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Are R&D investments by incumbents decreasing in the availability of complementary assets for start-ups?

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Are R&D investments by incumbents decreasing in the availability of complementary assets for start-ups?

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Abstract

This paper investigates, both theoretically and empirically, the implications that complementary assets needed for the formation of start-ups – proxied by the ease of access to financial resources – have on the innovative efforts of incumbent firms. In particular, we develop a theoretical model, highlighting a strategic incentive effect by which the innovative efforts of incumbent firms are decreasing in the availability of the complementary assets needed for the creation of a start-up. The empirical relevance of this effect is investigated by using firm level data drawn from the third Italian Community Innovation Survey covering the period 1998-2000. The results of our empirical analysis support our theory-based insights.

Keywords: R&D, Innovation, Start-up, Complementary Assets
JEL classification: O31, L26

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1 Introduction

It is often argued that the knowledge embodied in firms' employees is an important vehicle for the diffusion of technology. Indeed, there is broad empirical evidence showing that technological change in many industries is fostered by the entry of start-ups created by former employees of incumbent firms (see, e.g., Klepper and Sleeper, 2005, and Klepper, 2010). In this context, to the extent that the knowledge of 'key' employees can not be fully appropriated by an incumbent (for instance, because it is to some extent tacit knowledge), the threat of creating a new firm may distort incumbents' incentives to invest in innovative activities. Tacit knowledge plays a crucial role in several R&D oriented industries. For instance, the importance of tacit knowledge has been highlighted, among others, by Collins (1974) for the development of TEA lasers, by Zucker et Al. (1998) for the commercialization of biotechnologies, and by Fallick et Al. (2006) for the computer industry. For a more general analysis of the nature and implications of tacit knowledge in different industries, see e.g. Howells (1996) and Cowan et Al. (2000)[1]. The effects of employee mobility on firms' innovative efforts has been investigated in the literature. In particular, Franco and Filson (2006) develop a dynamic industry model with endogenous R&D effort in which spin-out firms can be started by former employees of incumbents. Using data from the disk drive industry, they also show that taking this channel into account helps explaining the pattern of start-ups formation and firms survival. Similarly, the theoretical work by Gersbach and Schmutzler (2003a,b) points to the importance of worker mobility for firms' incentives to invest in R&D. Indeed, they show that R&D incentives under price competition are larger than under quantity competition in the presence of endogenous spillovers stemming from worker mobility, while the converse is true when worker mobility is neglected. As in our model, in these papers the innovation effort of firms is endogenous. However, our main focus is on the effects of the availability of complementary assets for incumbents' R&D investment, an issue that has not been considered by this literature.

Starting with Teece (1986), a number of authors have pointed out the importance of different types of complementary assets for the creation of new firms[2]. Numerous examples of complementary assets, which are critical for the successful commercialization of new technologies, have been given in the literature. These include expertise and

[1] In a theoretical perspective, Spulber (2012) investigates the role of tacit knowledge in the trade-off between entrepreneurship and technological transfer.

[2] A different stream of literature studies the potential creation of start-ups by focusing on ex-ante and ex-post contracting between an incumbent firm and a key employee in the presence of weak (or absent) property rights (see, among others, Anton and Yao, 1994, 1995, and Anand and Galetovic, 2000).

infrastructure for product development, manufacturing, legal, sales, distribution and customer service activities, as well as access to capital markets (see, e.g. Rothaermel and Hill, 2005, Park and Steensma, 2012). An example of complementary asset that has received most attention in the literature is the availability of financial resources and especially venture capital. For instance, the country reports of the European Innovation Scoreboard, published annually by the European Commission, regard early stage venture financing as one of the key indicators of the innovation potential of a region. These reports also show that the availability of such assets differs substantially between regions and present the reduction of barriers for accessing them as an objective of innovation policies. The effect that a reduction in the barriers to start-up formation might have on the R&D investments of incumbent firms is however hardly understood and typically not considered in this discussion.

In this paper, we investigate the effects of complementary assets needed for the formation of start-ups on the innovative efforts of incumbent firms. In our model an incumbent invests in R&D generating new knowledge that is – at least partly – embodied in a key employee, who can possibly exploit it to create a new firm (a start-up). If the employee leaves the incumbent to create a start-up, the incumbent suffers a loss because it cannot fully appropriate the returns from its R&D efforts, as it looses the share of knowledge remaining with the employee. Eventually, the creation of a start-up is conditional on the availability of complementary assets and on the market demand the new start-up expects to face. The size of this demand is unknown when the firm decides about its R&D investment, where an increase in investment shifts the distribution of demand realizations upwards. The employee exits the firm and generates a start-up if her expected profit, which takes into account the costs of accessing the necessary complementary assets, exceeds her current income in the incumbent firm. When the needed complementary assets are easily available in the market, the value of the employee's outside option is large, which results in an increase in the ex-ante probability that a start-up is formed. Therefore, the incumbent's incentives to invest in R&D are reduced.

Our explanation of incumbents' innovative efforts as a function of the availability of complementary assets required for start-up formation builds essentially on a strategic argument: the more easily available complementary assets are, the higher the value of key employees' outside option is and the lower the incentives of incumbents to invest in R&D are. Quite obviously, however, a number of other factors may be at work, possibly entirely offsetting the negative strategic effect outlined above. For instance, in a static perspective, non-compete clauses (or other covenants allowing the key employee to credibly commit ex ante not to leave the firm), as well as the design of schemes protecting intellectually property deriving from innovative activities, may be effective in allowing the incumbent to fully appropriate the benefits of its innovative efforts. However, clauses of this type are likely to be ineffective in several cases: indeed, there is a large literature stating that non-compete covenants are not always enforceable (see, e.g., Fallick et Al., 2006), and property rights over R&D knowledge are often weak or absent (see, e.g., Anton and Yao, 1994, 1995). This is especially true when the knowledge acquired by key employees is to a large extent tacit, which is often the case in highly innovative sectors as already noted above.

Perhaps more important, in a dynamic perspective, start-up formation contributes to the creation of local clusters of firms, and there is robust evidence that the generation of knowledge in a cluster has positive knowledge externalities for the other firms in the cluster. Hence, the incumbent may benefit from the existence of a local cluster originated by the creation of start-ups (see, e.g., Colombo et Al., 2012 for an analysis taking into account these effects). Jaffe et Al. (1993) and Audretsch and Feldman (1996), among others, show that technological spillovers across firms are likely to emerge when firms are geographically concentrated. Although we emphasize the role of knowledge externalities, it is well known that several other types of (positive and negative) externalities are relevant in clusters; see, e.g., Hanson (2001).

