# The determinants of innovation levels in SMEs

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*The relationship between the level of competition and the intensity of innovation is an inverted-U curve. This curve is the result of the idea that competition may have a differentiated impact of firms depending on the dispersion of their technical levels. For example, keen competition is favourable for innovation when firms are neck-and-neck in terms of technological levels, since they have a strong incentive to differentiate themselves from the other firms in order to reduce the pressure of competition (escape-competition effect through innovation). In unlevelled sectors, where firms have different technological levels, keen competition does not promote innovation by the leading firm, which ends up with smaller rents (disincentive effect). Thus, depending on the nature of the competition in a given sector, a firm may respond positively to keener competition if it is on the ascending side of the inverted-U relationship or negatively if it is on the descending side. Regardless of the prevailing effect (escape-competition or disincentive effect), we show that, in both theoretical and empirical terms (based on the use of data from a panel of French businesses taken from the FIBEN database and that of the Banque de France balance sheet office), when the size of the firm is smaller compared to the cost of innovation, the prevailing effect is weaker, which means that the inverted-U curve is flatter and that the firm's innovation choices are less sensitive to competition policies.*

*By comparing firms' balance sheet data to the Banque de France database on bill payment incidents, we also show that SMEs may face credit constraints during the trough of the economic cycle, leading them to cut back their R&D investment at the very moment when they should be expanding it, thus resulting in a mean level of R&D investment that is lower than it should be.*

*These findings suggest that the impact that measures to promote competition have on R&D investment could be limited in sectors where firms are relatively small. On the other hand, support for SMEs during the trough of the business cycle could promote their ongoing innovation efforts.*

Key words: Innovation, R&D, competition, SMEs, credit constraints, cycle

JEL Codes: E22, E32, L51, 016, 030

*NB: This paper is based on two recent studies presented at the conference on innovation hosted jointly by the CEPR and the Banque de France at Enghien-les-Bains in July 2007: one was on the link between R&D investment, competition and the relative size of innovative firms [*"Competition, R&D, and the Cost of Innovation"* by Philippe Askenazy (PSE, Cepremap and Banque de France), Christophe Cahn (Banque de France) and Delphine Irac (Banque de France), the other dealt with the impact that credit constraints have on the cyclicality of the R&D investment of innovative firms [Nicolas Berman (Université de Paris 1, Banque de France), Laurent Eymard (Banque de France), Philippe Aghion (PSE, Harvard), Philippe Askenazy (PSE, Cepremap and Banque de France) and Gilbert Cette (Banque de France) "Credit Constraints and the Cyclicality of R&D Investment: Evidence from France, 2007"].*

SMEs' ability to innovate and grow is one of the key strengths of globalised economies.

Two recent studies (Askenazy *et al.*, 2007; Berman *et al.*, 2007) compiled a panel of firms from the FIBEN database and that of the Central Balance Sheet Data Office[1] at the Banque de France. The studies used these data, focusing on innovative firms, meaning firms that invested in R&D. Most of these firms are SMEs and the median firm has one hundred employees. The purpose is to examine the relationship between competition and the level of R&D investment depending on the size of the firm in relation to innovation in the firm's sector, and to explore the impact of credit constraints on R&D investment.[2] The first two sections of this paper deal with these two studies. The third section outlines the directions suggested by the findings of this research in terms of possible applications for government policies.

# 1| Competition and innovation

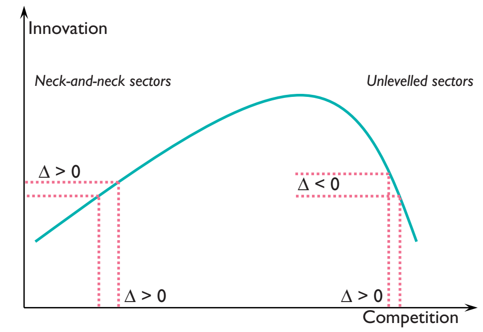
## 1|1 An inverted-U relationship

Many theoretical and empirical studies have focused on the relationship between innovation and competition[3] and, more generally, the effects that market structure may have on competition. We can derive two intuitions from preliminary survey of literature, but these intuitions may seem contradictory in some ways:

• On the one hand, the vision expressed by Schumpeter (1942) in which a firm that enjoys a monopoly has an incentive to innovate in order to keep potential competitors from entering its market. The monopoly gives the firm a long-term view and enables it to undertake risky R&D projects.

