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Financial Systems and Private Innovation Activity. A Research for OECD Countries

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ABSTRACT: This research shows the effect that financial markets development has on R&D private investment of OECD countries. The main porpoise of this research is to help policy makers to generate effective policies to spur innovation, especially in underdeveloped countries. Data used on this research comes from World Bank and Unesco for the period 2000-2016. Used methodology is a dynamic panel data in which macroeconomic, financial, innovation and structural variables are included. It was found that stock markets development is positively related with private expenditure on R&D, but bond markets are negatively related with it. Simultaneously, low inflation and stable exchange rates are positively related with R&D. This is a novel research given that we show that an effective innovation policy for private firms, should be accompanied of policies aimed to deepening financial markets as a way to spur investments on R&D.

KEYWORDS: Financial systems, stock markets, credit markets, R&D, innovation

Introduction

Innovation activity is uncertain and is affected by market failures on a deepest way than other type of firm activities, this causes that available financial sources for this type of ventures tend to be reduced and costly, increasing the financial cost of R&D and innovation projects. At the same time, innovation is a probed source of business growth and economic development, and therefore, one could think that governments around the world should develop strong policies in order to support R&D private financing to diminish market failures faced by firms trying to enroll on R&D&I activities. In line with this, the development of strong institutions and systems created to support the financing of R&D&I is fundamental to generate firms and economic growth.

At the same time, development of strong financial systems has been proved to be related with economic development; healthy, deep and well-regulated financial systems are related with regional and national growth. An explanation for this fact is that firms finding financial sources adjusted to their needs could deal with lower costs related to funding, and therefore, tend to be more profitable and generate economic growth.

Our hypothesis is that the development of strong financial markets on OECD countries tend to benefit the private investment on R&D and therefore, countries around the world need to develop policies to strengthen financial institutions if they want to be more competitive from the technological point of view.

The relationship between finance and innovation

The relationship between finance and innovation has been known for a long time now; since the seminal work of Schumpeter, innovation studies have tried to show the details of this connection, however, we still not fully understand the relationship between these two worlds. However, there are some examples of subjects that we know about this topic.

First, there are factors hampering private business expenditure on innovative activities. This issue has been researched since the seminal works of Nelson (1959) and Arrow (1972); in general, private investment on innovation is highly risky from the financial point of view, mostly because it requires high levels of cash flow, is a costly long-term venture, is highly uncertain, and sometimes produces outcomes that are intangible. Those factors are caused by market failures like information asymmetry and the impossibility of full outcomes appropriation; those market failures elevate the

risk and costs of innovation ventures relative to investments based on traditional capital assets (Hall and Lerner 2009).

At the same time, firms trying to implement innovation venture face strong impediments trying to raise money from internal and external sources. First, internal funds are scarce and sometimes available cash flow has to be used to cover other types of expenditures, especially if a company is cash restrained (Brown, Fazzari, and Petersen 2009), as is the typical case in young and small firms (Hall and Lerner 2009). In addition, innovative firms trying to raise money from external sources face high financial direct and sunk costs given the intangible nature of innovation and its uncertainty characteristics, therefore, a company facing internal and external restrictions could be taken to a situation where it has no internal or external funding for its R&D&I projects.

Second, some academics have proposed that differences in innovative inputs within countries may be due to the different organizational and institutional mixtures and relationships present in innovative markets across countries. For economies in which the private investment in R&D&I is low, it is consistent to think that the development of strong organizations backing up innovation is necessary, in that sense, one of the main functions of those organizations and institutions is to ease the way in which firms and more generally, the market, perceive and face impediments to innovation. This academic approach began with the seminal work of Freeman (1987; 1995), Lundvall (1999; 2010), and Nelson (1993); for Freeman, these relations are framed in what is known as the National Systems of Innovation (NSI), that he defined as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". In the same way, Edquist (2011), proposes that one of the fundamental activities of NSIs is the financing of private innovation activities facilitating commercialization and adoption of technologies; for countries with low amounts of private R&D expenditures, it is possible that some of the institutional and organizational framework already established in developed countries, still need to be generated. This is, an adequate form of institutional network directed to finance innovation, need to be developed. In this context, the study of the relationship of financial systems and finance of innovation, could give some clues about the policy actions related with the development of innovation and financial systems.

Financial systems and innovation

The study of the relationship between financial systems and innovation is not wide. Even when literature about NSI tends to highlight the fundamental role of financial institutions to generate innovations, there are few attempts to develop a holistic theory about this topic. However, there are some examples of researchers working on it.

