistic structure, the more the equilibrium price may deviate from the perfectly competitive price. The implied proposition then is that high expected returns would stimulate company's R&D investments. However, equally acceptable, it may be argued that lack of competition takes away company incentives to innovate. Consequently, the effect of concentration upon R&D is difficult to fix a priori but remains basically an empirical question.

The effect of diversification upon R&D appears to be less ambiguous. The most obvious effect relates to economies of scope in R&D. Research output typically is composed of inventions and discoveries in unexpected areas. Diversified firms can be expected to be better able to produce and market a higher proportion of these unexpected inventions than firms with a narrow base of operations. The expected profitability

of R&D will therefore be higher the more the firm is diversified. In line with this so-called Nelson diversification hypothesis, most researchers found a small positive relationship between R&D-intensity and diversification (Grabowski (1968), Link (1982), Scherer (1965b) and Switzer (1983)).

The role of government financed R&D also has drawn considerable research attention (see Lichtenberg (1984), Levy and Terleckyj (1983), Mansfield and Switzer (1985) and Scott (1984)). One of the basic hypotheses advanced in this context is that R&D may be a substitute or a complement for company financed R&D. These rival hypothesis would imply that the elasticity of GRD with respect to R&D (α_{4k}) is respectively less or greater than zero. Most researchers found a positive relationship, although the increase in company financed R&D due to the government supported R&D appears to be substantially smaller than the revenue losses by the government. Mansfield and Switzer (1985) found that government R&D spending on the company level exhibits a positive relationship with the company R&D spending, although some of their findings suggest that crowding out may occur.

Payments for royalties and fees, ROYFEE has not been included as regressor in earlier models. In general, the effects from alternative technological sourcing have received only little attention in the literature (see, however, Link, Tassej and Zmud (1983)). While the overall technological strength of the company is directly related to its size, the fact that it borrows extensively technology from the outside may not be neutral to its R&D decisions. Unfortunately the analytical and statistical framework does not allow to fully specify the substitution between own developed technology versus externally acquired technology. This would require to dynamically relate changes in ROYFEE

payments to cumulated R&D efforts of the company. Such a simultaneous equation model necessitates good panel data over a reasonably long period of time. Within the confines of the specified model the introduction of ROYFEE as a stock related measure of previously acquired technology intends to capture in a more structural way the basic orientation of the company with respect to the induce versus purchase of technology decision. This becomes highly relevant for foreign owned companies whose high dependence upon outside sources reflects the centralised R&D functions within the multinational company. It is hypothesized that the more the subsidiary is characterized by important technology transfers from the parent company, the higher is ROYFEE and the more this firm may behave differently and do less R&D than domestic companies.

Finally, the model is extended by controlling for the different two-digit industries in which the companies operate. As pointed out by John T. Scott (1984), industry dummies capturing fixed industry effects are important and affect some of the results obtained in the simple restricted models (without industry dummies).

III EMPIRICAL RESULTS

The model is tested against a pooled cross-section and time series sample of 236 observations covering information for 1980-1984 on companies operating in the three major Belgian sectors, chemicals, metals and machinery and electronics. Missing information on technology payments reduced the sample to 107 observations for testing the effects of royalties and fees payments. The sample characteristics, together with the origin of the industry data, are given in the appendix.

In estimating the pooled model we assumed, and found statistical support for the hypothesis that the coefficients remain invariant over the different years (see Howe and McFertridge (1976) who conducted similar tests). We further verified whether the regressions' disturbances are cross-sectionally, and time-wise independently distributed. Similarly, we found no evidence of heteroscedastic behaviour of the disturbances. The foregoing results would imply that OLS is still a BLUE estimator for the proposed model.

Table 1 shows the estimation results on the complete sample for the model without the variable of royalties and fees (ROYFEE). Equation (1.1) applies to the restricted model without industry dummies, while the other estimated equations take account of fixed industry effects. Comparing equations (1.1) and (1.2), the hypothesis that industry effects are important to explain R&D behaviour cannot be rejected. Interpretation of the sales coefficient in equation (1.2) and the corresponding standard error suggests that company financed R&D increases somewhat less than proportionately with the size of the company. This finding corresponds to earlier findings for Belgian data (Phlips (1970), Defay (1973), Finet (1975) et al.). With a restricted sample as in table 2 or with employment as alternative size measure, however, this finding no longer holds. The estimate of the employment coefficient for foreign companies is significantly larger than one, using a one percent significance level criterion. As clarified in the previous section, the question arises whether this effect is entirely due to the substitute relation $SALES = aEMPL^b e^{\epsilon_1}$, so that the sales size model would encompass the employment model.

