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Access to Finance for Innovation: The role of Venture Capital and the Stock Market

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Abstract

Financial constraints for young and small firms can prevent them from supporting innovation and employment creation. We analyze two of the various institutional mechanisms which have been proposed to circumvent it: the development of venture capital market and the stock market access. We will use the information provided by two Scoreboards - used to monitor innovative activity in Europe: the Innovation Union Scoreboard and the R&D Scoreboard. With the first, we study the determinants of the venture capital/GDP intensity in Europe. With the second, we try to assess the contribution of stock market to R&D investment. In the first part, we show that venture capital market complements structural feature such as R&D intensity and market capitalization, is more volatile and seems not affected by anticompetitive regulations. In the second part, we show that unlisted SMEs are more research intensive.

JEL Classification: M13, O31, O38

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1 Introduction

Faced with the competitive pressure from both advanced economies and emerging countries, the European Union has relaunched its ambitions of leadership by transforming the Lisbon Agenda (European Commission 2002; European Council, 2002) into the new Europe 2020 strategy (European Commission, 2010a).

The document makes the case for a better effectiveness of competitiveness enhancing policies in Europe after the not so satisfactory results of the previous strategy.

With regards to innovation, the content of the Agenda is delineated into the flagship titled "Innovation Union" (European Commission, 2010b). While in the Lisbon Agenda the main focus was on research (especially centred in the three percent target of R&D over GDP), the stance of the new initiative is on the importance of the channel of transmission.

By the latter, we mean the new core message of bringing ideas to the market, resulting from the insistence on the framework conditions, i.e. the access to finance, on a broader concept of innovation (beyond R&D), and the attention paid to the role of growing innovative SMEs and on young innovative companies.

The identification of fast growing innovative young and small companies as drivers of growth matches both the ongoing discussion in the Commission with regards to the addition of an innovation output indicator to the three percent target and the new consensus emerging in the academic community that these actors play a large role in accounting for aggregate dynamics of employment and productivity.

The former is witnessed by the fact that the High Level Panel established by the European Commissioner for Research and Innovation puts forth the share of high growth and innovative firms as proposed indicator (European Commission, 2010c).

For the second, we refer to the work done by OECD (summarized in OECD, 2010a) and by Haltiwanger et al. (2010) - although limited to the US case - that show clearly that the high growth firms account for a disproportionate part of employment growth, and for the work by Cincera and Veugelers (2010) which shows that young leading innovators explain the larger size of the research intensity gap with the US.

Summing up, there exists a clear policy priority related with identifying the constraints that bind for small and young innovative companies and prevent them from growing fast and diffuse the effects of their innovative effort, promoting employment creation and productivity growth.

The literature provides evidence that R&D is normally cash constrained (Carreira and Silva, 2010; Cincera and Ravet, 2010; Bogliacino and Gómez, 2010; Hall and Lerner, 2009; Hall, 2002), but R&D is predominantly conducted in large firms. When we come to the empirical evidence drawn from Community Innovation Survey (CIS) data[1], financing constraints to innovation seems more or less

[1] See Mairesse and Mohnen (2010) for a review, see also OECD (2010a) for the young and small firms.

binding depending on the country, i.e. on the institutional framework of each National Innovation System. Whenever financing constraints exist, they are also associated with other constraints, suggesting that the interaction with the institutional system can worsen the financing problem.
As a result, market failures are present but are not uniformly distributed across sectors and regions. It becomes then necessary to analyze the contribution that may come from the financial market. In this article we will focus in particular on venture capital and the stock market.
Historically, Venture Capital (VC) has always played the role of providing financial resources and organizational capabilities to new born companies in emerging sectors (Lerner, 2002a and 2002b; Kortum and Lerner, 2000). At the same time, the stock market can be a way to raise capital through Initial Public Offerings (IPOs), especially after the development of specific regulated markets for technology based firms. Indeed, there is evidence that the R&D boom of the 1990s in the US has been mainly financed through stock market listing (Brown et al. 2009).
We first discuss VC at country level (data coming from the Eurostat[2]), looking at the association with both economic performance and institutional variables, using information coming from various sources.
Secondly, we move to consider the difference between public and private[3] SMEs in their R&D investment. For this part we use the EU R&D Investment Scoreboard (European Commission, 2010d): it provides information on the top World 2000 R&D investors, covering more than 80% of world business R&D. The SMEs included in this sample are the top innovative players among the SMEs (they are concentrated in high tech sectors) so we capture those animals which are closest to the theoretical high growth innovative firm.

Methodologically, in both sections we use descriptive evidence and microeconometric techniques to empirically assess our research questions.
In the first part of the analysis we show that VC market is quite volatile, since it is affected by the business cycle, and it is positively associated with structural features of the innovation system, such as the R&D intensity. Interestingly, early stage VC seems to be not affected by anticompetitive regulation.
With regards to the difference between listed and unlisted firms, we use various econometric techniques to control for selection bias and we show that there isn't empirical support for the thesis that unlisted SMEs are less research intensive.

