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Abstract

Spillovers with demand-creating research and development (R&D) activities are investigated by revisiting a widely employed market-share rivalry demand structure. Positive technological spillovers may inflict positive or negative side effects on rivals and this has important implications for the effects on innovative efforts of loose or tight R&D cooperation in symmetric oligopolies. A comparison with the effects that apply with linear demand structures and implications for empirical analysis are also touched upon.

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I. INTRODUCTION

Firms that attempt to increase profitability through product improvements may realise that rivals may be affected by their efforts as well. Spillovers in demand-creating R&D are likely to be present and to be of importance for individual and industry innovative efforts and profitability. While the effects of spillovers on cost-reducing innovative efforts have recently received wide attention, little has been clarified on the impact of leakage in demand-creating efforts (an exception is Levin and Reiss (1988)).

The implications of spillovers for demand-creating innovative activities will be looked at, by revisiting a simple and widely employed market-share rivalry specification. Even though technological spillovers may be positive, R&D may inflict positive or negative effects on rivals, because it may enhance the competitiveness of the investing firm. This will be shown to have important consequences for the impact of cooperation or mergers on R&D and R&D intensity. The simple model thus clearly details the importance of spillovers for analysing the impact of loose or tight cooperation on innovative efforts. Similarities and differences with cost-reducing activities in oligopolies with linear demand structures will also be clarified.

The next two sections contain a description of the analytical set up and the equilibria. The subsequent sections describe the impact of externalities and number of rivals on innovative efforts, after which some conclusions are presented.

II. EXTERNALITIES WITH DEMAND-CREATING R&D

The intention here is to employ a well-known market share attraction model (Schmalensee (1976)) to analyse spillover effects in demand-creating R&D. There are N firms that compete in a differentiated oligopoly. Firm demand is given by :

$$q_i = A_i(x_i, x_{i-}) \cdot G(p)$$

$$A_i = \left[\frac{x_i^B}{\sum_{i=1}^N x_i^B} \right] (\sum_{i=1}^N x_i)^\alpha, \quad i=1, \dots, N \quad (1)$$

with G a decreasing function of the vector of all prices p . The R&D expenditures of firm i is x_i and x_{i-} is the vector of expenditures of the $N-1$ rivals, while α and β are nonnegative parameters ($\alpha \geq 0$, $\beta \geq 0$).

Price competition in output markets will be largely ignored. This allows to keep the analysis as simple as possible and does not seriously limit the interpretation of the results.⁽¹⁾ One can interpret the demand weight A_i as the perceived quality, or attractiveness, of the i th firm's product. The weights allow R&D expenditures to affect each firm's demand curve and they reflect both tastes and technological attributes of the products (Levin and Reiss (1988)).

The attractiveness A_i contains both expansion and rivalry effects of product R&D. The spillover of knowledge through transfers of information (leakage, reverse engineering), should allow rivals to enhance the quality of their products also. Given that consumers are willing to pay more for higher quality, the demand for each firm and total market demand should as a consequence increase. This is a market expansion effect of product R&D. As a new or improved product variety is marketed, customers may also be taken away from rivals, and this is a rivalry (or substitution) effect of demand creating R&D.⁽²⁾

With symmetric investments these effects can readily be detailed as follows. The elasticities of the weights with respect to R&D equal the corresponding elasticities of demand, and are given in Table 1 :

Table 1: Elasticities of perceived quality and firm demand with respect to product R&D in oligopoly with symmetric investment

Total effect = [Market expansion effect + Rivalry effect]				
$\epsilon_i^i = \frac{\delta \ln q_i}{\delta \ln x_i}$	=	[	α/N	+ (N-1) β/N] ≥ 0
$\epsilon_i^j = \frac{\delta \ln q_j}{\delta \ln x_i}$	=	[	α/N	- β/N] $\begin{matrix} > \\ = \\ < \end{matrix} 0$

¹ The assumption of multiplicative separability of demand in price and R&D is not without precedent (e.g. Dasgupta and Stiglitz (1980) and Levin and Reiss (1984) and (1988)).

² See Lambin, Naert and Bultez (1975) for the expansion and rivalry effect in marketing terms and Shaked and Sutton (1990) for similar tendencies with introduction of product varieties.

