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DOMESTIC R&D IN THE PRESENCE OF
MULTINATIONAL ENTERPRISES

by

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DOMESTIC R&D IN THE PRESENCE OF MULTINATIONAL ENTERPRISES

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Abstract : The impact of multinational presence on domestic firms' innovative efforts is explored in a game-theoretic model focusing on the strategic dimension of R&D. Circumstances can be found under which domestic R&D-intensities lower in the face of multinational competition. The empirical results support this hypothesis : domestic companies operating in a subset of Belgian manufacturing industries were found to have smaller R&D-intensities, the higher the presence of MNEs in the industry.

1. Introduction

A large strand of literature revolves around the relationship between R&D-efforts and multinational activity (for an overview see Caves (1982)). Since the knowledge that represents new products and processes is among the important intangible assets giving rise to multinational activity, MNE's are likely to devote above average resources to R&D.

It is not clear whether this positive relationship still holds within host-countries, as subsidiaries of multinational firms are characterized by a transfer of technology from the parent-firm. Van Den Bulcke (1981) found indeed no significant difference in R&D performance between foreign-owned firms and comparable Belgian-owned companies. Nevertheless the productivity of the subsidiaries exceeds substantially the one of their domestic counterparts, which may prove their role as efficient importers of R&D or may be due to their higher capital-intensity.

While for some countries the balance of evidence suggests that high

levels of foreign ownership have a depressing influence on industry-R&D-expenditures (Globerman and Meredith (1984)), the question remains if this effect is solely due to the presumed poorer R&D-efforts of the subsidiaries. The argument can be made that foreign participation influences domestic firms' R&D performance. In line with the hypothesis put forward by Richard Caves (1974), it can be argued that the dynamic efficiency of domestic firms is affected by the presence of multinational enterprises, and this through a competition effect. In this view, domestic producers are reinforced by the competition of foreign owned firms to perform at higher levels of efficiency, which could be translated in higher R&D-expenditures. Mansfield and Romeo (1980) investigated for the UK to what extent domestic firms' innovative efforts had been affected by the technology represented in competing American subsidiaries in the UK. Over half of the questioned firms believed that at least some of their products and processes had for this reason been introduced more quickly .(A rise in their R&D-efforts could have been expected).

Next to the positive competition effect on innovative efforts, a negative one could also be present. When entry of foreign owned firms causes competition to become more vigorous, domestic firms can be forced to economize on R&D, because its profitability is lowered. (Lake (1979)) This is especially relevant when a certain threshold is needed and when the R&D-activities entail sunk costs. As subsidiaries introduce in general more product differentiation in an industry, the resulting declines in product lengths-of-run, could further discourage domestic firms' R&D-expenditures.

Besides the competition effect, Mansfield and Romeo (1980) distinguish spill-over effects generated through the technology present

in multinational enterprises. Although the innovative capacity of domestic firms benefits from those spin-offs, the effect on their R&D-expenditures remains ambiguous. In general the effect is negative when the spill-overs substitute for domestic R&D. On the other hand a positive effect is possible when local firms reach through the spill-overs a knowledge level which permits them to perform additional research.

The following sections, attempt to provide at least some answers to the questions raised above. The effect of multinational presence on domestic firms' R&D-expenditures as well as R&D-intensities - a common proxy for measuring innovativeness - is developed theoretically, and tested empirically for Belgium.

2. The analytical model

A simple scenario can be set up to analyze the innovative activities of domestic firms in the presence of multinational competition. The case of a monopoly held by the domestic firm(s) will serve as the reference scenario. Since it is only the intention to uncover the essential factors determining DOM firm's R&D decisions, specifications will be kept simple : linear demand, constant marginal cost. The model is a simplified version of the framework employed by De Bondt, Sleuwaegen and Veugelers (1988).

