Innovation and Industrial Dynamics

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ABSTRACT: This special issue contains a set of papers that examine the interactions between innovation policy, innovation, and firm competitiveness and performance. Using mostly micro and mostly European data, these studies advance our understanding of these interactions, which can be rather complex and depend to some extent on the institutional and regulatory context in which firms operate.

KEYWORDS: Innovation, Industrial Dynamics, R&D, Industrial Policy, IP strategy, manufacturing

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1. Introduction: Innovation and industrial dynamics

Corporate R&D, innovation and technological development are crucial drivers for competitiveness, job creation and welfare. Innovation and technological development are at the core of the economic growth process and mark the evolution of the industrial structure of countries (Dosi and Nelson, 2010). Indeed, the latter is mainly the result of the accumulation of knowledge and the diffusion of innovation throughout the economy, which leads to the development of (new) capabilities across firms and may displace previous knowledge. This mechanism has drawn the attention on the importance of intangible capital (Corrado et al., 2005), leading to a growing literature on its role and determinants. To what extent this will give rise to a new approach to the study of R&D and intellectual property assets is still a matter of debate.

Innovation and industrial dynamics are two sides of the same coin. Indeed, the rate and the direction of technological change are determined by the specific characteristics of the industrial and economic structure of the system at each point in time and by their changes (Antonelli, 2014). The idea that changes in dominant technological systems influence the behaviour of the entire economy (and *vice versa*) was introduced by Perez (2003, 2009) through the concept of 'techno-economic paradigms' and is connected to Schumpeterian 'creative destruction'.

2. This special issue

Against this background and drawing from some of the papers submitted at the European conference on Corporate R&D and Innovation (CONCORDi 2017)[1], this special issue focusses on two main aspects of the *innovation and industrial dynamics* relationship: *i)* innovation and firms' competitiveness; and *ii)* policies and firms' innovation performance.

Table 1 provides an overview of the papers in this special issue, highlighting their findings and theoretical grounding. The first four papers are related to innovation and competitiveness, while the last four papers address the role of government policy directly. We give an overview of these papers in the next two subsections of this introduction.

[1] A selection of those presented at 6th European Conference on Corporate R&D and Innovation: "Innovation and Industrial dynamics: " (CONCORDi-2017), organised by the Joint Research Centre of the European Commission in Seville, September, 27-29, 2017 in collaboration of the OECD (http://iri.jrc.ec.europa.eu/concord/2017/index.html).