A one percent increase in total industry R&D results in a α percent increase in total demand, since $\Sigma q_i = (\Sigma x_i)^\alpha$. A one percent increase in a firm's R&D efforts therefore represents, in a symmetric setting, a $1/N$ percentage increase in industry efforts and hence leads to a (α/N) percent increase in total demand. Each of the N firms receives the same percentage increase in firm demand, because technological spillovers transfer the improved quality to all rivals. In other words (α/N) represents the market expansion effect of a one percent increase in a firm's product R&D.

Because of taste differences, an increase in a firm's product R&D may increase its market share, to the detriment of its rivals' market shares. As firm i increases its R&D with one percent, each of its rivals loses a fraction β of its market share $1/N$ and this is the rivalry effect. Similarly, with a one percent increase in a firm's product R&D, its market share and output will increase with $(N-1) \cdot (\beta/N)$ because of the improved attractiveness of the product vis à vis the rivals' varieties.

The impact of a firm's demand creating R&D on its demand and attractiveness is necessarily positive. The effect on rivals' attractiveness and demand may be positive or negative, depending on whether the market expansion effect is larger or smaller than the rivalry effect.

R&D is undertaken with constant returns to scale and identical costs of r for all firms. Production costs are c per unit of output, so that firm's profitability V_i can be written as :

$$V_i = A_i(x_i, x_{-i}) \cdot G(p)(p_i - c) - rx_i \quad i=1, \dots, N \quad (2)$$

with p_i the price of firm i 's product. An increase in demand-creating R&D may, in a symmetric setting, thus inflict a positive or a negative externality on rival demand and profitability, since it can be verified that for identical x_i :⁽³⁾

$$\text{sign} (\delta V_j / \delta x_i) = \text{sign} (\epsilon_i^j) = \text{sign} (\alpha - \beta), \quad i \neq j \quad (3)$$

This simple fact appears not to have been previously emphasized and it

³ In fact the sign of $\delta V_i / \delta x_j = \text{sign} [\alpha - (\beta x_i)^{\beta-1} (\Sigma_{i \neq j} x_i)^\alpha / (\Sigma_i x_i)^\alpha]$, which clearly depends on both (asymmetries in) investment levels and the parameters α and β . It is possible to look more closely at the impact of asymmetries in R&D levels, for example by supposing that all rivals set an identical investment level that may be different from what firm i chooses. This procedure allows to verify that the relation (3) will hold as long as the asymmetries in investment levels are not too large.

has, as will be seen below, important consequences for the comparison of competitive and cooperative R&D levels. Figure 1 graphically summarizes the tendencies of equation (3).

Figure 1. Externalities with demand-creating R&D

Even though purely technologically speaking, spillovers typically will be positive or zero ($\alpha \geq 0$), the impact on rival demand and rival profitability may be positive or negative, because of the accompanying rivalry effects ! (4)

III. COMPETITIVE AND COOPERATIVE SYMMETRIC EQUILIBRIA

The computation of the symmetric equilibria is relatively straightforward. The noncooperative Nash R&D strategies solve :

$$\frac{\delta V_i}{\delta x_i} - (p_i - c) \cdot G(p) \cdot \frac{\delta A_i(\cdot)}{\delta x_i} - r = 0 \quad \text{for } i, j = 1, \dots, N \quad (4)$$

$$i \neq j$$

The focus is on an industry with non-price competition where all firms charge the same price. Since they are identical, it seems plausible to

⁴ Similar features apply with linear demand, see De Bondt and Veugelers (1991). This point also appears in Levin and Reiss (1988).

look for symmetric equilibria, although even in this simple setting non-symmetric equilibria cannot be ruled out (Schmalensee (1976)).⁽⁵⁾ The symmetric innovative Nash (n) efforts x^n and corresponding profits v^n are:

$$x^n = \frac{1}{N} \left(\frac{1}{rN} [\alpha + (N-1)\beta] G(p)(p-c) \right)^{1/(1-\alpha)} \quad (5)$$

$$v^n = \frac{1}{N} \left(1 - \frac{\alpha + (N-1)\beta}{N} \right) \cdot \left(\frac{\alpha + (N-1)\beta}{rN} \right)^\alpha (p-c) G(p)^{1/(1-\alpha)} = \left(\frac{1-\epsilon_i^1}{\epsilon_i^1} \right) x^n \quad (6)$$

The non-cooperative equilibrium yields nonnegative profits in case $\epsilon_i^1 < 1$, which holds for any $\alpha < 1$ and $\beta \leq 1$. Moreover firms earn positive profits at equilibrium, independent of the number of firms.⁽⁶⁾ Second order⁽⁷⁾ and stability conditions⁽⁸⁾ are assumed to be satisfied.

