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The Determinants of Venture Capital: Additional Evidence

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Abstract:

This paper attempts to identify and evaluate the main determinants of venture capital (VC). We develop a theoretical model where macroeconomic conditions, technological opportunity, and the entrepreneurial environment affect the demand and supply of VC. The quantitative results, based on a panel dataset of 16 OECD countries from 1990 to 2000, show that VC intensity is pro-cyclical. Interest rates affect more the demand side of VC (entrepreneurs) than the supply side. Indicators of technological opportunity, such as the stock of knowledge and the number of triadic patents affect positively and significantly the relative level of VC. Labour market rigidities reduce the impact of the GDP growth rate and of the stock of knowledge, whereas a minimum level of entrepreneurship is required in order to have a positive effect of the available stock of knowledge on VC intensity.

Keywords: Venture Capital, Technological Opportuniy, Entrepreneurship, Labour Market Regidities

JEL-Classification: G24, O33, M13, C33

Non Technical Summary

The objective of this paper is to identify the main determinants of venture capital (VC). We develop a theoretical model where three main types of factors affect the demand and supply of VC: macroeconomic conditions, technological opportunity, and the entrepreneurial environment. The model is evaluated with a panel dataset of 16 OECD countries over the period 1990-2000. The results show that VC intensity is pro-cyclical. Short-term and long-term interest rates have a positive impact on VC intensity, which means that they affect more entrepreneurs than the supply of VC. Indicators of technological opportunity, such as the stock of knowledge and the number of triadic patents affect positively and significantly the relative level of VC. Labour market rigidities reduce the impact of the GDP growth rate and of the stock of knowledge, whereas a minimum level of entrepreneurship is required in order to have a positive effect of the available stock of knowledge on VC intensity.

Nicht-technische Zusammenfassung

Ziel des Diskussionspapiers ist die Bestimmung der wichtigsten Einflussfaktoren des Wagniskapitals. Wir entwickeln ein theoretisches Modell, bei dem die Nachfrage nach Wagniskapital und das Angebot an Wagniskapital im Wesentlichen durch drei Faktoren beeinflusst werden: die gesamtwirtschaftlichen Bedingungen, die technologischen Möglichkeiten und das unternehmerische Umfeld. Evaluiert wird das Modell anhand einer Reihe von Paneldaten aus 16 OECD-Ländern für den Zeitraum von 1990 bis 2000. Die Ergebnisse zeigen, dass die Wagniskapitalintensität prozyklisch ist. Kurz- und Langfristzinsen haben eine positive Wirkung auf die Wagniskapitalintensität. Dies bedeutet, dass sie die Unternehmer stärker als die Verfügbarkeit von Wagniskapital beeinflussen. Indikatoren der technologischen Möglichkeiten wie der Wissensbestand und die Anzahl triadischer Patente wirken sich positiv und signifikant auf das relative Niveau des Wagniskapitals aus. Rigiditäten am Arbeitsmarkt vermindern den Einfluss der BIP-Wachstumsrate und des Wissensbestands, während ein Mindestmaß an Unternehmergeist erforderlich ist, damit der verfügbare Wissensbestand einen positiven Effekt auf die Wagniskapitalintensität hat.

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1 Introduction

Venture capital (VC) is a financial intermediary that aims at fitting innovative start-up's needs, mainly because these firms are generally associated with large growth potentials and high levels of uncertainty. A growing number of scholars have documented the positive impact that venture funds have on the probability of success of start-ups, as well as on the growth of their sales and employees[1]. Most government bodies in industrialized countries now recognize the importance of VC as a factor of firm creation and sustainable growth. Access to finance is seen as a key factor in the process of R&D's translation into commercial outcomes. VC, as a specific type of finance for high-risk projects, has an important role to play in this translation. (OECD, 1996)

Despite this wide recognition of venture funds as key players underlying a country's entrepreneurial performances, there are huge differences across industrialized countries in the relative amounts invested in VC. VC intensity is relatively high in the USA and Canada for instance, whereas it is very low in Japan. The diversity of national financial systems is undoubtedly one important factor underlying these international differences. Black and Gilson (1998) find a linkage between countries' financial system and VC market. Active stock market is more appropriate to strong venture capital market than bank market because of the potential for VC exit through an IPO. An active VC market requires a liquid stock market.

Other factors also play an important role, as shown by Gompers and Lerner (1998), Jeng and Wells (2000) and Sherlter (2003). With a panel dataset of 21 countries Jeng and Wells show that labour market rigidities, the level of Initial Public Offerings

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1 See Engel (2002), Hellmann and Puri (2002), Kortum and Lerner (2000), Romain and van Pottelsberghe (2003) for empirical evidence on the economic impact of VC.

(IPO), government programs for entrepreneurship, and bankruptcy procedures explain a significant share of cross country variations in VC intensity.

The objective of this paper is to contribute to this recent stream of research in three ways. We first develop a theoretical model which takes into account the factors that affect the demand and supply of VC. These factors include the growth of GDP, short-term and long-term interest rates, several indicators of technological opportunity, and of entrepreneurial environment. Second, we exploit a panel dataset composed of 16 countries over an eleven years period. Third, we investigate to what extent the level of entrepreneurship and of labour market rigidities affect the impact of the GDP growth rate and the stock of available knowledge on VC intensity.

The results show that interest rates significantly influence VC intensity. The countries with lower labour market rigidities benefit from a higher impact of the GDP growth rate and the available stock of knowledge on the relative level of VC. Higher levels of entrepreneurship – i.e., the percentage of people being involved in the creation of nascent firms – induce a positive and significant relation between the R&D capital stock and VC intensity.

The paper is structured as follows: The next section summarizes the main findings of the few existing evaluation of the determinants of VC. A theoretical model of demand and supply of VC and the econometric model are developed in section 3. The empirical results are presented and interpreted in section 4. Section 5 concludes.