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[2] This is the main source for the analysis of the Innovation Union Scoreboard (see Innovation Union Scoreboard, 2010). The Innovation Union Scoreboard 2010 is a new composite indicator used to monitor the innovation activity in Europe. It provides a comparative assessment of the innovation performance of 27 European countries, showing the strengths and the weakness of the respective National Innovation Systems. The indicator is composed by 8 innovation dimensions, one of which collects data on financing and supporting activities which are supposed to enable innovation and research activities. This indicator studies the appeal of the economic system for the private funding and the ability of the government to stimulate research and development within countries.

[3] From now on, the term public and private SMEs refers to (resp.) listed and unlisted.

This article proceeds as follows. Section two presents the evidence on VC; section three analyzes the data from R&D Scoreboard. Finally, section four suggests some conclusions and highlights some issues that should deserve further analyses.

2 The Determinats of Venture Capital

2.1 Definition and Descriptive Evidence

The development of new and young firms is often related to the ability of entrepreneurs to obtain financial resources, especially when high levels of uncertainty reduce the possibility of traditional banking support. For young firms with high potential growth and strong technological opportunities, VC is an important source of private funding. It operates by reducing the distance between the primary sources of finance (insurance, pension funds, banks, etc.) and new unlisted young firms. Facing high initial levels of uncertainty and risk, investments in these companies can assure high rewards[4].

By supporting the birth and development rate of new enterprises, VC unleashes innovation and favours employment creation: an experimental indicator built by OECD, looking at the age distribution of patenting firms, shows that new firms contribute from 10% to 20% of the overall patenting within the economy (OECD, 2010b).

However, the amount of VC funds differs across countries and has a strong variability over time. This can dry up the financing at all the stages of development of young firms and reduce the support for business creation.

In this section, by analyzing the dynamics of VC investments for 23 European and EFTA (European Free Trade Association) countries from 1995 to 2009, we investigate the capacity of countries to mobilise private funding. In fact, constraints to VC investments and external funding can delay the entry rate of new firms and market selection. Data on VC investments are drawn from Eurostat. Investments are broken down into two stages: early (seed and start-up) stage, which involves planning and product development, and expansion and replacement stage[5].

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[4] For a theoretical discussion on the role of VC for financial and industrial markets, see Gompers and Lerner (2001). See also Gompers and Lerner (1999b) for the risk and return prospect of Venture Capital investment.

[5] Based on Eurostat definitions, seed investments are defined as financing provided to research, assess and develop an initial concept before a business has reached the start-up phase.

Start-up is defined as financing provided for product development and initial marketing, manufacturing, and sales. Companies may be in the process of being set up or may have been in business for a short time, but have not sold their product commercially.

Expansion capital is defined as financing provided for the growth and expansion of a company which is breaking even or trading profitably. Capital may be used to finance increased production capacity, market or product development,

The cross countries values of VC investments are shown in Table 1. In EU-15, the average level of investments from 1996 to 2009 has been 0.120% of GDP. In 2009, VC investments in EU-15 have amounted to the 0.091 %, showing a clear downswing due to the recent financial and economic crisis. On average, investments in expansion and replacement stage have been three times the capitals invested in early stages of development. The difference has been lower in 2000, during the boom of ICT sector. However, the best predictor of expansion and replacement VC is precisely the early stage investment: a random effect regression of the former over the latter and a constant gives a coefficient of 1.12, significant at 1% confidence level.

In 2009, three countries accounted for more than the 60% of total VC in EU-15: United Kingdom (30%), France (20%) and Germany (10%). Italy accounts for 7%, followed by Sweden (6%). In terms of GDP percentage, the United Kingdom and the Nordic countries (Denmark, Finland, Sweden) show higher share of investments than Mediterranean economies (Italy and Spain). Differences emerge in the composition of VC. The ratio of early over expansion and replacement capital is higher for Nordic countries. Italy, Spain and Poland are characterized by a low level of capital funding for seed and start-up companies.

Table 1. Average values of venture capital from 1995 to 2009 for selected countries. Percentage of GDP.

	Early Stage	Expansion and Replacement	Total Venture Capital	Public R&D
European Union (15 countries)	0.028	0.092	0.120	0.664
Denmark	0.036	0.068	0.104	0.771
Germany	0.024	0.048**	0.075**	0.762
Spain	0.011	0.080	0.092	0.477
France	0.026	0.074	0.100	0.783
Italy	0.009	0.050	0.059	0.531
Poland	0.007*	0.048*	0.055*	0.403
Finland	0.045	0.077	0.122	0.956
Sweden	0.053	0.141	0.194	0.931
United Kingdom	0.045	0.198	0.243	0.613

* from 1998; ** from 1997 Source: Eurostat

and/or provide additional working capital. It includes bridge financing for the transition from private to public quoted company, and rescue/turnaround financing.

Finally, replacement capital is defined as purchase of existing shares in a company from another private equity investment organization or from another shareholder or shareholders. It includes refinancing of bank debt.