In case firms choose their R&D efforts cooperatively, to maximise joint profits, their optimal cooperative R&D levels (x^c) are derived from:

$$\begin{aligned} \frac{\delta(\sum_{i=1}^N v_i)}{\delta x_i} &= G(p)(p-c) \cdot \frac{\delta(\sum_{i=1}^N A_i)}{\delta x_i} - r = 0 & \text{for } i, j=1, \dots, N \\ & & i \neq j \quad (7) \\ &= G(p)(p-c) \frac{\delta(\sum_{i=1}^N x_i)^\alpha}{\delta x_i} - r = 0 \end{aligned}$$

whereby it is again assumed that all firms charge the same price. The innovative efforts in a symmetric equilibrium are indicated by x^c , and the resulting firm profits by v^c , with :

⁵ Especially with cooperative conduct, firms could be better off with asymmetric outcomes. Note also that with the multiplicative demand structure, sequential and simultaneous moves in R&D and prices coincide.

⁶ See also Schmalensee (1976), where it is pointed out that if $\beta < 1$, there are diminishing returns to market share, which restrains R&D competition sufficiently to provide excess profits to any number of firms. Hence in the present setting, there is no free entry equilibrium, satisfying a zero profit condition.

⁷ At a symmetric equilibrium, $V_{ij} < 0$ iff $[\alpha + (N-1)\beta]^2 < \alpha + (N-1)\beta(N+\beta)$. The Hessian matrix is negative semi-definite in a symmetric equilibrium, for a duopoly, in case $\alpha < 1$. For an oligopoly, the second order conditions are only checked for the parameter values used in the numerical simulations.

⁸ The stability condition invoked is due to Seade (1980) and requires: $1/(N-1) > V_{ij}/V_{ii} > -1/(N-1)$, which can be rearranged as $|V_{ij}| > (N-1)|V_{ij}|$ or $|\alpha + (N-1)\beta| [1 - \alpha + \beta + (1-\beta)N] + \alpha N + \beta(N-1)(1-\beta) > (N-1) |\alpha + (N-1)\beta| (\alpha - 1 - \beta) + \beta(N-1 + \beta)$

in symmetric equilibria. Numerical calculations show that the severity of this condition depends on the number of firms in the market. In case of a duopoly ($N=2$), this condition is fulfilled for all $0 < \alpha \leq 1$ and $0 < \beta \leq 1$. For 'small' N , the condition holds for all small β (independent of α), and for large β , if α is sufficiently large. For 'intermediate' N (e.g. $N=100$), the stability condition is not satisfied, while for 'large' N , similar restrictions hold as for small N .

$$x^c = \frac{1}{N} [\alpha(p-c)G(p)/r]^{1/(1-\alpha)} \quad (8)$$

$$v^c = \left(\frac{1-\alpha}{N}\right) \cdot \left[\left(\frac{\alpha}{r}\right)^\alpha (p-c)G(p)\right]^{1/(1-\alpha)} = \left(\frac{1-\alpha}{\alpha}\right) \cdot x^c \quad (9)$$

Second-order conditions are fulfilled with $\alpha < 1$. (10)

IV. EXTERNALITIES AND INNOVATIVE EFFORTS

The comparison of non-cooperative and cooperative demand-creating R&D can now be related to the externality effects. Both the impact on R&D expenditures and R&D intensities are looked at.

A. Conduct and R&D Investment

Differences in demand-creating investments are driven by the externalities inflicted upon rivals, since :

$$\text{sign}(x^c - x^n) = \text{sign } \delta V_i / \delta x_j \quad (10)$$

which can be verified from the equations (5) and (8). It is likewise easy to verify that profitability always increases because of cooperative investments.

