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DOES GOVERNMENT RESEARCH FUNDING TO UNIVERSITIES SUBSTITUTE, COMPLEMENT OR LEVERAGE INDUSTRY FUNDING?

Alessandro Muscio *Davide Quaglione* *Giovanna Vallanti*

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Center for Labor and Economic Growth
Department of Economics and Business
LUISS Guido Carli
Viale Romania 32, 00197, Rome – Italy
http://www.luiss.edu/celeg

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Alessandro Muscio

Dipartimento Di Scienze Economiche, Matematiche e Statistiche (DSEMS)

Università degli Studi di Foggia

Largo Papa Giovanni Paolo II, 1, 71100 Foggia (Italy)

Tel (+39) 0881-753730

Fax (+39) 0881-775616

Email al.muscio@unifg.it

Davide Quaglione

Dipartimento di Economia e Storia del Territorio

Università "G. d'Annunzio" di Chieti e Pescara

v.le Pindaro, 42, 65127 Pescara (Italy)

Tel (+39) 085-4537610

Fax (+39) 085-4537565

Email d.quaglione@unich.it

Giovanna Vallanti

Dipartimento di Scienze Economiche e Aziendali (DPTEA)

Università Luiss Guido Carli

Viale Romania, 32 - 00197 Roma (Italy)

Tel (+39) 06-85225910

Fax (+39) 06-85225949

Email gvallanti@luiss.it

Abstract

There is increasing political pressures on universities to raise research funding from industry and contribute actively to economic development. However, whether or not promotion of the so called third mission in universities, of interacting with industry, is effective without government funding remains an open question, and we do not know whether government funding 'crowds-out' or 'crowds-in' business funding. In this paper we argue that government funding provides universities with the vital resources to carry out research activities whose results can be transferred at a later stage to industry, leveraging private funding. It is inevitable, therefore, that without government support to academic institutions knowledge transfer activities will be hampered, and financial cuts to universities may reduce rather than foster their self-financing capability. The empirical analysis presented in this paper is based on financial data for the whole population of Italian university departments engaged in research in the Engineering and Physical Sciences. Based on a set of probit and tobit cross-section and panel data models this paper investigates the impact of different forms of public funding to university departments, on their abilities to attract private funding.

Keywords

University; Collaboration; Technology transfer; Research funding

JEL codes

L24, L31, O32, O33

1 INTRODUCTION

One of the key institutional challenges governments face in their efforts to support innovation activity in firms is easing the process of technology transfer (TT) from research institutions to businesses (OECD, 2003). There is increasing awareness in industrialized countries of the importance of scientific research for providing the foundations for technological change and economic competitiveness. Historically, bringing research results to market has not been of prime concern to academic institutions. However, since the late 1970s, we have seen the emergence and consolidation of a third university mission - that of transferring knowledge to industry - in addition to the traditional missions of education and scientific research (Geuna and Muscio, 2009).

Technology transfer and university-industry collaboration have gained strategic relevance in terms of their potential as sources of funding for universities. There is growing pressure on universities to produce research which is valuable for industry, and to establish closer linkages with the business community. Moreover, universities and individual academic researchers have been encouraged to seek industry funding and to patent the results of their research activities. However, *'the results of these efforts are mixed under every respect. Besides some success stories, in many other instances these experiences have not (yet?) delivered the expected outcomes'* (Bruno and Orsenigo, 2003:???).

Universities primarily are motivated to collaborate with industry by the need to raise additional resources required to fund research and other university activities (Cohen et al., 1998). However, the benefits from university-industry collaborations for businesses and universities are reciprocal: as well as supporting firms' innovation activities, collaboration with industry has positive effects on academic research, improving the performance of researchers (Gulbrandsen and Smeby, 2005) without necessarily being detrimental to academics' careers. It follows that there is substantial agreement in the economic literature that universities should collaborate with businesses, and that the role of governments is to ease this process, thereby helping to bring the results of academic research to market.

Several empirical works have investigated the drivers of university-industry collaborations and business funding to universities. However, a key factor, and one that may have been overlooked, is the capability of government funding to leverage business funding to universities. There is extensive evidence of the effects of funding on the generation of innovations and the development of university-industry networks. However, we do not know whether and to what extent government funding to universities stimulates business funding to university activities, 'crowding in' extra research funding or substituting business funding, barring the gates to the 'ivory tower' (Mowery et al., 2004).