Authors like Hsu, Tian, & Xu (2014), show that countries in which stock markets are strong, tend to have higher growths on innovation expenditures, at the same time, those authors highlight the importance of legal protection for stock holders as a way to generate positive outcomes one innovation, all this accompanied by good policies to foment import and export markets.

Tee et al. (2014) demonstrate that the development of banking markets and stock markets, tend to be related with strong developments on innovation. At the same time, Acharya and Xu (2017) shown that the development of strong banking markets is related with the growth of patent applications, therefore, if those patents tend to generate products and services, economic growth is guaranteed.

Acharya & Xu (2017) and Da Rin & Penas (2007) demonstrate that public traded and private equity firms, have completely different logics regarding R&D investments. Public firms tend to have more R&D expenditures and their patents, tend to have a bigger commercial impact than private firms. At the same time, firms with strong risk control systems tend to have more likelihood to receive government funds and a higher internal R&D expenditure, generally, this kind of firms are bigger and tend to be public on stock markets. These kind of results could highlight that the type of financial system in which a firm is immerse, tend to benefit some characteristics of innovation activity and therefore, the study of the relationship between innovation results and financial system frameworks is a fundamental one. At the same time, Maskus, Neumann, and

Seidel (2012) find that bond markets tend to have high impact on innovation intensities specially form firms financially restricted. In the same direction, Gur and Avşar (2016) demonstrate that financially restricted firms tend to export more R&D related products when they are financed by more specialized financial systems.

All these literature point out the relevance of financial systems as a key factor to support innovation expenditures and ventures. However, literature seems to be also contradictory, some studies demonstrate that bond markets tend to be the most related with innovation, on the other side, some point the importance of stock markets and some tend to signal the credit markets as the one supporting innovation in a strong way. This research is a small contribution to the literature, given that we include all OCDE countries in our study and we take account of stock markets, debt markets and bond markets as possible sources for R&D private expenditure. Our hypothesis are:

H1: Bank markets have a positive relationship with private R&D expenditures.
H2: Bond markets have a negative relationship with private R&D expenditures.
H3: Stock exchange markets have a positive relationship with private R&D expenditures.

Methodology

Using data collected from World Bank and UNESCO data banks between years 2000 and 2016, we developed an econometric strategy through estimations of longitudinal models. These models, group observations by cross-section and by time series, taking the X_{it} form, where (i) takes into account individuals, in our case, OECD countries, and (t) takes into account each year for the interval 2000-2016. At the same time, this method allows us to take into account the effect of heterogeneity among individuals over time.

Independent variable in our models is percentage of R&D performed by business sector, and the vector of covariates X_{it} is divided into three subgroups, the first one taking account of some macroeconomic country characteristics as GDP per capita, exchange rate index against dollar, and inflation rate. The second group, taking account of the possible financing sources of firms to perform R&D ventures and one variable measuring financial structure within countries like, private credit to firms, stock market capitalization, volume of corporative bonds traded in market and banking concentration; and third, we include a vector of variables related with national systems of innovation like government expenditure on R&D, and number of employees working directly on R&D of firms within countries.

Our estimations where performed with two strategies, in the first one, we consider the assumption of strict exogeneity of estimators. For this strategy, we performed a fixed effect model:

$$Y_{it} = \alpha X_{it} + \vartheta_i + \varepsilon_{it} \; ; \; \forall \; i = Colombia, Spain, \dots, N; t = 2000, 2001, \dots, 2016 \qquad (1)$$

Where (ϑ_i) parameter refers to the error term taken by each individual (countries), and that is named fixed effects estimator. This estimator needs to be correlated with covariates, should not vary among time, but should vary among countries. A good example of this type of variance could be local financial laws, which are not integrated in our model, and therefore are captured for (ϑ_i), are related with covariates like banking concentration or market capitalization, are generally fixed over time and could vary among OECD countries. If this term is correlated with covariates or independent variable, then the best approach is to estimate the model by a random effects model:

$$Y_{it} = \alpha X_{it} + \mu_{it} \; ; \; \forall \; i = Colombia, Spain, \dots, N; t = 2000, 2001, \dots, 2016 \qquad (2)$$

Where, $\mu_{it} = \vartheta_i + \varepsilon_{it}$, is taken as an independent term, and must be estimated with a generalized method of moments methodology.