Cooperative conduct allows firms to internalize externalities of R&D. A firm that increases its demand-enhancing R&D inflicts a positive externality on rivals, if market expansion effects because of technological spillovers, are more important than the rivals' losses of market share ($\alpha > \beta$, see Figure 1). The cooperative R&D takes this positive side-effect into account and this results in larger investments than with Nash competition. Similarly, if rivalry effects are larger than expansion effects there is a negative externality, and demand-creating R&D inflicts a negative externality on others. Internalizing this effect results in smaller efforts (see also Stonemann and Vickers (1988)). (11)

In cost-reducing R&D games with a linear demand structure, (12) the positive (or negative) sign of the externality also corresponds with important (or low) technological spillovers (De Bondt and Veugelers

¹⁰ Stability conditions could also be looked at if firms are supposed to choose independently the cooperative responses.

¹¹ In the razor's edge case where the expansion and substitution effect are identical ($\alpha = \beta$), firms undertake the same R&D investments, independent of their cooperative or non-cooperative behavior.

¹² In those settings, the R&D investments can also be viewed as shifting the linear demand curve in a parallel fashion.

(1991)). At the same time the positive (negative) effect corresponds with R&D activities that have upward (downward) sloping reaction curves.⁽¹³⁾ This fact helps to "explain" the impact of conduct in the linear case, since with upward (downward) sloping curves,⁽¹⁴⁾ cooperative efforts are larger (smaller) than Nash levels. Many authors emphasize this point to interpret this comparison, even though it is not robust to changes in the demand structure.

The market attraction specification analysed here, nicely highlights this point. In a symmetric equilibrium, firms may react positively or negatively to increases in a rival's efforts, since

$$\text{sign } \frac{\delta^2 V_i}{\delta x_i \delta x_j} = \text{sign} [\alpha(\alpha-1) + (N-2)\beta(\alpha-\beta)] \quad (11)$$

while the sign $(\delta x_i / \delta x_j) = \text{sign} (\delta^2 V_i / \delta x_i \delta x_j)$. It can easily be verified that in case $\alpha \leq \beta$, firms have negatively sloped reaction curves (at least around symmetric investment levels). In case $\alpha > \beta$, the firms' reaction curves are downward (upward) sloping if the number of firms is sufficiently small (large). For a symmetric duopoly the slope is always negative.

With a sufficiently small number of firms, say in a duopoly, noncooperating firms respond negatively to increases in rivals' investments, but externalities inflicted upon rivals can be positive or negative and cooperative efforts larger or smaller than noncooperative ones! In a cost-reducing duopoly with a linear demand structure a positive externality would necessarily be accompanied by positively sloped curves. A numerical example presented in Figure 2 further illustrates this case of the market attraction model.

¹³ More specifically this prediction emerges clearly from settings with linear demand and diminishing returns to R&D efforts. See Henriques (1990), d'Aspremont and Jacquemin (1990), De Bondt and Veugelers (1991) and the references cited therein. In the terminology of Bulow et al. (1985), upward (downward) sloping R&D reaction curves mean that innovative investments are strategic complements (substitutes).

¹⁴ Existing empirical evidence points to both downward sloping or upward sloping reaction curves, although the dependence on spillovers still remains to be investigated. See Veugelers and Vanden Houte (1990) and Meron and Caves (1991).

Figure 2: Reaction curves, cooperative R&D investments and externalities in duopoly with demand specification (1)*

* The graphs depict a symmetric cooperative (x_1^c) and non-cooperative (x_1^n) equilibrium for a duopoly. Isoprofit curves are indicated by solid lines and reaction curves by dotted lines.

B. Conduct and R&D Intensity

In the present setting, firms' R&D intensities (R&D-to-sales ratio), τ , can easily be characterised under different behavioral assumptions :⁽¹⁵⁾

$$\tau = \frac{r \cdot x_i}{p \cdot q_i} = \frac{\epsilon_i^i}{|\mu_i^i|} \quad (12)$$

whereby $|\mu_i^i|$ is the absolute value of firms' price elasticity at equilibrium. Table II gives the intensities and shows the differences between Nash and cooperative conduct in a symmetric R&D (and price) equilibrium.

¹⁵ This is a Dorfman-Steiner (1954) type of result, which has a long tradition in the economics of R&D. The results of Table II would apply with a constant price elasticity that is identical for all firms. It is well known that a demand function of the form $q_i = A G(p)$ with A a constant and $p = (p_1, p_2, \dots, p_N)$, which is derived out of a utility maximisation problem, can be approximated by $q_i = Z_0 p_i^{-\mu}$ if the number of varieties (or firms N) is sufficiently large (Dixit & Stiglitz (1977), Tirole (1988)).