Buyout is instead defined as the purchase of a company or a controlling interest of a corporation's shares or product line or some business. Its analysis is not inserted in this study.

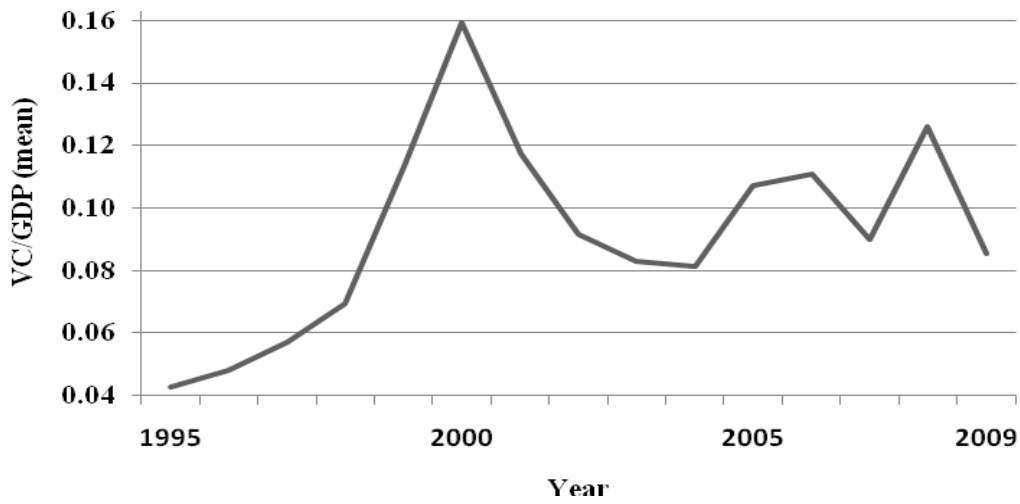
The comparison between the share of public R&D expenditure as a percentage of GDP and venture investments provided in Table 1 highlights the orientation of the structure of external financing of each country[6]. The latter integrates the level of private investments in R&D, which can be below the social optimum[7].

Interestingly, we find a high correlation between VC investments in early stages and public R&D expenditure. This aspect can be explained by the fact that the institutional characteristics in Nordic countries, with high level of public expenditure and a consolidated system of innovation and social and labour relations, reduces the uncertainty of more risky investments.

Conversely, capitals invested in the expansion and replacement phases are driven by the stability of financial markets and securitization of innovation based assets. However, Table 1 shows clearly that the UK has the most developed VC market; there is indeed evidence that the catching up of Europe with respect to the US in this market is largely explain by the boom occurred in this country (Revest and Sapio, 2010).

When we consider the dynamics of VC over time, we find that the amount of investments is highly unstable, as shown in Figure 1.

Figure 1. The share of VC on GDP. Average annual value for 23 countries.



Source: Eurostat

[6] Public R&D activities are defined by Eurostat as all the R&D expenditure in the government sector and the higher education sector.

[7] Venture capital and public R&D as a percentage of GDP are the financing component of the Innovation Union Composite Indicator included into the IUS 2010. The finance and support dimension is able to explain a great part of the variance in Member State's innovative performance. See the IUS 2010.

The level of VC on GDP for EU-15 has grown considerably during the ICT boom in 1995-2000 (the Pre-Lisbon Strategy Period), while has decreased until 2005. A similar dynamics has characterized both early stage and expansion and replacement stages of investments, although the latter results more variable. Outside the EU the trend has been similar, showing a strong dependence of VC level of investments on economic cycle. In the last years, the rise in 2005-2006 has been followed by a drop of VC investments, especially in expansion and replacement stages of funding. During the downswings of the economic activity, the supply of VC funds is reduced, as the expected profits from investments are lower; the demand of funds is also affected by macro fluctuations as the lack of demand of goods and services reduces the opportunity of growth of new firms. By comparison, the trend of public R&D expenditure on GDP has had a countercyclical trend and it has continued rising during the financial crisis.

One important point to stress is that structural features of the innovation system, such as the share of business and public R&D expenditures and the share of high tech services are much more stable than VC investment. For instance, business R&D has a persistence coefficient (coming from a random effect regression of business R&D on the first lag) close to 99% while the early VC investment shows a 0.60%. Another way to look at the same aspect is the comparison of between and within variability: while R&D and the share of high tech services have a larger between variability, VC has almost equal within and between shares of variability. As a result, the role of VC for innovation should be correctly interpreted and not exaggerated.

At the same time, indicators of companies birth rate are highly correlated with the share of venture capital on GDP, which implies that VC appear to be an important determinant of job creation.

Further descriptive statistics and the data sources are included into Table A1 in the Appendix.

2.2 Analysis

In order to isolate the differences in macro determinants of VC investments across countries, we focus on the dynamics of early stage VC, which are specifically connected to birth of new firms. We consider 23 European and EFTA countries, from 1995 to 2009. The list of countries is provided in the Appendix.