Table 1: Synoptic table of the papers

Authors	Title	Countries	Years	Sample	Methods	Focus	Main results	Theoretical background
Mulkay	How does competition affect innovation behaviour in French firms?	France	2000-2013	Community Innovation Survey (CIS) panel	Dynamic panel data probit model with individual random effects.	The relationship between competition and market shares, and the probability of introducing product or process innovations.	Competition has a linear negative effect on innovation. Absolute market share positively related to the probability of innovation, whereas innovation has a clear inverted U-shaped relationship to relative market share.	Aghion et al. (2005) and Askenazy et al. (2013) on the existence of an inverted U-shaped relationship between competition and innovation.
Coad & Vezzani	Three cheers for industry: Is manufacturing linked to R&D, exports, and productivity growth?	Global (30 countries)	2001-2013	Country-level panel combining different sources	OLS, fixed effects; dynamic panel GMM.	Does a larger manufacturing sector foster i) R&D investments, ii) exports, & iii) productivity growth?	A manufacturing target (20% of GDP) is compatible with efforts to boost R&D. However, no robust relationship between manufacturing and i) productivity growth or ii) exporting.	'Industrial commons' refer to the complex web of collective R&D, engineering and manufacturing capabilities that are needed to sustain innovation (Pisano and Shih, 2009).
Capponi, Criscuolo, Martinelli, & Nuvolari	Profiting from innovation: Evidence from a survey of Queen's Awards winners	UK	2000-2017	Survey of winners of the Queen's Award for Innovation	Focus on innovation rather than firm. Descriptive statistics	Appropriability strategies used for successful breakthrough innovations.	Relative stability in firms' general appropriability strategies. Besides sectoral conditions, firms' idiosyncratic characteristics matter	Appropriability strategies depend on a number of contextual factors which go beyond the use of intellectual property rights (Teece, 1986).
Romano	Explaining growth differences across firms: The interplay between innovation and management practices	Italy	2010-2015	CIS + Industry & services Census + FRAME-SBS statistical register	Factor analysis; cluster analysis; OLS & quantile regression	How choices concerning investments in technological innovation and the management of human resources interact in affecting firm growth.	Potential detrimental effects of pay-for-performance schemes on firm's performance. This distortion is particularly relevant for firms pursuing explorative and research-based activities.	Kremp and Mairesse (2004) and Bartz et al. (2016) on the link between knowledge management and firms' innovation & productivity.
Bianchini, Llerena, & Martino	The impact of R&D subsidies under different institutional frameworks	Spain / 13 EU countries	1990-2010 / 2014	Spanish Survey on Business Strategies + Community Innovation Survey (CIS)	Average treatment on the treated with nearest-neighbor matching	Estimating the impact of public support to R&D activities, looking at how the efficiency of a policy instrument is mediated by the framework in which firms operate.	Crowding-out effects rejected. Positive impact of public support for firms in regions where the quality of public institutions is lower, particularly for innovative activities.	Risk aversion, capital market imperfections and incompleteness in appropriating returns (knowledge spillovers) make private investment in R&D lower than the social optimum (Arrow, 1962)
Ciriaci, Grassano & Vezzani	Regulations and location choices of top R&D investors worldwide	Global (39 countries)	2013	Subsidiaries of top R&D investors	Multilevel mixed-effects logistic regression	How different framework conditions affect the organization of cross-border operations by top corporate R&D investors.	Product Market Regulation and Employment Protection Legislation exert a mutually reinforcing negative effect on the location choice of top R&D investors' subsidiaries.	Aghion et al. (2005, 2009), on the effects of structural policies on innovation and productivity. Also Belderbos et al. (2008) on the role of competitive product & labour markets in affecting the location decisions of technological

								leaders
Santos	Do selected firms show higher performance? The case of Portugal's innovation subsidy	Portugal	2006-2016	Applicants to Portuguese Innovation Incentive System	Propensity score matching - Difference in difference regression	Whether the investment projects of subsidized firms have a higher impact, in terms of a battery of firm performance indicators.	Subsidized firms invest more, create more new jobs, and increase sales and technological progress (TFP) more than non-subsidized firms. Results seem sustainable over the post-intervention period.	Public expenditure can substitute or crowd out private R&D, or have no effects on the development of new products (Cerrulli and Potí, 2016; Hashi and Stojčić, 2013).
Thum-Thysen, Voigt, Bilbao-Osorio, Ognyanova & Maier	Investment dynamics in Europe: Distinct drivers and barriers for investing in intangible versus tangible assets?	13 EU Member States	1995-2013	INTAN-invest database + Eurostat + OECD	Accelerator model estimated using fixed effects panel estimator	Analysing drivers and barriers for investment in intangible & tangible assets.	Investment in intangible assets is more correlated with structural factors, whereas investment in tangible assets is more correlated with cyclical factors.	Intangible investment plays an increasing role for economic growth (Corrado et al., 2009). Draws on Egert (2018) to analyse whether the relationship between investment and structural policies may differ between tangible and intangible assets.