• On the other hand, Arrow (1962) expressed the view that firms have a strong incentive to differentiate themselves from each other to attenuate competitive pressures.

**Chart 1 Effects of increased competition on innovation**




Aghion *et alii* (2002, 2005b) introduced the notion of the inverted-U curve in an attempt to reconcile these two approaches. We use a simplified version here to incorporate the dimension of innovation costs relative to firm size, which is relevant to the specific issue of the impact that competition has on innovation in SMEs.

In this model, households are assumed to maximise an intertemporal utility function and consume a final good stemming from the aggregation of a variety of intermediate goods. Each type of intermediate good is produced by a sector made up of two firms, each of which has its own level of technology. Productivity gains are obtained sequentially and depend on the R&D investment of each firm.

If these firms are at the same distance from the technology frontier, meaning that they have the same level of technology or productivity, then the theory shows that the "escape-competition" effect prevails and has a positive effect on innovation. On the other hand, if the sector is made up of two firms with different levels of technology, then competition acts as a disincentive for R&D investment.

Thus, aggregation of both types of sector at the level of an economy produces the inverted-U relationship between competition and innovation.

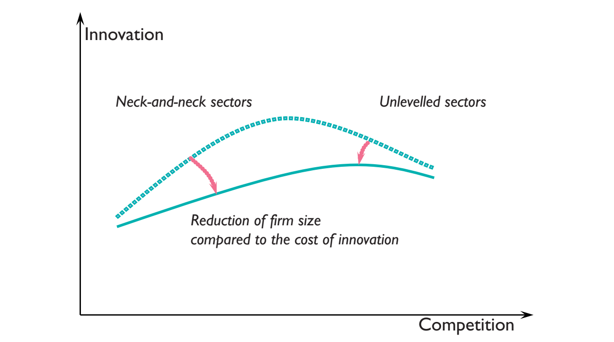
1 The FIBEN database contains standard accounting data from the tax returns of some 230,000 companies. The Central Balance Sheet Data Office is a subset of some 30,000 companies that voluntarily provide additional information for more refined economic analysis.
2 These two studies do not look at the determinants for innovation decisions, but the level of R&D investment in innovative firms. See Savignac (2006) for a discussion of the former.
3 See Aghion and Howitt on this topic (1998, Chapter 7). They devote a whole chapter to this topic in their book on the endogenous growth theory.

## 1|2 Firm size and the cost of innovation

In their paper, Askenazy, Cahn and Irac (2007) present an enhanced version of the model by Aghion *et alii* (2005b). They use this model to study the size of the impact of competition on firms' R&D activity, taking into account firm size, which is directly related to the cost of innovation.

Intuitively, the larger and more costly innovations are in a given sector, the greater competitive shocks have to be to affect a firm's R&D decisions. For example, a firm in a highly competitive sector seeking to differentiate itself will find it more difficult to undertake an innovative project, since such a project would be very costly. On the other hand, a market leader would have less to fear from the laggard firms because catching up to the leader in terms of technology would imply a high cost of innovation. Consequently, in such sectors, the inverted-U relationship would be flatter, meaning that policies to improve competition would have less impact on innovation.

**Chart 2 Effects of a reduction in the size of firms compared to the cost of innovation in a sector**




## 1|3 Empirical illustration

The theoretical predictions resulting from the model in the preceding section are compared empirically to the data. The data are taken from two complementary databases:

- The first database, from which the variables of interest, meaning R&D investment and a measurement of competition in a sector are derived, has been extracted from the FIBEN and the Central Balance Sheet Data Office databases at the Banque de France;

- The second database is that of the Research Ministry's R&D survey, which contains data on total R&D expenditure and the number of patents filed by some 3,000 firms. This database is used to calculate the average cost of innovation in each sector. The mean cost of a patent is the proxy for mean cost of innovation.

Using a data sample containing all of the information on firms that invested in R&D, the table shows the results of estimating the model (see Box). According to these results, it seems that a concave function is a fitting description of the relationship between innovation and competition, which validates the inverted-U relationship between innovation and competition, especially in sectors where the cost of innovation appears to be lower. However, the results show that the relationship is less significant as firm size compared to the cost of innovation diminishes.

These results also show that the inverted-U relationship is closer to a horizontal straight line for firms under a certain size (value added less than 130% of the cost of innovation). The relationship between competition and innovation disappears statistically below this value. Yet, firms of this type are the most representative, accounting for some 85% of the sample.