The purpose of this paper, based on extensive data on university funding in Italy, is to provide policy evidence on the role of government funding in knowledge transfer activities and investigate whether the financial pressures that universities (specifically those in Italy) have been subjected to in recent years are driving these academic institutions to look for alternative sources of funding to stimulate university-industry interactions, or conversely is hampering the capability of university departments to leverage funds from businesses.

The paper is organized as follows. Section 2 sets the theoretical background to university governance of TT, and university-industry collaboration and the role of governments in easing this process. Section 3 presents our empirical results for the determinants of industry funding to universities. We apply descriptive statistics and regression models to analyze the data on universities. Section 4 discusses the results and their implications for policy.

2 THEORETICAL BACKGROUND

2.1 The Role of Universities in the Innovation System

Knowledge is considered to be a primary resource for wealth creation and economic growth (Drucker, 1993; Nonaka and Takeuchi, 1995; Florida, 1995; Romer, 1993, 1995; Leonard-Barton, 1995). Knowledge and ideas are critical components of economic advantage in the knowledge economy, with intellectual capital (Stewart, 1997; Edvinsson and Malone, 1997) a pivotal resource. Considered in the context of this broader economic transformation, it is clear that the role of the university as an economic and social institution has become increasingly important (Florida and Cohen, 1999).

Universities have long been involved in so-called 'third-stream' activities (Geuna and Muscio, 2009), and make a significant contribution to economic development and firm competitiveness. However, a deeper connection between university and industry is being seen as essential, and this requires structural change in the role of the university in the national innovation system and modernization of its managerial and organizational skills (European Commission, 2008). The expectation is that universities should not only produce new knowledge, but that this knowledge should be related to established social and economic targets (Laredo, 2007).

This view is supported by and has been developed in a vast scientific and multidisciplinary literature. In the social science literature, Gibbons et al. (1994) drew attention to the changing structures of disciplinary science in their 'Mode 2' model of knowledge production which is problem-focused and interdisciplinary. Etzkowitz and Leydesdorff (2000) contributed to the debate by proposing their 'Triple Helix Model', according to which different resolutions of the relations among the institutional spheres of university, industry, and government are possible and can help to generate alternative strategies for economic growth and social transformation. The notions of the 'entrepreneurial university' and 'the university third mission'' (Etzkowitz, 1998, 2003; Etzkowitz and Leydesdorff, 2000) advocate for a new social contract for science, within which universities face an evolution characterized by: more involvement in economic and social development; more intense commercialization of research results, patenting and licensing activities; institutionalization of spin off activities; and managerial and attitudinal changes among academics with respect to collaborative projects with industry (Van Looy et al., 2004).

Many policy makers have been pushing for this 'second revolution' in academia, in the sense of the evolution in research funding since the 1980s. While some countries are in the process of rethinking the role (and funding) of research institutions within their national innovation systems (Arnold et al., 2006), several European country governments are applying increasing pressure for universities to raise research funding from industry and to contribute actively to industrial innovation. As Geuna (1999) notes, since the early 1980s European governments have been intervening more directly in terms of guiding national research systems. This intervention has taken different forms in different countries, but is being driven by similar overall targets, which are promoting a contractual-oriented approach to university research funding, aimed at indirect control of the behaviour of universities through the introduction of (quasi-market) financial incentive schemes. These policies are aimed at improving the efficiency of research funds, and also increasing the accountability of universities and increasing the pressure to reduce their costs, this latter objective being crucial in view of the constraints on public budgets resulting from the enforcement of the Maastricht criteria (see also Sörlin, 2007).

Within this framework, university-industry collaboration has become strategically important for universities from several view points: both because it represents a source of innovation for businesses, and a source of economic development for policy-makers, and because it represents a source of funding for university research, (Geuna and Muscio, 2009).

2.2 The effects of government funding on university knowledge transfer

The new academic funding rationale and explicit external orientation have raised several theoretical and policy questions about the future role of universities and future funding options. The literature so far has provided only partial answers. There is a huge stream of the literature focussing on assessment of the potential advantages and disadvantages of such a shift for the way universities create and transfer knowledge. Some authors point to the potentially negative effects of this shift toward industry funding on academic activities (Geuna, 2001; Elzinga, 1985; Florida and Cohen, 1999), others show that collaboration *per se* has little negative impact on these activities. Gulbrandsen and Smeby (2005) conclude that both universities and businesses benefit from university-industry collaboration, and that as well as supporting firms' innovation activities, collaboration with industry has positive effects on academic research, improving the performance of researchers without necessarily being detrimental to academics' careers.