2.1 Innovation and firms' competitiveness

There are several conceptual and methodological challenges to our understanding of the complex but crucial relationship between innovation and productivity. For example, although in the past many have relied on the use of R&D and patents as proxies for innovative activity, it has become increasingly obvious that these measures are incomplete, especially when considering the service sector. A number of firms undertake both process and product innovation without formally reporting R&D spending and such activity has been shown to contribute to productivity (Crepon, Duguet, and Mairesse, 1998; Hall, 2011; Mohnen and Hall, 2013). There is also still scope to improve methods to measure productivity (e.g., refining the use of capital stock as a proxy for the flow of capital services and the precise treatment of intangible capital created by innovation investment).

More broadly, tracing the channels between innovation at the firm level and the overall economy requires attention to the diffusion process by which innovations are adopted by the firms that have not made them, the way firms resort to different appropriability mechanism to protect their innovations, and the institutional framework in which the firms operate. In addition, many researchers (beginning with Arrow, 1962) have studied the relationship between the competitive structure of industry and the incentive for productivity-enhancing innovation (Aghion et al. 2005). The consensus at the present is that there is a U-shaped relationship between the two, which is pinned down at both ends of the competitive spectrum by two facts: 1) Perfect competition leaves no profit available for innovative activity and 2) Perfect noncontestable monopoly has no incentive for innovative activity. But almost all industries operate between these two unrealistic structures and less is known about when and where the curve between rises and falls, and how this relates to institutional features of the economy. Recently concern has been raised that industry structure in both the US and Europe post-2000 has evolved in a direction that leads to more concentration and lower productivity growth (Gutierrez and Philippon, 2019; Autor et al., 2017a,b).

Research in this special issue looks at the competition-innovation relationship, the use of appropriability strategies by innovators, the importance of the manufacturing sector for R&D, productivity, and exporting, and the role of management practices in the innovation-growth relationship at the firm level. Using Community Innovation Survey data for French firms, Mulkay (this issue) finds that the relationship between competition and innovation is linear and negative, in contrast to the inverted U-shaped finding of Aghion et al. (2005). However, the U-shape reappears when innovation is related to market share measured relative to the leading market share in the industry. The interpretation is that when differences across industries in the firm size distribution are controlled for, firms that are very close to the leader innovate less, in contrast to those that are further away.

Coad and Vezzani (this issue) investigate the evidence for the oft-stated hypothesis that "manufacturing matters," one that is relevant considering the decline of the manufacturing sector share in most highly developed economies during the recent decades. They look at the relationship between the size of the manufacturing sector and R&D, productivity, and exporting across a set of 30 (mostly OECD) countries. They find, as others have, that R&D investment is associated with manufacturing and that therefore one route to higher R&D investment might be an increased share of manufacturing, although this view should be tempered by the fact that the

relationship may be not causal. In contrast, in their panel of countries neither productivity nor exporting are related to the share of manufacturing in the economy, which implies that the role of manufacturing may be somewhat overestimated.

Two papers in this special issue look at the choice of firm strategies associated with innovation and their results. Capponi et al. (this issue) use the results of their own survey of firms that received the UK Queen's Award for Innovation to investigate the firms' choice of different mechanisms used to secure the returns to these innovations. The paper is notable for its detailed discussion of the response rate and selectivity of the survey. They find that firms tend to use a combination of formal and informal intellectual property to prevent imitation, and that informal methods such as lead time and the presence of complementary assets are used by many more firms than the formal methods. Although these results are not necessarily new (Cohen et al. 2000; Levin et al. 1987), they are among the few (if any) that have been obtained at the innovation level, rather than simply at the firm level.

Romano (this issue) examines the interaction of innovation and human resource management (HRM) strategies on firm growth in Italy. He finds that technology investment and the HRM practice of performance pay are associated independently with turnover, employment, and productivity growth, but that there is no premium for the use of HRM jointly with technology investment. In fact, the association between complex technology investment and pay for performance is negative for growth, meaning that the net effect of performance pay is insignificant in complex technology environments where uncertainty and risk are large.