Models that study the determinants of VC across countries include Gompers and Lerner (1999a), Jeng and Wells (2000), Marti and Balboa (2001), Schertler (2003), Santana Felix, Gulamhussen and Pires (2007), Cherif and Gazdar (2009), Bonini and Alkam (2011). While different proxies are used for similar determinants, the literature identifies three groups of variables which are supposed to affect the level and the growth of venture capital investments: different macroeconomic conditions, entrepreneurial variables and technological opportunities of countries (Santana Felix, Gulamhussen and Pires, 2007).

Following the literature, we use the following explanatory variables. First, an increase of the technological opportunities of sectors is supposed to promote high values of VC. A high public R&D expenditure is generally associated with a better context for innovation and the specialization of

employment towards high technology sectors. Also business R&D can influence the entry of VC investors, but we have to keep in mind that there may be reverse causality.

Second, the stock market capitalization on total GDP is an indicator of the size of stock market. It expresses the level of the dynamism, readiness and maturity of the financial market as well as the level of its market liquidity. Many studies have highlighted the relationship between the IPO market and VC investments. A more refined exit market for VC rises the opportunity to obtain higher profits when divestments are applied. The stock market capitalization is calculated by multiplying the volume of shares issued by companies and quoted on the stock market by their market value. Market value is determined by trading on the stock market (data are drawn from Eurostat).

Third, the level of the labour market rigidities is supposed to negatively affect investments in equity markets. The measure of the Strictness of Employment Protection is provided by OECD. This indicator is a “synthetic representation of the strictness of regulation on dismissals and the use of temporary contracts” (Venn, 2009). The version of the indicator here included is the un-weighted average of sub-indicators for regular employment and temporary employment that incorporates 14 data items. Scale is from 0 (least stringent) to 6 (most restrictive). Labour market rigidities are usually blamed for reducing the flexibility needed to innovate (Bassani and Ekkehard, 2002; Scarpetta and Tressel, 2004; Aghion et al., 2007); in this particular context, the hypothesis is that the rigidity in labour market affects the entrepreneurial activity and makes the perspective of divestments and exit not easy. Given the economic success of institutional system very far from each other (only in Europe, it is the case for the UK, Germany and Scandinavian countries), we have the impression that the concrete role played by labour market rigidities is overrated, but we control for it to be in line with the literature.

Finally, while a higher level of unemployment can favour entrepreneurship (Felix, Gulamhussen and Pires, 2007), it is very likely that higher unemployment rates reduce the supply of VC funds. In our view, this variable should catch the dependence of VC on market cycles.

As a robustness check, we will run a regression with the real long run interest rate, to control for macroeconomic condition (in particular for liquidity availability and the state of expectation).

Since we have both a cross section and a time series component, we have to deal with error component models. The choice is between random effects and fixed effects: the former is more efficient if the time invariant error is not correlated with the explanatory variables, while the latter is consistent even under existence of correlation. A way to test it is through Hausman test. The null hypothesis of non systematic differences of the coefficients is non rejected (chi-2 with four parameters 5.64, p-value 22.8%) so we use the random effects model.

The results of the regression on early stage of VC investments are shown in Table 2.

Table 2. Dependent Variable: Venture Capital Investments – Early stage

	(1) Random Effect	(2) Random Effect	(3) Random Effect
Public R&D on GDP	0.0256 (0.010)**		0.0450 (0.0136)**
Business R&D on GDP		0.0119 (0.0031)***	
Market Capitalization on GDP	0.0003 (0.0001)***	0.0003 (0.0001)***	0.0002 (0.0000)***
Unemployment Rate	-0.1001 (0.0497)***	-0.0976 (0.0355)***	
Real Long Term Interest Rate			-0.1929 (0.1066)*
Strictness of Employment Protection	-0.0028 (0.0022)	-0.0016 (0.0024)	-0.0011 (0.0029)
Constant	0.0026 (0.0088)	0.0047 (0.0075)	-0.0104 (0.0099)
Observations	194	196	196
R2	0.35	0.39	0.26
Wald test	105.33***	97.44***	56.51***

Source: Eurostat and OECD. Robust standard errors are reported in parentheses. One, two, and three stars mean significance at respectively 10, 5 ad 1 percent.

The countries which are characterized by a higher share of Research and Development expenditure show a positive relationship with VC. Higher technological opportunity stimulates the supply as well as the demand of funds. This is robust to the use of both public and business R&D.

As expected, a large value of the market capitalization of the financial market as a percentage of GDP is associated with a higher level of VC. The latter asks for a higher readiness and maturity of the financial markets.

The unemployment rate is inversely correlated with early stage VC. This effect can be due to the strong dependence of investments on economic cycle. Lower levels of employment creation are in fact related to lower expected profits for investors. In a parallel regression estimated through a between regression, unemployment rate is not significant, showing the importance of time dimension. The result is robust to the use of long term interest rate as measure of macroeconomic condition.