The domestic firm's (DOM) profit function is posited to be :

$$\pi^d = [\alpha^d(r^d) - x^d - \beta x_2^M] x^d - c^d x^d - r^d \quad (1)$$

where x^d = domestic firms output

r^d = R&D expenditures by the DOM firm

$p^d = \alpha^d(r^d) - x^d - \beta x_2^M$

The multinational firm's (MNE) profit function is

$$\pi^M = [\alpha_2^M(r^M) - x_2^M - \beta x^d] x_2^M - c_2^M x_2^M - [\alpha_1^M(r^M) - x_1^M] x_1^M - c_1^M x_1^M - r^M \quad (2)$$

where subscript 1 denotes MNEs home market and

subscript 2 its foreign market populated by the domestic firm. Multinationals, whilst operating in several markets, can enjoy economies of scope which lowers c_1^M and c_2^M in comparison with a unational firm.

The DOM and MNE products may be differentiated since $0 < \beta \leq 1$. The reference scenario of a monopolistic DOM firm can be simply constructed by setting $\beta=0$. The DOM and MNE competition is envisaged to be of the Cournot-Nash type.

R&D expenditures are supposed to shift the demand function according to :

$$\alpha^d = h^d + \sqrt{r^d} \quad (3)$$

$$\alpha_1^M = h_1^M + \sqrt{r^M} \quad (4)$$

with h^d and h_1^M given constants. The square root specification captures diminishing returns to R&D (see d'Aspremont and Jacquemin (1987) for an analogous specification). r^M measures the total R&D expenditures of the multinational corporation (mother company as well as subsidairies).

Cost reducing R&D can be modelled analogously as :

$$c^d = k^d - \sqrt{r^d} \quad (3')$$

$$c_1^M = k_1^M - \sqrt{r^M} \quad (4')$$

and would yield similar results. Notice that with homogeneous products ($\beta=1$ and $\alpha_1^M=\alpha$), cost reducing R&D is the relevant scenario.

When deciding on their R&D expenditures firms take into account the strategic effect of R&D on output. In order to determine optimal R&D levels, a two-stage game approach will therefore be used, where first the output game is solved given R&D levels, after which the R&D game is obtained given the solution of the output game (feedback equilibrium),

yielding subgame perfect equilibrium levels for R&D and output.

3.1. The DOM firm as a monopolist

The monopoly equilibrium of the output game x^{d*} results from

$$\begin{aligned} \max_{x^d} \pi^d &= (\alpha^d(r^d) - x^d)x^d - c^d x^d - r^d \\ \text{from which } x^{d*} &= \frac{\alpha^d(r^d) - c^d}{2} \end{aligned} \quad (5)$$

The monopoly equilibrium of the R&D game r^{d*} is obtained from

$$\max_{r^d} V^d = (\alpha^d(r^d) - x^{d*})x^{d*} - c^d x^{d*} - r^d$$

Filling in (3) for $\alpha^d(r^d)$ and (5) for x^{d*} yields finally:

$$r^{d*} = [(h^d - c^d)/3]^2 \quad (6)$$

3.2. The DOM-MNE competition

The intention is to characterize what happens with r^d in the presence of MNE competition. The Cournot-Nash equilibrium of the output game is obtained from solving simultaneously $\max_{x^d} \pi^d$ and $\max_{x_1^M, x_2^M} \pi^M$, yielding:

$$x^{d0} = \frac{2[\alpha^d(r^d) - c^d] - \beta[\alpha_2^M(r^M) - c_2^M]}{4 - \beta^2} \quad (7)$$

$$x_2^{M0} = \frac{2[\alpha_2^M(r^M) - c_2^M] - \beta[\alpha^d(r^d) - c^d]}{4 - \beta^2} \quad (8)$$

$$x_1^{M0} = \frac{[\alpha_1^M(r^M) - c_1^M]}{2} \quad (9)$$

Optimal R&D levels in the case of DOM-MNE Cournot competition can now be obtained from solving simultaneously :

$$\max_{r^d} V^d(x^{d^0}, x_2^{M^0}) \quad \text{and} \quad \max_{r^M} V^M(x_1^{M^0}, x^{d^0}) \quad \text{yielding :}$$

$$\frac{\partial V^d}{\partial r^d} = \frac{\partial \pi^d}{\partial x_2^{M^0}} \cdot \frac{\partial x_2^{M^0}}{\partial r^d} + \frac{\partial \pi^d}{\partial r^d} = 0 \quad (10)$$

$$\frac{\partial V^M}{\partial r^M} = \frac{\partial \pi^M}{\partial x_2^{d^0}} \cdot \frac{\partial x_2^{d^0}}{\partial r^M} + \frac{\partial \pi^M}{\partial r^M} = 0 \quad (11)$$

The first term of expression (10) and (11) represents the strategic effect of R&D. The second term captures the open-loop or commitment effect of R&D.

