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QUARTERLY REVIEW OF ACADEMIC LITERATURE ON THE ECONOMICS OF RESEARCH AND INNOVATION

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1. Financing innovation: evidence from R&D grants

Howell, S. T. (2017). Financing innovation: evidence from R&D grants. *The American Economic Review*, *107*(4), 1136-1164.

- The paper presents unique evidence from the first quasi-experimental evaluation of R&D grants from the Small Business Innovation Research (SBIR) programme, based on a large sample of US firms applying for funding from the US Department of Energy.
- Contrary to some priors, the findings show that early-stage grants are not crowding out private money.
- On the contrary, a firm which received early-stage funding is far more likely to subsequently attract venture capital as well as to acquire a higher propensity to patent and to generate positive revenue as well as secured investments.
- Results are confirmed to be stronger for firms which truly face financing restrictions.
- The paper offers a novel approach by identifying a plausibly exogenous cash flow shock to establish causality between constraints in funds and investment responses.

The analysis makes use of a regression discontinuity design to estimate the economic impact of R&D grants of over USD 884 million to 7436 high-tech enterprises in the United States between 1983 and 2013. Specifically, the methodological design to isolate a causal relation makes use of the fact that the ranking procedure of applicant firms prior to the funding decision is undertaken by officials who are unaware of the number of grants made available. This setting is close to conducting an experiment on the effects of R&D subsidies, i.e. a random assignment of R&D subsidies. Hence the study can establish a causal link on measures of innovation as well as financial and commercial success and funding, resolving selectivity in R&D grant application.

Here innovation is proxied by a weighted patent metric, financial success is determined by raised venture capital and technology commercialisation is measured as revenue. Further, the paper also finds that grant recipients are more likely to remain in business. The program itself consists of two phases; the first phase attributes USD 150 000 to successful companies, which 9 months later can apply for a USD 1 million Phase 2 grant. The Phase 1 grant has three main positive effects: it increases weighted patents, the likelihood of attracting venture capital and also revenue. And the grant recipients also have a higher probability of survival and IPO/acquisition. Similarly strong measurable effects could not be found for the Phase 2 grants.

The author concludes that from a policy perspective this implies that funding should be reallocated towards a larger amount of small scale early-stage grants as opposed to large, later-stage awards. The authors also argue that grants should be given to younger firms that have not been awarded any grants in the past as the paper also shows that start-ups can use the award to establish the viability of their technology to the market and investors, particularly when it comes to clean innovations.

2. The location of multinational firms' R&D activities abroad: host country university research, university-industry collaboration, and R&D heterogeneity

Suzuki, S., Belderbos, R., & Kwon, H. U. (2017). The location of multinational firms' R&D activities abroad: Host country university research and R&D heterogeneity. Advances in Strategic Management, 36, 127-162.

- The paper provides insights on the R&D activities of Japanese multinational firms across their host countries.
- The probability of a multinational company to engage in R&D is found to be positively correlated with the strength of university research in the host country.
- The larger the manufacturing share of the multinational and the more extensive the experience, the likelier it is that it performs R&D.

The paper uses original survey data of 498 Japanese multinational companies operating in 24 host countries in 1996 to test, via a two-stage estimation framework, which determinants can be linked to R&D activity abroad. The data allows for the distinction between different types of R&D activity, namely basic research, applied research, development for local markets and/or development for global markets. The database which consists of unpublished data from a survey conducted by the Ministry of Economy, Trade, and Industry on parents firms and their foreign affiliates was augmented to include publication data from the Thomson Reuters' Web of Science database to establish university-industry research collaborations. The examined subset of firms is from the manufacturing sector and operates at least one additional foreign affiliate. The results provide support for the initial thesis of a greater propensity of multinationals to invest in R&D abroad in the presence of university research activities of the host country, including basic R&D. This implies that university research can be considered a determinant for the location decision of multinational firms. Further, the study also confirms the role of local university-industry collaboration in establishing increased investment in applied research activities of multinationals, particularly for those lacking basic R&D capacity to reach out on a global scale.

3. Spillovers from R&D and other intangible investment: evidence from UK industries

Goodridge, P., Haskel, J., & Wallis, G. (2017). Spillovers from R&D and other intangible investment: evidence from UK industries. Review of Income and Wealth, 63(s1), S22-S48.

