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Firms' R&D Expenditure, Banks and University-Industry Cooperation: What is the Importance of Local Factors?

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Abstract

Over the recent years the macroeconomic performance of Europe has been persistently weak, with low growth and high unemployment, in absolute and relatively to rest of the world. There seems to be a widely shared consensus on the idea that potential growth is low in Europe and that this "structural slump" reflects mainly a "productivity deficit".
In order to put in place possible remedies for this decline the European Union (EU) has set the "Lisbon Agenda", where several objectives are defined and are announced to be met in 2010. In particular, related to the "productivity deficit", the goal for the research and development (R&D) expenditures / GDP ratio is to achieve at least 3% for the EU as a whole and to have two thirds of R&D expenditure financed by the business sector.
But the achievement of the goal for R&D intensity requires a clear understanding of what are the constraints for higher levels of R&D expenditure. In the present analysis, focusing on the case of Italy, we examine two important potential constraints for firms' R&D expenditure: local banking development and university-industry knowledge spillovers. Moreover we examine the causal relationship between university-industry cooperation and local R&D intensity of higher education sector. Using a large database of Italian firms taken from the Capitalia Survey, we show that geographical differences in the R&D intensity of higher education sector play a key role in increasing the probability of cooperation between universities and firms and, hence, knowledge spillovers. Moreover we find that, while university-industry cooperation represents an important determinant of R&D expenditures financed by business sector, local banking development does not have a significant impact. We argue that our findings have important policy implications.

KEY WORDS: Firm, Bank, Banking Development, R&D, University-Industry Cooperation.
JEL CLASSIFICATION: D21, D24, G21, G28, O31, O32, O38

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1. Introduction

Over the recent years the macroeconomic performance of Europe has been persistently weak, with low growth and high unemployment, in absolute and relatively to rest of the world. There seems to be a widely shared consensus on the idea that potential growth is low in Europe and that this "structural slump" reflects mainly a "productivity deficit".

In order to put in place possible remedies for this decline the European Union (EU) has set the "Lisbon Agenda", where several objectives are defined and are announced to be met in 2010. In particular, related to the "productivity deficit", the goal for the research and development (R&D) expenditures / GDP ratio is to achieve at least 3% for the EU as a whole and to have two thirds of R&D expenditure financed by the business sector.

But the achievement of the goal for R&D intensity requires a clear understanding of what are the constraints for higher levels of R&D expenditure. In the present analysis, focusing on the case of Italy, we examine two important potential constraints for firms' R&D expenditure: local banking development and university-industry knowledge spillovers.

As shown by Guiso *et al.* (2004a) for Italy, differences in local banking development have an important impact on firms' growth, even in an integrated financial market. The result that financial development promotes growth is shown to be weaker for larger firms, which can more easily obtain credit outside from the local market. The analysis carried out by Guiso *et al.* (2004a) is based on a new indicator of financial development derived by estimating a regional effect on the probability that a firm is shut off from the local credit market. Their findings pose the question, relevant for the present analysis, of whether local financial constraints may affect also firms' amount of R&D expenditures.

So far there exists some evidence for Italy, although the findings are mixed. Benfratello *et al.* (2006) and Rotondi (2005) have shown that local banking development does not affect the probability of product innovation. Moreover, Benfratello *et al.* (2006) have found that local banking development does not affect significantly the amount of R&D expenditures, but affects process innovation and increases the probability that firms will engage in R&D, especially for small firms. In their study they do not use the indicator of financial development computed by Guiso *et al.* (2004a).[3] Finally, Herrera and Minetti (2005), by developing an analysis of the effect of "informed finance" on technological change, show that banks' information promotes more firms' introduction of new technologies rather than firms' R&D.

[3] As indicator of banking development Benfratello *et al.* (2006) use the number of bank branches per capita in a province.

In the present analysis we use the same indicator, extending therefore the analysis of Guiso *et al.* (2004a) to firms' R&D expenditures. Our results confirm that local financial development does not affect firms' amount of R&D expenditures. Moreover, we extend the findings of Guiso *et al.* (2004a) by showing that for R&D firms the effect of local financial development on growth is statistically not significant.

Another potential constraint for engaging in R&D is related to the influence of university research on industrial innovation (e.g. Adams *et al.*, 2000). Also the geography of university-industry cooperation may play an important role as there is evidence that knowledge spillovers are mostly localized (e.g. Jaffe *et al.,* 1993).

In the present analysis we examine the nexus between firms' R&D expenditures and university-industry cooperation. We perform also a comparative analysis of local differences in the allocation of financial resources for basic research. In particular we study the effect of local R&D intensity of higher education sector on university-industry cooperation.

Our results confirm the significant role of university-industry cooperation in enhancing R&D expenditures found in the literature. Moreover geographical differences in the R&D intensity of higher education sector play a key role in increasing the probability of cooperation between universities and firms and, hence, the knowledge spillovers.

The remainder of the paper is organized as follows. Section II reviews the literature on banking liberalization and discusses the impacts on local banking development. Section III reviews the literature on the interaction between R&D expenditures and university-industry cooperation. Here are examined also the data on R&D available for Italy, developing a comparative analysis across both countries and Italian regions. Section IV provides a descriptive analysis of the data used in the present research. Section V discusses the main findings. Section VI concludes.

2. Deregulation and local banking development

The period examined in our analysis is 1995-2003, subsequent to a period of ten years where the banking sector has witnessed a gradual liberalization.[4] In Italy the implementation in 1993 of the Second Banking Coordination Directive (with the introduction of the Testo Unico Bancario) completed the process of banking deregulation started in the mid 80s. What are the implications of this substantial liberalization of the banking sector for local banking development?

Casolaro *et al.* (2005) have shown that the geographical differences in the degree of development across local credit markets reflect differences in the efficiency of courts, in social trust and in

[4] See Guiso *et al.* (2003) for the importance of the banking regulation for firms' growth and aggregate growth.

exposure to regulation. Deregulation has led to fast lending growth, but lack of appropriate reforms for improving the working of the judicial system and the persistent limit represented by geographical differences in the endowment of social capital still constrain incentives to extend credit. It is argued that these forces provide a major explanation for the lower size of the Italian household loan market compared to the main euro area countries.

Bofondi e Gobbi (2004) have argued that deregulation per se is not a sufficient condition for ensuring free entry in local credit markets as endogenous barriers implied by information asymmetries continue to play an important role. By examining the data for the period 1986-1996, they have found that both adverse selection and informational advantages explain a significant amount of the entrants' loan default rates. This finding provides an explanation of why in many local credit markets entry by domestic and foreign banks was slow despite the deregulation process.

Nevertheless Guiso *et al.* (2003) have provided evidence that liberalization has significantly increased the efficiency of banks. They find that restrictions on bank competition have led to higher cost of credit and more difficult access to credit. More importantly, instead of presenting advantages in terms of increased stability, more severe restrictions on competition have implied more bad loans. They show also that the inefficiency in the allocation of credit is initially increased after the liberalization of entry in 1990. Moreover, these negative effects of regulation on the performance of the banking sector have indirectly implied lower aggregate and firms' growth.