2 Literature review

Some articles have so far focused on the determinants of VC performance (Hege *et al*. 2003; Manigart *et al*. 2002). Hege *et al*. (2003) present a rigorous comparative study of the determinants of performance between the European VC industry and the US VC industry. They show that the US VCs perform better than the European ones under the two performance measures: type of exit and internal rate return of the financed project. There are several differences in the US and the EU behaviour. The use of convertibles and replacement of the entrepreneur as the syndication are more frequent in the US. Hege *et al.* suggest that either US venture capitalists are more sophisticated than their European counterparts, or the network effects are very important.

In the US, the origin of funds is not the same as in the EU. It has been widely accepted in the literature that VC investments in the US have been positively influenced by the clarification of the Employee Retirement Income Security Act (ERISA) "prudent man" rule of 1979. As a result pension funds started to invest substantial amounts of money into VC funds. In 1978 pension funds accounted for 15% of VC funds in the US and in the middle of the 80's, the share had risen to more than 50 %.

Behaviors may not be the only factor of differences between US and EU. The definition of VC may also have an impact on the performance analysis. Indeed, the European Venture Capital Association included management buy-outs (MBOs) and management buy-ins (MBIs) in the definition of the VC. In that matter, we decided to include in venture expenditures only seed, start-up and early stage capital and not replacement capital and buyout. By this way, we obtain the same definition of VC for each country.

To the best of our knowledge, however, only a few articles attempted to evaluate quantitatively the macroeconomic determinants of VC. Jeng and Wells (2000) develop a model aiming at identifying the determinants of VC and test it on a cross-section of 21 countries over a period of 10 years. Gompers and Lerner (1998) focus on the US economy over the period 1969-1994. Schertler (2003) analyses the driving forces of VC activity with data from 14 Western European countries for the time period 1988 to 2000. These main results are summarised in Table 1.

Table 1: Potential determinants of VC

	Gompers and Lerner (1998)	Jeng and Wells (2000)	Schertler (2003)
	US, 1972-1994	21 countries, 1986-1995	14 European countries, 1988-2000
Potential Determinants			
Initial Public Offering	No effect at aggregate level	+ Except for early stage funds	
Gross Domestic Product	+	Not significant	n.a.
Stock Market Opportunities[1]	+	Not significant	+ on early stage investments
Finance reporting standards	n.a	-	n.a.
Labour market rigidities	n.a.	Not significant for total VC investment but - for early stage funds	+ on early stage investments
Private pension funds	(Dummy for changes in ERISA's prudent man rule) +	(Level and growth of pension funds) *+ Over time but not across countries*	n.a.
Capital Gains Tax Rate	-	Not significant	n.a.
Level of interest rate	+ At aggregate level and – at state level	n.a.	n.a.
Industrial and academic R&D	(expenditures) +	n.a.	(number of employees) +
Number of Patent	n.a.	n.a.	Misspecification of the model

1. This variable is proxied by an indicator of market capitalization growth by Jeng and Wells (not significant, but probably correlated with GDP and IPO), by an indicator of equity market return by Gompers and Lerner (positive and significant) and by an indicator of stock market capitalisation by Schertler (positif on early stage investments).

According to Black and Gilson (1998), active stock market is important for strong venture capital market because of the potential for VC exit through an Initial Public Offering. IPO is considered as being a very important determinant of VC. It is the strongest driver of VC according to Jeng and Wells (2000) because it reflects the potential return to VC funds. Gompers and Lerner (1998) take it as a proxy for fund performance but cannot find any significant effect in their multivariate regressions. It seems that the IPO variable is strongly correlated with the expected return on alternative investments and with the Gross Domestic Product (GDP), which is also a proxy for exit opportunities. GDP and Market Capitalization Growth (MCG) are part of the impact of IPOs and therefore turn out to be not significant for Jeng and Wells (2000). However the reverse is true for Gompers and Lerner who find a positive and significant impact of Equity Market Return and GDP on VC but no impact of IPO. Higher GDP growth implies higher attractive opportunities for entrepreneurs, which lead to a higher need for venture funds. Schertler (2003) uses either the capitalisation of stock markets or the number of firms listed as measure of the liquidity of stock markets. He finds that liquidity of stock market has a significant positive impact on VC investments at early stages. However, as Jeng and Wells (2000), he finds that the growth rate of the stock market capitalisation does not have significant impact on VC investments at early stages.

For Jeng and Wells (2000), getting the basic legal and tax structures into place appears to be an important factor influencing VC. Gompers and Lerner (1998) also recognize the importance of government decisions on the private equity funds. The labour market legislation is typically put in place to protect employees from arbitrary, unfair or discriminatory actions by employers. Some authors argue that venture financing can suffer from the rigidity of the labour market in Europe (e.g. Ramón and Marti, 2001). Jeng and Wells (2000) show that it does not significantly influence total VC but affects negatively the early stage of VC investment. According to Shertler (2003), labour market rigidities are significant and positive. That can be the result of differences in the labour-capital ratio of high-technology enterprises. He also argues that high-technology enterprises operating in rigid labour markets may demand more capital than comparable high-technology enterprises operating in flexible labour markets.

With the clarification of the Employee Retirement Income Security Act (ERISA) "prudent man" rule of 1979, the share of money invested by pension funds had risen to more than 50 %. Jeng and Wells (2000) find that the level of investment by private pension funds in VC is a significant determinant of VC over time but not across countries. Gompers and Lerner (1998) use a proxy for the amendment of the "prudent man" rule to show the impact of pension regulation and reach a similar conclusion. After 1979, the additional capital provided by pension funds led to a dramatic shift in commitments to VC.