TABLE 1: Regressions with $\log(R\&D)$ as the dependent variable, with sales, and employment as alternative size measures ($N = 236$).

Independent Variables	Equation			
	1.1	1.2	1.3	1.4
Intercept	-4.636 (1.246)	Industry Effects	Industry Effects	Industry Effects
MNC	-0.344 (1.682)	-0.009 (1.595)	-1.386 (0.735)	2.538 (1.683)
G	1.998 (0.808)	3.098 (0.747)	2.537 (0.680)	2.437 (0.667)
$\log(\text{SALES-MNC})$	0.828 (0.093)	0.856 (0.094)		0.018 (0.134)
$\log(\text{SALES-DOM})$	0.781 (0.088)	0.847 (0.082)		0.563 (0.168)
$\log(\text{EMPL-MNC})$			1.271 (0.101)	1.262 (0.159)
$\log(\text{EMPL-DOM})$			0.975 (0.088)	0.370 (0.200)
$\log(\text{GRD-MNC})$	0.406 (0.083)	0.484 (0.076)	0.322 (0.072)	0.315 (0.071)
$\log(\text{GRD-DOM})$	0.383 (0.090)	0.424 (0.083)	0.363 (0.077)	0.353 (0.075)
DIV	0.029 (0.012)	-0.009 (0.013)	0.022 (0.013)	0.022 (0.013)
H	-0.004 (0.005)	-0.013 (0.005)	-0.009 (0.005)	-0.012 (0.005)
R ²	0.822	0.860	0.886	0.892
F	130.947	97.337	122.812	112.744

Standard errors are given in parentheses.

The nesting model estimation results (equation 1.4.) do not allow us to conclude that sales is a superior size measure, and encompasses the role of employment. On the contrary, in the case of foreign companies the employment-size model seems to encompass the sales-size

model. However, when the same tests were done on the more restricted sample, as in table 2, similar inferences are no longer grounded.

The fact that employment shows up as more important for foreign companies than for domestic companies may be related to the fact that the importance of the activities performed by the foreign companies is reflected better in employment than in sales figures. The sales variable may seriously overestimate this importance because of the weight of intra-company trade in the foreign companies operations. All in all, the conclusion would seem to be that employment and sales are not perfect substitute size measures in the R&D regressions, but are both relevant to include in the model. To what extent including employment as regressor does pick up something of factor intensity effects is hard to disentangle from the results given in table 2 (see, on this point Bound, Cummins, Griliches, Hall and Jaffe (1984)). Given the outcome of this testing and in order to attenuate the omitted variable bias problem, we shall only look at the estimates of the other variable coefficients in the nesting equation (1.4).

The estimates for the government sponsored R&D are significantly positive and do not differ statistically between foreign companies and domestic companies. This non-difference between the two groups of companies may be related to the results obtained by Albert Link (1982) who showed that government support favours product or process development and not so much basic or applied research. The former activities are typical for decentralized foreign R&D operations of multinational corporations. The point estimate of .3 corresponds closely to what has been found for the U.S. and Canada. One should observe, however, the estimated positive effect of the G dummy variable, implying

that these companies that receive no government incentive grants are not necessarily the least innovative in the sample.

The estimated effects of diversification (DIV) is also in line with the a priori hypothesis about the effect of this variable. More unexpected is the negative coefficient of the Herfindahl concentration variable. This negative effect may be very specific to the particular industries included in the sample (see, for instance, Globerman (1973) who found a negative effect for a similar subset of Canadian industries).

Performing the same tests on a smaller set of observations for which data on ROYFEE were available, resulted in the detection of similar basic tendencies (see table 2). As expected, the inclusion of ROYFEE, royalties and fee payments, showed up only for multinational companies as an important variable. (Tests on a restricted model against the restricted sample, leaving ROYFEE, suggest that the omission of this variable did not cause serious bias in the complete sample (Table 1)).