Nevertheless, by using the same indicator of financial development derived in Guiso *et al.* (2004a), Rotondi (2005) has shown that after the liberalization the importance of the effect of local banking development on firms' growth is weakened but it is still statistically significant.

The deregulation process was followed by an intensive process of consolidation during the period of 1993-1999. Did this process of concentration in the credit market affect negatively competition in local credit markets?

Angelini and Cetorelli (2003) have shown that banks involved in operations of M&A did not increase their market power as a consequence of consolidation. In particular, after 1993 they present declining estimated markups as well as lower than average marginal costs.

Sapienza (2002) has shown that after in-market mergers credit conditions offered by consolidated banks improves, but as the local market share of the target bank increases the efficiency effect on the allocation of credit is offset by market power. Moreover, mergers imply a contraction of the supply of credit for small borrowers. However, Bonaccorsi di Patti and Gobbi (2003) have found that the adverse effect of mergers on credit availability is concentrated mainly on firms that have excess credit availability with respect to their needs, reflecting a more efficient credit policy

following the merger. Over all their findings support the hypothesis that bank mergers increase the availability of credit for the acquired lenders.

Finally, Focarelli and Panetta (2003) and Panetta *et al.* (2005) have found that in-market mergers have long run beneficial effects in terms of efficiency, that compensate short run adverse effects on deposit rates, and improve the information processing needed for screening borrowers by means of a more intensive use of "hard" information by consolidated banks.

3. R&D expenditures and cooperation with university

There exists a vast and recent literature showing that cooperation with university is critical for knowledge transmission and is an important determinant of R&D expenditure. Adams *et al.* (2000), for instance, show that Industry-University Cooperative Research Centers (IUCRCs) play an important role in the process of technology transfer and contribute to increase R&D expenditures. IUCRCs are small academic centers aimed at promoting technology transfer between university and firms in US. Moreover, as shown for example by Hall *et al.* (2000), university-industry research partnerships play a key role in the US innovation system.

The debate on university-industry cooperation, started in the early 1980s, has yielded a large number of contributions aimed at explaining, justifying and regulating the interaction between universities and firms. There is a widespread agreement on the idea that the US policy regulation has played an important role in promoting the cooperation between universities and firms. Just to recall briefly the main policy decisions, the Bayh-Dole Act of 1980 established the right for universities to patent inventions resulting from federally funded research. While the Economic Recovery Tax Act of 1981 extended the R&D tax credit to company-financed academic research. And finally the Small Business Innovation Research Act of 1982 (SBIR) promoted agency-financed start-ups supporting in particular those headed by university researchers.

On the contrary, as discussed in Bianchi and Ramaciotti (2005), the Italian higher education sector has witnessed a long period of incomplete reforms. On one hand, in the 90s have been introduced reforms ensuring university autonomy in managing its own resources and organization. On the other hand the normative framework on intellectual property rights attributes the property rights exclusively to the university researcher, weakening the mechanism which allows universities to finance their development by means of the industrial spillovers of their research. This need of structural reforms of the Italian university is shared, despite the ambitions of the Lisbon Agenda, with most European universities (see Jacobs and van der Ploeg, 2005).

The literature has highlighted also the importance of localization of university-industry knowledge spillovers. Jaffe *et al.* (1993), by using patent citations, have shown that knowledge spillovers are strongly localized.[5] More recently, Adams (2001) finds that academic research spillovers are more localized than industrial research spillovers. This finding reflects the open science and university-industry cooperative movement, which stimulates firms to work with local universities, in contrast to the case of cooperation with other firms, where contractual agreements must be reached in order to access proprietary information often at relatively distant locations. On the other hand Agrawal and Cockburn (2002) show that the presence of a large, local, R&D-intensive firm makes local university research more likely to be absorbed by and to stimulate local industrial R&D ("anchor tenant hypothesis"). Thus differences in the local interaction between universities and firms affect the productivity of the local innovation systems and constitute an economically important aspect of the institutional structure of local economies.

Let's examine the data available for Italy.[6] In figure 1 is reported R&D intensity for the main developed countries in 2003. As it is possible to see Italy's R&D intensity is close to 1% well below the ambitious target of 3% set by the Lisbon Agenda. Italy is also well below the EU25 average (close to 2%). The Lisbon Agenda has as additional target also to have two thirds of R&D expenditure financed by the business sector. As it is possible to see from figure 2, again Italy is below this latter target (below 50%) and below EU25 average (above 50%).

How does the situation look for Italian regions? In figure 3 is reported R&D intensity across Italian regions. As it is possible to see there exists a great variability. We have a value close to 2% (in line with EU25 average) for Lazio and Piemonte, seven regions with a value close to 1% (i.e. equal to the national average), while more than half of the regions have a value well below 1%. The comparison with the data of 2003 with that of 1995 shows an improvement, albeit very modest. It is important to notice that several regions with the most developed local economies, like Lombardia, and Emilia Romagna, are characterized by R&D intensity close to 1% in line with the less developed local economies like for example that of Campania. Lazio is usually included among the less developed regions of South (see for instance Guiso *et al.*, 2004a), but it presents one of the highest level of R&D intensity. More importantly, as it is possible to see in figure 4, the R&D intensity of higher education sector is lower in the regions with the most developed local

[5] See Thompson and Fox-Kean (2005) for less strong evidence of intra-national localization of knowledge spillovers. Although they continue to find strong evidence of international localization effects of the same size of what found by Jaffe *et al.* (1993).

[6] See also Pasetto (2006) for a regional comparison based on recent survey-based data on cooperation of firms with universities.

economies, like Piemonte, Lombardia, Veneto and Emilia Romagna, compared to most of the less developed regions.

This picture changes radically when we look at the percentage of R&D expenditure financed by business sector across regions, reported in figure 5. Now Piemonte, Lombardia, Emilia Romagna, present the highest shares, close to 60 % or even above.

In figure 6 is reported the regional employment in R&D. As it is possible to see the figure reflects relatively accurately the pattern represented in figure 3, as R&D expenditures reflect mainly wages for employees specialized in R&D. Similarly, the pattern for patent intensity - reported in figure 7 - reflects roughly that of figure 5. As expected the most developed regions are those with the highest patent intensity, reflecting the highest percentage of R&D expenditure financed by business sector.

The situation above described implies that where firms need greater concentration of local spillovers of knowledge from universities there are less financial resources for local of higher education sector. In the present empirical analysis we will examine whether there is a causal link between local R&D intensity of higher education sector and university-industry cooperation. Moreover, in order to seek for explanations of the low firms' R&D intensity, we will study the importance of university-industry cooperation, beyond local financial development, for the amount of firms' R&D expenditures.

4. Data description

We use the data from the Survey of Italian manufacturing firms run formerly by Mediocredito Centrale and nowadays by Capitalia, two credit institutions (Mediocredito Centrale is now part of Capitalia). Our analysis builds on three waves run in 1998 (covering the 1995-1997 period), 2002 (covering the 1998-2000 period) and 2004 (covering the 2001-2003 period). The resulting samples are stratified by firm size (number of employees), by sectors (four sectors according to Pavitt taxonomy) and by geographical area (North and Center-South). They are representative of Italian manufacturing firms with more than 10 employees. Each sample comprises over 4000 firms.