From (7) and (8) it can be easily seen that :

$$\frac{\partial x_2^{M^0}}{\partial r^d} = \frac{-\beta}{2(4-\beta^2)} (r^d)^{-1/2} < 0 \quad (12)$$

$$\frac{\partial x^{d^0}}{\partial r^M} = \frac{-\beta}{2(4-\beta^2)} (r^M)^{-1/2} < 0 \quad (13)$$

Firms, when deciding on R&D, take into account that a rise in their R&D expenditures will lower their rivals' output choice and thus increase their own profits (since $\partial V^d / \partial x_2^{M^0} = -\beta x^{d^0} < 0$).

Combining strategic and open-loop effects of R&D yields :

$$\frac{\partial V^d}{\partial r^d} = \frac{2}{4-\beta^2} x^{d^0} (r^d)^{-1/2} - 1 = 0 \quad (14)$$

$$\frac{\partial V^M}{\partial r^M} = \left[\frac{4}{4-\beta^2} x_2^{M^0} + x_1^{M^0} \right] \frac{1}{2} (r^M)^{-1/2} - 1 = 0 \quad (15)$$

Substituting x^{d^0} , $x_1^{M^0}$ and $x_2^{M^0}$ from resp. (7), (8) and (9) the system (14)-(15) yields r^{d^0} after a few computations:

$$r^{d^0} = [(h^d - c^d)A - \beta(h_2^M - c_2^M)3B - \beta(h_1^M - c_1^M)B]^2 \quad (16)$$

$$\begin{aligned} \text{with } A &= \frac{12(4-\beta^2)^2 - 64 + 16\beta^2}{C} \\ B &= \frac{2(4-\beta^2)^2}{C} \\ C &= [(4-\beta^2)^2 - 4](3(4-\beta^2)^2 - 16) - 16\beta^2 \end{aligned}$$

When comparing R&D under MNE competition (r^{d^0}) with the R&D performed in the absence of MNE competition (r^{d^*}), it can be established that the R&D of the domestic firms will decrease in the light of MNE competition ($r^{d^*} > r^{d^0}$) if and only if

$$(h^d - c^d) < \frac{18\beta(4-\beta^2)^2}{|D|} (h_2^M - c_2^M) + \frac{6\beta(4-\beta^2)^2}{|D|} (h_1^M - c_1^M) \quad (17)$$

$$\text{where } D = [(3(4-\beta^2)^4 - 64(4-\beta^2)^2 - 64\beta^2 + 256]$$

A closer look at (17) reveals that the higher the product substitutability, the more likely that MNE competition will lower domestic innovation efforts. It can furthermore be established that if the domestic firm has a smaller initial demand-cost margin than the MNE, (17) always holds. The smaller β , the smaller the demand-cost advantage of the domestic firm needs to be, in order for (17) to hold. If the competition would not be of the multinational type, the third term of equation (16) would drop out. As a consequence, MNE competition has a larger negative influence on DOM R&D compared with unational competition.

The driving force behind this negative influence is the strategic substitutability of r^d and r^m : an increase in rival R&D lowers own output and thereby reduces own R&D. The negative influence of foreign

competition on domestic R&D is indeed reinforced by the strategic interaction terms. A comparison of the open-loop equilibrium levels for r^d (1) with their feedback counterparts of (16) proves R&D to become relatively more sensitive to rival demand-cost margins in a closed loop scenario thereby reducing further R&D expenditures.