All these factors – that are likely to have a bite in practice – are neglected by our model, which focuses entirely on the incentive effects stemming from the impact of the incumbent's decisions on the key employee's outside options. One may therefore question whether our arguments are of large practical relevance, or whether the trade-off between the negative incentive effect we highlight and the direct effects of start-up formation (favoring the emergence of industrial clusters, and generating positive externalities through local technological spillovers) should be resolved unambiguously in favor of the latter.

The second part of this paper addresses exactly this issue. After introducing in Section 2 a very stylized and simple theoretical setup illustrating our argument, we bring the model to the data (in Section 3), to check whether the negative strategic relationship between the innovative efforts of established firms and the availability of complementary assets is of any empirical relevance. In particular, we investigate whether – *ceteris paribus* – there exists an inverse relationship between the availability of complementary assets (proxied in our analysis by the availability or lack of financial resources experienced by new entrants) and the R&D expenditures by incumbents[3].

[3] As discussed above, the availability of the financial resources needed to start and develop a new company (be it in the form of bank loans, private equity, or venture capital) is a key factor in all industries to gain access to the complementary assets that are needed for start-up formation. Hence,

The results of our empirical analysis (in Section 4) strongly support our theoretical claim that the R&D intensity of incumbents is – *ceteris paribus* – negatively correlated with the availability of complementary assets.

2 The model

In what follows we develop a simple model of the interaction between an incumbent firm investing in R&D and one of its key employees, who has the option the leave the firm and use the knowledge acquired when working for the incumbent to form a start-up. In order to create the new firm the employee needs access to complementary assets, that are obtained by matching with a third party.

The following timing of events is considered.

1. The incumbent invests in order to generate the knowledge stock K.
2. The key employee determines her search effort for finding a complementary assets provider.
3. In case there is a successful match with a provider of complementary assets, the start-up forms and only a fraction of the knowledge stock remains within the incumbent firm.
4. The incumbent and the start-up (if it has been founded) realize their profits.

Our main goal is to establish the impact of the frictions in the search for complementary assets on the incumbent's incentives to invest in R&D.

To be more precise, we consider an incumbent firm acting as a monopolist for its product and facing an inverse demand curve $p^F(q, K)$, where q denotes output quantity and K is the knowledge stock of the firm determining the quality of the product. We make the following (standard) assumptions concerning p:

$$\frac{\partial p^F}{\partial q} < 0, \quad \frac{\partial p^F}{\partial K} > 0, \quad \frac{\partial^2 p^F}{\partial q \partial K} \geq 0, \quad \frac{\partial^2 p^F}{\partial K^2} < 0. \tag{1}$$

Furthermore, we assume that for any given quantity q the price $p^F(q, K)$ exhibits constant elasticity with respect to K. Marginal costs of production are normalized to zero. The profit of the firm when it produces the optimal quantity is denoted by $\pi^F(K)$. In order to build the knowledge stock K, the firm has to make the investment $I(K)$ in

we use this indicator as a proxy for the easiness of accessing complementary assets and founding a start-up.

R&D, with $\frac{\partial I}{\partial K} > 0$ and $\frac{\partial^2 I}{\partial K^2} > 0$ for $K \geq 0$. The knowledge stock is embodied in a key R&D employee of the firm, and it is assumed to be, at least partly, tacit. In case the employee leaves the firm to form a start-up, only a fraction $\delta^F K$, with $0 \leq \delta^F < 1$, of the generated knowledge is retained by the firm.

However, it is assumed that the effect of the entry of the start-up firm on the demand for the product of the incumbent is negligible[4], and therefore the profit of the incumbent firm after the formation of the start-up is given by $\pi^F(\delta^F K)$.

Upon leaving the firm, the R&D employee might use her knowledge stock to found a start-up company. The employee is not necessarily able to use the full knowledge acquired while working for the incumbent, due for instance to intellectual property right issues, or non-compete clauses. We denote the knowledge stock the employee can use in the start-up by $\delta^S K$, with $0 < \delta^S \leq 1$. The inverse demand function expected by the start-up is given by $p^S(q, \delta^S K)$, which satisfies the same assumptions as p^F. The corresponding expected profit of the start-up is denoted as $\pi^S(\delta^S K)$, which takes into account the costs borne to found the start-up, including the opportunity costs of the employee's wage income at her former employer[5]. The assumptions on the expected inverse demand imply that $\frac{\partial \pi^S}{\partial K} > 0$. Furthermore, we define $\bar{K} \geq 0$ as the lowest knowledge stock such that the expected start-up profit is non-negative (i.e. $\pi^S(\delta^S K) > 0,\ \forall K > \bar{K}$).

In order to form a start-up, complementary assets are needed, which are provided by a third party. The probability that the employee matches with an appropriate complementary assets provider is given by the linear matching technology $m(e) = \min(\gamma e, 1)$, where e denotes the employee's search effort and $\gamma > 0$ is a proxy of the availability of complementary assets in the considered industry. In what follows we assume that the parameter γ is sufficiently small such that $\gamma e < 1$ under the optimal level of effort of the employee.

Once a match is realized and the employee obtains access to the complementary assets, the start-up is founded. In this case a fraction $\kappa \in (0, 1)$ of the profit generated

[4] Case studies in the literature suggest that start-ups might directly compete with parent companies (see e.g. Klepper and Sleeper (2005)) or provide products and services that are complementary to those of their parent company (see e.g. Chesbrough and Rosenbloom (2002)). In such cases the profit function of the incumbent is directly affected by start-up creation. Colombo and Dawid (2013) consider an instance of such a setup in which the incumbent and the start-up compete in a common market. The analysis carried out in that paper shows that the main qualitative insights obtained under the simplifying assumption made here extend to such a setting with more involved strategic interaction.

[5] In general the start-up faces uncertainty in assessing market demand, but the relevant factor for her decision to form a new firm is her ex-ante expectation. In what follows we assume that the R&D employee and the incumbent firm share the same expectation about the profitability of the start-up.

by the start-up accrues to the provider of the needed complementary assets. The employee faces quadratic costs of the form $C(e) = e^2/2$ when searching for complementary asset providers[6]. Therefore, she faces the problem

$$\max_e \gamma e(1-\kappa)\pi^S(\delta^S K) - \frac{e^2}{2},$$

leading to the optimal effort $e^* = \gamma(1-\kappa)\pi^S(\delta^S K)$. Hence, the probability that a start-up is formed is given by

$$v(K;\gamma) = \gamma e^* = \gamma^2(1-\kappa)\pi^S(\delta^S K). \tag{2}$$

The incumbent chooses its R&D investment in order to maximize its expected payoff taking into account the possibility for the employee to leave the firm and form a start-up. Formally, the problem of the incumbent can be written as

$$\max_{K\geq 0} J^F(K;\gamma) := \left[\pi^F(K)(1-v(K;\gamma)) + \pi^F\left(\delta^F K\right) v(K;\gamma) - I(K)\right]. \tag{3}$$