**Box**

## Estimation of the model

*The only R&D expenditure amounts available in the database are at constant prices. The cost of innovation is evaluated on the basis of an R&D survey by the Research Ministry by calculating the ratio total R&D expenditure in a sector to the number of patents in the same sector. The cost of innovation was estimated in this way for some 200 sectors from 1999 to 2002. The observed sizes are consistent with some of the empirical studies: the sectors where patents are valued at less than 2,000 euros include publishing, leather and wood. The sectors where innovation is costliest include transport, pharmaceuticals, software, etc.*

*Then the flow of innovation, n, for each firm is defined by the ratio of the firm's R&D expenditure to the cost of innovation in its sector, using the observed expenditure from the FIBEN database. All of the firms under consideration had invested in R&D on at least one occasion over the period.*

*In order to validate the existence of an inverted-U relationship, the following quadratic equation is estimated:*

$$n_j = \lambda^2 (- \alpha_1 + \alpha_2 x \ln (\text{cost of innovation})) + \lambda (\beta_1 - \beta_2 x \ln (\text{cost of innovation})) + c_j + years + \varepsilon,$$

*where $\lambda$ is a measurement of the degree of competition (Lerner index).*

*All of the parameters $\alpha_1$ and $\beta_1$ could be expected to be positive, according to the theoretical predictions. With the introduction of the parameters $\alpha_2$ and $\beta_2$, the relationship between innovation and the Lerner index (competition) is inverted. If $\alpha$ and $\beta$ are positive and significant, then the curve grows flatter as the cost of innovation increases. These intuitions are borne out by the results shown in Table 1.*

In the few sectors where the relative cost of innovation is low, the maximum of the inverted-U curve is obtained for a competition index value that is higher than that for some 75% of the sample.

In other words, if we restrict our analysis to sectors where the inverted-U curve is validated empirically, the firms in these sectors seem to be neck-and-neck in terms of technology levels and, therefore, competition would have a positive effect on innovation for these types of firms.

**Table 1 Cost of innovation and size of the inverted-U relationship**

| Dependent variable: potential innovation flow | | |
|---|---|---|
| | (a) | (b) |
| $\alpha_1$ | 0.0020*** (4.02) | 0.0004** (2.51) |
| $\alpha_2$ | 0.0003*** (4.02) | 0.0001*** (2.83) |
| $\beta_1$ | 0.0021*** (4.79) | 0.0008*** (3.70) |
| $\beta_2$ | 0.0003** (5.47) | 0.0002*** (5.84) |
| Years | yes | yes |
| Fixed firm effect | yes | yes |
| Number of observations | 100,089 | 100,043 |
| Number of firms | 15,592 | 15,586 |
| $R^2$ | 0.73 | 0.73 |

*(a) Absolute cost of innovation.*
*(b) Relative cost (to value added) of innovation.*
*** Significant at 5%.*
**** Significant at 1%.*
*Sources: Banque de France (FIBEN) and Askenazy, Cahn and Irac (2007).*

## 2| Credit constraints and fluctuations in R&D investment

A second study using the same data from the FIBEN and Central Balance Sheet Data Office databases shed further light on the determinants of R&D investment levels in innovative firms. Berman *et alii* (2007) investigated the effects of credit constraints on the cyclicality of investment structure.

The "Schumpeterian" view of business cycles and growth leads to the assumption that recessions provide the productive apparatus with opportunities to improve performances by correcting organisational inefficiencies and encouraging firms to reorganise, innovate or penetrate new markets, while eliminating those that are unable to do so.

This view implicitly assumes that firms are able to raise enough money to change their activities. In the absence of credit constraints, their investment choices would be dictated by the opportunity-cost effects of long-term investments over short-term investments, since the former are weaker during recessions than during recoveries. Consequently, long-term investment as a share of total investment should be contracyclical, in contrast to short-term investment, which would be procyclical.