In table 1 are reported some descriptive statistics for the data used. Firms' R&D Intensities are R&D expenditure ratios relative to production. R&D expenditure is deflated with a weighted average of the hourly earnings in manufacturing index and the aggregate business investment price index, where the weights used are respectively 0.9 and 0.1, as in Parisi *et al.* (2005). Production is computed as the sum of sales, capitalized costs and the change in work-in-progress and in finished goods inventories, with all variables deflated with the appropriate production price index. South is a

dummy for regions south of Rome, with Lazio excluded. Firm size is the log of the number of employees.

Following Guiso *et al.* (2004a), the maximum rate of growth internally financed is given by max g = ROA/(1-ROA), where ROA is the return on assets. Variables like ROA, sales, capitalized costs and the change in work-in-progress and in finished goods inventories, derived from Firms' balance sheet, are from AIDA databank.

Moreover we have used some variables of the dataset used in Guiso *et al.* (2004b,a). Share of bank branches owned by local banks, number of saving banks per 10000 inhabitants in the region, number of cooperative banks per 10000 inhabitants in the region, bank branches per 10000 inhabitants in the region are a set of variables that describes the banking market as of 1936. Financial development is the indicator of local banking development computed by Guiso-Sapienza-Zingales. They show that the determinants of the geographical differences in the degree of financial development are those variables that describes the structure of the banking market in 1936. Social capital is measured by average voter turnout at the province level for all referenda in the period between 1946 and 1987. Per capita GDP is the log of per capita net disposable income in the province in 1991. Social capital is measured by average voter turnout at the province level for all referenda in the period between 1946 and 1987.

From ISTAT (Italian Bureau of National Statistics) we have taken the regional R&D intensity of higher education sector in 1995 and the GDP per capita in euro prices in 1991.

Let's examine how firms' R&D expenditures are financed according to the Capitalia survey. From table 2 it is possible to see that the main source of financing for R&D investments is internal funds, with a percentage of 80% on average for the three surveys taken together. On the contrary bank lending is considerably less important, suggesting that banking development may have a minor role compared to that played for fixed investments (see Benfratello *et al.*, 2006). This can be argued also from the shares of firms with 100% internal finance and with no bank finance, with a percentage respectively of 65% and 85% on average for the three surveys taken together.

Finally table 3 reports the mean for firms' R&D intensity. The R&D intensity is computed for the total sample of firms, for firms that are engaged in R&D activities (with R&D expenditures greater than zero) and for firms that are engaged in R&D activities in cooperation with university. As it is possible to see the share of firms that are engaged in R&D activities is relatively low and they have also low R&D intensity, with a percentage of respectively 34% and 2% on average for the three surveys taken together. Interestingly, firms that cooperate with university on R&D activities feature a relatively higher R&D intensity compared to those that do not cooperate with university, namely a

percentage of 3% on average for the three surveys taken together. This suggests the presence of an important role played by university for firms' R&D expenditures.

5. Findings

5.1 Determinants firms' R&D expenditures

Let's start with the determinants of firms' R&D expenditures. In particular, we look at differences in the amount of investments in R&D induced by local differences in banking development and by cooperation with university on R&D activities. Since in all the regressions we are going to perform one of our main variable of interest (banking development) varies only at the regional level, standard errors are adjusted for the possible dependence of the residuals within regional clusters. We estimate regressions on the pooled firm level data covering the 1995-2003 period.

The dependent variable is deflated R&D expenditures which are greater than zero. Besides calendar year and industry dummies, as control variables we use a combination of both individual, provincial and regional characteristics. As individual characteristics of the firm we use the following variables. Cooperation with university on R&D activities and our estimated internally financed maximum growth (see section 4), in order to control for internal finance. Firm's size (employees) and the share of graduated employed, which behave like measures of size and appropriateness. As provincial characteristics, first we have per capita GDP in the province of 1991 (expressed in euro prices) as a measure of economic development of the area. Second, we control for the level of social capital in the province (see again section 4 for the definition). As regional characteristics we have the chosen indicator of banking development and a South dummy for regions South of Rome with Lazio excluded.

Table 4 presents the results. Column 1 reports the OLS pooled-regression estimates of the impact of the above variables on the amount of R&D expenditures. As it is possible to see the indicator of banking development is statistically not significant. On the contrary cooperation with university is highly significant (at the 1 percent level) and has a positive effect on the amount of R&D investments. The individual characteristics are all statistically significant and have the expected effect. Regarding the provincial characteristics, while social capital is not significant, per capita GDP has a positive and significant impact on R&D expenditures.

Column 2 re-estimates the same specification inserting a South dummy. As discussed in Guiso *et al.* (2004b), it is important to control for the South in order to examine whether the effect of banking

development found is not simply due to a North-South divide. As it is possible to see, in our case the location of the firm does not affect the probability of access the local credit market, even after controlling for the South dummy. Anyway the inclusion of this latter dummy implies a positive and significant (at the 10 percent level) impact of social capital on R&D expenditures.

In columns 3 and 4 are reported two tests of robustness.

First we control for the possibility that after liberalization the indicator computed by Guiso-Sapienza-Zingales may reflect less accurately geographical differences in baking development. In fact their indicator is based on the data on credit rationing available from the Survey of Households Income and Wealth (SHIW) at the beginning of 90s. In order to control for the existence of a break after 1995, we use the determinants of the indicator instead of the indicator of banking development. Guiso *et. al* (2004a) have shown that access to credit in the 90s can be explained by the level and composition of the supply of credit in 1936. In particular, they have shown that the indicator of banking development is correlated with those variables that describes the structure of the banking market in 1936: the share of bank branches owned by local banks, the number of saving banks in the region, the number of cooperative banks in the region, the bank branches in the region. Now as it is possible to see from column 3, in regions with more savings banks in 1936 the amount of R&D expenditures increases. But the impact of the other variables that describes the structure of the banking market in 1936 is not significant. Moreover the F test accepts the null that the variables that describes the structure of the banking market in 1936 are jointly not significant.

Another robustness test consists in estimating with Instrumental Variables (IV) the specification used in the first two columns, by taking as instruments the variables that describes the structure of the banking market in 1936. Guiso *et al.* (2004a) have shown that these instruments, although they are correlated with local access to credit, have no connection to economic development in 1936. They have argued that the structure of the banking sector in 1936 was basically unrelated to economic development and was instead the result of historical accidents and forced consolidation due to the 1936 Law that regulated the sector. In column 4 we can see that the estimated coefficients are almost the same of those reported in column 2 and that the coefficient of the indicator of banking development is still not significant.

5.2 The effect of banking development on the growth of R&D firms

Here we replicate the empirical analysis of Guiso *et al.* (2004a) by considering firms' growth. In particular we consider only the subset of firms with R&D expenditures greater than zero. Consistently with our findings on R&D expenditure discussed above, we expect that banking

development does not play an important role for the growth of R&D firms. Indeed this is the case, as it is possible to see from table 5. In table 5 we have replicated all the type of estimations performed in table 4. In the present case the only significant effects are those related to the size and the internally financed growth.