For our second strategy, we relax the assumption of strict exogeneity of estimators, taking into account countries and time variance, and therefore, obtaining a dynamic panel model. We

began this model with the insertion of a lag term of independent private R&D expenditure variable ($Y_{i-\rho}$), which allows us to control for endogeneity of independent variables with dependent variable (Arellano 2003). In this case, we suspect the presence of endogeneity, because R&D expenditure tends to increase firm revenues in the long term, and this makes companies to look for internal and external financial sources like banks, bonds or stock markets to finance new R&D ventures, which will elevate the R&D private expenditure. Then, our model will be expressed as:

$$Y_{it} = \phi Y_{it-\rho} + \alpha X_{it} + \mu_{it} \; ; \forall \; i = Colombia, Spain, \dots, N; t \; \& \; \rho = 2000, 2001, \dots, 2016 \qquad (3)$$

In this methodology, the error term is discomposed into three variance terms; According to Amemiya (1971), $\mu_{it} = \vartheta_i + \lambda_t + \varepsilon_{it}$, where $\vartheta_i, \lambda_t, \varepsilon_{it} \sim (0, \sigma^2)$, and are independently and identically distributed. The (ϑ_i) term, is the within fixed effect parameter, the (λ_t) term measures the time effect not included directly in the regression and that could be measuring a special situation like an oil bonanza or a financial crisis. In our case, these two phenomena are true, given that the world faced two financial crisis in our time span (2001, 2008) and oil prices raise enormously in 2009 and 2010. The (ε_{it}) term accounts for not observed time and countries effect of the model. To estimate this model a set of binary variables vectors were constructed:

$$U = Z_\mu \mu + Z_\lambda \lambda + \varepsilon \qquad (4)$$

Where Z_μ is a vector of dummy variables for each country; Z_λ is a vector of dummy variables for each year (2000-2016), and $\varepsilon' : (\varepsilon_{11}, \dots, \varepsilon_{1T}, \dots, \varepsilon_{NT})$ is a vector of general residuals of the model. The estimation ends up being consistent and robust when the error term is controlled and discomposed into these three factor and if is estimated for a balanced panel, which is our case.

Results

Results of our regression can be seen in table 1. In first place, it is worth noting that the lag of our dependent variable is significant and positive in all cases, with this, we can assume that past expenditures on private R&D are related with present expenditures, this is, countries in which in the past firms invest in higher proportion on R&D tend to remain on this condition. In relation with GDP per capita, our finding suggests that wealthier countries are not necessarily, the ones in which private firms tend to invest higher proportions on R&D. This could be interpreted as counter-intuitive results, however, it is possible that countries in which inhabitants are wealthier, tend to expend a higher proportion of R&D from governments; in that case, our results are not counter intuitive.

Macroeconomic variables seem to have negative relationships with private R&D expenditures, this seems logic given that high exchange and inflation rates play against firm productivity. In that case, firms tend to expend less on R&D on an environment in which macroeconomic figures are against productivity.

At the same time, bank concentration seems to have positive relationship with private R&D, this is, countries in which a smaller proportion of banks have high proportions of market share, tend to expend more on private R&D. A possible explanation for this could be that banks on those countries need to compete with a smaller number of rivals and therefore, the likelihood of generate credit contracts with higher interest rates is higher, and given that R&D ventures are riskier, those type of contracts need to be issued with these type of rates; however, private credit variable and its lag, do not confirm those results, and as it can be seen on table 1, credit variables and its lag, are not related with private R&D expenditures, therefore, bank credit seems not be related with the proportion of private R&D expenditure. H1 is not confirmed.

Market capitalization seems to be positively related with private R&D expenditure, however this relationship seems to be strong on the medium term, this because our variable without lag have no explicatory power but the lagged variable is strong. This seems to be logical in the light of theory, stock markets could be a short-term market for investors, however, for firms, money received from those markets implies a long-term commitment with stock holders, therefore, if firms

are using stock markets to perform R&D ventures, this type of investments must be visible in the middle and long-term at aggregate level. H2 is confirmed.