These arguments highlight the paucity of evidence on the impact of different funding schemes on the capability of universities to develop their activities. It is especially important to understand the real effects of government funding on universities and, specifically, whether it crowds out or leverages private funding. The implications for policy of the first effect would be that government could reduce public funding to universities and cut public spending, while the second effect would mean that public funding jwould be indispensable for the survival and the financial sustainability of universities and, if anything, should be increased. The small amount of empirical evidence on the effects of public research funding to universities focuses mostly on specific complementary issues. which do not help to answer the research question posed in this paper.

A first strand of literature assesses *the effects of government funding on the creation of university-industry research networks and their economic returns.* A significant stream of scientific work focuses on assessing the additionality of government funding for the creation of collaborative programmes, such as the European Framework Programmes, and solving the problems of market-failure in knowledge generation and exchange. Additionality is the difference between the presumed underinvestment in research by firms and actual joint investment by firms and public agencies in research that is being promoted by public programmes (Luukkonen, 2000). These works start from the assumption that university-industry collaboration is highly important for the purpose of technological change and no single organization has all the knowledge and know-how needed for technological change in a particular field. Clark et al. (2004) reviews the literature on the impacts of international collaborative research programmes, concluding that it is reasonably consistent with regard to the unique potential of an international research and development (R&D) programme, as compared to (even large) national programmes. The literature makes it clear that the value of R&D is not confined to (eventual) commercial outputs. 'Indirect' payoffs such as expanding the supply of trained graduates may be as or even more important to business and society. Furthermore, the European Commission's Framework Programme evaluations conclude that participants, especially academics, are overwhelmingly positive in their assessment of the experience of European participation (Bach et al., 1994; Georghiou, 1994). Clark et al. (2004) confirm these findings in an evaluation of other European national schemes (EUREKA, COST, LINK, etc.). However, Peterson and Sharp (1998), in a study of EUREKA,[1] should that only projects that are 'truly additional' should be funded and that some sort of direct subsidy via collaborative programmes should be avoided. Metcalfe (1995) draws attention to the need to avoid substituting corporate investment in R&D with public money while Quintas and Guy (1995) suggest that government schemes may be funding 'trivial' collaborations.

There is another stream of literature that deals with *the effects of government funding on research productivity.* Governments in most industrialized countries have become increasingly concerned about the economic returns from investment in science (Mansfield and Lee, 1996). This is calling for a much closer link between science and technology and greater scrutiny of universities in documenting the economic impact of the R&D projects that receive public support (Link and Scott, 1998; Geuna and Martin, 2003). However, as Crespi and Geuna (2008) point out, after more than 50 years of scholarly work on the importance of public academic research, there is little systematic evidence on

[1] EUREKA is the largest non-EU collaborative programme in Europe, involving near to market research conducted by organizations that and are responsible for designing collaborative projects.

how public investments can lead to increased levels of scientific output, improved patenting and innovative output, better economic performance and, ultimately, to increased national wealth. Only a few studies focus on the relationship between investment in science and measurement of research outputs (Johnes and Johnes, 1995; Adams and Griliches, 1998; Bonaccorsi and Daraio, 2003). Crespi and Geuna (2008) conduct an empirical assessment of scientific production at cross-country level. They highlight two important phenomena: first, given that it takes some seven years to capture the returns from investment in science in terms of its most direct outputs (publications and citations), it is reasonable to expect that it will take a significantly longer period of time for the socio-economic benefits to emerge. This long time frame could explain why frequently it is difficult to link research inputs and outputs. Second, the authors find evidence of major spillovers across countries, leading to the conclusion that examining funding, management and organization of science at national level could lead to inaccurate results.

These two bodies of the economics literature provide many useful insights into the design of more efficient government schemes to support university knowledge transfer. However, they do not answer the question of whether government research funding - no matter what its purpose (e.g. increased research productivity or creation of research networks) - leverages further funding from industry. Promoting knowledge transfer and accessing business funding have become very relevant for universities where knowledge transfer is high on the agenda in relation to the development of plans for promoting initiatives aimed at bridging between academic research and industry needs (Geuna and Muscio, 2009). Notwithstanding the huge empirical literature on the entrepreneurial university (D'Este and Fontana, 2007) and the 'beneficial' effects of university-industry linkages, very few studies focus on the financial sustainability of universities from a funding rationale. Universities currently are facing a situation where public funding is decreasing and the proportions of public research funding from contracts are increasing. At the same time, new streams of revenue are coming from patenting and licensing, but whether these are sufficiently high and sufficiently stable to offset the decrease in public fund to universities is an open question. In addressing these aspects of 'third-mission', knowledge transfer activities by academic institutions is key to understanding the economics of science.