In order to guarantee the concavity of the objective function in (3), we assume that the following inequality holds for all $K \geq 0$

$$\begin{aligned}\frac{\partial^2 I(K)}{\partial K^2} \quad > \quad & \frac{\partial^2 \pi^F(K)}{\partial K^2}(1-v(K;\gamma)) - 2\frac{\partial \pi^F(K)}{\partial K}\frac{\partial v(K;\gamma)}{K} + \\ & + \left(\delta^F\right)^2 \frac{\partial^2 \pi^F\left(\delta^F K\right)}{\partial\left(\delta^F K\right)^2} v(K;\gamma) + 2\delta^F \frac{\partial \pi^F\left(\delta^F K\right)}{\partial\left(\delta^F K\right)}\frac{\partial v(K;\gamma)}{\partial K}.\end{aligned} \tag{4}$$

This condition requires that the marginal costs of producing knowledge grow sufficiently fast with K to dominate any non-concavity of the expected market profit of the incumbent with respect to changes in the knowledge stock. It is also convenient to define with $\epsilon(K) = \frac{K\pi^{F\prime}(K)}{\pi^F(K)}$ the elasticity of π^F with respect to K. The dependence of this elasticity from the knowledge stock is characterized in the following Lemma.

Lemma 1 *Under the assumptions in (1) the elasticity $\epsilon(K)$ is increasing with respect to K.*

Proof. Taking into account that the firm is choosing the profit maximizing monopoly quantity $q^m(K)$ for each K, it follows from the envelope theorem that

$$\pi^{F\prime}(K) = \frac{\partial p^F(q^m(K),K)}{\partial K} q^m(K).$$

Hence,

$$\epsilon(K) = \frac{1}{p^F(q^m(K),K)} K \frac{\partial p^F(q^m(K),K)}{\partial K}.$$

[6] Properly defining the units in which effort is measured gives rise to the coefficient $1/2$ of e^2.

Taking the derivative with respect to K we obtain

$$\begin{aligned}
\epsilon'(K) &= \frac{1}{p^F(q^m(K),K)^2}\left[\left[\left(\frac{\partial^2 p^F}{\partial K^2}+\frac{\partial^2 p^F}{\partial K \partial q}\frac{\partial q^m(K)}{\partial K}\right)K+\frac{\partial p^F}{\partial K}\right]p^F+\right.\\
&- \left. K\frac{\partial p^F}{\partial K}\left(\frac{\partial p^F}{\partial K}+\frac{\partial p^F}{\partial q}\frac{\partial q^m(K)}{\partial K}\right)\right]\\
&= \frac{1}{p^F(q^m(K),K)^2}\underbrace{\left[\left(K\frac{\partial^2 p^F}{\partial K^2}+\frac{\partial p^F}{\partial K}\right)p^F-K\left(\frac{\partial p^F}{\partial K}\right)^2\right]}_{=0 \text{ (due to constant elasticity of } p)}+\\
&+ \frac{1}{p^F(q^m(K),K)^2}\left[\frac{\partial^2 p^F}{\partial K \partial q}p^F-\frac{\partial p^F}{\partial K}\frac{\partial p^F}{\partial q}\right]K\frac{\partial q^m(K)}{\partial K}\\
&> 0
\end{aligned}$$

The last inequality follows from assumptions (1) and the observation that $\frac{\partial q^m(K)}{\partial K}>0$, which is implied by the assumption of constant elasticity of p^F with respect to K. ∎

The optimal solution of the maximization problem (3) is denoted by $K^*(\gamma)$. To rule out the uninteresting case in which the employee's search effort is zero under the optimal investment of the incumbent for all $\gamma \geq 0$ we assume that $K^*(0) > \bar{K}$. The following Proposition shows our main result. Whenever there is a threat of start-up formation under optimal R&D investment of the incumbent, this investment decreases as complementary assets become more easily accessible. We define $\bar{\gamma} = \sup\{\gamma \geq 0 | K^*(\gamma) > \bar{K}\}$ as the largest level of complementary assets availability such that the employee can profitably form a start-up if the incumbent firm invests optimally.

Proposition 1 *Assume that (4) holds. Then, $K^*(\gamma)$ is decreasing in γ for all $\gamma \in [0,\bar{\gamma})$. For $\gamma \geq \bar{\gamma}$ the optimal R&D investment is given by $K^*(\gamma) = \bar{K}$.*

Proof. Consider first the case $\gamma \in [0,\bar{\gamma})$. Due to the global concavity of (3) for all γ such that $K^*(\gamma) > \bar{K} \geq 0$, the optimal solution of the profit maximization problem is determined by the first order condition

$$\begin{aligned}
\frac{\partial J^F(K^*;\gamma)}{\partial K} =& \frac{\partial \pi^F(K)}{\partial K}(1-v(K;\gamma))-\pi^F(K)\frac{\partial v(K;\gamma)}{\partial K}+\delta^F\frac{\partial \pi^F\left(\delta^F K\right)}{\partial\left(\delta^F K\right)}v(K;\gamma)+\\
&+\pi^F\left(\delta^F K\right)\frac{\partial v(K;\gamma)}{\partial K}-\frac{\partial I(K)}{\partial K}\\
=&0. \qquad (5)
\end{aligned}$$

Implicit differentiation of this condition with respect to γ yields

$$\frac{\partial K^*}{\partial \gamma} = -\frac{\frac{\partial^2 J^F(K^*;\gamma)}{\partial K \partial \gamma}}{\frac{\partial^2 J^F(K^*;\gamma)}{\partial K^2}}.$$

Due to (4) we have $\frac{\partial^2 J^F(K^*;\gamma)}{\partial K^2} < 0$ such that the sign of $\frac{\partial K^*}{\partial \gamma}$ is equal to that of $\frac{\partial^2 J^F(K^*;\gamma)}{\partial K \partial \gamma}$. Considering this expression, we get

$$\begin{aligned}\frac{\partial^2 J^F(K^*;\gamma)}{\partial K \partial \gamma} = \frac{\partial v(K^*;\gamma)}{\partial \gamma}\left(\delta^F \frac{\partial \pi^F\left(\delta^F K^*\right)}{\partial\left(\delta^F K\right)} - \frac{\partial \pi^F(K^*)}{\partial K}\right) + \\ + \frac{\partial^2 v(K^*;\gamma)}{\partial \gamma \partial K}\left(\pi^F\left(\delta^F K^*\right) - \pi^F(K^*)\right).\end{aligned}$$