The finding on the irrelevance of the local access to credit for the growth of R&D firms extends the finding on the importance of banking development for firms' growth of Guiso *et al.* (2004a). The only discriminant found by Guiso-Sazienza-Zingales is the size of the firm, with large firms less exposed to local banking development. Here we have found another discriminant for the importance of banking development more related to the type of activity of the firm. What is the rationale for this result for firms involved in R&D activities? Indeed, the high degree of risk and the complexity of evaluating future prospects of activities related to innovation makes banking intermediaries not ideal for financing R&D expenditures. This increases the probability of firms, especially high-tech ones, of being credit constrained (see Guiso, 1998) independently of the degree of banking development. Thus, as discussed in section 4, not surprisingly the main source of financing for R&D investments is internal funds. While, on the contrary, bank lending is considerably less important.

5.3 The effect of local R&D intensity of higher education sector on university-industry cooperation

Here we perform a comparative analysis of local differences in the financing of basic research. In particular we study the effect of local R&D intensity of higher education sector on university-industry cooperation. Similarly to the previous analysis, before presenting our estimates we need to identify a set of instruments that can be used for IV estimation. Now, it is possible to show that our variable of interest - regional R&D intensity of higher education sector – is correlated with the number of universities with faculty of science in the region. In table 6 panel A, is reported the OLS regression of regional R&D intensity of higher education sector in 1995 on the regional number of universities with faculty of science in the region in 1995. As it is possible to see the estimated coefficient is positive and significant at the 5 percent level, with an R-squared of about 30 percent. Is it possible to show that this instrument, although being correlated with regional R&D intensity of higher education sector, has no connection to economic development in 1995? In table 6 panel B it is possible to see that the correlation between the regional number of universities with faculty of science and the log of provincial value added per capita in 1995 is significant, but the R-squared is

only 10 percent or less depending whether we control for the South dummy.[7] Thus we can argue that our instrument is correlated with the variable of interest (local R&D intensity of higher education sector), but is uncorrelated with the error in our regressions relating economic cooperation between firms and universities and local differences in the financing of basic research.

Let's turn to the findings of the comparative analysis of local differences in the financing of basic research. Now the dependent variable is cooperation with university on R&D activities. Besides calendar year and industry dummies, as control variables we use again a combination of both individual, provincial and regional characteristics. As individual characteristics of the firm we use the following variables. The deflated R&D expenditures which are greater than zero, firm's size (employees), firm's age and the share of graduated employed. As provincial characteristics we have per capita GDP in the province of 1991 (expressed in euro prices) and the level of social capital in the province. As regional characteristics we have the regional R&D intensity of higher education sector and a South dummy for regions South of Rome with Lazio excluded.

Table 7 presents the results. Column 1 reports the OLS pooled-regression estimates of the impact of the above variables on the cooperation with university on R&D activities. As it is possible to see the regional R&D intensity of higher education sector is statistically significant (at the 1 percent level) and has a positive impact. The individual characteristics are all statistically significant and have the expected effect. Regarding the provincial characteristics, both social capital and per capita GDP have a not significant impact on cooperation with university on R&D activities. As it is possible to see from column 2, the inclusion of a South dummy does not change the significance and size of the coefficient related to the regional R&D intensity of higher education sector. Finally, in column 3 we report the estimation with IV of the specification used in the first two columns, by taking as instrument the regional number of universities with faculty of science. As it is possible to observe, this estimation confirms the importance of local differences in the financing of basic research in explaining the cooperation with university on R&D activities.

6. Conclusions

In the present analysis, focusing on the case of Italy, we have examined two important potential constraints for firms' R&D expenditure: local banking development and university-industry knowledge spillovers. Our results show that local financial development does not affect firms' amount of R&D expenditures. A rationale for this result is the following. The high degree of risk

[7] In this estimation standard errors are corrected for regional clustering.

and the complexity of evaluating future prospects of activities related to innovation makes banking intermediaries not ideal for financing R&D expenditures and increases the probability of firms, especially high-tech ones, of being credit constrained (see Guiso, 1998) independently of the degree of banking development.

Consistently with our findings on R&D expenditures, we have found that for R&D firms the effect of local financial development on growth is statistically not significant.

Our results confirm the significant role of university-industry cooperation in enhancing R&D expenditures found in the literature. Moreover geographical differences in the R&D intensity of higher education sector play a key role in increasing the probability of cooperation between universities and firms and, hence, the knowledge spillovers.

These findings have interesting policy implications. First, the fact that local banking development does not affect firms' R&D expenditures explains why even in the more financially developed regions, with relatively easier access to bank credit, firms' R&D intensity is low. In absence of developed venture capital or private equity markets, like in Italy, it implies R&D expenditures relying heavily on internal finance and on transfers and fiscal subsidies. Thus there is a fundamental role for the government in promoting an active specialized capital market, more ideal for financing firms' R&D activities.

Second, our findings suggest also an important role for the government in promoting industrial research not only through demand for subsidies to firms, but also by means of improving the spatial concentration of financial resources for basic research. According to our findings, the strengthening of the offer of basic research - in order to reflect more effectively the needs of the local innovation system - improves the cooperation between firms and university and thereby increases R&D expenditures.

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TABLE 1 – Descriptive statistics

	MAX	MIN	MEDIAN	MEAN	1ST PERCENTILE	99TH PERCENTILE	STANDARD DEVIATION
South	1.00	0.00	0.00	0.15	0.00	1.00	0.35
Banking development	0.587	0.000	0.435	0.414	0.027	0.587	0.134
LOG (firm's age)	5.74	0.00	3.09	3.03	1.10	4.58	0.70
LOG (number of employees)	9.58	1.73	3.48	3.79	2.40	7.22	1.11
GDP per capita in 1991 (euro)	23.53	7.71	16.65	16.30	8.64	23.53	3.58
Social capital	0.92	0.62	0.86	0.84	0.66	0.91	0.06
Maximum growth internally financed	0.60	0.00	0.08	0.10	0.01	0.41	0.08
Regional R&D intensity of higher education sector (perc. of GDP)	1.29	0.01	0.28	0.39	0.23	1.29	0.19
Bank branches per 10000 inhabitants in the region in 1936	5.31	0.57	2.22	2.48	0.57	5.31	1.20
Share of bank branches owned by local banks in 1936	0.97	0.46	0.89	0.82	0.51	0.97	0.14
Number of saving banks per 10000 inhabitants in the region in 1936	0.12	0.00	0.03	0.03	0.00	0.10	0.03
Number of cooperative banks per 10000 inhabitants in the region in 1936	0.22	0.00	0.06	0.09	0.00	0.22	0.06
Share of new equity used for financing R&D	1.00	0.00	0.00	0.02	0.00	0.85	0.11
Share of internal funds used for financing R&D	1.00	0.00	1.00	0.84	0.00	1.00	0.31
Share of fiscal subsidies used for financing R&D	1.00	0.00	0.00	0.04	0.00	1.00	0.15
Share of public transfers used for financing R&D	1.00	0.00	0.00	0.07	0.00	1.00	0.19
Share of bank debt used for financing R&D	1.00	0.00	0.00	0.07	0.00	1.00	0.23
Share of bank debt subsidised used for financing R&D	1.00	0.00	0.00	0.05	0.00	1.00	0.17
Share of graduates employed	1.00	0.00	0.03	0.06	0.00	0.39	0.08
Cooperation with university on R&D	1.00	0.00	0.00	0.14	0.00	1.00	0.35
Rate of growth of production	0.56	-0.40	0.02	0.02	-0.31	0.39	0.13
LOG (R&D expenditure)	14.86	-2.34	6.69	6.80	2.96	11.76	1.77
R&D intensity (perc. of production)	21.87	0.00	0.99	1.99	0.02	14.56	2.80