- This paper examines the relationship between Total Factor Productivity (TFP) growth and investment into intangibles in seven industries.
- The main data sources are U.K. industry-level data from 1992-2007, EUKLEMS and the paper follows the Corrado *et al.* (2005)[1] methodology to capture sector investment in intangible assets.
- The authors establish a positive correlation between the external R&D knowledge stock growth and TFP growth (reflecting knowledge spillovers), as well as other intangible assets.

The paper sets out with the question of whether there is evidence that intangible investments, R&D and other categories, generate social returns above private returns. Intangible investment is categorised into three areas: software and computerised databases, innovative property and economic competencies. Using a firm-level model to look at the relationship between industry TFP growth and lagged external/ internal knowledge stock, and controlling for industry and time effects, the authors document a significant and positive correlation between industry TFP growth and outside R&D knowledge, consistent with the spillovers from R&D established by other studies. Furthermore, a positive correlation is confirmed for outside total intangible knowledge stock growth; the correlation with industry internal intangible capital is less pronounced.

[1] Corrado, Carol, Charles Hulten, and Daniel Sichel. "Measuring capital and technology: an expanded framework." *Measuring capital in the new economy*. University of Chicago Press, 2005. 11-46.

4. Innovation and employment growth in Japan: analysis based on microdata from the basic survey of Japanese business structure and activities

Fukao, K., Ikeuchi, K., Kim, Y. G., & Kwon, H. U. (2017). Innovation and Employment Growth in Japan: Analysis Based on Microdata from the Basic Survey of Japanese Business Structure and Activities. *The Japanese Economic Review*, *68*(2), 200-216.

- The authors examine the effects of total factor productivity (TFP) on employment, through R&D and capital investment, taking into account firm-specific labour hoarding.
- Estimations based on the microdata for the period 1992-2010 from the Basic Survey on Japanese Business Structure and Activities reveals, after using a correction method, that there exists a positive relationship between TFP- and employment growth.

Using a theoretical model on the relationship between innovation and employment growth, the paper studies the relationship between innovation and employment growth in Japan, where labour hoarding is frequently observed. The authors hypothesise that many studies which attempt to quantify this relationship have not found any impact as TFP is measured as a residual which also absorbs excess labour. As firms hoard during a recession, TFP would typically decline; this is unrelated to any innovation investments by the firm. It is found that larger firms are more prone to hoard labour than smaller ones. As labour rigidity in Japan is pronounced, firms cannot immediately react in a downturn and hence shedding of excess workers occurs in the consecutive years; conversely, firms which expect to engage in innovation activity are shown to increase employment. By correcting for this confounder, the authors' methodology manages to isolate the effects of the variables of interest and finds that TFP growth induced by innovation has a positive impact on employment growth, specifically product innovations in the manufacturing sector. Conversely process innovation has a positive employment impact in the nonmanufacturing sector.

5. The role of science parks: a puzzle of growth, innovation and R&D investments

Lamperti, F., Mavilia, R., & Castellini, S. (2017). The role of Science Parks: a puzzle of growth, innovation and R&D investments. *The Journal of Technology Transfer*, *42*(1), 158-183.

- The study finds evidence of a significant role of science parks in boosting investment in research and innovation as well as higher patenting activity.
- Furthermore, the higher the degree of sectoral concentration within the science park, the stronger result with regard to R&I investment behaviour.
- The paper finds no direct or indirect causal link with the location of a firm in a science park and growth performance.

This paper sets out to investigate which role science parks (SP) play in the Italian research and innovation ecosystem. In particular, the links between R&D, innovation output and growth are analysed. It is often debated whether SPs reach their aim to nurture close interactions of enterprises and universities, higher education institutes and research organisations as well as acting as an incubator for start-ups and to foster knowledge creation.

By matching on-park firms with off-park firms, and through a methodology known as coarsened exact matching, the authors establish whether there exist differences in firm performance indicators such as patents, R&D investment and sales growth from 2004 to 2012. On-park firms form the treatment group which consists of 150 Italian firms operating within, or are associated with, a SP. The extended database was constructed by combining three sources of data: Firm specific characteristics like industry and sector affiliation were obtained via specific surveys, whilst performance measures were extracted from the Bureau van Dijk's ORBIS database and information on patenting activity came from the EPO Worldwide Patent Statistical Database (PATSTAT).

Albeit innovation is shown not to impact on a firms' growth performance, either by being actively incubated or being associated to a SP, the results point towards a robust effect on R&D investment and patent applications. Investment in R&D is preeminent for on-park firms, also during the crisis years, suggesting a positive and counter-cyclical impact of SPs on research activities.