Taking into account (2) we immediately obtain for all K

$$\begin{aligned}\frac{\partial v(K;\gamma)}{\partial \gamma} &= 2\gamma \pi^S\left(\delta^S K\right) > 0 \\ \frac{\partial^2 v(K;\gamma)}{\partial \gamma \partial K} &= 2\gamma \delta^S \frac{\partial \pi^S\left(\delta^S K\right)}{\partial\left(\delta^S K\right)} > 0.\end{aligned}$$

Moreover, using Lemma 1, we conclude that

$$\begin{aligned}&\left(\delta^F \frac{\partial \pi^F\left(\delta^F K^*\right)}{\partial\left(\delta^F K\right)} - \frac{\partial \pi^F(K^*)}{\partial K}\right) \\ &= \frac{\pi^F(K^*)}{K^*}\left(\frac{\partial \pi^F\left(\delta^F K^*\right)}{\partial\left(\delta^F K\right)}\frac{\delta^F K^*}{\pi^F(K^*)} - \frac{\partial \pi^F(K^*)}{\partial K}\frac{K^*}{\pi^F(K^*)}\right) \\ &= \frac{\pi^F(K^*)}{K^*}\left(\frac{\pi^F\left(\delta^F K^*\right)}{\pi^F(K^*)}\epsilon\left(\delta^F K^*\right) - \epsilon(K^*)\right) \\ &< \frac{\pi^F(K^*)}{K^*}\left(\epsilon\left(\delta^F K^*\right) - \epsilon(K^*)\right) \\ &< 0,\end{aligned}$$

where the inequalities in the last two lines follow from the monotonicity of $\pi^F(K)$ and $\epsilon(K)$ with respect to K.

Therefore, we have

$$\begin{aligned}\frac{\partial^2 J^F(K^*;\gamma)}{\partial K \partial \gamma} = \underbrace{\frac{\partial v(K^*;\gamma)}{\partial \gamma}}_{>0}\underbrace{\left(\delta^F \frac{\partial \pi^F\left(\delta^F K^*\right)}{\partial\left(\delta^F K\right)} - \frac{\partial \pi^F(K^*)}{\partial K}\right)}_{<0} + \\ + \underbrace{\frac{\partial^2 v(K^*;\gamma)}{\partial \gamma \partial K}}_{>0}\underbrace{\left(\pi^F\left(\delta^F K^*\right) - \pi^F(K^*)\right)}_{<0} \\ < 0.\end{aligned}$$

This shows that $K^*(\gamma)$ decreases in γ for all $\gamma \in [0, \bar{\gamma})$.

Focus now on $\gamma > \bar{\gamma}$. In such a case, the first order condition (5) yields an investment level $\tilde{K} < \bar{K}$. However, for this investment level, $\pi^S(\delta^S \tilde{K}) < 0$, which implies that the search effort of the employee is zero. Taking into account that $e^* = 0$, the actual first order condition for the incumbent becomes

$$\frac{\partial \pi^F(K)}{\partial K} - \frac{\partial I(K)}{\partial K} = 0,$$

which corresponds to (5) for $\gamma = 0$. Hence, under the assumption that no start-up forms the incumbent's optimal investment level would be $K^*(0) > \bar{K}$. It follows that the incumbent's profit is an increasing function of K for $K < \bar{K}$. Putting this together with the observation that the incumbent's profit is decreasing in K for $K > \bar{K}$, we obtain that $K^*(\gamma) = \bar{K}$ for $\gamma \geq \bar{\gamma}$. This completes the proof. ■

To gain an economic intuition for this result in the interesting case in which the optimal investment level of the incumbent induces a positive probability of start-up formation (i.e. $\gamma < \bar{\gamma}$), it should be realized that the sign of the relationship between K^* and γ depends on the sign of the cross derivative of the incumbent's objective function with respect to K^* and γ. The observation that K^* is decreasing in γ is equivalent to the statement that the marginal increase of the objective function given in (3) becomes smaller as γ is increased. An increase of γ has two effects on the derivative of J^F with respect to K. First, increasing γ increases the probability $v(K;\gamma)$ that a start-up is formed and, since the marginal return from additional R&D investment for the incumbent is smaller if a start-up is formed compared to the case in which the employee stays in the firm, this effect reduces $\frac{\partial J^F}{\partial K}$. The second effect is less straightforward. Increasing γ affects also the size of the marginal effect of K on the probability of start-up formation. Increasing K makes the probability of start-up formation higher and this reduces the incentive of the incumbent to invest in K. If this disincentive were to be reduced by increasing γ then this second effect would contribute to a positive relationship between K^* and γ and, if dominant, it could imply that $K^*(\gamma)$ is an increasing function. However, Proposition 1 shows that under our assumptions both effects work in the same direction such that the incumbent's incentives to invest in R&D decrease if the availability of complementary assets increases.

3 Data and key variables

In order to empirically test the relevance of the result in Proposition 1, we use firm-level microdata drawn from the third Italian Community Innovation Survey (CIS), conducted over a three-year period (1998-2000) by the Italian National Institute of Statistics (ISTAT)[7]. This survey is representative of the entire population of Italian

[7] CIS surveys are currently systematically collected every three-years in most European countries (as well as in extra-European countries, such as Korea). Presidents of the companies' boards and CEOs

firms with more than 10 employees, at the sectoral, regional and the firm-size level. In more detail, the CIS 3 dataset adopts a weighting procedure that relates the sample of firms interviewed to the entire population (ISTAT, 2004)[8]. The dataset comprises a set of general information (industry of affiliation, group belonging, turnover, employment, exports) and a set of innovation variables measuring firms' innovativeness, subjective evaluations of factors hampering or fostering innovation, participation in cooperative innovation activities and access to public funding. The response rate was 53%, determining a full sample size of 15,512 firms, both in manufacturing and service sectors.

As far as the focus of our paper is on innovative companies, we only keep firms declaring Research and Development expenditures (R&D) greater than zero (2,308 companies). Furthermore, in order to identify incumbent and start-up firms in each industry, we use the 1994 year of foundation to discriminate between the two sub-groups (incumbent are identified as founded before 1994, young start-up companies as created in 1994 or afterwards)[9]. This step – due to missing values in the year of foundation – slightly reduces the number of available observations to 2,124. Finally, as we assume that spin-offs are specific to a given industry and affected by sectoral complementary assets (see previous section), we use a rather detailed sectoral criterion in assigning firms to a given industry by adopting a three-digit industrial classification[10]. To have

are recipients of the questionnaires and in charge of filling them in. Surveys run in different periods slightly differ in the design of the questionnaire and/or in the disclosure policy of some of the variables. For our purposes, the CIS 3 survey is the more complete among the ones currently available. It is important to note that the different CIS surveys are conducted independently, with the only aim to be representative, with no attention to the longitudinal dimension of the data. Therefore, each survey is largely composed by different firms and no panel data are currently available.