**Table 2 Credit constraints and the cyclicality of R&D investment**

| Dependent variable: ratio of R&D investment to total investment (decomposition by sector) | | |
|---|---|---|
| | (a) | (b) |
| $^{H}\Delta CA_t$ | -0.019*** (0.004) | -0.018*** (0.004) |
| $^{L}\Delta CA_t$ | -0.013** (0.006) | -0.016*** (0.006) |
| $^{H}\Delta CA_{t-1}$ | -0.013*** (0.004) | – |
| $^{L}\Delta CA_{t-1}$ | -0.013*** (0.006) | – |
| $IP_{t-1}$ | – | 0.003 (0.002) |
| $^{H}\Delta CA_t * IP_{t-1}$ | – | 0.007 (0.015) |
| $^{H}\Delta CA_t * IP_{t-1}$ | – | 0.056*** (0.017) |
| Number of observations | 73.237 | |
| Number of groups | 12.966 | |
| $R^2$ | 0.01 | |
| Estimation | Within | |

*(a) With lagged terms.*
*(b) With cross terms.*
*** Significant at 5%.*
**** Significant at 1%.*
*The figures in brackets denote robust standard deviations.*
*Note:* ΔCA *denotes the variation in the revenue of firms above the third quartile* $^{H}$ *or the first quartile* $^{L}$.
IP *denotes the payment incidents variable.*
*Sources: Banque de France (FIBEN) and Berman* et alii *(2007).*

Nonetheless, this mechanism is compromised when we introduce credit constraints that could restrict firms' capacity for innovation and reorganisation during recessions (Aghion *et alii*, 2005a). Suppose, for example, that a firm can choose between short-term and long-term R&D investment, and that the latter investment requires the firm to be able to cope with short-term liquidity shocks, while relying on its income and its short-term borrowing to cover liquidity costs. This means that, when a firm needs to cope with a negative (idiosyncratic or aggregate) shock, its current income is reduced and so, consequently, is its ability to finance innovation through borrowing. This implies that the effects of a negative shock on R&D investment are greater if the firm has credit constraints. In other words, R&D investment is expected to be more procyclical in firms with tighter credit constraints.

The authors of this study have combined accounting data with information about bill payment incidents. Bill payment incidents are a sign of problems meeting supplier credit payments and such incidents occur when the firm's ability to meet its commitments is severely compromised. The authors use this information as an evaluation variable for credit constraints.

Once again, the database obtained is made up primarily of SMEs (median size: about 100 employees).

Using the panel data at the firm level, the authors looked for an econometric relationship between the R&D investment as a share of total investment, revenue and credit constraints. The findings presented in Table 2 show that:

- R&D investment as a share of total investment is contracyclical, but it becomes more procyclical when the firm is coping with tighter credit constraints.
- The latter effect is seen only in the trough of the cycle.
- On the whole, the mean level of R&D investment is lower for constrained firms.

This means that credit constraints may slow down mean productivity growth by preventing R&D investment as a share of total investment from being contracyclical.

## 3| Economic policy implications

The findings of these two studies suggest some avenues for developing policies to stimulate or promote innovation by SMEs.

The theoretical predictions and empirical demonstrations in the first study highlight the heterogeneous impact of competition levels on the R&D effect, particularly in SMEs. This means that thought should be given to differentiating competition policy by sector. On the one hand, the inverted-U relationship suggests that competition measures should be adapted to the status of a given sector (Aghion *et alii*, 2005b). On the other hand, it would be appropriate to differentiate measures according to the nature of innovations in a given industry. If the cost of innovation is high, changes in the competitive environment would have to be very substantial to lead to any significant changes in firms' innovation behaviour. Ultimately, the relationship between competition and innovation is so flat in such sectors that measures to stimulate innovation by promoting competition would be largely ineffective.

However, this analysis needs further refinement in many areas, particularly with regard to the endogenous nature, from a theoretical viewpoint, of innovation levels or firm sizes.

The other study shows the non-neutrality of credit constraints on SMEs for their R&D investment. The study measures such constraints by bill payment incidents, which identify firms with severe liquidity problems and a high risk of business failure. This finding leads to consideration of policies to provide support for financially fragile SMEs that are safe enough from bankruptcy, yet face particularly severe credit constraints during the turnaround in the business cycle. Such policies would enable these firms to maintain their innovation efforts. These policies could include, for example, modulation of the research tax credit, instead of an acyclical across-the-board increase in the credit.

*Firms' innovation efforts could be improved by policies aimed at competition on the product market. Yet, such policies should be differentiated by sector, depending on whether the firms in each sector are at the same distance from the technology frontier or whether productivity levels are differentiated. Furthermore, the limitations of such measures lie in their lack of effectiveness in sectors where the scale or cost of innovation is large compared to firm size, as is generally the case for SMEs.*

*In addition, firms may be coping with credit constraints that accentuate the procyclical pattern of such firms' innovation activities during downturns in the business cycle. This leads to lower mean productivity growth. Special support for SMEs during such downturns could be helpful for maintaining their innovation efforts.*

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