The statistically negative coefficient of ROYFEE is in line with the a priori made hypothesis that ROYFEE for foreign owned companies measures the importance of technology transfer from the parent company to its foreign subsidiary. This reflects the centralization of the R&D function within the multinational company which, in turn, put severe constraints on the R&D autonomy of the foreign subsidiaries. The fact that ROYFEE takes on a large positive coefficient for domestic companies in equation (2.2) is explained by the omission of sales from the estimation equation. This effect disappears in the sales extended model (2.3).

TABLE 2: Regressions with $\log(R\&D)$ as the dependent variable and $\log(ROYFEE)$ included as regressor ($N = 107$).

Independent Variables	2.1	Equation 2.2	2.3
MNC	0.233 (1.749)	1.939 (1.137)	2.609 (1.909)
G	2.545 (0.706)	1.890 (0.761)	2.768 (0.756)
$\log(\text{SALES-MNC})$	1.015 (0.099)		0.594 (0.136)
$\log(\text{SALES-DOM})$	0.978 (0.129)		1.132 (0.278)
$\log(\text{EMPL-MNC})$		1.257 (0.116)	0.626 (0.158)
$\log(\text{EMPL-DOM})$		0.933 (0.161)	-0.289 (0.326)
$\log(\text{ROYFEE-MNC})$	-0.143 (0.055)	-0.088 (0.058)	-0.100 (0.052)
$\log(\text{ROYFEE-DOM})$	0.100 (0.163)	0.518 (0.136)	0.095 (0.169)
$\log(\text{GRD-MNC})$	0.372 (0.073)	0.243 (0.082)	0.355 (0.08)
$\log(\text{GRD-DOM})$	0.180 (0.086)	0.074 (0.098)	0.250 (0.106)
DIV	0.033 (0.031)	0.100 (0.034)	0.054 (0.031)
H	-0.011 (0.007)	-0.017 (0.008)	-0.020 (0.007)
R^2	0.940	0.933	0.951
F	94.827	84.529	101.069

Standard errors are given in parentheses.

IV SUMMARY AND CONCLUSION

In studying the determinants of innovation expenditures, this paper tackled the problem of the R&D and size of company relationship. Unlike suggestions from earlier research on this Schumpeterian hypothesis, it is found that sales and employment are not simply substitute size measures in the R&D model, but are both important to include in the model.

The empirical results presented in this paper further suggest that government sponsored R&D has not substituted for privately funded R&D in the sample of companies operating in an important subset of Belgian manufacturing industries: chemicals, metals and machinery, and electrical industry. This positive effect is not significantly different between the groups of foreign and domestic companies.

Foreign companies, however, seem to behave differently and to do less R&D, the higher are their royalties and fees payments. Since these payments go predominately to the parent company, this finding can be interpreted to reflect the degree of centralization of the R&D functions, inversingly measuring the degree of R&D autonomy of the foreign subsidiary, within the multinational corporation.

It is important to recall that the tests presented in this paper are based on a simple, highly stylized analytical model. The reality of R&D decision is undoubtedly more complex. However, severe data problems, as well as the analytical difficulty of specifying the very specific features of these processes, leave us, for the time being, with little alternatives.

APPENDIX

Data sources and sample composition

The R&D expenditures, government R&D incentive grants, the employment of the firm, and the royalties and fees-payments were derived from a survey organized by "l'Université Libre de Bruxelles". Diversification and the Herfindahl index were obtained from the N.I.S. (National Institute of Statistics of Belgium). The sales of the companies were obtained from the tapes of the National Bank of Belgium.