[8] Firm selection is carried out through a 'one step stratified sample design'. The stratification of the sample is based on the following three variables: firm-size, sector, regional location. Technically, in the generic stratum h, the random selection of n_h sample observations among the N_h belonging to the entire population is realized through the following procedure: (i) a random number in the 0-1 interval is attributed to each N_h population unit; (ii) N_h population units are sorted by increasing values of the random number; (iii) units in the first n_h positions in the order previously mentioned are selected. Estimates obtained from the selected sample are very close to the actual values in the national population. The weighting procedure follows the Eurostat and Oslo Manual (OECD, 1997) recommendations: weights indicate the inverse of the probability that the observation is sampled. Therefore, sampling weights ensure that each group of firms is properly represented and correct for sample selection. Moreover, they help reducing the heteroskedasticity commonly arising when the analysis focuses on survey data.

[9] As far as the age of the firms in the 'start-up' sub-sample is concerned, the 5 years threshold is chosen to solve the trade-off between a lower age and the representativeness of the sub-sample of young companies. With our selection procedure we end up with about 22% of the entire sample as start-ups.

[10] We use NACE rev.1.1 industrial classification and consider industrial three-digit disaggregation.

a representative number of start-ups in each three-digit industrial sector, we exclude observations/industries with less than three start-ups. We end up with a sample of 1,721 innovate firms, of which 1,337 are incumbent and 384 young start-ups[11].

In order to empirically test the result of Proposition 1, we use the incumbent sub-sample as the R&D investors we are interested in, while the start-up sub-sample is used to get the information concerning the perception of the role of industrial complementary assets in affecting new firm formation based on innovation. Therefore, in the following econometric analysis, on the one hand we consider as dependent variable the R&D investments by the incumbent firms, normalized by sales in order to control for the scale effect due to the different size of the investigated firms[12]. On the other hand, our main impact variable (the regressor representing the role of complementary assets in affecting the possible decision by an R&D employee to use her knowledge to spin-off) is measured by the perception of young start-ups of the lack of financial sources as an obstacle to innovation (see Mancusi and Vezzulli, 2014). More in detail, this variable has been constructed on the basis of the question 12.3 of the Italian CIS 3 questionnaire, asking: "how important was the availability of finance as a constraint on innovation activities in influencing a decision not to innovate?" (rated on a Likert scale from 1 to 4; 1 = high, 4 = irrelevant/ not experienced)[13].

According to our model, if the availability of financial resources is not an obstacle for potential start-ups, R&D employees easily spin-off from incumbent firms and incumbents – backwards – are not keen on investing in R&D. Therefore, we expect a negative coefficient linking the availability of "complementary assets" (higher score of our impact variable) with incumbents' R&D investment.

Represented industries are reported in the Appendix, Table A1.

[11] While it has to be admitted that start-ups and spin-offs are not exactly overlapping, previous empirical literature shows that in between 70/80% of start-ups are actually spin-offs by former employees in the same sector (for instance, analyzing a sample of 720 Italian newborn firms in a period not so far from the one investigated in the present study - 1988 - Vivarelli, 1991, found that 68.8% of the interviewed entrepreneurs had come from the same sector; see also Storey, 1982 and 1994; Arrighetti and Vivarelli, 1999; Shane, 2000; Klepper, 2001; Helfat and Lieberman, 2002; Stam, 2007; Vivarelli, 2013), the residual being young people starting their first job experience, unemployed, serial entrepreneurs and founders coming from other sectors.

[12] No information about the knowledge stock is available in the CIS database. However, this is not a problem within our model setting, where the R&D investment (I) is assumed to be positively correlated with the knowledge stock (K). In fact, since $I^t(K) > 0$, to empirically show that incumbents' R&D investments and complementary assets (γ) are inversely correlated is equivalent to prove the obtained result that the incumbents' knowledge stock is decreasing with respect to γ.

[13] As discussed in the Introduction, a variety of complementary assets may be needed to create a start-up, widely differing across industrial sectors. However, the availability of financial resources is the key factor in gaining access to those assets in all industries.

CIS 3 provides further information on firms beyond their innovative activity. The following estimates adopt some of these indicators as further controls; in particular, we include five additional covariates in our specifications. The first accounts for a firm's access to policy support for innovation. A government subsidy or a fiscal incentive should increase a firm's innovative performance, although the empirical evidence on this is quite controversial, due to the possible insurgence of crowding out effects, displacing privately funded R&D investments (see Wallsten, 2000; Gonzáles et Al., 2005; Catozzella and Vivarelli, 2012). The second controls for firms participating in a cooperation agreement for innovation[14]. The third accounts for firms adopting organizational changes, which might create an encouraging environment in the company to make an innovation strategy more likely to be effective – especially in terms of the overall productivity performance of the company[15]. The fourth additional covariate accounts for firm's human capital – measured as the percentage of firm's employees with at least a university degree – in order to take into account the likely complementarity between innovation and skills, as shown by the extant literature (see Goldin and Katz, 1998; Machin and Van Reenen, 1998; Bresnahan et Al., 2002). The fifth control looks at a firm's export propensity. Global competition can spur innovation and capabilities, while technologically inactive firms are doomed to be excluded from the international arena (see Archibugi and Iammarino, 1999; Narula and Zanfei, 2003). Finally, our econometric specification includes the four Pavitt's sectoral dummies (Pavitt, 1984) plus a 'service-industries' dummy in order to control for the different sectoral technological opportunity and appropriability conditions (on the role of the so-called 'sectoral systems of innovation', see Malerba and Orsenigo, 1995; Breschi et Al., 2000).

Equation (6) describes the specification adopted for the empirical test.

$$\begin{aligned} log(R\&D/Sales)_i \;=\;& C + \beta_1 Complementary\ Assets_i + \beta_2 Support_i + \\ & + \beta_3 Cooperation_i + \beta_4 Organizational\ Change_i + \\ & + \beta_5 Human\ Capital + \beta_6 log(Export/Sales)_i + \\ & + \sum \gamma_k Pavitt_{ki} + \varepsilon_i, \end{aligned} \tag{6}$$

where C is the constant, i is the firm-index (incumbents), $log(R\&D/Sales)$ represents the innovative investments intensity, *Complementary Assets* is computed as the average evaluation of start-ups (in each three-digit industrial sector), *Support*,

[14] The important role of cooperation agreements in affecting the innovative output of firms is highlighted by Cassiman and Veugelers (2002), Piga and Vivarelli (2004), Fritsch and Franke (2004), and De Silva and McComb (2012).

[15] See Schmidt and Rammer (2007). On the complementarity between technological and organizational change, see Brynjolfsson and Hitt (2000), Bresnahan et Al. (2002), and Piva et Al. (2005).