Finally, the rigidity in labour market does not seem to affect VC opportunities. Considering a period with strong macroeconomic fluctuations, the dynamics of employment protection could have been caught by the rate of unemployment[8]. One possible explanation is that the emphasis on flexible labour market to promote innovation is excessive (or even wrong according to Lucidi and Kleinknecht, 2010). However, one could argue that simply High Tech firms choose capital intensive strategies due to the uncertainty associated with their trajectory and the strictness of protection (Schertler, 2003)[9]. We should say that, in a similar vein, simple regressions of venture capital investment on other anti-competitive regulations (such as barriers to entrepreneurship index and product regulation index from OECD) are not significant, even without controlling for other factors.

3 Public and Private SMEs: The R&D Performance

3.1 Definition and Descriptive Evidence

Another important source of data to monitor the emergence of new actors and sectors is the R&D Scoreboard. As we said above, the R&D Scoreboard covers almost the entire population of Business R&D expenditure around the world. The top 1000 EU companies and the top 1000 Rest-of-the-World companies are included. Data are consolidated at group level and the data on R&D refers to investment and not expenditures, i.e. including the part of the investment which is capitalized (according to the International Accounting Standard 38).

We take the last edition (European Commission, 2010c) which reports the data for 2009 and for the three preceding years (for the companies which were operatives in those years). We select the sample of SMEs, defined as companies with less than 249 employees, which together account for two billions euro of R&D.

We have 22 US SMEs and 110 EU ones, among the latter there are 23 unlisted firms, while the rest of the sample is all made by public companies. Among the European companies, 65% are located in UK, France and Germany (resp. 41, 16 and 15).

If we look at the sectoral composition (ICB code at four digits) three fourth of them are concentrated in three sectors: 45% are biotech firms, 16.67% are pharmaceuticals and 11.36% are software firms. Unsurprisingly, the three sectors are both high tech and young.

8

9 One possible solution is to opt of flexicurity. High levels of public R&D expenditures, together with a not aggressive employment protection can stimulate a good level of external investment, when the institutional context reduces the degree of uncertainty of investments.

The companies themselves have the typical profile of the research lab[10]. While on aggregate the ratio of R&D on sales is 3.25%, for our SMEs sample it is 80%. Moreover while the median of the distribution[11] of research intensity for the overall 2000 Scoreboard companies is 4.4%, the one for our sample is 128.18%. This is clear cut evidence that those companies are investing deeply into intangible assets with the perspective of either growing fast or perishing.

It is interesting to see if there is an association between the type of financing and the amount invested. Using the information provided by the Scoreboard we want to check if the stock market is acting as a kind of fundraising mechanisms (as in the 1990s boom, as shown by Brown et al., 2009) or rather if the strategy of raising private equity (which includes also VC investment) is a better way to prevent financing constraints.

The simple descriptive statistics tells that on average unlisted firms invest 0.23 millions euro per employees (standard error 0.16), while listed have 0.17 millions euro per employee as average investment (s.e. 0.24). We use R&D per employee to have some sort of normalization: in fact, R&D investment has typically a fat tail distribution. Given that the share of unlisted is smaller, we prefer to think at the treatment as "being privately owned".

3.2 Analysis

To infer some sort of causal relationship, we should control for a number of biases.

In particular we have to address three potential concerns. A) Companies may be at different stages of their trajectories, as reflected into sales and other sources of investments, so it is important to control for all these factors. B) The sample design includes the top 1000 ranked companies for Europe and for the rest of the world, but given that the RoW and EU are not comparable economies, the top spenders outside Europe are likely to be larger on average. C) Firms endogenously choose to go on public offering depending on their characteristics (or may be privately owned because of their potential profitability).

To correct for A) and B) we use current year information on capital expenditure and sales and a dummy for US. To correct for C), we first instrument using previous year information and then we use propensity score matching to balance the distribution of listed and unlisted firms.

A simple OLS regression gives the results presented in Table 3. Unlisted and US are self-explanatory dummies. All the other variables are contemporaneous. Although all nominal variables are rescaled by employment, we add the latter separately to control for other size effect.

[10] For a full characterization of SMEs in the Scoreboard see Ortega-Argilés et al. (2009).

[11] Looking at the sample mean can be misleading, because the distribution is fat-tailed.

Table 3. Dependent Variable: R&D investment per employee.

	(1)
Unlisted	0.078
	(0.038)**
Sales per employee	0.023
	(0.053)
Capital expenditure per employee	0.193
	(0.107)*
Employment	-0.001
	(0.000)***
US	0.214
	(0.038)***
Sectoral Dummies	Yes
Constant	0.217
	(0.034)***
Observations	132
R2	0.53
F-test	18.28
(p-value)	(0.00)

Source: EU R&D Investment Scoreboard 2010. Robust standard errors are reported in parentheses. One, two, and three stars mean significance at respectively 10, 5 ad 1 percent. Sectoral dummies are the three dummies for biotech, pharma and software.

Even after controlling for these effects, the treatment is still significantly positive, in the sense that unlisted firms are likely to invest more in R&D. Employment has a negative effect but with a very tiny impact.