Number of observations for the total sample:

Year	Machinery and Metal	Chemical	Electrical	Total
1980	16	13	9	38
1981	19	14	11	44
1982	24	16	13	53
1983	24	17	13	54
1984	20	15	12	47
Total	103	75	58	236
MNAT	32	59	24	115
DOM	71	16	34	121

Number of observations for the restricted sample:

Year	Machinery and Metal	Chemical	Electrical	Total
1980	7	6	4	17
1981	8	8	6	22
1982	9	9	6	24
1983	9	8	6	23
1984	7	8	6	21
Total	40	39	28	107
MNAT	24	33	15	72
DOM	16	6	13	35

REFERENCES

- De Bondt, R. , L. Sleuwaegen, and R. Veugelers 1986. Innovative Strategic Groups in Multinational Industries. *Research Paper 8606*, DTEW, K.U.Leuven.
- Defay, J. 1973. Recherche et Croissance Economique 3, S.P.P.S., Brussels.
- Bound, J., C. Cummins, Z. Griliches, B.H. Hall, and A. Jaffe 1984. Who Does R&D and Who Patents?. In *R&D, Patents, and Productivity* (Z. Griliches). The University of Chicago Press.
- Finet, P. 1975. Déterminants de la Recherche-Développement Industrielle en Belgique. *Recherches Economique de Louvain*, 41 (March), 51-61
- Globerman, S. 1973. Market Structure and R&D in Canadian Manufacturing Industries. *Quarterly Review of Economics and Business*, 13, 59-67.
- Grabowski, H.G. 1968. The Determinants of Industrial Research and Development: A Study of the Chemical, Drug, and Petroleum industries. *Journal of Political Economy*, 76 (March), 292-306.
- Griliches, Z. 1984. *R&D, Patents, and Productivity*. The University of Chicago Press.
- Granger, D.F. and J.F. Richard 1983. The Econometric Analysis of Economic Time Series. *International Statistical Review*, LI, 111-163.
- Grashof, R.C. and R.E. Caves 1981. Research and Transfer of Technology by Multinational Enterprises. *Oxford Bulletin of Economics and Statistics*, 43 (May), 115-130
- Howe, J.D. and D.G. McFetridge 1976. The determinants of R&D expenditures. *Canadian Journal of Economics*, IX (February), 57-71.
- Jacquemin, A.P. and H.W. De Jong 1977. *European Industrial Organization*. London: Macmillan.
- Kamien, M.I. and N.L. Schwartz 1982. *Market Structure and Innovation*. Cambridge University Press.
- Levin, R.C., W.M. Cohen, and D.C. Mowery 1985. R&D Appropriability, Opportunity, and Market Structure: New Evidence on Some Schumpetrian Hypothesis. *American Economic Review*, 75 (May), 20-24.

- Levy, D.M. and N.E. Terleckyj 1983. Effects of Government R&D on Private R&D Investment and Productivity: a Macroeconomic Analysis. *The Bell Journal of Economics*, 14 (Autumn), 551-561.
- Lichtenberg, F.R. 1984. The Relationship Between Federal Contract R&D and Company R&D. *American Economic Review*, 74 (May), 73-78.
- Link, A. 1982. An Analysis of the Composition of R&D Spending. *Southern Economic Journal*, 49 (Oktober), 342-349.
- Link, A.N., G. Tassej and R.W. Zmud 1983. The induce versus purchase decision: An empirical analysis of industrial R&D. *Decision Sciences* 14, 46-61.
- MacDonald, J.M. 1985. R&D and the Directions of Diversification. *The Review of Economics and Statistics*, LXVII (November), 583-590.
- Mansfield, E. and L. Switzer 1985. How Effective are Canada's Direct Tax Incentives for R and D? *Canadian Public Policy*, XI (June), 241-246.
- Phlips, L. 1970. Concentration, Dimension et Recherche dans l'Industrie Manufacturière Belge. *European Economic Review*, 4 (Summer), 553-569.
- Scherer, F.M. 1965a. Size of Firm, Oligopoly, and Research: A Comment. *Canadian Journal of Economics and Political Science*, 31 (May), 256-266.
- Scherer, F.M. 1965b. Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions. *American Economic Review*, 55 (December), 1097-1125.
- Scherer, F.M. 1984. *Innovation and Growth: Schumpeterian Perspectives*. London: The MIT Press.
- Scott, J.T. 1984. Firm versus Industry Variability in R&D Intensity. In *R&D, Patents, and Productivity* (Z. Griliches). The University of Chicago Press.
- Soete, L.L.G. 1979. Firm Size and Inventive Activity. *European Economic Review*, 12 (Oktober), 319-340.
- Switzer, L. 1984. The determinants of Industrial R&D: a Funds Flow Simultaneous Equation Approach. *The Review of Economics and Statistics*, LXVI (February), 163-168.