Geuna and Nesta (2006: 805) highlight that

the substitution of short-term funds and licenses for structural funds carries two types of threat. In the short run, it is likely that the net difference in the financial resources on which universities may base their activities will be negative for the vast majority. Although the scope of the net loss of financial, and thus research, resources may, in turn, not be dramatic for most, it is not clear what the consequences for basic research and teaching may turn out to be. Neither is it clear who between the students and the universities will support the financial gap. In the long run, cumulative effects are likely to exacerbate differences between universities. Universities with low revenues from royalties will be penalized in order to spur them to come up with future highly valuable inventions. Universities with high revenues from royalties will be able to enjoy above normal research budgets that will allow them to implement above normal research projects.

Seen alongside Mowery's (2002) remarks, the overall picture is less promising: '*First, 'home runs,' i.e. successful or lucrative inventions, utterly dominate the income flows from academic licensing. This observation is hardly surprising and describes a common characteristic of most invention or patent portfolios — the distribution of inventions or patents by importance and/or potential profitability is very skewed. Second, biomedical inventions appear to be among the most consistently profitable inventions in licensing transactions. Universities without strong medical or biological research centres may wish to pursue objectives other than income from licensing and technology transfer programs*.' (Mowery, 2002: 267).

We are interested here is whether, in this context, public research funding to universities (typically aimed at basic research activities) leverages private funding to universities.[2] To our knowledge, and despite the substantial stream of theoretical and empirical innovation literature dealing with public policies aimed at stimulating business R&D expenses, no scientific study focuses on testing the working hypothesis of additionality within university units. The construction of an efficient and complementary mix of policy instruments for business R&D support has been a priority for policy makers and economists.

We need to know whether promotion of the so called third mission in universities, of interacting with industry, works without government funding. The aim in this paper is to discover whether government funding 'crowds-out' or 'crowds-in' business funding. We extend the literature on university-industry collaboration by testing hypotheses related to the composition of the streams of funding to universities. We argue that government funding leverages private funding enabling universities to carry out research activities whose results can be transferred later to industry. Therefore, lack of government support to academic institutions will inevitably hamper universities' knowledge transfer activities . This issue is particularly relevant for countries such as Italy where, following progressive cuts in research funding, universities have been encouraged (or forced) to collaborate with industry and to develop initiatives to support knowledge transfer.

Research hypothesis: government funding to universities leverages private funding.

3 EMPIRICAL ANALISYS

3.1 Description of the data

The empirical analysis is based on financial data from the whole population of university departments in Italy engaged in research in all nine scientific areas

2 The existence of a form of additionality between public and private funds to universities would imply that universities are able to strategically exploit this channel to increase the incidence of collaboration with industry – since higher public funding works as a signalling device or reputational effect – and univesities' fundraising capabilities.

(SA) of the Engineering and Physical Sciences (EPS).[3] The data were provided by the Italian Ministry of University and Research (MIUR). We obtained financial data for the period 2005-08, which identified 1,232 EPS departments[4] In 65 public universities (5 of them polytechnic universities) located in 54 municipalities. Table 1 reports the distribution of departments across the nine EPS SA. Most of these departments are in the field of Medicine, which counts 450 units and represents 36% of the total population (Table 1). Industrial engineering accounts for 11.6% and Biology, Agriculture & Veterinary, Civil Engineering & Architecture account for around 10% each. Over the four-year period considered there was a substantial increase in research staff (+12%) especially junior level (+19% assistant professors).

<INSERT TABLE 1 HERE>

In the wake of the positive experience of northern European countries, academic institutions in Italy have been increasing their involvement in knowledge transfer. Despite the rather slow emergence of initiatives to support knowledge transfer (Muscio and Orsenigo, 2010), the political pressure to commercialize the results of academic research has increased,[5] prompting several universities to construct plans to support the commercial exploitation of scientific research. By 2000-05 the majority of Italian universities had Technology Transfer Offices (TTO), some of which had been established for several years.

The financial data reported in Table 2 confirm a substantial cut in research funding in the period 2005-08. In 2008 the primary sources of funding for university departments were research contracts and consultancies (28.63%), transfers from the university (15.17%), funding from MIUR (13.74%) and other public bodies (11.93%). In the same period, research funding from MIUR was reduced by 22.79% whilst revenues from other sources increased. This reduced funding from MIUR has been partially offset by an increase in the transfers from universities to departments (+14.32%) and other public sources such as regional and local government institutions. EC funding via competitive programmes such as the Framework Programmes, also increased - by 11.99% over the period considered. The reduction in MIUR funding is even more striking if considered in terms of thousands of Euros per capita: total revenues remained basically stable

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3 The National University Council (CUN) classification of scientific areas is similar to that applied by the OECD in its Frascati Manual (OECD, 2002). The scientific areas considered here correspond to the areas identified by the Frascati Manual as: 1. Natural Sciences, 2. Engineering & Technology, 3. Medical Sciences, 4. Agricultural Sciences.