Table II: R&D Intensity with noncooperative and cooperative conduct (and rivalry in prices)⁽¹⁶⁾

R&D intensity τ	R&D Conduct	
	Nash	Cooperation
	$\tau^n = \frac{\alpha + (N-1)\beta}{N \mu }$	$\tau^c = \frac{\alpha}{ \mu }$

They only depend on the magnitude of the expansion and rivalry effect, since :

$$\text{sign}(\tau^c - \tau^n) = \text{sign}(\delta V_j / \delta x_i) \quad (13)$$

in view of Figure 1. R&D investment levels and R&D intensities change in the same direction with a move towards cooperative R&D conduct (that leaves price rivalry intact). In case of positive (negative) externalities [$\alpha > (<) \beta$], cooperating firms spend not only more (less) on R&D in absolute terms (see above), but they also spend a larger (smaller) fraction of their sales on demand-creating R&D ! This analytical result illustrates that in empirical research, technological spillovers will matter a great deal in comparing R&D investment levels or R&D intensities across firms and industries, as measures of their innovative efforts.

¹⁶ It is possible to extend the comparison to different conduct in pricing behavior. To illustrate this point, let demand be represented by:

$$q_i = A_i(x_i, x_{-i}) \cdot p_i^\mu \cdot \pi_j^{\frac{\mu}{N-1}} [p_j^{\frac{\sigma}{N-1}}]$$

As usual, it is assumed that own price effects outweigh cross effects, that is, $|\mu| > |\sigma|$.

R&D intensities can easily be calculated for different modes of price and R&D conduct (the first superscript refers to price conduct, the latter to R&D conduct). In case of Bertrand-Nash price behavior, R&D intensities are $\tau^{nn} = [\alpha + (N-1)\beta] / N|\mu|$ and $\tau^{nc} = \alpha / |\mu|$. In case of cooperative pricing, R&D intensities are $\tau^{cn} = [\alpha + (N-1)\beta] / N|\mu + \sigma|$ and $\tau^{cc} = \alpha / |\mu + \sigma|$. It can easily be seen that R&D intensities are lower with independent (Nash) decisions in both stages (price and R&D) than with full cooperation (in price and R&D) if nonnegative externalities apply ($\alpha \geq \beta$). With negative externalities ($\alpha < \beta$), no general result emerges in this setting. It can also be checked that, for this specification, firms' R&D investment levels would always be higher with cooperative pricing, than with Bertrand pricing.

V. THE NUMBER OF FIRMS AND INNOVATIVE EFFORTS

The impact of the number of rivals on noncooperative R&D can be summarized by :⁽¹⁷⁾

$$\begin{aligned} \text{sign of } \delta x^N / \delta N &= \text{sign of } [(2-\alpha)(\beta-\alpha)/(1-\alpha) - N\beta] \\ &\text{and } \delta x^N / \delta N < 0 \text{ for } \beta < \alpha \end{aligned} \quad (14)$$

$$\text{sign } (\delta \tau^N / \delta N) = \text{sign } [\delta(Nx^N) / \delta N] = \text{sign } (\beta - \alpha) \quad (15)$$

Non-cooperative innovative efforts could increase or decrease with the number of firms in a symmetric equilibrium. This ambiguity results because of two conflicting incentives : less appropriation and stronger rivalry. As the number of firms grows, a smaller fraction of the expansion effect accrues to the firm in question, because of the technological spillovers, and this tends to discourage its efforts. On the other hand, with more rivals, the firm enjoys a larger rivalry effect from R&D : by increasing its R&D, it hopes to get a fraction of a larger rival market share. Although the net effect is not clear in general, it can easily be checked that innovative efforts are discouraged by entry, if the market expansion effect outweighs the rivalry effect ($\alpha > \beta$), and they may be stimulated, only if the rivalry effect is dominant.⁽¹⁸⁾ It can further be shown that individual and industry profitability will decrease with entry in the analysed setting.

Competitive total industry R&D declines or rises with more rivals depending on whether externalities of demand-creating R&D are positive or negative. Hence with $\alpha > \beta$, the growing number of firms imply important technological spillovers that are not compensated by a spur from rivalry effects and the proportional reduction in individual efforts is important enough for total industry investments to decline. With $\beta > \alpha$, on the other hand, positive rivalry incentives dominate the expansion effect and even if individual efforts were to decline, the total industry effort increases. This last prediction also emerged in technology race models without spillovers (see Reinganum (1989)).