TABLE 2 – Sources of finance for investments in R&D

	1995-1997	1998-2000	2001-2003
Number of observations	1320	1545	1609
Sources of finance (in % of total finance):			
New equity	1.6	1.3	0.7
Internal funds	81.7	78.7	79.7
Transfers and fiscal subsidies	5.1	10.4	9.2
Bank debt	9.3	8.3	9.2
Not subsidised	5.2	5.5	5.8
Subsidised	4.1	2.9	3.4
Importance of bank finance and internal funds (in %):			
Share of firms with 100% internal finance	70.2	63.0	60.9
Share of firms with no bank finance	83.9	87.1	85.2
Share of firms with 100% bank finance	4.1	4.1	3.6

Notes: Number of observations is referred to the firms that have answered the question on R&D in the questionnaire of the Capitalia survey and have R&D expenditure greater than zero. Averages, all averaged over each three-year period of the Capitalia survey.

TABLE 3 – Firms' R&D intensity and cooperation with university

	1995-1997	1998-2000	2001-2003
Number of observations	4490	4603	4171
Firms with R&D > 0 (in %)	29.0	34.9	39.8
Firms coop. with university / R&D > 0 (in %)	12.3	13.3	14.8
R&D intensity (in %)	0.6	1.0	0.6
R&D intensity / R&D > 0 (in %)	2.0	3.5	1.6
R&D intensity / R&D > 0 and cooperation with university (in %)	3.2	4.8	2.3

Notes: Number of observations is referred to the firms that have answered the question on R&D in the questionnaire of the Capitalia survey. Averages, all averaged over each three-year period of the Capitalia surveys. Intensities are R&D ratios relative to production. R&D expenditure is deflated with a weighted average of the hourly earnings in manufacturing index and the aggregate business investment price index, where the weights used are respectively 0.9 and 0.1 (see Parisi *et al.*, 2005). Production is computed as the sum of sales, capitalized costs and the change in work-in-progress and in finished goods inventories, with all variables deflated with the appropriate production price index.

TABLE 4 – Determinants of firms' R&D expenditures

	OLS	OLS	OLS	IV
Cooperation with university	0.317745*** (0.081020)	0.321406*** (0.080798)	0.315626*** (0.080887)	0.325012*** (0.081237)
Share of graduates employed	4.056491*** (0.348534)	4.056186*** (0.347793)	3.998535*** (0.348464)	4.054463*** (0.347419)
Internally financed growth	0.889672*** (0.329723)	0.856629*** (0.330446)	0.880357*** (0.331029)	0.861021*** (0.330103)
Size	0.909407*** (0.024984)	0.914066*** (0.025760)	0.912266*** (0.025812)	0.913089*** (0.025838)
South		0.073080 (0.066928)	0.034153 (0.068885)	0.071757 (0.066962)
Banking development	0.323613 (0.373362)	0.317724 (0.373383)		0.558346 (0.459653)
Share of bank branches owned by local banks in 1936			-0.055770 (0.332484)	
Number of saving banks per 10000 inhabitants in the region in 1936			3.166299** (1.510134)	
Number of cooperative banks per 10000 inhabitants in the region in 1936			-1.093778 (1.202433)	
Bank branches per 10000 inhabitants in the region in 1936			0.033360 (0.058036)	
Per capita GDP	0.019590** (0.009431)	0.021533** (0.009560)	0.026190** (0.011024)	0.020801** (0.009550)
Social capital	1.410615 (0.874840)	1.588970* (0.883845)	1.351140 (1.052411)	1.193299 (1.019045)
F test (p-value)			1.360 (0.246)	
Observations	2401	2401	2401	2401
$\overline{R}^2$	0.433	0.433	0.433	0.433

Notes: Pooled regressions. The left-hand variable is the log of R&D expenditure deflated with a weighted average of the hourly earnings in manufacturing index and the aggregate business investment price index, where the weights used are respectively 0.9 and 0.1 (see Parisi *et al.*, 2005). IV uses as instrument a set of variables that describes the banking market as of 1936 (see Guiso *et al.*, 2004a). Banking development is the indicator of local financial development computed by Guiso *et al.* (2004a). Per capita GDP is the per capita net disposable income in the province in 1991. Social capital is measured by average voter turnout at the province level for all referenda in the period between 1946 and 1987 (see Guiso *et al.*, 2004b). South is a dummy for regions South of Rome, with Lazio excluded. The maximum rate of growth internally financed is max g = ROA/(1-ROA), where ROA is the return on assets. Firm size is the log of the number of employees. Cooperation with university is a dummy equal to 1 if the firm cooperates with university on R&D (otherwise 0). All regressions include constant, industry and time dummies. F test is for the null that the coefficients of the four indicators of the banking structure in 1936 are jointly equal to zero; the p-value of the test is reported in brackets. Robust standard errors, reported in brackets, are adjusted for regional clustering. (*): coefficient significant at 10 percent; (**): coefficient significant at 5 percent; (***): coefficient significant at less than 1 percent.

TABLE 5 – The effect of banking development on the growth of R&D firms

	OLS	OLS	OLS	IV
Internally financed growth	0.055568* (0.031770)	0.053554* (0.031883)	0.057025* (0.031731)	0.053302* (0.031887)
Size	0.010766* (0.006528)	0.011290* (0.006565)	0.010897* (0.006570)	0.011225* (0.006566)
South		0.005367 (0.006205)	0.002303 (0.006653)	0.005528 (0.006177)
Banking development	0.038896 (0.028691)	0.038712 (0.028733)		0.053607 (0.034676)
Share of bank branches owned by local banks in 1936			0.043997 (0.029108)	
Number of saving banks per 10000 inhabitants in the region in 1936			0.170131 (0.111201)	
Number of cooperative banks per 10000 inhabitants in the region in 1936			-0.003637 (0.085024)	
Bank branches per 10000 inhabitants in the region in 1936			-0.001725 (0.004020)	
Per capita GDP	-0.000927 (0.000766)	-0.000787 (0.000774)	-0.000662 (0.000910)	-0.000815 (0.000779)
Social capital	-0.104102 (0.068568)	-0.091080 (0.072364)	-0.123637 (0.087626)	-0.115748 (0.082018)
F test (p-value)			1.162 (0.326)	
Observations	2726	2726	2726	2726
$\bar{R}^2$	0.017	0.017	0.017	0.017