6. What promotes R&D? Comparative evidence from around the world

Brown, J. R., Martinsson, G., & Petersen, B. C. (2017). What promotes R&D? Comparative evidence from around the world. *Research Policy*, *46*(2), 447-462.

- The paper analyses the role of intellectual property rights protection, financial market rules and tax credits in promoting industry R&D investment in a sample of OECD countries.
- Tax credits are found to be positively associated with R&D investment only in low tech industries which, in turn, are characterised by higher levels of cash flows.
- The improvement of financial market rules, measured by accounting standards and contract enforcements, are a determining factor for R&D investment for high-tech companies which have lower cash flows and rely more on arm's length financing.
- Intellectual property protection promotes R&D investment in high-tech sectors.

Constraints to fully benefit from the returns to R&D investment and to access finance may lead to investment in R&D below the optimal social level. Intellectual property rights protection, tax incentives and improved financial market conditions are policy levers aimed at increasing business R&D investment towards the social optimum. The study investigates the impact of these factors on R&D investment at the industry level for 19 OECD countries from 1990 to 2006, focusing on the differential effect in four sectors characterised by high innovative intensity, i.e. chemicals, office, radio and tv, computing and scientific instruments. Results suggest that higher intellectual property protection has a positive effect on R&D investment in innovative sectors, while tax credits are more effective for low-tech industries. The latter finding confirms the positive role of tax incentives in sectors characterised by larger cash flows and less uncertainty in the investment process. Finally, three financial market conditions are considered: i) accounting standards and ii) contract enforcements, determinants of an economy's supply of arm's length financing, and iii) creditor rights. Results suggest that the first two conditions are positively correlated with R&D investment in high tech sectors, which have lower internal cash flows, while a negative relationship is found for creditor rights.

7. Persistent heterogeneity of R&D intensities within sectors: evidence and policy implications

Coad, A. (2017). Persistent heterogeneity of R&D intensities within sectors: Evidence and policy implications. *JRC Working Papers on Corporate R&D and Innovation*, No 04/2017, Joint Research Centre.

- The study investigates the evolution in R&D intensities of top R&D investing companies within the same sector to assess whether a process of convergence is in place.
- A catching up process is found to be in place within sectors, with the R&D intensity of the least investing firms growing faster than for those having the largest R&D intensity at the beginning of the period.
- However, despite the catching up process, heterogeneity of R&D investments remains a key feature even within the same industry, with the dispersion of R&D intensity in 2015 being larger than in 2000.
- The results suggest that encouraging R&D investment of incumbent companies within sector is as important as stimulating the emergence of new firms in high tech industries.

The Lisbon Strategy in 2000 set the R&D intensity target for the EU at 3% of GDP in order to reduce the productivity gap with global competitors. Such a target may be achieved by increasing the share of medium-high and high tech sectors ("structural effect"), or by stimulating higher R&D investment by companies within the same industry ("intrinsic effect"). The former approach has been the most emphasised in the policy and academic debate, following also the observation that European firms are not less R&D intensive than international competitors in the same sector. However, the intrinsic effect maintains its importance as long as strong heterogeneity in R&D intensity persists between companies within an industry. By using a sample of top R&D investors from the EU Industrial R&D Investment Scoreboard for the period 2000-2015, the study investigates whether i) companies with the lowest R&D intensities in 2000 have been catching up with the leading ones in the same sector over the period (β-convergence) and ii) the dispersion of R&D investment within sector has decreased, implying similar R&D intensities between firms (σ-convergence). While a catching up process by the "laggards" is observed, results indicate that the heterogeneity of R&D intensity has been increasing overtime and its distribution is more disperse in 2015 than 2000. In addition, some companies in low tech sectors are found to be more R&D intensive than others in high tech sectors. This suggests that, while the structure of the economy is an important driver of the overall R&D intensity, low investment by incumbent companies within an industry is a factor to be acknowledged and tackled by policy making.

8. The walking dead? Zombie firms and productivity performance in OECD countries

McGowan, M. A., Andrews, D., & Millot, V. (2017). *The walking dead?: Zombie firms and productivity performance in OECD countries* (No. 1372). OECD Publishing.

- The paper analyses the effect of zombie firms on labour productivity performance, capital and employment reallocation in a sample of OECD countries.
- The non-exit from the market of non-viable companies is found to reduce the growth of employment and capital stock in non-zombie firms, suggesting a misallocation of resources.
- Furthermore, higher shares of zombie companies create additional barriers to entry into the market for potentially more innovative young firms, negatively affecting the pressure on incumbent companies to improve their productivity.