We now try to control for selection bias. The decision to stay unlisted can be related with private equity investors which search for potentially innovative firms. If this is the case, both R&D investment and being unlisted are codetermined by a third factor, firm idiosyncratic competitiveness. We can use observable characteristics for 2008 to control for pre-sample competitiveness (we go back only to the previous year to avoid sample reductions, given that many firms are very young). In particular, we introduce capital expenditure per employee, employment, operating surplus per employee and sales per employee.

The results are shown in Table 4 below.

Table 4. The results with two stages estimation.

	(1) Dependent Variable: R&D per employee	(2) Dependent Variable: Unlisted
Unlisted (predicted)	0.497 (0.123)***	
Sales per employee	0.034 (0.061)**	
Sales per employee (first lag)		-2.634 (1.131)**
Capital expenditure per employee	0.319 (0.126)**	
Capital expenditure per employee (first lag)		-0.570 (1.121)
Employment	-0.000 (0.000)***	
Employment (first lag)		-0.002 (0.002)
Operating Surplus per employee (first lag)		0.190 (0.242)
US	0.196 (0.046)***	
Sectoral Dummies	Yes	
constant		-0.300 (0.324)
Observations	130	130
R2	0.71	0.06
F-test (p-value)	35.94 (0.00)	
Log Likelihood		-56.76

Source: EU R&D Investment Scoreboard 2010. Robust standard errors are reported in parentheses. One, two, and three stars mean significance at respectively 10, 5 ad 1 percent. Column (1) is estimated with OLS. Column (2) is estimated with probit. Sectoral dummies are the three dummies for biotech, pharma and software.

We can further exploit the information provided by pre-sample characteristics to balance the distributions of unlisted and listed firms. By a propensity score matching, we match each treated observation with an untreated one, using the prediction from column (2) above to define the closest observations. By means of this technique, the listed and unlisted firms are approximately equal in all observable characteristics referred to pre-sample year, except for being public and private.

In Table 5 below we run the same OLS regression. As can be seen, after controlling for endogeneity the unlisted companies invest 0.113 millions euro more than listed ones.

Table 5. Dependent Variable: R&D investment per employee.

	(1)
Unlisted	0.113 (0.046)**
Sales per employee	-0.009 (0.250)
Capital expenditure per employee	0.850

	(0.329)**
Employment	-0.002
	(0.000)***
US	0.369
	(0.149)**
Sectoral Dummies	Yes
constant	0.232
	(0.075)***
Observations	46
R2	0.55
F-test	4.92
(p-value)	(0.00)

Source: EU R&D Investment Scoreboard 2010. Robust standard errors are reported in parentheses. One, two, and three stars mean significance at respectively 10, 5 ad 1 percent. Sectoral dummies are the three dummies for biotech, pharma and software. The control group has been defined with propensity score matching based on Column (2) of Table above.

The results again do not reject the hypothesis that private equity is a better instrument to boost intangible investment than stock market listing. This is consistent with the literature which says that for European technology based company stock market did not played a significant financing role, as compared with the US (Revest and Sapio, 2010).

4 Conclusions

In this contribution we address the question of financing of young and small innovative companies. This particular type of business is deemed to play a large role in the process of innovation and employment creation in the modern economies; however, being such a dynamic subject, it may be serious harmed by financing constraints. VC and stock market can play a role in softening this constraint.

Our empirical evidence shows that unlisted SMEs in the R&D Scoreboard are more research intensive after controlling for various sources of endogeneity. As a result, the contribution of stock market to boost R&D should be taken with caution. Although we cannot push too further on the interpretation, we remind that the evidence on the role of stock market to feed R&D boom in the US was referred to a bubble phenomenon, so happening under rather special conditions. This suggests that private equity instruments and VC among them are likely to play a major role.

On the latter, although it is difficult to infer casual relationships, we show that it is both subject to cyclical effects and to structural determinants of the innovative performance of the economy. Promoting structural change and investing in public research is thus likely to promote also private participations in the financing of innovation. In fact, the cyclical nature of investments in VC reduces the opportunity of financing during the phases of downswing of the economic activity, widening the market failure and lessening the perspective of recovery of firms. In this context, the need to equally reinforce private and public factors emerges as a possible solution.

On the other hand, there is not a clear relationship between the forms of deregulation and a strong development of VC market in the first stage of development of enterprises. Our aim was to examine whether a more flexible labour market was able to support VC investments. Although it would be wrong to infer that flexibility cannot improve the context for entrepreneurial activity in VC investments, we note that, in the long period, a lower level of employment protection can be related to a worsening of the skill formation and, as a consequence, a reduction of the technological opportunities of the economic system. More in general, we suggest that the role of labour market rigidities for financing can have been overrated, lacking a solid empirical evidence in support of the hypothesys.

The recipe for flexible labour market and services de-regulation can be a tool able to stimulate agents to devote resources to innovate. However, we know from modern institutional analysis that the variety of institutional arrangements that are complementary to business success is quite broad (Guy, 2009); further analysis on the framework conditions that are more favourable to financing of innovation is required.