Notes: Pooled regressions. The left-hand variable is the annual rate of growth in production. Production is computed as the sum of sales, capitalized costs and the change in work-in-progress and in finished goods inventories, with all variables deflated with the appropriate production price index. IV uses as instrument a set of variables that describes the banking market as of 1936 (see Guiso *et al.*, 2004a). Banking development is the indicator of local financial development computed by Guiso *et al.*, (2004a). Per capita GDP is the per capita net disposable income in the province of 1991. Social capital is measured by average voter turnout at the province level for all referenda in the period between 1946 and 1987 (see Guiso *et al.*, 2004b). South is a dummy for regions South of Rome, with Lazio excluded. The maximum rate of growth internally financed is max g = ROA/(1-ROA), where ROA is the return on assets. Firm size is the number of employees divided by 1000. All regressions include constant, industry and time dummies. F test is for the null that the coefficients of the four indicators of the banking structure in 1936 are jointly equal to zero; the p-value of the test is reported in brackets. Robust standard errors, reported in brackets, are adjusted for regional clustering. (*): coefficient significant at 10 percent; (**): coefficient significant at 5 percent; (***): coefficient significant at less than 1 percent.

TABLE 6 – Regional R&D intensity of higher education sector and regional structure of higher education sector as of 1995

A

	R&D intensity of higher education sector in the region in 1995
Number of universities with faculty of science in the region in 1995	0.100902** (0.035319)
Observations	19
R^2	0.324

B

	Number of universities with faculty of science in the region in 1995	Number of universities with faculty of science in the region in 1995
Log of provincial value added per capita in 1995	1.131161*** (0.044035)	1.361792*** (0.047383)
South		-0.638080*** (0.098251)
Observations	102	102
R^2	0.089	0.101

Notes: All regressions include constant. In panel B robust standard errors, reported in brackets, are adjusted for regional clustering. (*): coefficient significant at 10 percent; (**): coefficient significant at 5 percent; (***): coefficient significant at less than 1 percent.

TABLE 7 – The effect of local R&D intensity of higher education sector on university-industry cooperation

	OLS	OLS	IV
R&D expenditure	0.023038*** (0.004983)	0.023130*** (0.004935)	0.023124*** (0.004936)
Size	0.028863*** (0.007360)	0.025806*** (0.007423)	0.025815*** (0.007427)
Share of graduates employed	0.627640*** (0.100752)	0.618951*** (0.100076)	0.617336*** (0.100314)
Age	0.030678*** (0.009752)	0.027898*** (0.009765)	0.027945*** (0.009749)
South		-0.062004*** (0.016027)	-0.062975*** (0.016931)
Local R&D intensity of higher education sector	0.106992*** (0.038588)	0.133973*** (0.038933)	0.143626** (0.068214)
Per capita GDP	-0.042881 (0.038325)	-0.066802* (0.038313)	-0.065926* (0.039245)
Social capital	-0.159678 (0.158656)	-0.285319* (0.162333)	-0.284371* (0.162394)
Observations	3067	3067	3067
$\overline{R}^2$	0.079	0.082	0.082

Notes: Pooled regressions. The left-hand variable is a dummy equal to 1 if the firm cooperates with university on R&D. IV uses as instrument a variable that describes a feature of the regional structure of the higher education sector relevant for knowledge spillovers: the number of universities with faculty of science in the region in 1995. Firm's R&D expenditure is the log of R&D expenditure deflated with a weighted average of the hourly earnings in manufacturing index and the aggregate business investment price index, where the weights used are respectively 0.9 and 0.1 (see Parisi *et al.*, 2005). Per capita GDP is the log of per capita net disposable income in the province in 1991. Social capital is measured by average voter turnout at the province level for all referenda in the period between 1946 and 1987 (see Guiso *et al.*, 2004b). South is a dummy for regions South of Rome, with Lazio excluded. Firm size is the log of the number of employees. Firm's age is the log of the number of years from its birth. Local R&D intensity of higher education sector is the regional R&D expenditure as percentage of GDP in 1995. All regressions include constant, industry and time dummies. Robust standard errors, reported in brackets, are adjusted for regional clustering. (*): coefficient significant at 10 percent; (**): coefficient significant at 5 percent; (***): coefficient significant at less than 1 percent.

FIGURE 1 - R&D intensity

R&D expenditure as percentage of GDP ; source EUROSTAT

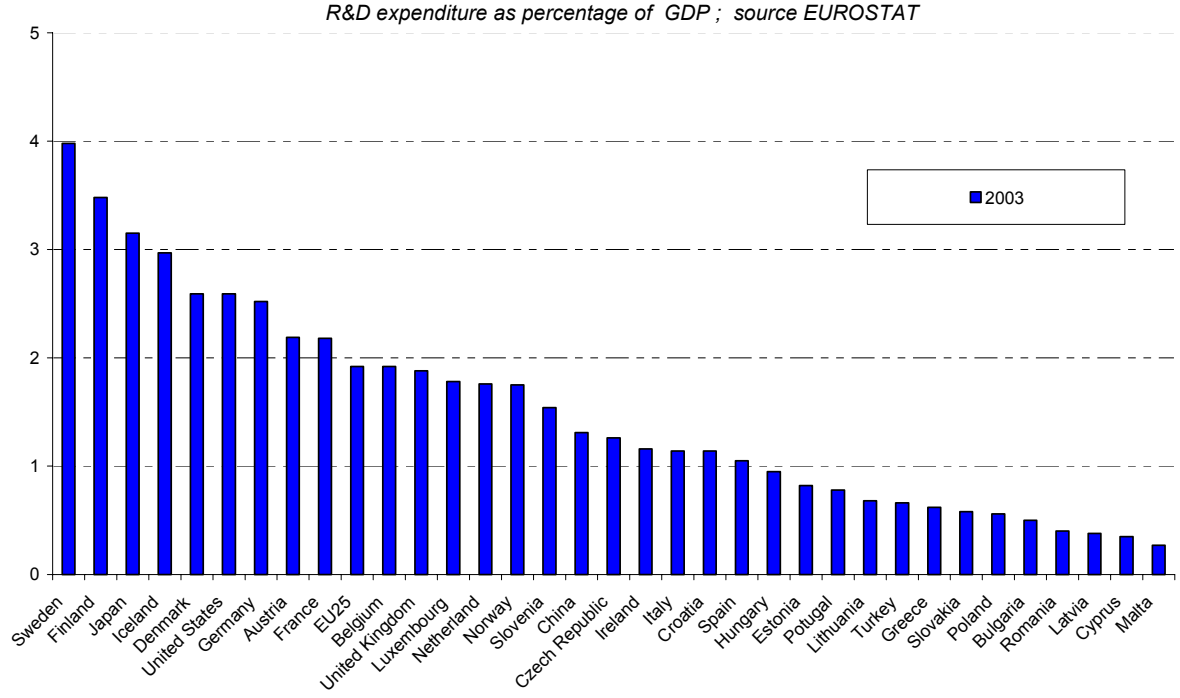

FIGURE 2 - R&D expenditure financed by business sector

As percentage of total R&D expenditure; soruce is ISTAT for Italy and EUROSTAT for other countries