Following the last economic crisis, prolonged monetary stimulus and SME support policies may have had the side effect of increasing the survival rate of non-viable "zombie" companies that would have otherwise left the market. Zombie firms are defined as those companies with a ratio of operating income to interest expenses less than one for three consecutive years. While heterogeneous among countries, the rise of zombie firms is a widespread phenomenon, in terms of capital stock and employment shares locked-in, as well as in terms of number of companies. The paper investigates the extent to which the persistency in the market of non-viable firms affects overall labour productivity via two channels: First, via the reduction in the entry rate of new innovative and potentially more productive firms; second, by hindering the reallocation of productive factors – capital and employment – towards more productive companies. Results from a sample of OECD economies from 2003 to 2013 confirm that zombie firms have had a negative effect on the growth rate of both employment and capital of non-zombie companies. Furthermore, the more the share of non-viable companies, the larger the multi factor productivity gap between leaders and laggards. Finally, it is estimated that the increase in zombie shares with respect to the pre-crisis period is associated with a cumulative loss in investment and employment for a typical non-zombie firm equal to 2% and 0.7% respectively for the OECD average.

9. Estimating dynamic R&D choice: an analysis of costs and long-run benefits

Peters, B., Roberts, M. J., Vuong, V. A., & Fryges, H. (2017). Estimating dynamic R&D choice: an analysis of costs and long-run benefits. The RAND Journal of Economics, 48(2), 409-437.

- The study investigates the impact of R&D investment on i) the probability of process and product innovation and ii) long run productivity for a sample of German manufacturing benefits.
- Investing in R&D increases the probability to innovate in both low and high tech industries and a larger effect is found for the latter sectors.
- Product innovation is an important factor increasing future firm productivity in high tech sectors, while process innovations are more relevant for low tech companies and such an effect is persistent over time.
- Investing in R&D increases the expected long term value of a firm and the effect is particularly relevant in high tech sectors and for older and larger companies.

While the standard approach in the literature assesses the effect of R&D investment in the context of a knowledge production function, this study analyses its impact in terms of both the probability to innovate and of expected increases in the productivity and long term value of a firm. Exploiting a database of German manufacturing firms, the authors estimate the long-run payoff of R&D investment and obtain several interesting results. First, R&D is neither a sufficient nor necessary condition for innovation to take place. Nevertheless, companies investing in R&D have a much higher probability to innovate and this is particularly true for firms in high tech manufacturing industries. Second, product innovation increases future productivity of high tech companies by 3.6%, while process innovations are found to be more relevant for low tech companies with an effect on productivity of 3.5%. Third, R&D investment has a long term effect on the expected value of a firm. Such an impact varies across industries and companies, being higher for older and larger firms in high tech sectors. The differential between the high tech and low tech sector is due to the larger effect of innovation on high tech firms' productivity and profits. Finally, the cost of innovation is smaller for firms with prior R&D investment and which are not starting investments.

10. Does intellectual capital allow improving innovation performance? A quantitative analysis in the SME context

Agostini, L., Nosella, A., & Filippini, R. (2017). Does intellectual capital allow improving innovation performance? A quantitative analysis in the SME context. Journal of Intellectual Capital, 18(2), 400-418.

- The paper investigates the relationship between intellectual capital and innovation performance for a sample of Italian SMEs in the medium-high tech sector.
- Three different dimensions of intellectual capital are considered: human capital, organisational capital and relational capital.
- SMEs characterised by higher intellectual capital experience larger turnover, employment and patents, as well as radical and incremental innovation performance.

Drawing from survey data for a sample of Italian SMEs belonging to the medium-high tech manufacturing sector, the authors analyse the relationship between the intellectual capital endowment and both incremental and radical innovation performance. Firms are distributed in two groups according to the strength of intellectual capital through a cluster analysis approach. In particular, three different dimensions of intellectual capital are considered. First, human capital measured with the set of skills available to the firm and the ability to search for external knowledge. Second, the innovation aspect of organisational capital, in particular the technological endowment of the company, its absorptive capacity and the use of formal innovation plans. Finally, relational capital defined as technological reputation, openness (i.e. business and research networks, including with universities) and brand orientation. Results show that, consistently with previous empirical evidence companies characterised by higher endowment in all the above dimensions have better turnovers, employment and patents, while being also more likely to produce statistically more radical and incremental innovations.