Table 1. Regressions results

	R&D private expenditure as GDP %					
	Fixed effects	**Random effects**	**Dynamic random effects**	**Fixed effects t-1**	**Random effects t-1**	**Dynamic random effects t-1**
	(1)	´(2)	´(3)	(4)	(5)	(6)
R&D private expenditure t-1	0.396*** (0.046)	0.822*** (0.030)	0.560*** (0.015)	0.500*** (0.050)	0.827*** (0.028)	0.572*** (0.017)
GDP per cap	-0.0001 (0.0001)	-0.0001*** (0.00002)	-0.0001*** (0.00002)	0.00004 (0.0001)	-0.0001*** (0.00002)	-0.0001*** (0.00002)
Exchange rate index	-0.074*** (0.025)	-0.012 (0.024)	-0.064*** (0.009)	-0.071*** (0.024)	-0.007 (0.022)	-0.062*** (0.009)
Inflation	-0.244* (0.128)	-0.244** (0.100)	-0.299*** (0.042)	-0.230** (0.095)	-0.440*** (0.085)	-0.336*** (0.034)
Bank concentration	0.050** (0.025)	0.016 (0.016)	0.035*** (0.007)	0.080*** (0.024)	0.023 (0.014)	0.056*** (0.008)
Private credit	-0.020 (0.013)	0.001 (0.007)	-0.004 (0.004)			
Private credit t-1				0.003 (0.012)	0.003 (0.006)	0.002 (0.004)
Market capitalization	0.024** (0.011)	0.011 (0.009)	0.003 (0.004)			
Market capitalization t-1				0.024** (0.011)	0.015** (0.007)	0.014*** (0.004)
Corporative bonds	-0.604*** (0.217)	-0.727*** (0.172)	-0.500*** (0.083)			
Corporative bonds t-1				-0.338* (0.204)	-0.603*** (0.143)	-0.525*** (0.077)
Government R&D expenditure	-0.432*** (0.089)	-0.113*** (0.036)	-0.265*** (0.023)			
Government R&D expenditure t-1				0.079 (0.085)	-0.028 (0.034)	0.034 (0.026)
Full time researches on business	0.212*** (0.062)	0.107*** (0.023)	0.187*** (0.014)	0.343*** (0.054)	0.123*** (0.021)	0.267*** (0.016)
Constant		8.677*** (2760)	24.416*** (1420)		4.976* (2613)	12.663*** (1659)
Observations	262	262	262	266	266	266
R2	0.606	0.903	0.906	0.617	0.916	0.921
Adjusted R2	0.539	0.899	0.902	0.553	0.913	0.918
F Statistic	31.226*** (df=11; 223)	212.350*** (df=11; 250)	194.607*** (df=11; 250)	33.237*** (df = 11; 227)	252.760*** (df = 11; 254)	239.159*** (df = 11; 254)

Source: Own calculations

Corporative bonds as a percentage of GDP have negative and strong relationships with the proportion of private R&D aggregate expenditure. It seems that a higher volume of corporative bonds on OECD markets is related with low expenditures on private R&D. We have a possible explanation for this result. Strong bond markets could be identify as money markets in which investors prefer low risk and short-term available investments. R&D ventures are the opposite of this type of investments, they imply risky and long-term commitments from the firm's point of view; therefore, this result can confirm that logic, bond markets are not well suited for R&D investments. It is important to note that this relationship seem stable on time, given that on time, and lag bond variables, have negative and significant relationships with private R&D; H3 is confirmed. At the same time, government expenditure on R&D has a negative relationship with private expenditure, it seems that a crowding-out effect can be seen at aggregate level for OECD countries, at least for the on time variable. Those results seem to be contradictory, especially for results gathered at microeconomic level in which public subsidies are related with higher expenditures on private R&D (Aerts and Czarnitzki 2004; Czarnitzki and Lopes-Bento 2013; Chudnovsky et al. 2006), therefore, we need to study this result deeper.

Conclusions

We use panel models to verify the relationship between financial development and private R&D expenditure in OECD countries. Using data from 2000 to 2016, we found that banks seem not to be related with provision of finance to private R&D. Bond markets have a negative relationship with

private R&D and it seems that this type of markets are not suited for innovation ventures. Stock markets are related with private R&D but in the mid and long term, it seems that this type of markets reinforce the R&D infrastructure of OECD countries. It seems that there is a crowding-out effect between public and private investments on R&D, however, this effect seems to be only for the short term.

Our results reinforce the idea behind National Systems of Innovation; strong financial markets have an important role on the provision of money to develop R&D and innovation ventures. Those results send an important message to policy makers, it is important to develop strong specialized financial markets to spur innovation practice of firms. It looks that long term and risky markets are the ones related with innovation, i.e. stock exchange markets; at the same time, a stable and robust macroeconomic situation, represented on competitive foreign exchange and inflation rates, tend to incentive private R&D expenditure.

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