Concerning the impact of the Capital Gains Tax Rate (CGTR) on VC activity, Gompers and Lerner (1998) show that a decrease in CGTR has a positive and important impact on commitment to new VC funds. In fact, they confirm the result of Poterba (1989) who built a model of decision to become an entrepreneur. He found that decreases in CGTR might increase the raising of VC funds not through stimulation of the supply side (i.e., the potential fund providers) but rather on the demand side. Indeed, decreases in CGTR often encourage entrepreneurship and thus the desire of people to create their own firm and to engage in R&D activities. Anand (1996) also highlights the fact that the level and composition of investments appear to be negatively affected by increases in the CGTR but investments in one industry may be affected by myriad of other factors like technology shifts, tastes, etc.

Both industrial and academic R&D expenditures are significantly related to venture capital activity at the State level in the model of Gompers and Lerner (1998). For them, the growth VC fundraising in the mid-1990s may be due to increases in technological opportunities. Shertler (2003) tests the number of employees in research and development and the number of patents as the approximation of the human capital endowment. He finds a positive impact of the number of R&D employees. Also, he highlights that the coefficients of the patent variable are positive and highly significant. However, there is a misspecification in the model due to the low number of observations because patent data are not available for 1999 and 2000.

Interest rates might also be an important factor influencing VC. Although Jeng and Wells (2000) do not take this factor into account into their cross country investigation, Gompers and Lerner (1998) show that it affects positively the demand for

VC funds in the US. Economic theory would suggest a reverse relationship: if interest rates rise, the level of investment should fall. The positive impact estimated by Gompers and Lerner is probably due to the fact that they use a short-term interest rate. If short-term interest rates increase, the attractiveness of venture financing versus credit through usual financial institutions increases from the entrepreneur's viewpoint.

Concerning government programs for entrepreneurship, a main rationale of direct government intervention in the VC industry is the stimulation of economic growth. Manigart and Beuselinck (2001) find some evidence that a good economic climate, high stock market returns and a high number of IPO would lead to a lower supply of government funds to the VC industry.

Some scholars have also focused on the micro determinants of VC. For Gompers and Lerner (1998) the individual firm performance and reputation, measured with the firm age and size, positively impact the capacity to raise larger funds. Hellmann and Puri (2000) use a probit model to show that the strategy of a company is one of the determinants of VC investment when controlling for the age of the company and its industrial sector. If the strategy is an innovative one (the company is the first to introduce a new product or service on the market), it has a higher probability to benefit from VC compared to companies that follow an imitation strategy (the company uses existing technologies to develop and improve products and processes). They also find that innovating companies are able to raise VC earlier in their life cycle than companies with a strategy of imitation. In other words, their analysis suggests that VC is stimulated by technological opportunities. However there is less evidence of such a relationship at the aggregate macroeconomic level.

In a nutshell, there are several potential determinants of VC. Some of them can be measured qualitatively or quantitatively at the macro level whereas others like the fund reputation and the strategy of the venture funded firms are microeconomic factors. In the next section we develop a theoretical model that takes into account the various macroeconomic factors that might affect the demand and supply of VC.

3 Modelling the amount of Venture Capital

As Poterba (1989) and Gompers and Lerner (1998), we argue that changes in the level of VC funds come from changes either in the supply or the demand of VC. The demand comes from the entrepreneurs interested in setting up an innovative start-up. The supply of VC corresponds to the share of risk capital provided by private investors, pension funds and banks. The actual amount of VC invested represents the equilibrium between the demand and the supply of VC.

The demand and supply of VC can be modelled through equations (1) and (2) that characterize the demand price of VC, P^d, and the supply price of VC, P^s, respectively. The supply price of VC is assumed to be a positive function of the available VC funds, the interest rate (r) and the corporate tax rate (TAX). The more VC is available on the market, the higher will be the supply price of VC, due to increasing marginal costs ($a_{vc}>0$). If interest rates increase we can expect the fund providers to increase their return requirement ($a_r>0$; otherwise they would opt for alternative investments opportunities). Similarly, an increase in the corporate income tax rate would increase the return requirements ($a_{tax}>0$).

$$P^{s}{}_{VC} = a_C + a_{vc} VC + a_{tax} TAX + a_r r \quad (1)$$

$$P^{d}{}_{VC} = b_C + b_{vc} VC + b_{\hat{Y}} \hat{Y} + b_{to} TO + b_{en} EN + b_{tax} TAX + b_r r \quad (2)$$

The equation of the demand price of VC reflects the entrepreneurs' viewpoint. Decreasing marginal returns to VC is assumed (the projects with the largest expected returns are selected first). The more VC is available the lower is the demand price of VC (bvc<0). The other factors that are assumed to influence the demand of VC are the GDP growth (Y), technological opportunities (TO), entrepreneurial culture (EN), the level of corporate income tax rate (TAX) and interest rates (r). The countries with a high GDP growth, large technological opportunities and a strong entrepreneurial culture are more likely to be associated with a strong demand for VC (and hence positive effects on the demand price of VC: bY>0; bTO>0; bEN>0). The general level of taxation will

probably reduce the rate of entrepreneurship (the demand for VC and therefore btax<0). Concerning interest rates, we consider that innovative start-up's need important amounts of money in the short-term. Therefore if the cost of capital increases entrepreneurs are more likely to switch from the banking sector to the venture fund providers (br>0).