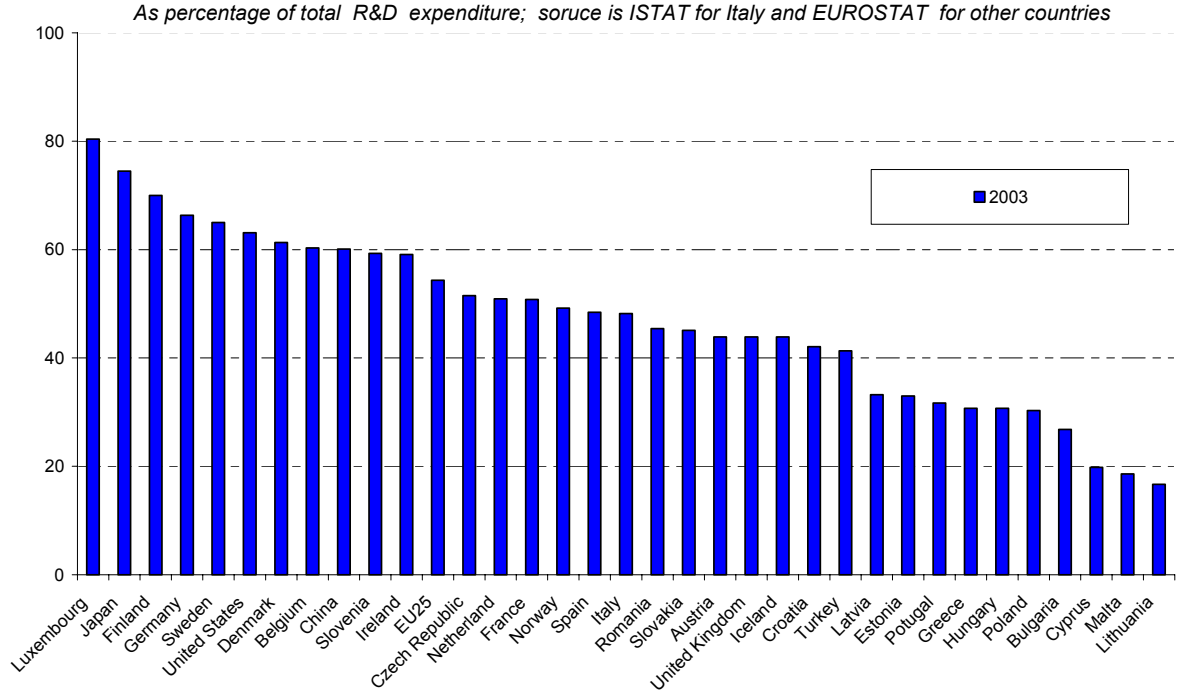

FIGURE 3 - R&D intensity in Italian regions

R&D expenditure as percentage of GDP; source ISTAT

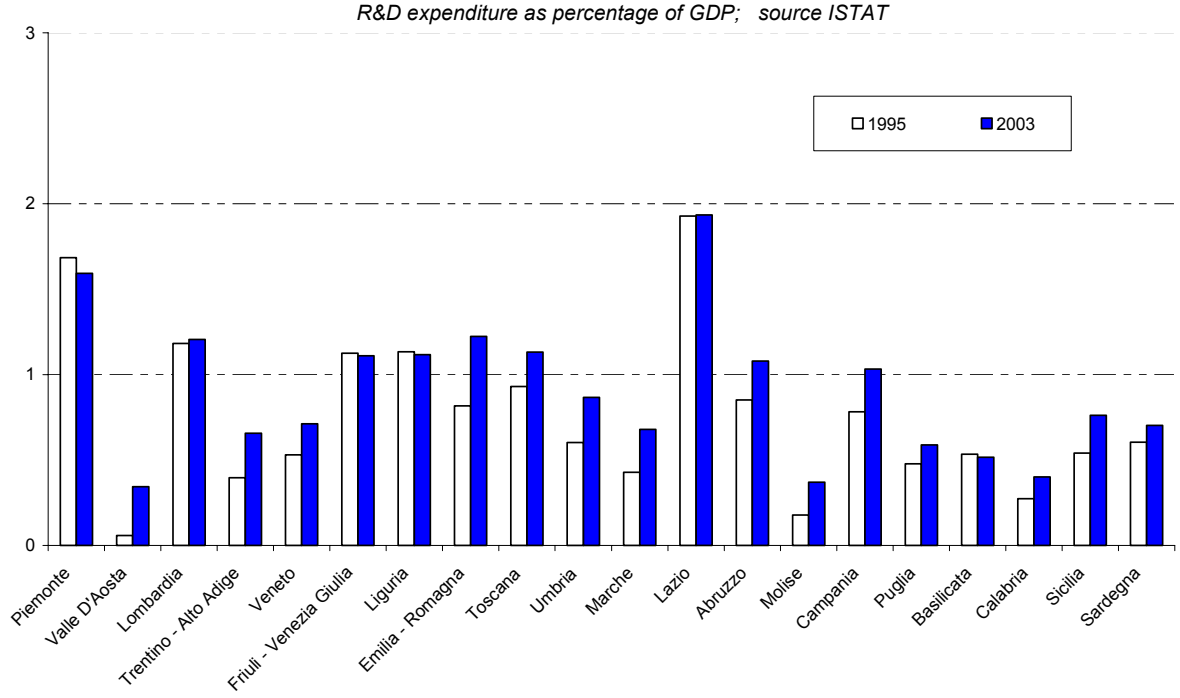

FIGURE 4 - R&D intensity of higher education sector in Italian regions

R&D expenditure as percentage of GDP; source ISTAT

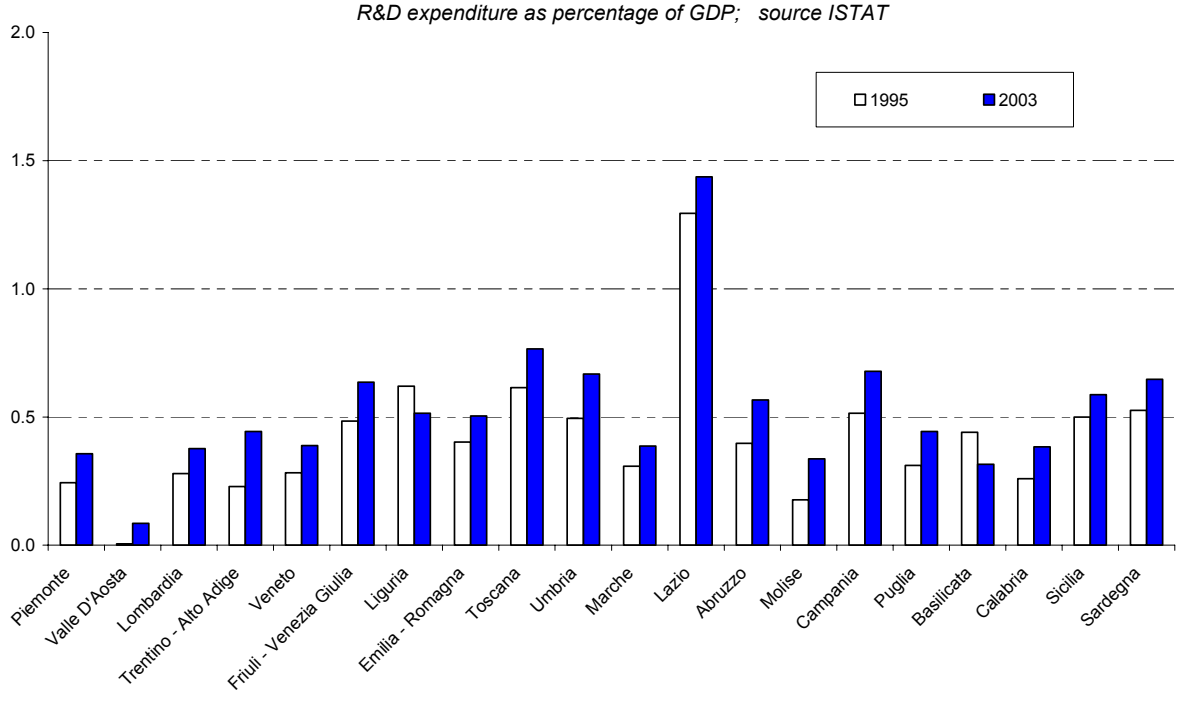

FIGURE 5 - R&D expenditure financed by business sector in Italian regions