Spill-overs from the multinational firm to the domestic firm would strengthen the negative influence of multinational presence on domestic innovative efforts, if dissipated knowledge can be considered a substitute to own-built up knowledge. On the other hand possible spill-overs from the domestic firm to the multinational firm would have the opposite effect : they would lower multinational R&D, thereby increasing domestic R&D in view of the substitutability of both types of R&D.

Output changes under multinational competition can be analysed along similar lines. First stage firm's output levels under competition are lower than monopoly levels (unless $\beta=0$ or a very small MNE demand cost margin). This difference is further strengthened in the second stage if (17) applies and vice versa if this inequality does not hold.

The combination of R&D and output effects to assess competition effects on R&D-intensities, inevitably renders the analysis more complicated. It can be established that multinational competition

(1) The open-loop values for r^{d^0} can be obtained from solving $\partial \pi^d / \partial r^d$ and $\partial \pi^m / \partial r^m$ simultaneously :

$$r^{d^0}_{open-loop} = [(h^d - c^d)A' - \beta(h_2^m - c_2^m)3B' - \beta(h_1^m - c_1^m)B']^2 \quad (16')$$

where $A' = \frac{6(4-\beta^2)}{C'} - 8 + 2\beta^2$

$$B' = \frac{(4-\beta^2)}{C'}$$

$$C' = [2(4-\beta^2)-2][3(4-\beta^2)-4] - 2\beta^2$$

It can easily be checked that if $\beta=0$, closed loop and open loop values coincide: (16) = (16').

The open-loop decrease in firm's R&D due to an increase in the number of firms corresponds to the Dasgupta and Stiglitz (1980) results.

lowers domestic R&D-intensity if and only if:

$$(h^d - c^d)^2 < \frac{96\beta^2(4-\beta^2)B^2}{E-6A^2(4-\beta^2)} (h^M - c^M)^2 + \beta \frac{F-48(4-\beta^2)AB}{E-6A^2(4-\beta^2)} (h^d - c^d)(h^M - c^M) \quad (18)$$

with $E = 2AC(1+4A)/G$

$F = 4(4-\beta^2)^2 (C+4G+4\beta^2)/CG$

$G = 3(4-\beta^2)-16$

$(h^M - c^M) = (h^M_2 - c^M_2) = (h^M_1 - c^M_1)$

Whether (18) applies, depends crucially on the product substitutability β and on the relative magnitude of both firms' demand-cost margins, as the following figure illustrates :

Figure 1

Figure 1 plots the change in domestic R&D intensity due to multinational competition as a function of relative demand cost margins,

and this for various levels of product substitutability, which yield positive outputs.

If entry of multinationals induces more differentiation in an industry, the R&D intensities of domestic firms lowers, made abstraction of relative efficiency levels.⁽²⁾ Given relative demand-cost margins, the more heterogeneous the products become, the greater the likelihood that multinational competition reduces domestic R&D intensity.

This surprising result can be explained as follows : the smaller β , the smaller the negative effect of competition on R&D. However, with a smaller β , output becomes even more insensitive to the competition effect, thereby minimizing the influence of output on R&D-intensities, such that the latter will decrease more easily. Figure 2 further clarifies this.

Given β (e.g. 0.7 as in figure 2), the effect of competition on domestic R&D-intensities depends on the relative demand-cost margins. The decline in domestic R&D-intensities through MNE competition occurs with a relative domestic demand-cost margin lying between 0.75 and 1.6. In this area (I), competition lowers output, as well as R&D, but the R&D effect dominates, which explains the negative effect on R&D intensities.

(2) This insight is consistent with De Bondt, Sleuwaegen and Veugelers (1988) who find that domestic firms in multinational industries tend to posit themselves in small market niches and emphasize product differentiation. Those strategies, although significantly related to success, require less R&D-efforts.