Cooperation, *Organizational Change*, *Human Capital* and *log*(*Export*/*Sales*) (i.e., export intensity) are the control variables previously discussed, and Pavitt are the sectoral dummies (science-based, scale-intensive, specialized-suppliers, services, with the suppliers-dominated firms as the default category; $k = 4$). Note that, as it is common in the literature, continuous variables are log-transformed both to smooth heteroskedasticity problems and to mitigate the role of possible outliers.

4 The evidence

Table 1 describes the variables used in the empirical analysis and reports the corresponding descriptive statistics.

< Insert *Table 1: The variables – descriptive statistics* about here >

The correlation matrix for the entire sample is reported in Table 2. As can be seen, all the correlation coefficients are less than 0.42 showing that data are not affected by serious collinearity problems.

<Insert Table 2: *Correlation matrix about here*>

Table 3 reports the econometric results of the estimates run on the 1,337 incumbent firms. Diagnosis tests (F-test and R-squared) are satisfactory, taken into account the cross-sectional nature of the data. Moreover, the estimation has been controlled for both heteroskedasticity (using robust standard errors) and multicollinearity (VIF=1.49).

<Insert Table 3: *dependent variable: log(R&D/SALES); observations = 1,337* about here>

Looking at column (1) in Table (3), our results show a negative and significant impact of the availability of complementary assets (evaluated by start-ups) upon incumbents' R&D intensity. This lends considerable support to the theoretical claim of Proposition 1, which establishes that incumbents' R&D investment is expected to decrease as complementary assets become more easily available. Indeed, the correspondent coefficient shows the expected (negative) sign, a high level of significance (t-statistics equal to 2.32) and a considerable magnitude.

Turning our attention to the control variables, only the support for innovation and human capital turn out to be positively correlated with R&D intensity, while the other controls do not reveal any significant impact.

Finally, focusing on the sectoral dummies and taking into account that the less innovative supplier-dominated firms are the reference category, not surprisingly science-based firms, followed by service companies and specialized suppliers, turn out to be more R&D intensive (see the values and significance of the corresponding Pavitt's dummies).

Column (2) in Table 3 replicates the previous estimate dropping all the not significant variables (but the sectoral controls): as can be seen, the overall picture is fully confirmed, both in terms of coefficients' significance and magnitude.

Finally, Column (3) in Table 3 is the outcome of an important robustness check; in particular, our baseline specification has been extended to the inclusion of the perception - by the incumbent firm – of its own financial constraints to innovation. This additional regressor has been added in order to check both for its direct impact on incumbent firm's R&D investment and for a possible interaction effect with our main variable of interest (that – as a sole indicator of financial constraints – might spuriously capture the former effect or be affected by the latter one in a not predictable way). As can be seen – notwithstanding the expected negative and highly significant impact of the new variable – our main result remains virtually unchanged both in terms of its significance ($t-$statistics equal to 2.42) and magnitude.

5 Concluding remarks

Since innovation can be considered the main driver of economic growth, to investigate the factors that are fostering or hampering R&D investment is relevant. The theoretical model proposed in this paper claims that there is a strategic (negative) relationship between the availability of the complementary assets needed for the creation of a new firm and the innovative effort by incumbent firms. The evidence provided in the second part of the paper supports this theoretical prescription.

An important implication of our analysis is that the evaluation of policy measures aimed at reducing the barriers faced by potential start-up founders should not focus exclusively on the induced effects on the frequency of start-up formation and the subsequent success of these start-ups. Such an evaluation should also take into account the negative effects that these policies might have on the R&D intensity of incumbents. Our theoretical and empirical results suggest that such negative effects exist across different sectors and regions. How large and relevant they are for different specific sectors and regions is an empirical issue open for future research.

Although the empirical results of this paper are consistent with the proposed theoretical model, our analysis suffers from important limitations. First, both the theoretical model and the empirical specification focus exclusively on a strategic argument, while other factors may play a role, as discussed in Section 1. In this perspective, accounting for possible clustering and learning effects would be valuable extensions. Second, since complementary assets are specific to the single sectors, there is a need for a data collecting purposely addressed to catch and measure those assets, beyond the general availability of financial resources used in this paper. Third, the estimates in this study have a cross-sectional nature, while a dynamic specification would have allowed to properly compute the knowledge stock and to obtain more robust results. In this context, a need for longitudinal CIS data clearly emerges as a preliminary condition to extend the analysis through a dynamic test of the theoretical hypothesis proposed here.

References

Anand, B., Galetovic, A., 2000. Weak property rights and holdup in R&D. *Journal of Economics and Management Strategy* 9, 615-642.

Anton, J., Yao, D., 1994. Expropriations and inventions: appropriable rents in the absence of property rights. *American Economic Review* 84, 190-209.

Anton, J., Yao, D., 1995. Start-ups, spin-offs, and internal projects. *Journal of Law, Economics and Organization* 11, 362-378.

Archibugi, D., Iammarino, S., 1999. The policy implications of the globalisation of innovation. *Research Policy* 28, 317-336.

Arrighetti, A., Vivarelli, M., 1999. The role of innovation in the post-entry performance of new small firms: Evidence from Italy. *Southern Economic Journal* 65, 927-939.

Audretsch, D., Feldman, M., 1996. R&D spillovers and the geography of innovation and production. *American Economic Review* 86, 630-640.

Breschi, S., Malerba F., Orsenigo L., 2000. Technological regimes and Schumpeterian patterns of innovation. *Economic Journal* 110, 388-410.

Bresnahan, T.F., Brynjolfsson, E., Hitt, L.M., 2002. Information technology, workplace organization and the demand for skilled labor: firm-level evidence. *Quarterly Journal of Economics* 117, 339-376.

Brynjolfsson, E., Hitt, L.M., 2000. Beyond computation: information technology, organizational transformation and business performance. *Journal of Economic Per-*

spectives 14, 23-48.

Cassiman, B., Veugelers, R., 2002. R&D cooperation and spillovers: some empirical evidence from Belgium. *American Economic Review* 92, 1169-1184.

Catozzella, A., Vivarelli, M., 2012. The possible adverse impact of innovation subsidies: some evidence from a bivariate switching model. *Economics Bulletin* 32, 648-61.

Chesbrough, H., Rosenbloom, R.S., 2002. The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-off Companies. *Industrial and Corporate Change* 11, 529-555.

Collins, H.M., 1974. The TEA Set: Tacit Knowledge in Scientific Networks. *Science Studies* 4, 165-186.

Colombo, L., Dawid, H., 2013. Complementary Assets, Start-Ups and Incentives to Innovate. *Bielefeld Working Papers in Economics and Management No. 07-2013.*

Colombo, L., Dawid, H., Kabus, K., 2012. When do thick venture capital markets foster innovation? An evolutionary analysis. *Journal of Evolutionary Economics* 22, 79-108.