All in all, in the current policy debate (and in the public discussion in general) the emphasis given to the role of VC and the stock market in supporting innovation is quite impressive. Of course, we think that there is a large space for re-discuss the real contribution that they can play in spurring innovation. However, a better understanding of their real potential is the key for better policy design.

The coexistence of technological change, research growth, VC and IPOs that has marked the dot com surge in 90s, has brought about the striking exploiting of ICT technologies but it has been also associated with a high financial instability. We put forward that the policy debate should deepen the role of the public action as a tool to support the financing of innovation and manage the occurrence of technological breakthroughs. In fact, in the same way as we learned that R&D investments are not enough to fuel economic growth, neo-Schumpeterian analyses have shown us that: (a) in the seed phase the public intervention is fundamental in many radical innovations, more than VC; (b) the State has been actively involved in developing and managing more than one technological breakthrough; (c) once a technological revolution is established, its complete deployment requires active public participation (Mazzucato, 2011; Perez, 2010).

The future research agenda should be better focused on the various corporate governance and ownership structure that lead to better innovative performance, keeping into account the framework conditions and the complementarities with institutional mechanisms.

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References

Aghion P., Askenazy P., Bourlès R., Cette G., Dromel N. 2007. Education, Market Rigidities and Growth. *IZA Discussion Paper*, 3166.

Bassani A., Ekkehard E. 2002. Labour Market Institutions, Product Market Regulation, and Innovation: Cross-Country Evidence. *OECD Economics Department Working Paper*, 316.

Bogliacino F., Gómez S. 2010. The determinants of R&D Investment: the role of Cash flow and Capabilities. *IPTS Working Paper on Corporate R&D and Innovation*, 10.

Bonini S., Alkam S. 2011. The macro and political determinants of venture capital investments around the world, *Small Business Economics*, online first 02 April 2011, DOI 10.1007/s11187-011-9323-x.

Brown J., Fazzari S., Petersen B. 2009. Financing Innovation and Growth: Cash Flow, External Equity, and the 1990s R&D Boom. *Journal of Finance*, 64(1): 151-185.

Carreira C., Silva F. 2010. No deep pockets: some stylized empirical results on firms' financial constraints. *Journal of Economic Surveys*, 24(4): 731-753.

Cherif M., Gazdar K. 2009. Public institutions and venture capital in Europe: a cross-country panel data analysis. *International Journal of Public Sector Management*, 1(3): 275-294.

Cincera M., Ravet J. 2010. Financing constraints and R&D investments of large corporations in Europe and the USA. *IPTS Working Paper on Corporate R&D and Innovation*, 3.

Cincera M., Veugelers R. 2010. Young Leading Innovators and EU's R&D intensity gap. *IPTS Working Paper on Corporate R&D and Innovation*, 7.

European Commission 2002. *More Research for Europe. Towards 3% of GDP*. COM(2002) 499 final, Brussels.

European Commission 2010a. *EUROPE 2020. A strategy for smart, sustainable and inclusive growth.* COM(2010) 2020, Brussels.

European Commission 2010b. *Innovation Union*. COM(2010) 546, Brussels.

European Commission 2010c. *Elements for the setting-up of headline indicators for innovation in support of the Europe 2020 strategy*. Report of the High Level Panel on the Measurement of Innovation established by Ms Máire Geoghegan-Quinn, European Commissioner for Research and Innovation.

European Commission 2010d. *The 2010 EU Industrial R&D Investment Scoreboard*. JRC Scientific and Technical Research.

European Council 2002. *Presidency Conclusions. Barcelona European Council*. 15 and 16 March 2002, Brussels.

Gompers P., Lerner J. 1999a. What drives venture capital fundraising? *NBER Working paper*, 6906.

Gompers P., Lerner J. 1999b. An analysis of compensation in the U.S. venture capital partnership. *Journal of Financial Economics*, 51(1): 3-44.

Gompers P., Lerner J. 2001. The venture capital revolution, *Journal of Economic Perspective*, 15(2): 145-168.

Guy, F. 2009. The Global Environment of Business. Oxford University Press. Oxford, New York.

Hall B. 2002. The Financing of Research and Development. *Oxford Review of Economic Policy*, 18(1): 35-51.

Hall B., Lerner, J. 2009. The financing of R&D and innovation, in Hall B.H., Rosenberg N. (eds) *Handbook of the Economics of Innovation.* North Holland: Amsterdam.

Haltiwanger J.C., Jarmin R.S., Miranda J. 2010. Who Creates Jobs? Small vs. Large vs. Young. *NBER Working Paper Series*, 16300.

Innovation Union Scoreboard 2010. *The Innovation Union's performance scoreboard for Research and Innovation*. http://www.proinno-europe.eu/metrics.

Jeng L.A., Wells P.C. 2000. The determinants of venture capital fundraising: evidence across countries. *Journal of Corporate Finance*, 6(3): 241-289.