Figure 2

<u>Area I</u>	<u>Area II</u>	<u>Area III</u>	<u>Area IV</u>
$r^* > r^\circ$	$r^* > r^\circ$	$r^* < r^\circ$	$r^* < r^\circ$
$X^* > X^\circ$	$X^* > X^\circ$	$X^* > X^\circ$	$X^* < X^\circ$
$RDI^* > RDI^\circ$	$RDI^* < RDI^\circ$	$RDI^* < RDI^\circ$	$RDI^* < RDI^\circ$

With a smaller demand-cost margin for the domestic firm in the small interval $[1.6, 1.9]$, competition still lessens domestic R&D-expenditures, but reduces output even more, such that R&D-intensities increase (area II).

With a relatively high domestic demand-cost margin $[(h^d - c^d) > 1.9 (h^M - c^M)]$, the same positive effect of competition on domestic R&D-intensities occurs but as a consequence of different processes (see

legend of figure 2).

3. Empirical Results

In order to determine the effect of multinational competition on domestic firm's R&D-intensity, the latter is regressed on the multinationalization degree of the industry in which the domestic firm is operating. Despite the ambiguity of the results surrounding previous empirical studies (e.g. Newman, Böbel and Haid (1982)), the Herfindahl index is included as well to capture effects of possible other competition, e.g. within the group of domestic firms, which can also lower firm's R&D (cfr. supra).⁽³⁾ Finally, dummies are added to correct for technology : since multinationals can spread their R&D efforts over a wider range of applications, they tend to be more present in R&D-intensive industries (see e.g. De Bondt, Sleuwaegen and Vanden Houte (1988)), from which they obtain their comparative advantage. Sectoral dummies are therefore introduced to exclude high domestic R&D-efforts in multinational industries due to a R&D-intensive technology.

A pooled cross-section and time series sample of 123 observations is used, covering information on Belgian domestic companies operating in chemicals, metals and machinery, food and beverages and electronics for the years 1980-1983 ⁽⁴⁾. It was verified whether the regression disturbances are cross-sectionally and time-wise independently distributed. Similarly, no evidence of heteroscedastic behaviour of the disturbances was found. Hence, ordinary least squares remains a BLUE

(3) It needs to be stressed that a concentration index is not a perfect measure for competition. Industries with high degrees of concentration are not necessarily lacking effective competition.

(4) The authors would like to thank Claude Carbonelle, J.F. Hoffelt, S. Janssens and Leo Sleuwaegen for kindly providing the R&D survey data.

estimator for the proposed model.

The following results are obtained :

$$\begin{aligned}
 \text{RDINT} = & .024 - .030 \text{ MULTI} + .012^{\circ} \text{HERF} \\
 & (.003) \quad (.008) \quad \quad (.009) \\
 & + .019 \text{ D1} + .038 \text{ D2} - .005^{\circ} \text{D3} + .045 \text{ D4} \quad (19) \\
 & (.009) \quad (.005) \quad (.005) \quad (.013)
 \end{aligned}$$

$$R^2 = 0.42$$

$$R^2_{\text{ADJ}} = 0.39$$

$$\text{S.E.R.} = 0.018$$

$$\text{M.D.V.} = 0.026$$

$$F = 16.53$$

$^{\circ}$ = not significant at the 5 % significance level

Between brackets are the standard errors.

with RDINT = Domestic firm's reported R&D divided by firm's output.

MULTI = Multinational presence in the NACE-3-digit industry in which the DOM firm is operating, measured as the share of industry output controlled by foreign enterprises in the year 1978. Source : INCAP

HERF = The Herfindahl index (ranging from 0 (perfect competition) to 1 (monopoly)) as an average over the years 1980-1983

D1 = Chemical industry

D2 = Manufacture of office machinery, data processing machinery and electrical engineering

D3 = Food, drink and tobacco industry

D4 = Processing of rubber and plastics.

A significant negative coefficient for MULTI is obtained. As the theoretical framework points out, a negative influence of multinational

competition on domestic R&D-intensity can only occur with a strong negative influence on domestic R&D-expenditures ⁽⁵⁾. The data therefore suggest that domestic and multinational R&D-expenditures can indeed be considered as strategic substitutes. This result might be an indication that multinational entry is characterized by more product differentiation or that their cost efficiency and/or market size is not too different from local firms, since these conditions facilitate the negative effect of competition (figure 1). The magnitude of the coefficient of MULTI indicates a rather strong effect.