Equations (3) and (4) show the equilibrium level of VC that equalizes the supply and demand of VC.

$$(a_{vc} - b_{vc})VC = (b_C - a_C) + b_{\hat{Y}}\,\hat{Y} + b_{to}\,TO + b_{en}\,EN + (b_{tax} - a_{tax})\,TAX_{it} + (b_r - a_r)\,r \tag{3}$$

$$\begin{cases} a_{vc} > 0 \rightarrow \\ b_{vc} < 0 \rightarrow \\ (a_{vc} - b_{vc}) \rightarrow \end{cases}$$

where
- increasing marginal cost of VC Investment
- decreasing marginal return
- always positive

$$VC = \left[\frac{(b_C - a_C)}{(a_{vc} - b_{vc})}\right] + \left[\frac{b_{\hat{Y}}}{(a_{vc} - b_{vc})}\right]\hat{Y} + \left[\frac{b_{to}}{(a_{vc} - b_{vc})}\right]TO + \left[\frac{b_{en}}{(a_{vc} - b_{vc})}\right]EN + \left[\frac{(b_{tax} - a_{tax})}{(a_{vc} - b_{vc})}\right]TAX + \left[\frac{(b_r - a_r)}{(a_{vc} - b_{vc})}\right]r \tag{4}$$

Since the denominator is always positive, the numerator provides the expected sign of the parameters between brackets. All the right-hand side variables, except the level of taxation and the interest rate, are expected to have a positive impact on VC. For the interest rate (r), the impact is either negative or positive depending on the difference between the demand price effect and the supply price effect. If the demand price effect of a high interest rate is larger than its supply price effect, then the overall impact of interest rates on VC should be positive. The effect of the level of corporate income tax rate on the equilibrium level of VC will always be negative since ($b_{tax} - a_{tax}$) is always negative.

The empirical implementation of equation (4) is presented in equations (5) and (6). The growth rate of GDP allows testing the cyclicality of VC. Regarding interest rate we suspect that short-term and long-term interest rates could affect differently the venture fund providers and the 'high-tech' entrepreneurs. We therefore plan to use a

short-term interest rate (one year, r^{ST}), a long-term interest rate (ten years, r^{LT}) and the spread (difference between short-term and long-term) in the empirical model. Technological opportunity is proxied by three variables, the growth rate of business R&D outlays, the business R&D capital stock and the number of triadic patents[2]. The growth rate of business R&D expenditures represents the research dynamics of a country. The business R&D capital stock is an indicator of the available stock of knowledge (or of the cumulated innovative efforts). The number of triadic patents is an indicator of innovative output. It measures the number of highly valuable inventions invented in each country (it is counted by country of inventor and by priority year).

The entrepreneurial environment can be measured with three variables: the level of taxation, the level of entrepreneurial activity and labour market rigidities. Further variables like shareholder rights, legal protection, accounting standards could be included, but due to non-availability of the data, we could not test these variables. The level of taxation is measured with the corporate income tax rate (CITR). The measures of entrepreneurial activity (TEA) and labour market rigidity (RIG) are indices that are available for one year in our database. We therefore introduce them in interaction with other variables. For instance, we test whether RIG would affect the impact of GDP growth rate on the intensity of VC. This is equivalent to test whether the impact of GDP growth rate on VC intensity is composed of a fixed component ($\beta^{c}{}_{\Delta\, gdp}$) and a component that varies across countries according to the level of labour market rigidities (i.e., $\beta_{\Delta\, gdp} = \beta^{c}{}_{\Delta\, gdp} + \beta_{rig}\, \Delta$ GDP). Similarly, labour market rigidity (RIG) and the level of entrepreneurship (TEA) might affect the impact of the available stock of knowledge, SBRD, on VC. These interactions are illustrated in equation (6).

Model with no interaction

$$VC_{it} = \beta_{\Delta gdp}\, \Delta GDP_{it} + \beta_{r}\, r_{it} + \beta_{\Delta brd} \Delta BRD_{it-1} + \beta_{sbrd} SBRD_{it-1} + \beta_{pat} LPAT_{it-2} + \beta_{citr} CITR_{it} + \sigma_{G}\, G + \phi_{i} + \varphi_{t} + \mu_{it} \quad (5)$$

[2] The objective of this paper is not to provide evidence on the causality issue between VC and technological opportunities. We know that there is interaction between these variables but here we would like to test the impact of the growth rate of business R&D outlays, the business R&D capital stock and the number of triadic patents on VC intensity.

Model with interactions with TEA and RIG

$$VC_{it} = \beta_{\Delta gdp}\ \Delta GDP_{it} + \beta_r\ r_{it} + \beta_{sbrd} SBRD_{it-1}\ \beta_{citr} CITR_{it} + \beta_{rig}(\Delta GDP_{it} * RIG_i) + \beta_{tea}\ (SBRD_{it-1} * TEA_i) + \sigma_G\ G + \phi_i + \varphi_t + \mu_{it} \qquad (6)$$

where Δ represents the first logarithmic difference and *L* the natural logarithm. In this equation, the parameters that are to be estimated are assumed to be constant across countries and over time; they are defined as follows (the expected signs are presented between parentheses):

$\beta_{\Delta\ gdp}$ The impact of GDP growth (+).

β_r The impact of interest rate (?).

$\beta_{\Delta\ brd}$ The impact of business R&D expenditures growth rate (+).

β_{sbrd} The impact of the level of business R&D capital stock (+).

β_{pat} The impact of the number of triadic patents (+).

β_{rig} The impact of labour market rigidities on $\beta_{\Delta\ gdp}$ (-) or on β_{sbrd} (-).

β_{tea} The impact of the level of entrepreneurship on β_{sbrd} (+).

β_{citr} The impact of the CITR (-).

A range of control variables is included in all the regressions.

G is a dummy equal to 1 for Germany in 1991, and 0 otherwise; in order to take into account the exogenous shock of the German unification.

ϕ_i are country dummies which take into account country-specific framework conditions that might affect VC intensity.

φ_t are time dummies which take into account exogenous shocks that are common to several countries, such as changes in exchange rates.

The variables (for country *i* and time *t*) are defined as follows:

VC is the venture capital intensity, i.e. the VC funds divided by GDP (Sources: EVCA and OECD)[3].