As percentage of total R&D expenditure; source ISTAT

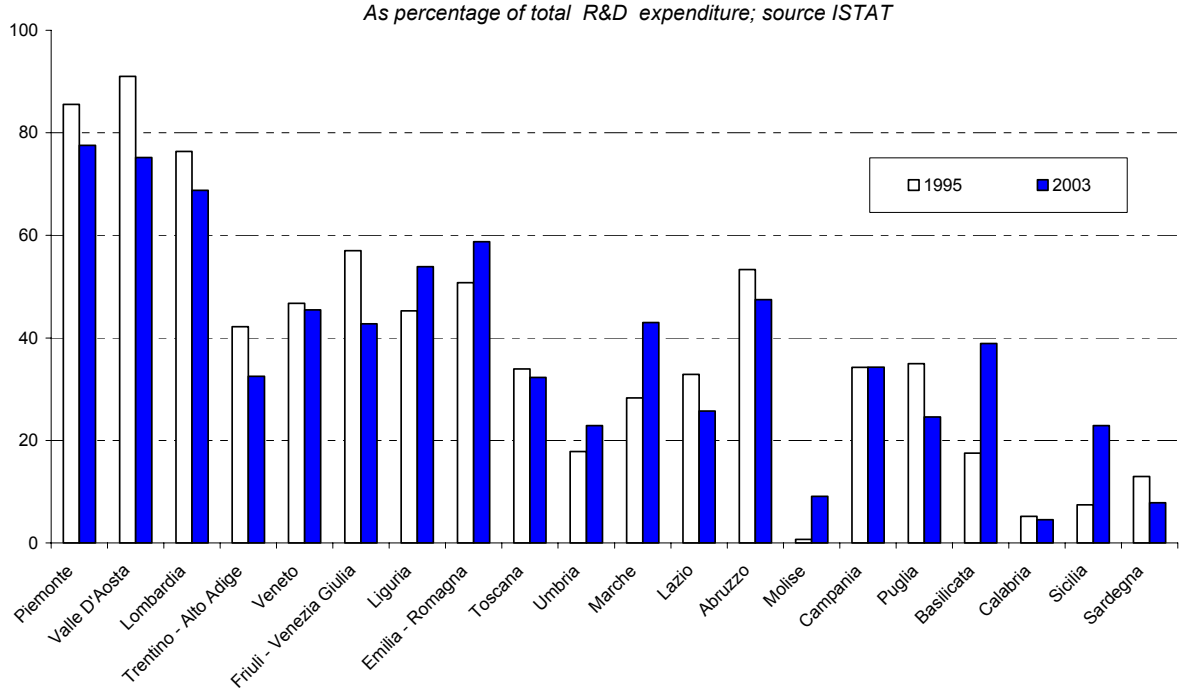

FIGURE 6 - Employment in R&D in Italian regions

Number of employees in R&D per 1000 of inhabitants ; source ISTAT

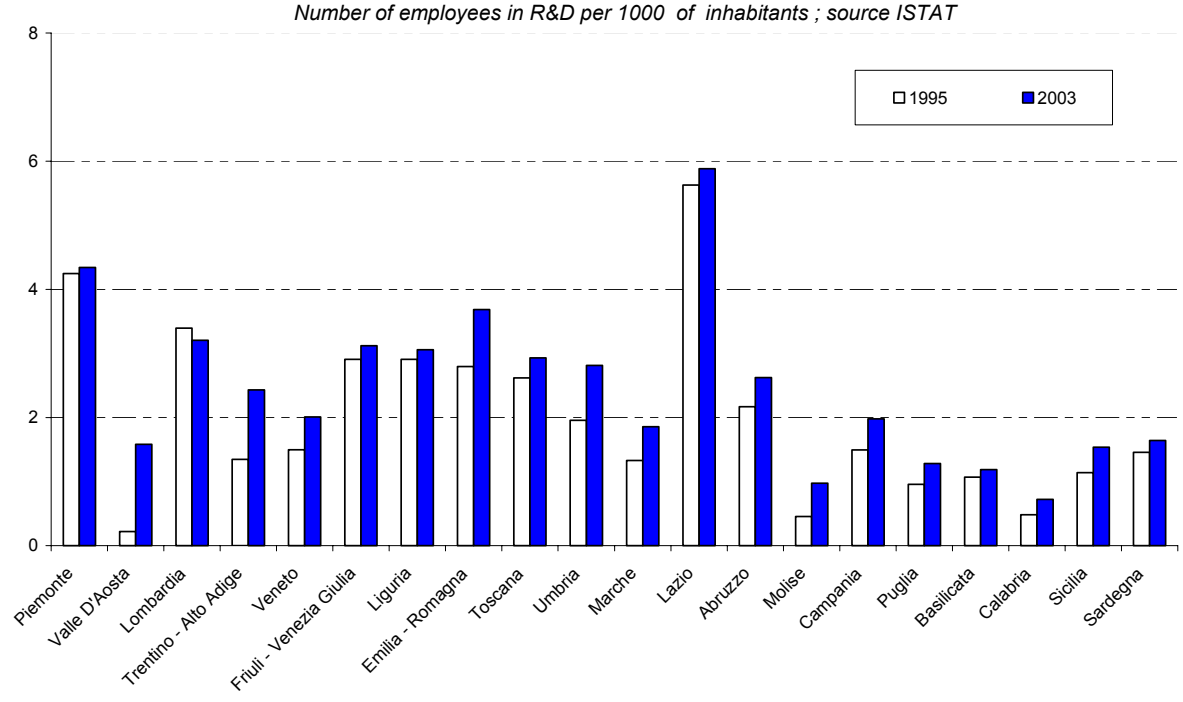

FIGURE 7 - Patent intensity in Italian regions

Number of patents registered at the European Patent Office (EPO) per millions of inhabitants; source ISTAT