The lower R&D-expenditures of domestic firms in multinational industries would seem to support the idea that domestic firms constitute a distinct strategic group from multinational firms on the aspect of innovativeness ⁽⁶⁾. This different strategic positioning of domestic

(5) Deleting domestic firm's sales from the regression doesn't change the significant negative coefficient of MULTI, but it does considerably decrease the explanatory power of the regression

$$\begin{aligned} \text{Log(R\&D)} = & 9.020 - 2.400 \text{ MULTI} + 3.393 \text{ HERF} + 2.966 \text{ D1} + 2.221 \text{ D2} \\ & (.335) \quad (.833) \quad (.960) \quad (.957) \quad (.513) \\ & + 0.081^{\circ} \text{D3} + 2.181^{\circ} \text{D4} \quad R^2_{\text{adj}} = .248 \\ & (.4691) \quad (1.305) \end{aligned}$$

The logarithmic version of R&D expenditures on sales and MULTI, show a coefficient for sales which cannot be rejected to be equal from 1, as in accordance with many other studies (see e.g. Sleuwaegen and Horemans (1988)). The option of using R&D-intensity as dependent variable was therefore chosen, dropping the logarithmic transformation since all variable values are situated between 0 and 1.

(6) It can be established that, under a broad set of circumstances, the MNE increases its R&D when going multinational, as compared with a single monopoly situation in its only (home) market.

$$\begin{aligned} r^M_{\text{MON}} > r^{M^0} \text{ if} \\ (h^M_1 - c^M_1) > \frac{24\beta(1+A)}{24\beta^2+16} (h^d - c^d) - \frac{3(24\beta^2B+16)}{24\beta^2+16} (h^M_2 - c^M_2) \quad (5') \end{aligned}$$

Notice that (5') becomes more likely, the higher the cost advantage of the multinational firm. The higher the product substitutability, the smaller the possible cost disadvantage of the MNE to satisfy (5'). With a higher r^M and a lower r^d , the difference between r^M and r^d is established.

and multinational firms has already been theoretically established in a more general model and documented from survey data by De Bondt, Sleuwaegen and Veugelers (1988).

Inclusion of the Herfindahl index does not contribute to a better explanation of the variations in domestic R&D-intensities. Its positive, although not significant coefficient nevertheless seems to suggest that overall competition in the industry further lowers domestic firm's R&D. To check for a possible simultaneity bias, regression (19) was rerun with HERF for the year 1979, but its positive coefficient remains.

If no correction would have been made for technology, we would have found a significant positive sign for MULTI, as was expected. Inclusion of the sectoral dummies raises R^2_{adj} indicating the importance of technological opportunity (see Scherer (1983) for similar results).⁽⁷⁾

(7) $RDINT = 0.018 + 0.012 \cdot MULTI + 0.260 \cdot HERF$ $R^2_{adj} = .059$
 (.004) (.008) (.011)

4. Conclusions

The influence of multinational presence on domestic firm's innovative efforts has been explored in a game-theoretic model focusing on the strategic dimension of R&D, and further tested against survey data. Although the theoretical model does not provide any clear-cut answers, circumstances could be pinpointed under which domestic and foreign R&D can be considered as strategic substitutes.

The empirical results presented in this paper were found to support this hypothesis. Domestic companies operating in a subset of Belgian manufacturing industries were found to have smaller innovative intensities, the higher the presence of multinational firms in the industry. Since this result indicates that domestic and foreign R&D can be considered as strategic substitutes, policy measures aimed at selectively stimulating any one of these firms, should bear in mind the negative effect of these measures on the R&D-efforts of the other firms, which could harm overall welfare.

It needs to be stressed that in the light of possible policy implications, no claims have been made regarding total R&D-expenditures in the industry. In order to characterize fully industry innovativeness, technology transfers from parent companies to their affiliates, together with possible synergetic effects between establishments within the industry, need to be assessed. However, this requires a richer data base as well as a more detailed analytical model.

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