GDP is the gross domestic product (Source: OECD, Main Science and Technology Indicators).

r is the one-year national deposit interest rate (Source: IMF) or the long-term national interest rate (10 years, Source: OECD).

BRD is the business R&D expenditures (Source: OECD, Main Science and Technology Indicators).

SBRD is the business R&D capital stock. It has been computed using the perpetual inventory method from total intramural business R&D expenditures, in constant 1990 GDP prices and US PPPs (see appendix 1). The depreciation rate is 15%. Sensitivity analysis show that the results of the regressions do not change significantly with the chosen depreciation rate (Guellec and van Pottelsberghe, 2001 and 2004) (Source: OECD Main Science and Technology Indicators).

PAT is the number of Triadic patents. These patents have been applied at the USPTO, the Japanese Patent Office and the European Patent Office. We can therefore assume that they reflect patents with a very high value (Source: OECD, Main Science and Technology Indicators).

RIG is the employment protection index drawn up by the OECD (1994a) and based on the strength of the legal framework governing hiring and firing of employees. It is a measure of labour market rigidities. The countries are ranked from 1 to 20 with 20 being the most strictly regulated. Since the indicator is fixed over time, it is introduced in interaction with GDP and SBRD.

TEA is the Total Entrepreneurship Activity (TEA)-index computed by adding the proportion of adults involved in the creation of nascent firms and the proportion involved in new firms (Source: The Global Entrepreneurship Monitor 2001). The variable is a ranking from 1 to 20. This measure of entrepreneurial activity

[3] In this paper, in order to have the same definition of VC for each country, venture expenditures include only seed, start-up and early stage capital and do not include replacement capital and buyout.

can be meaningfully used for international comparisons. Since the indicator is fixed over time, it is introduced in interaction with SBRD.

CITR is the corporate income tax rate (Source: OTPR - Office of Tax Policy Research).

The estimates are performed with a panel data set of 16 OECD countries over the period 1990-2000[4]. These 16 countries are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, United Kingdom and United States. The period can vary across countries based on availability of information. Descriptive statistics of all the variables are presented in Table 2. The average value of the dependent variable (VC intensity) varies from 0.02 percent in Denmark and Japan, to 0.18 percent in Canada, as shown in the last column.

[4] The time period examined could be biased by an extraordinary environment (i.e. Stock market bubble in the late 90s, declining interest rate level). Theoretically, we would have control for this bias by expanding the time period, but due to non-availability of data we cannot.

Table 2: Descriptive statistics (%)

Country	Period	GDP[1]	Business R&D invest.[2]	Business R&D capital stock[2]	Number of Patents*[2]	One-year Interest rate[2]	Long-Term Interest rate[2]	Corporate Income Tax Rate[2]	Level of entrepre-neurship[2]	Labour market rigidities[2]	VC Intensity (GDP)[3]
Australia	1995-1998	3.47%	-4.64%	5.79%	6.87%	-13.95%	-15.67%	0.35	15.2	4	0.09
Belgium	1990-1998	1.68%	5.28%	3.72%	6.77%	-8.51	-9.09%	0.39	4.5	17	0.06
Canada	1995-1999	3.49%	3.83%	4.93%	10.47%	-8.97%	-8.96%	0.38	12.2	3	0.18
Denmark	1990-1999	2.25%	6.95%	7.18%	7.11%	-12.31%	-8.21%	0.36	7.6	5	0.02
Finland	1990-2000	2.44%	9.84%	8.33%	12.36%	-14.16%	-8.42%	0.26	12.5	10	0.06
France	1990-2000	1.88%	1.37%	2.70%	0.89%	-5.23%	-5.92%	0.34	5.0	14	0.07
Germany	1990-1999	2.87%	0.59%	1.52%	4.23%	-11.19%	-7.07%	0.41	6.9	15	0.05
Ireland	1990-2000	7.42%	14.21%	14.37%	5.99%	-33.91%	-6.09%	0.37	9.1	12	0.08
Italy	1990-2000	1.74%	0.62%	2.35%	1.20%	-12.25%	-8.49%	0.36	8.1	20	0.04
Japan	1994-1998	0.94%	4.86%	3.55%	5.83%	-36.87%	-22.91%	0.38	5.7	8	0.02
Netherlands	1990-2000	3.21%	3.01%	2.26%	3.63%	-1.35%	-4.89%	0.35	6.4	9	0.15
Norway	1990-1999	3.10%	3.50%	3.31%	10.41%	-6.32%	-7.11%	0.28	10.9	11	0.07
Spain	1990-1999	2.37%	1.23%	4.16%	4.83%	-17.67%	-11.77%	0.35	6.6	19	0.04
Sweden	1990-2000	1.93%	8.21%	6.33%	10.11%	-14.19%	-8.58%	0.30	6.6	13	0.07
United Kingdom	1990-2000	2.42%	0.12%	0.97%	2.99%	-12.07%**	-7.68%	0.33	6.9	7	0.13
United States	1990-1999	3.11%	3.71%	2.96%	3.05%	-4.61%	-4.52%	0.35	16.7	1	0.12

[1] Yearly average growth rates

[2] Average

3 % Shares

* The data “Number of Triadic Patent” are not available after 1998.

** Between 1990-1998.

Sources: OECD, MSTI, EVCA and own calculations

4 Empirical results

Each variable of equation (5) has first been included separately in the empirical model. The estimated parameters are presented in Table 3. All variables have the expected impact as far as their sign and significance are concerned. Results concerning the growth rate of GDP (Table 3, column 1) are in line with those of Gompers and Lerner (1998) for the USA but do not confirm the non-significant impact obtained by Jeng and Wells (2000). Several tests have been carried out in order to determine whether a time lag is necessary. However, only the contemporaneous GDP growth rate has a significant impact on VC intensity.