¹⁷ In analysing the impact of the number of firms or varieties on innovative efforts, it is implicitly assumed that the number of available varieties does not affect the $G(p)$ -function, i.e. does not change the outcome in the product market. This would e.g. be the case if demand functions are of the form discussed in footnote 16. In this specification consumers regard all varieties as identical substitutes for a given product. This specification implies that, in a symmetric equilibrium absent R&D, each firm's demand does not depend on the number of available varieties. Total market demand, on the other hand, increases with the number of varieties.

¹⁸ It can also be shown that $\alpha + \beta < 1$ is sufficient for x to decrease with N .

Each firm's R&D intensity evolves in the same direction as the industry level of innovative expenditures. This result can be compared with the Dasgupta and Stiglitz (1980) findings. In a setting absent spillovers, they observe a proportional equilibrium relationship between R&D intensity and concentration, thereby concluding that in a cross-section of industries with the same demand elasticity at equilibrium, but varying by way of the size of the market and R&D technologies they face, one would observe a linear relationship between R&D intensities and concentration.⁽¹⁹⁾

In the present setting with technological spillovers, a smaller number of firms (more concentrated industry) is accompanied by a higher R&D intensity, only in case of positive R&D externalities, i.e. important technological spillovers. This is in the Schumpeterian tradition, where "monopoly" is most conducive to innovation, because of its better appropriation possibilities. Only with small technological leakage and high rivalry effects, may competitive incentives of rivalry dominate and may monopoly result in low total industry efforts and intensities compared with what would obtain in more competitive situations.

The fact that individual firms' total R&D efforts may rise while their R&D intensity declines after entry if $\alpha < \beta$,⁽²⁰⁾ likewise illustrates that empiricists should be careful in choosing R&D expenditures or R&D intensities as measures of innovative efforts.

VI. CONCLUSIONS

A move from independent towards cooperative conduct as well as a reduction in the number of firms (e.g. due to mergers) may be regarded as different modes of interfirm cooperation. A comparison of the findings for these "loose" and "tight" forms of R&D cooperation reveals that both modes stimulate R&D in symmetric equilibria in case a substantial expansion effect outweighs a possible rivalry effect. Furthermore they both affect firms' R&D intensities and total industry effort in the same way. Again the impact on individual firms' absolute innovative efforts is, even in

¹⁹ In Dasgupta and Stiglitz (1980), the impact of the number of firms on R&D intensity operates through the demand structure. De Bondt et al. (1991) shows, in a cost-reducing game with linear demand and spillovers, that inverted U-shaped relations may be expected between innovative output and the number of firms if technological spillovers are sufficiently important. Such relations have received empirical support, see Cohen and Levin (1989).

²⁰ This would occur e.g. in a duopoly, for $\beta = 0.9$, as long as $\alpha \leq 0.6$.

this simple setting, somewhat more involved. In any case all of this begs for empiricists to include an interaction between measures of technological spillovers and market power in empirical work attempting to unravel the impact of market structure on R&D efforts.⁽²¹⁾

Cost-reducing investments with linear demand appear to imply that R&D reaction curves are downward sloping if and only if spillovers are modest, otherwise they slope upwards. And cooperation in R&D results in lower (higher) individual efforts if and only if reaction curves slope downwards (upwards). Within the analysed demand-enhancing scenario however, R&D reaction curves are downward sloping for symmetric (or close to symmetric) investments in industries with not too many rivals, regardless the importance of the spillovers. The beneficial or detrimental effects of cooperation for individual investments continue to crucially depend on the sign of the externalities inflicted on rival firms, which in turn are determined by the magnitude of the spillovers. This suggests that it may be difficult to test for the sign of (symmetric) strategic interactions in R&D, because not only the importance of spillovers, but also the number of rivals and the demand structure may determine the reaction curve effects.

Perhaps the results presented here can inspire their investigation in settings with more general demand structures and hopefully they can be of some use for the empirical investigation of spillovers in industries where rivals compete in R&D.

²¹ For example the weak correlations between entry and innovative activities (Geroski (1991)) perhaps could be attributed to spillover effects.

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