Kortum S., Lerner J. 2000. Assessing the contribution of venture capital to innovation. *RAND Journal of Economics* 31(4): 674–692.

Lerner J. 2002a. Boom and bust in the venture capital industry and the impact on innovation. *Federal Reserve Bank of Atlanta Economic Review*, Q4: 25-39.

Lerner J. 2002b. When bureaucrats meet entrepreneurs: the design of effective public venture capital programmes. *Economic Journal*, 112(477): 73–84.

Lucidi F., Kleinknecht A. 2010. Little Innovation, Many Jobs: An Econometric Analysis of the Italian Labour Productivity Crisis. *Cambridge Journal of Economics*, 34(3): 525-546

Mairesse J., Mohnen P. 2010. Using Innovations Surveys for Econometric Analysis. *NBER working paper*, 15857.

Marti J., Balboa M. 2001. Determinants of private equity in fundraising western Europe. *Working paper IVIE*, 15.

Mazzucato M. 2011. *The Entrepreneurial State.* Demos: London.

OECD 2010a. *High-Growth Enterprises: What Governments Can Do to Make a Difference*. OECD Studies on SMEs and Entrepreneurship, Paris.

OECD 2010b. *Measuring Innovation. A new perspective*, OECD Innovation Strategy, Paris.

Ortega-Argilés R., Potters L., Voigt P. 2009. R&D-intensive SMEs in Europe: What do we know about them? *IPTS Working Paper on Corporate R&D and Innovation*, 15.

Perez C. 2010. The financial crisis and the future of innovation: A view of technical change with the aid of history. *Tallin University of Technology Working Papers in Technology Governance and Economic Dynamics*, 28.

Revest V., Sapio A. 2010. Financing technology-based small firms in Europe: what do we know? *Small Business Economics*, online first 11 July 2010, DOI 10.1007/s11187-010-9291-6.

Santana Felix E.G., Gulamhussen M.A., Pires C. 2007. The determinants of venture capital in Europe – Evidence across countries. *CEFAGE-UE Working paper*, 01.

Scarpetta S., Tressel T. 2004. Boosting Productivity via Innovation and Adoption of New Technologies: Any Role for Labour Market Institutions. *World Bank Discussion Papers Series*, 3273.

Schertler A. 2003 Driving forces of venture capital investments in Europe: a dynamic panel data analysis. *Kiel Institute for the World Economy Working paper*, 1172.

Venn, D. 2009, Legislation, collective bargaining and enforcement: Updating the OECD employment protection indicators, *www.oecd.org/els/workingpapers.*

Annex

Country Level Information: variables and sources

In the following Table we report some basic information regarding the variable used for the country level analysis.

Table A1. Descriptive Statistics

Variable	**Source**	**Mean (Standard deviation)**
Early Stage Venture Capital (Share of GDP)	IUS – Eurostat	0.023 (0.027)
Expansion VC (Share of GDP)	IUS – Eurostat	0.071 (0.073)
Unemployment Rate	Eurostat	0.079 (0.037)
Business R&D (Share of GDP)	Eurostat	0.956 (0.692)
Public R&D (Share of GDP)	Eurostat	0.560 (0.225)
Market Capitalisation (Share of GDP)	Eurostat	72.368 (61.902)
Share of High Tech Services[12] (Share of Employment)	Eurostat	0.032 (0.002)
Long Run Real Interest Rate	OECD	0.027 (0.017)
Strictness of Employment protection (Index)	OECD	2.106 (0.781)
Product Market Regulation (Index)	OECD	1.755 (0.611)
Barriers to Entrepreneurship (Index)	OECD	1.770 (0.592)

[12] I64, K72 and K73

Employer Birth Rate	OECD	11.125 (2.678)
WBNew[13]	World Bank	4.002 (2.279)

The countries included are those belonging to EU-15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom), plus Bulgaria, Czech Republic, Hungary, Poland, Romania Slovakia and -outside Europe- Norway and Switzerland.

For the main variable the time window is 1995-2009, with a few exceptions:

a) Product market regulation and barriers to entrepreneurship indices are available only for three years (1998-2003-2008);

b) WBNew covers only the time window 2004-2008;

c) Birth is only available for the years 2007-2008.

[13] Number of newly registered Limited Liability Companies per 1000 working age people (15-64).

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Abstract

Financial constraints for young and small firms can prevent them from supporting innovation and employment creation. We analyze two of the various institutional mechanisms which have been proposed to circumvent it: the development of venture capital market and the stock market access. We will use the information provided by two Scoreboards - used to monitor innovative activity in Europe: the Innovation Union Scoreboard and the R&D Scoreboard. With the first, we study the determinants of the venture capital/GDP intensity in Europe. With the second, we try to assess the contribution of stock market to R&D investment. In the first part, we show that venture capital market complements structural feature such as R&D intensity and market capitalization, is more volatile and seems not affected by anticompetitive regulations. In the second part, we show that unlisted SMEs are more research intensive.

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