Both one-year and ten-year interest rates have a positive and significant impact, suggesting that the demand effect of interest rates is stronger than the supply-side effect. Since entrepreneurs must have a shorter vision of financial constraints (or return) than fund providers, we would have expected a negative impact of the long-term interest rate. It is worth mentioning that the adjusted R-squared is the smallest with the ten-year interest rate. Column 4 of Table 3 reports the impact of the difference between the long-term and short-term interest rates (spread). The negative and significant impact suggests a stronger supply-side effect. What matters is not only the level of the long-term interest rate but also the difference between the long-term and short-term rates. The larger this difference, the less venture fund providers would be attracted towards risky investment. In the 90s the level of interest rates decreased in most countries, but VC market boomed. It may be perhaps explained by a statistically significant negative relationship. To ensure that the results are robust over the business cycle and thus control this bias, we need to test our regressions on a longer period (e.g. 20 years). Unfortunately, we could not proceed to this exercise because of the non-availability of data.

The three variables representing technological opportunity and research efforts play a significant role in determining VC intensity. The strong and positive impact of the growth rate of business R&D expenditures, the business R&D capital stock and the number of triadic patents show that the demand of VC is sensitive to the dynamics of research activities, to the available stock of knowledge and to the level of innovation output, as proxied by the number of high value patents.

Table 3: Estimation results of the VC intensity, single explanatory variables

		Dependent variable: VC intensity (VC/GDP)							
		GLS	GLS	GLS	GLS	GLS	GLS	GLS	GLS
Regressions		1	2	3	4	5	6	7	8
Economic variables									
GDP growth rate	ΔGDP_{it}	0.002*** (2.74)							
One-year Interest rate	r_{it}		0.00005*** (4.13)						
Long-Term Interest rate (10 years)	r_{it}			0.00009*** (3.90)					
Log [r10/r1]	r_{it}				-0.0001*** (-2.87)				
Technological opportunity									
Business R&D investment growth rate (t-1)	ΔBRD_{it-1}					0.001*** (2.88)			
Business R&D capital stock (t-1) (*10^{-14})	$SBRD_{it-1}$						1.33*** (4.57)		
Log Number of triadic Patents	$LPAT_{it-2}$							0.0003** (2.24)	
Entrepreneurial environment									
Corporate Income Tax Rate	$CITR_{it}$								0.0004 (1.20)
Control variables									
German reunification dummy (t)		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific intercept		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared		0.897	0.916	0.819	0.906	0.900	0.895	0.901	0.912

Note: Panel data, 16 OECD countries, 1990-2000, 154 observations. * Indicates the parameters that are significant at a 10% probability threshold, ** 5% probability threshold and *** 1% probability threshold. The econometric method is GLS.

The two variables that yield the highest adjusted R-squared are the short-term interest rate, the difference between the long-term and short-term interest rates. Then come the GDP growth rate and the technological opportunity variables. The short-term cost of money and technological opportunity seem to be the strongest drivers of VC. The adjusted R-squared is the smallest with the long-term interest rate. Corporate income tax rate has no impact on the VC intensity.

Table 4 presents the results of the estimates with several variables introduced simultaneously in the model[5]. The sign and significance of the impact of all these variables remain unchanged when they are introduced simultaneously in the model except for the business R&D investment growth rate.

Columns 1 to 3 present the basic model described in equation (5), with different indicators for the interest rates. The GDP growth in column 1 is still significant, whereas in column 2, it is less significant, probably due to the simultaneous introduction of the long-term interest rate in the model. The difference between short-term and long-

[5] The Durbin-Watson statistic is used to test the presence of autocorrelation in the residuals of our regression equations. The formula for the statistic where d = Durbin-Watson Statistic, e = residual and t = time period counter is: $d = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n}(e^2)}$ The 5% critical value for the true distribution of d must lie to the right of the critical value of d_l and to the left of critical value of d_u. Therefore, the test that may be carried out is: We do not reject H_0 if $d > d_u$. We reject H_0 if $d < d_l$. No conclusion is drawn if $d_l \leq d \leq d_u$.
In this paper, we can imagine that there is autocorrelation but our data are included in the Durbin and Watson bounds test presented in the paper of Savin and White (1977) so no conclusion can be given.

Table 4: Estimation results of the VC intensity, complete model and interactions

		Dependent variable: VC intensity (VC/GDP)							
		GLS	GLS	GLS	GLS	GLS	GLS	GLS	GLS
Regressions		1	2	3	4	5	6	7	8
Economic variables									
GDP growth rate	ΔGDP_{it}	0.002*	0.002	0.002*	0.003***	0.009***	0.002**	0.002**	0.009***
		(1.67)	*(1.50)*	*(1.64)*	*(3.17)*	*(3.68)*	*(2.07)*	*(2.46)*	*(3.72)*
One-year Interest rate	r_{it}	0.0004**			0.00005***	0.00004***	0.00005***	0.00005***	0.00004***
		(2.35)			*(3.01)*	*(2.56)*	*(3.51)*	*(3.54)*	*(2.99)*
Long-Term Interest rate (10 years	r_{it}		0.00007***						
			(2.95)						
Log [r10/r1]	r_{it}			-0.0001***					
				(-2.49)					
Technological opportunity									
Business R&D investment growth rate (t-1)	ΔBRD_{it-1}	0.0006*	0.0005	0.0005$^{\nabla}$					
		(1.68)	*(1.39)*	*(1.48)*					
Business R&D capital stock (t-1) (*10^{-14})	$SBRD_{it-1}$	1.43***	1.32***	1.44***	1.23**	1.07***	1.36***	-1.42**	-1.23**
		(4.47)	*(4.05)*	*(4.69)*	*(3.99)*	*(3.43)*	*(3.92)*	*(-2.40)*	*(-2.19)*
Log Number of triadic Patents	$LPAT_{it-2}$	0.0003**	0.0004***	0.0003***					
		(2.31)	*(2.93)*	*(2.52)*					
Entrepreneurial environment									
Corporate Income Tax Rate	$CITR_{it}$	-0.0002	0.0004	-0.0002	0.00002	0.00004	-0.0003	-0.0002	-0.0001
		(-0.50)	*(1.19)*	*(-0.75)*	*(0.07)*	*(0.12)*	*(-0.80)*	*(-0.60)*	*(-0.48)*
Labour Market Rigidities	$\Delta GDP_{it} * RIG_i$					-0.0006***			-0.0006***
						(-2.69)			*(-2.99)*
Labour Market Rigidities (*10^{-14})	$SBRD_{it-1} * RIG_i$						-1.35***		
							(-2.53)		
Level of entrepreneurship (*10^{-15})	$SBRD_{it-1}$ *							1.70***	1.51***
								(3.90)	*(3.53)*
Adjusted R-squared		0.939	0.927	0.930	0.939	0.939	0.898	0.933	0.945