2.2 Policies and firms' innovation performance

Economists have long argued that higher R&D investments by corporate actors are socially desirable because of the positive externalities on the society as a whole, both in terms of the technological opportunities which would benefit a wide range of users and the economic returns (Arrow, 1962; David *et al.*, 2000). Such a "market failure" argument justifies government support to business R&D activities, and public funding to R&D (i.e., subsidies) is one among the key policy options. The literature on the impact of subsidies for business R&D has for long focused on whether public support is characterised by either crowding-in – i.e., additional investment by recipient companies compared to those who do not receive public support – or crowding-out – i.e., recipient firms substitute their own resources with external funding.

However, other policy measures may also influence firm investment decisions. For example, structural and regulatory policies as well as institutions affect innovation and productivity (Aghion *et al.* 2005; 2009), the location decisions of firms (Ciriaci *et al.*, this issue) and the choice to invest in intangible assets (Thum-Thysen *et al.*, this issue). This has led to calls for more and better use of evidence-based policies because the lack of appropriate contextual evidence for the design and implementation of national or regional Industrial Research and Innovation policies may lead to misuse of the available evidence (Dosso et al., 2018).

Two of the papers in this special issue evaluate the performance of RDI (R&D and Innovation) subsidies: Bianchini *et al*. (this issue) and Santos (this issue). The papers differ in their data coverage as well as the details of their analysis. Bianchini *et al.* present evidence for R&D subsidies in 13 EU countries as well as a number of Spanish regions, while Santos looks at the case of Portugal and studies innovation subsidies more broadly. Both of these papers apply

matching estimators, in an attempt to make treatment and control group firms as comparable as possible, in order to obtain estimates of what might be the 'causal' effect of the innovation subsidy. Matching estimators are useful techniques, bearing in mind that successful applicants to innovation support schemes might be larger and more productive than non-applicants (consistent with the idea that government evaluators 'pick the winners,' Santos, 2019). Both studies find that RDI subsidies are effective – Bianchini *et al*. refute the hypothesis that R&D subsidies crowd out private R&D investments, while Santos reports that innovation subsidy recipients invest more in innovation, create more new jobs, and increase sales and productivity (TFP) more than non-subsidized firms.

The two studies then diverge in terms of how they take their papers beyond a basic evaluation of R&D subsidies. Bianchini *et al.* explores the influence of heterogeneous institutional frameworks on policy effectiveness, exploiting the cross-country nature of their data. The paper shows that R&D subsidies are effective even in those regions and countries that have weaker public institutions (based on measures of absorptive capacity and generalized property rights). Santos observes that the post-subsidy performance of successful applicants helps them to reach their performance targets, while – interestingly – some non-subsidized firms also reach their performance targets, even in the absence of the subsidy.

RDI subsidies represent, of course, only a subset of the available policy levers available to governments (Borras and Edquist, 2013). Other policy levers include the regulation of labour markets and product markets. Ciriaci *et al.* (this issue) investigates the role of innovation policy by examining how product market regulations (PMR), as well as employment protection legislation (EPL), affect the way in which top corporate R&D investors organize their cross-border operations worldwide. These authors confirm that regulation in these areas has a role to play, because they observe that both PMR and EPL affect the location strategies of top R&D investors. In particular, PMR and EPL exert a mutually reinforcing negative effect on the location of subsidiaries. The negative effect of PMR is due, to a large extent, to barriers to trade and investment. This underlines the need to critically evaluate whether the intended regulations are effective, because excessive regulation may discourage private investment and thereby harm the economy.

Finally, Thum-Thysen et al. (2019) investigate the role of policy for stimulating investment in intangible assets. To begin with, they show that there are differences in investment patterns for tangible and intangible assets, which suggests that policies to support investment in intangibles might be different from those designed to stimulate investment in tangibles. Empirical analysis suggests that investment in intangible assets tends to be more correlated with relatively time-invariant structural factors, while investment in tangible assets appears to be more correlated with cyclical factors. The relevant policy levers for stimulating investment in intangibles include improving access to finance, investing in education, skills and training, and intellectual property rights (IPR) regulations, in addition to more direct public support such as devoting public funds to R&D investment.