Cowan, R., David, P.A., Foray, D., 2000.The Explicit Economics of Knowledge Codification and Tacitness. *Industrial and Corporate Change* 9, 211-253.

De Silva, D.G., McComb, R. 2012. Research universities and regional high-tech firm start-up and exit. *Economic Inquiry* 50, 112-130.

Fallick, B., Fleischman, C., Rebitzer, J., 2006. Job-hopping in Silicon Valley: some evidence concerning the microfoundations of a high-technology cluster. *Review of Economics and Statistics* 88, 472-481.

Franco, A., Filson, D., 2006. Spin-outs: knowledge diffusion through employee mobility. *RAND Journal of Economics* 37, 841-860.

Fritsch, M., Franke, G., 2004. Innovation, regional knowledge spillovers and R&D cooperation. *Research Policy* 33, 245-255.

Gersbach, H., Schmutzler, A., 2003a. Endogenous spillovers and incentives to innovate. *Economic Theory* 21, 59-79.

Gersbach, H., Schmutzler, A., 2003b. Endogenous technological spillovers: causes and consequences. *Journal of Economics and Management Strategy* 12, 179-205.

Goldin, C., Katz, L., 1998. The origins of technology-skill complementarity. *Quarterly Journal of Economics* 113, 693-732.

Gonzáles, X., Jaumandreu, J., Pazó, C., 2005. Barriers to innovation and subsidy effectiveness. *RAND Journal of Economics* 36, 930-949.

Hanson, G.H., 2001. Scale economies and the geographic concentration of industry. *Journal of Economic Geography* 1, 255-276.

Helfat, C.E., Lieberman, M.B., 2002. The birth of capabilities: Market entry and the importance of pre history. *Industrial and Corporate Change* 11, 725-760.

Howells, J., 1996. Tacit Knowledge, Innovation and Technology Transfer. *Technology Analysis & Strategic Management* 8, 91-106.

Jaffe, A., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics* 108, 577-598.

Klepper, S., 2001. Employee startups in high-tech industries. *Industrial and Corporate Change* 10, 639-674.

Klepper, S., 2010. The origin and growth of industry clusters: the making of Silicon Valley and Detroit. *Journal of Urban Economics* 67, 15-32.

Klepper, S., Sleeper S., 2005. Entry by spinoffs. *Management Science* 51, 1291–1306.

ISTAT, 2004. *Statistiche sull'Innovazione delle Imprese. Settore Industria. Anni 1998-2000*, Rome: ISTAT.

Malerba, F., Orsenigo, L., 1995. Schumpeterian patterns of innovation. *Cambridge Journal of Economics* 19, 47-65.

Machin, S., Van Reenen, J., 1998. Technology and changes in the skill structure: evidence from seven OECD countries. *Quarterly Journal of Economics* 113, 1215-1244.

Mancusi, M.L., Vezzulli, A. 2014. R&D and credit rationing in SMEs. *Economic Inquiry* 52, 1153-1172.

Narula, R., Zanfei, A., 2003. The international dimension of innovation. In J. Fagerberg, D.C. Mowery and R.R. Nelson, eds., *The Oxford Handbook of Innovation.* Oxford: Oxford University Press, 318-345.

OECD, 1997. *Oslo Manual: The Measurement of Scientific and Technological Activities. Proposed Guideline for Collecting and Interpreting Technological Innovation Data.* Paris: OECD.

Park, H., and H. Steensma, 2012. When does corporate venture capital add value for new ventures?. *Strategic Management Journal*, 33, 1-22.

Pavitt, K., 1984. Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy* 13, 343-373.

Piga, C.A., Vivarelli, M., 2004. Internal and external R&D: a sample selection approach. *Oxford Bulletin of Economics and Statistics* 66, 457-482.

Piva, M., Santarelli, E., Vivarelli, M. 2005. The skill bias effect of technological and organisational change: evidence and policy implications. *Research Policy* 34, 141-157.

Rothaermel, F., Hill, C., 2005. Technological discontinuities and complementary assets: a longitudinal study of industry and firm performance. *Organization Science*

16, 50-70.

Schmidt, T., Rammer, C., 2007. Non-technological and technological innovation: strange bedfellows? *ZEW Discussion Paper No. 07-052*.

Shane, S., 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science* 11, 448-469.

Spulber, D., 2012. Tacit knowledge with innovative entrepreneurship. *International Journal of Industrial Organization* 30, 641-653.

Storey, D.J. , 1982. *Entrepreneurship and the New Firm*. London: Croom Helm.

Storey, D. J., 1994. *Understanding the Small Business Sector*. London: Routledge.

Stam, E., 2007. Why butterflies don't leave. Locational behavior of entrepreneurial firms. *Economic Geography* 83, 27-50.

Teece, D. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, 15, 285-305.

Vivarelli, M., 1991. The birth of new enterprises. *Small Business Economics* 3, 215-223.

Vivarelli, M., 2013. Is entrepreneurship necessarily good? Microeconomic evidence from developed and developing countries. *Industrial and Corporate Change* 22, 1453-1495.

Wallsten, S.J., 2000. The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research Program. *RAND Journal of Economics* 31, 82-100.

Zucker, L., Darby, M., Brewer, M., 1998. Intellectual human capital and the birth of U.S. biotechnology enterprises. *American Economic Review* 88, 290-306.

Appendix

<Table A1: Three-digit sectoral classification – Incumbents and start-ups>

Table 1: The variables – descriptive statistics

	Mean	***Standard Deviation***
R&D investment normalized by sales (year 2000)	0.028	0.058
COMPLEMENTARY ASSETS = Likert-scale: 1 (lack of financial resource is a serious problem) to 4 (lack of financial resource is not an issue), as evaluated by young start-up firms	2.928	0.473
SUPPORT Dummy = 1 if the firm has received public support for innovation	0.554	0.497
COOPERATION Dummy = 1 if the firm takes part into cooperative innovative activities	0.249	0.433
ORGANIZATIONAL CHANGE Dummy =1 if the firm has introduced organizational changes	0.689	0.462
HUMAN CAPITAL = percentage of employees with at least a university degree	0.104	0.163
EXPORT normalized by sales (year 2000)	0.278	0.292
Pavitt sectoral dummies		
SB Dummy = 1 if science-based firm	0.185	0.388
SI Dummy = 1 if scale intensive firm	0.137	0.344
SS Dummy = 1 if specialized supplier firm	0.350	0.477
SD Dummy = 1 if supplier-dominated firm	0.192	0.322
SER Dummy = 1 if firm in service industries	0.136	0.343