Note: Panel data, 16 OECD countries, 1990-2000, 154 observations. * Indicates the parameters that are significant at a 10% probability threshold, ** 5% probability threshold and *** 1% probability threshold. The econometric method is GLS. All Regressions with German reunification dummy (t), country-specific intercept and time dummies

term interest rates has a significant and negative impact (column 3). It seems therefore that the short-term and long-term cost of capital and their difference play an important role in explaining the intensity of VC. These results witness a stronger influence of the cost of capital on the demand side (entrepreneurs) than on the supply side (investors). However, the larger the difference between long-term and short-term interest rates, the lower the VC intensity, suggesting a stronger influence of the spread on the supply-side of VC.

The parameters associated with the business R&D capital stock and the number of triadic patents are positive and significant. This result about triadic patents is consistent with the results of Kortum and Lerner (1998) or Tykvova (2000) who show that a surge of patents may increase the VC fundraising. In other words, the property of highly valued intellectual assets (triadic patents are associated with a much higher value than the patents applied only in one country or region) seems to stimulate the demand for VC.

The remaining columns test other specifications described in equation (6), with two interaction variables representing a country's entrepreneurial environment. The index of labour market rigidities is first interacted with the GDP growth rate variable (see column 5). The results suggest that the impact of GDP growth rate on the VC intensity is composed of a fixed and significant component (0.0092) and a country specific component that depends on labour market rigidities (-0.00057). The positive impact of GDP on the VC intensity is therefore reduced in countries with high labour market rigidities. Jeng and Wells (2000) obtain a similar result but only for early stage funding. Over the threshold of 16.1 in the index of labour market rigidities, the impact of GDP growth becomes negative. Column 6 presents the estimated parameters related to the interaction between labour market rigidities and the stock of business R&D. Again, we find a negative and significant impact of the interaction term.

The level of entrepreneurship is interacted in a similar way with the stock of available knowledge (the R&D capital stock, in column 7). Estimates indicate that the impact of the R&D capital stock on the VC intensity is composed of a fixed negative component and a country specific component that depends on the relative level of entrepreneurship (TEA): the higher the level of entrepreneurship, the stronger the

impact of the business R&D capital stock on VC intensity. In order to have a positive impact of the available stock of knowledge on VC performances, a minimum level of entrepreneurship is required. The estimated parameters suggest that the impact of the business R&D capital stock on the VC intensity becomes positive and significant above a threshold of 8.4 in the TEA index (level of entrepreneurship).

The estimated parameters associated with the interaction between the two country-specific variables representing the entrepreneurial environment are stable. Column 8 shows that the simultaneous introduction of the two indicators (RIG and TEA) yields jointly significant parameters. Figure 1 illustrates the results of the estimates presented in table 4 (column 5 and 6). It shows how the level of labour market rigidities affects the impact of two determinants of VC. The effect of the rigidities on the impact of the stock of knowledge (SBRD) and of the GDP growth rate decrease with an increase of labour market rigidities. They become negative over a threshold of 10 and 16 respectively.

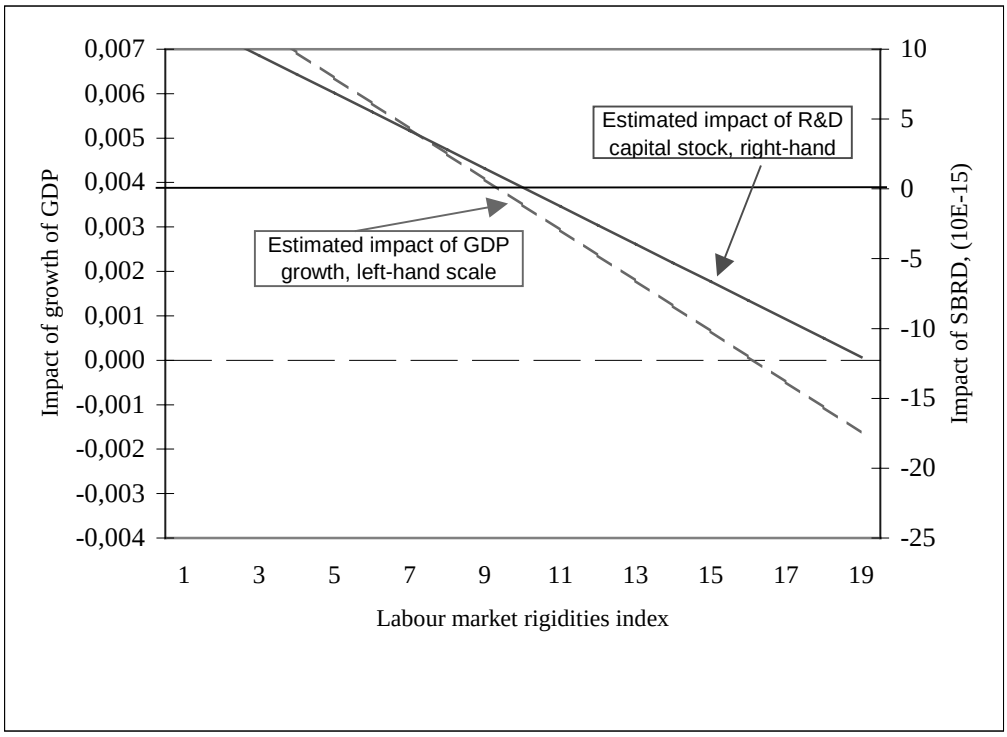
Table 5 summarizes the main findings of our empirical investigation and compares them with the results obtained by Jeng and Wells (2000) and Gompers and Lerner (1998). The cyclicality of VC with respect to GDP growth confirms both our expectation and the results of Gompers and Lerner (1998). Jeng and Wells (2000) did not find any significant effect partly because of the structure of their dataset (cross section of countries) and partly because of the use of the IPO variable.