3. Conclusions and policy implications

Overall, the papers included in this special issue lead to some conclusions and raise a number of challenges to be addressed by scientists, firms and policy-makers.

The link between innovation and competitiveness is a well acknowledged fact in the economic literature. Augmenting productivity through innovation in order to be more competitive is a recognised common strategy for firms. However, several conceptual and methodological challenges still exist to further advance our understanding of the complex but crucial relationship between innovation and productivity. For example, the industry in which a firm operates, and its size compared to that of other actors present in the market, makes a difference in the propensity to innovate. This calls for both more sector-specific research as well as more targeted policy interventions. This is particularly true when considering that the manufacturing sector is still very relevant when it comes to R&D and innovation (Rodrik, 2004).

Furthermore, a pivotal innovation strategy is the protection of a firm's intangible assets, which is central in the transition towards a knowledge economy. Companies adopt mixed intellectual property protection strategies with mechanisms both formal and informal that depend somewhat on individual firm characteristics. The increasing complexity and speed of innovation development offer opportunities and pose challenges to innovation actors at all stages of technological development. New policy instruments targeting innovation outputs (patents or profit deriving from patents) rather than inputs (R&D) may further exacerbate this trend (Cantner and Kösters; 2012; Moncada-Paternò-Castello *et al.,* 2017).

The evaluation of the outcomes of public policies focuses on input additionality to private R&D spending (increase in firms' R&D following public support), output additionality (e.g. patents, productivity) or behavioural additionality (e.g. changes in firms' capabilities and learning curves, the economic signals they face, their interactive behaviour). The assessment of additionality should go beyond the concept of opportunity cost and be related to the different policy intervention options and the design of instruments. In this respect, one instrument that has been found quite effective in stimulating innovation is R&D subsidies. Their individual or combined effects depend on the type of R&D project targeted (basic, applied research or development). Intangible assets (such as R&D) do in fact differ from tangible assets in the way they respond stimulus programs, which is another element in favour of tailored policy interventions. R&D subsidies can also be complemented by other interventions that are better targeted at innovative young/small firms (Brown *et al*., 2017).

As well as direct policies to support R&D investment (and investment in intangible assets in general), also indirect interventions via altering the framework conditions can make a difference. Regulation of labour markets and product markets is in fact important in determining R&D investments, both within a country and in attracting cross-border investment. Also, more rigid labour markets impose additional costs on firms. The knowledge-base and framework conditions of a country constitute fundamental prerequisites to attract innovation investment, but also signal that public-policy strategies should take into account the specificities of targeted investments inflows, in order to better tailor their possible strategic interventions.

Overall the papers' results call for more research on how firms react to different types of support, and whether this relates to specific market failures.

There are broad implications of policies supporting industrial innovation. It is now more widely recognised that innovation and its processes exhibit important sector specificities (e.g. conditions for knowledge accumulation, appropriability, and diffusion). These heterogeneities raise fundamental questions on how innovation should be supported by policy interventions in a context-specific and effective manner. In addition, the (expected) impacts of innovation extend well beyond pure economic outcomes. In policy terms, this means that innovation and its likely direction have to be identified in relation to the final expected outcome(s), which is not innovation in itself but, for instance, growth, productivity, inequality reduction, and environmental sustainability or social inclusiveness (Dosso *et al,* 2018).

Future work will use new indicators and variables, and richer data, to continually improve our understanding of innovation and to better design innovation policy. In fact, as science, technology and innovation are fundamental to economic and social progress, effective policies (and effective management strategies) are needed to ensure the potential benefits are actually achieved. There are no doubts that data, methods, analytical tools, conceptual frameworks and perhaps eventually theories help ensure better policies, and that the resulting evidence-based policies would, in turn, lead to greater benefits for humanity (Martin, 2016).

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