Table 2: Correlation matrix

	R&D/ SALES	COMP. ASSETS	SUPPORT	COOP.	ORG. CHANGE	HUMAN CAP.	EXP/ SALES	SB	SI	SS
COMP.ASSETS	-0.108*									
SUPPORT	0.122*	-0.066*								
COOP.	0.113*	-0.041	0.177*							
ORG.CHANGE	0.012	0.022	0.026	0.103*						
HUMAN CAP.	0.235*	-0.089*	0.081*	0.188*	0.102*					
EXP/SALES	0.040	0.071*	0.072*	0.007	0.028	-0.056*				
SB	0.100*	-0.359*	0.066*	0.130*	0.028	0.125*	-0.000			
SI	-0.086*	0.043	-0.037	-0.064*	0.008	-0.141*	-0.021	-0.189*		
SS	-0.118*	0.183*	0.024	-0.061*	-0.006	-0.159*	0.071*	-0.349*	-0.292*	
SER	0.269*	-0.025	-0.064*	0.093*	0.059*	0.418*	-0.054*	-0.189*	-0.158*	-0.291*

Note: * significant at 5%,

Table 3: dependent variable: log(R&D/SALES); observations = 1,337

	(1)	(2)	(3)
CONSTANT	-4.581*** (0.334)	-4.665*** (0.332)	-4.282*** (0.350)
COMPLEMENTARY ASSETS	-0.244** (0.105)	-0.266** (0.104)	-0.247** (0.102)
INCUMBENTS' EVALUATION			-0.141*** (0.034)
SUPPORT	0.677*** (0.080)	0.649*** (0.078)	0.639*** (0.078)
HUMAN CAPITAL	1.081*** (0.318)	1.027*** (0.316)	0.999*** (0.313)
COOPERATION	-0.078 (0.099)		
ORGANIZATIONAL CHANGE	-0.130 (0.081)		
Log(EXPORT/SALES)	-0.247 (0.250)		
SB	0.967*** (0.131)	0.931*** (0.131)	0.909*** (0.130)
SI	0.149 (0.130)	0.137 (0.130)	0.162 (0.135)
SS	0.492*** (0.102)	0.462*** (0.101)	0.451*** (0.100)
SER	0.403** (0.200)	0.416** (0.192)	0.427** (0.191)
F	23.14***	31.90***	30.66***
R^2	0.14	0.14	0.15

Notes: - Robust standard errors in brackets: * significant at 10%, ** significant at 5%, *** significant at 1%
- No multicollinearity problems have been detected

Table A1: Three-digit sectoral classification – Incumbents and start-ups

NACE Rev.1.1	INCUMBENTS Code	Freq.	Percent	START-UPS Code	Freq.	Percent
- Manufacturing of dairy products;	155	13	0.97	155	4	1.04
- Manufacturing of other food prods;	158	31	2.32	158	10	2.60
- Manufacturing of other textiles;	175	12	0.90	175	3	0.78
- Manufacturing of knitted articles;	177	11	0.82	177	4	1.04
- Manufacturing of other wearing app.;	182	20	1.50	182	5	1.30
- Manufacturing of articles of paper;	212	22	1.65	212	5	1.30
- Printing and service act. for printing;	222	24	1.80	222	3	0.78
- Manufacturing of basic chemicals;	241	33	2.47	241	13	3.39
- Manufacturing of paints, varnishes;	243	33	2.47	243	4	1.04
- Manufacturing of pharmaceuticals;	244	61	4.56	244	6	1.56
- Manufacturing of soap;	245	20	1.50	245	6	1.56
- Manufacturing of other chemicals;	246	23	1.72	246	9	2.34
- Manufacturing of rubber products;	251	15	1.12	251	4	1.04
- Manufacturing of plastic products;	252	79	5.91	252	10	2.60
- Manufacturing of glass;	261	11	0.82	261	3	0.78
- Manufacturing of ceramic tiles;	263	35	2.62	263	6	1.56
- Manufacturing of articles of concrete;	266	15	1.12	266	3	0.78
- Other first processing of iron;	273	11	0.82	273	6	1.56
- Manufacturing of non-ferrous metals;	274	7	0.52	274	3	0.78
- Manufacturing of metal prods;	281	13	0.97	281	5	1.30
- Treatment and coating of metals;	285	13	0.97	285	6	1.56
- Manufacturing of other metal prods;	287	31	2.32	287	7	1.82
- Manufacturing of machinery;	291	46	3.44	291	10	2.60
- Manufacturing of other gen. p. mach.;	292	57	4.26	292	12	3.13
- Manufacturing of machinetools;	294	18	1.35	294	5	1.30
- Manufacturing of special p. mach.;	295	75	5.61	295	19	4.95
- Manufacturing of office machinery;	300	29	2.17	300	12	3.13
- Manufacturing of electric motors;	311	30	2.24	311	8	2.08
- Manufacturing of electricity distrib.;	312	27	2.02	312	3	0.78
- Manufacturing of insulated cable;	313	8	0.60	313	3	0.78
- Manufacturing of electrical equip.;	316	46	3.44	316	11	2.86
- Manufacturing of electronic valves;	321	22	1.65	321	10	2.60
- Manufacturing of television & radio;	322	40	2.99	322	11	2.86
- Manufacturing of medical equipment;	331	34	2.54	331	10	2.60
- Manufacturing of instr. for measuring;	332	34	2.54	332	8	2.08
- Manufacturing of indust. cont. equip.;	333	28	2.09	333	8	2.08
- Manufacturing of optical instruments;	334	16	1.20	334	3	0.78
- Manufacturing of bodies motor vehi.;	342	11	0.82	342	4	1.04
- Manufacturing of parts motor vehi.;	343	33	2.47	343	9	2.34
- Building and repairing of ships;	351	5	0.37	351	4	1.04
- Manufacturing of motorcycles;	354	17	1.27	354	4	1.04
- Manufacturing of furniture;	361	42	3.14	361	5	1.30
- Manufacturing of gas;	402	4	0.30	402	3	0.78
- Wholesale of household goods;	514	9	0.66	514	3	0.78
- Wholesale of machinery;	518	9	0.66	518	3	0.78
- Other supporting transport act.s;	632	6	0.44	632	3	0.78
- Activities of travel agencies;	633	3	0.22	633	5	1.30
- Monetary intermediation;	651	24	1.80	651	16	4.16
- Software consultancy and supply;	722	55	4.11	722	27	7.03
- Data processing;	723	8	0.60	723	3	0.78
- Other computer related activities;	726	2	0.15	726	5	1.30
- Research on natural sciences;	731	18	1.35	731	8	2.08
- Legal,accounting,auditing activities;	741	5	0.37	741	4	1.04
- Architectural/engineering activities;	742	31	2.32	742	12	3.13
- Technical testing and analysis;	743	12	0.90	743	8	2.08
	Total	1,337	100.00	Total	384	100.00