Concerning the cost of capital, we confirm the positive impact of the short-term interest rate obtained by Gompers and Lerner (1998) at the aggregate level. We also show that the difference between the long-term interest rate and the short-term interest rate has a negative and significant impact on the VC intensity.

Table 5: Comparison of our results with the state of the art

	Jeng and Wells (2000), 21 countries, Panel data and cross section	Gompers and Lerner (1998) US industry aggregate data	Our analysis 16 countries, panel data
Macroeconomic conditions			
Gross domestic Product	0	+	+
Interest rate 1 year		+ at aggregate level and – at state level	+
Interest rate 10 years			+
Difference between 10 years and 1 year Interest rate			-
Private Pension Funds	+ Over time 0 Across countries	+ Over time	
Entrepreneurial Environment			
Taxation rate	0	-	0
Labour market rigidities	- at the early stage 0 at expansion stage		- (This variable reduces the impact of GDP and R&D on VC)
Initial Public Offering	0 at early stage across countries + at expansion stage	0	
Stock Market Opportunities	(Market Capitalization Growth)	(Equity Market Return).	
Level of entrepreneurship	0	+	+ Increases the impact of R&D on VC
Technological opportunity			
Number of Triadic Patents			+
Business R&D growth		+	+
Stock of knowledge		+	+

Figure 1: The indirect effect of labour market rigidities on VC



Note: Estimated impact of the growth rate of GDP and the stock of knowledge on VC intensity, according to the level of labour market rigidities. See table 4, columns 5 and 6.

Labour market rigidities reduce the intensity of VC. On the other hand, a strong entrepreneurial culture and more intense technological opportunities and research efforts improve the positive effect of the stock of knowledge on the VC intensity.

5 Concluding remarks

This paper aims at contributing to the literature on the determinants of VC. Our contribution consists in (1) developing a theoretical model that takes into account the supply-side and demand-side variables to explain VC intensity; and (2) introducing simultaneously traditional determinants of VC and new potential determinants like the cost of capital, the level of entrepreneurship, and novel proxies aiming at measuring technological opportunity. The empirical results can be summarized as follows.

Interest rates have a significant impact on VC intensity. Whereas short-term and long-term interest rates influence positively the relative level of VC via a strong

demand-side effect, the difference between long-term and short-term interest rates has the opposite impact, via a stronger supply-side effect.

VC is pro-cyclical. It follows a similar evolution than GDP growth rate. In periods of high growth, the flow of venture capital outperforms the GDP growth rate, and *vice versa*. This cyclicality is reduced by the degree of labour market rigidities. A high level of labour market rigidity reduces the positive impact of GDP growth on VC intensity, as well as the positive impact of the knowledge capital stock on VC.

We also show that indicators of technological opportunity, such as the growth rate of R&D investment, the available stock of knowledge and the number of high value patents (triadic patents), influence significantly a country's investment in VC. The positive impact of the stock of knowledge is strongly reinforced in the countries were the rate of entrepreneurship is very high.

One important policy implication that emerges from these results is that in order to stimulate VC in a country, demand-side factors have to be taken into account. The most important factors affecting the demand of VC are the stock of knowledge, innovative outputs, and interest rates. In addition, labour market rigidities and the level of entrepreneurship do play an important role. Changing these factors would require adjustment in structural policies (labour market and education), whose impact can only appear in the long term.

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APPENDIX: Calculation of the variables

Business R&D capital stocks

R&D capital stocks are calculated following the perpetual inventory method. The stock at time *t* is equal to the new investment at time *t* plus the stock at time *t-1* minus depreciation:

$$SR_t = r_t + (1-\delta)SR_{t-1} \quad \text{(A1.1)}$$

$$SR_t = r_t + (1-\delta)r_{t-1} + (1-\delta)^2 r_{t-2} + (1-\delta)^3 r_{t-3} + ... \quad \text{(A1.2)}$$

To construct the initial stock we assume a constant annual rate of growth of the past investments,

$$SR_t = r_t + (1-\delta)\lambda r_t + (1-\delta)^2 \lambda^2 r_t + (1-\delta)^3 \lambda^3 r_t + ... \quad \text{(A1.3)}$$

$$SR_t = \frac{r_t}{1-\lambda(1-\delta)} \quad \text{(A1.4)}$$

here SR_t = R&D capital stock at time *t*.

r_t = R&D investment at time *t*.

δ= Depreciation rate (constant over time).

$\lambda = \frac{1}{1+\eta}$ and η is the mean annual rate of growth of r_t .

This formula has been used to calculate the Business R&D Capital Stock (SBRD).

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