4 The list of the Italian departments is available at: www.cineca.it.

5 E.g., national laws D.L. 27/7/1999 no. 297 and D.M. 8/8/2000 no. 593 encourage and regulate the creation of university TTO. Art. 65 of the Codice dei Diritti di Proprietà Industriale, 10/02/2005, introduced Bayh-Dole Act-like regulation of intellectual property, granting intellectual property rights to scientists for their scientific discoveries.

(-1.24%), whilst MIUR funding shrank by 30.95% but was offset by modest increases in all other areas.

MIUR categorizes private funding to departments as revenues from enterprises and revenues from research contracts and consultancies. Since 2006, funding from enterprises grew by 11.17% and revenue from research contracts increased by 9%. This is confirmed empirically by Muscio (2010b) which investigates the frequency of university-industry linkages and university use of TTOs. Muscio's survey of 197 departments shows that in 43.1% of cases the frequency of collaborations increased over time, and in 38.6% of cases it was stable.

<INSERT TABLE 2 HERE>

3.2 Empirical results

This section provides empirical evidence on what determines the capability of university departments to raise private funding. In particular, we investigate whether and to what extent public funding crowds out or crowds in private funding. Table 3 presents information on the variables used in the regressions. We consider as regressors indicators of departments' sources of revenue, department and university characteristics and geographical indicators. Table 4 reports some descriptive statistics for the variables included in the regressions. Two main regression models are estimated. First, a panel random effect probit model predicts the effect of the independent variables and in particular of the amount of previous year funding from different sources (European Union -EU, MIUR, university transfers), on whether or not a department is able to raise a positive amount of private funding in the current year. In order to consider all forms of financing symmetrically, we control for the (lagged) yearly amount of university transfers to departments. In the probit model the dependent variables is a binary variable that is equal to 1 if the department received any private funding in the reference year, and 0 otherwise. Second, a panel random Tobit model[6] estimates the link between the amount of private funding in the current year and the amount of funding received from public institutions in the previous year.[7]

<INSERT TABLE 3 HERE>

6 Both the random effects probit and random effects Tobit are fitted by using Butler and Moffitt's method with a 32 point Hermite quadrature. See Butler and Moffitt (1982) for details of the estimation technique.

7 We use a 1-limit Tobit model, because some 18% of observations in our sample are censored at 0.

<INSERT TABLE 4 HERE>

Table 5 reports the estimated parameters for the panel data regressions. When funding is lagged just one year, the results show that EU funding has a strong and positive impact on departmental capability to leverage private funding in both the Tobit and probit regressions (F_EC). MIUR funding affects positively the probability of raising business funding but not its sheer volume (F_MIUR).

University transfers to departments do not contribute to the capability to attract private funding (F_UNI). Overall, public research funding contributes to developing a research base that can be commercialized to businesses later on.

The results show that university structural characteristics have little or no impact on business funding to departments. University size (SIZE_UNI1-3) and department location in a polytechnic university (POLYTECH) do not have a significant impact on whether funding from enterprises can be leveraged. Only the probit regression provides evidence that medium sized universities are less likely to attract business funding. Universities with more EPS departments, such as polytechnic universities, are likely to have more refined practices and better services for technological collaborations with companies, but this does not seem to affect the volume of business funding. Existence in the university of an office to manage European patents (EPO_MNGMT) affects only the probability of attracting funding not its volume. There has been a substantial increase in public and private investment in TTOs (Link and Scott 2007) and there is a growing empirical literature on their contribution to the technology transfer process (Muscio, 2010b).

Analysis of the impact of the department's geographical location on its capability to raise business funding provides mixed results. The Tobit and probit regressions show that low levels of industrialization, high unemployment and poor infrastructure, e.g. the case of southern Italy (GEO_S), strongly affects a department's capability to establish collaboration with industry and raise private funding. Academic institutions in southern Italy are disadvantaged with respect to institutions located elsewhere in the country. However, the proxy for local absorptive capacity for research services is negative and not significant (LOCAL_EPO), corroborating the hypothesis that departments establish wide networks of interaction with companies not located in the immediate surrounding area (Muscio, 2010a). Chapple et al. (2005) find that universities in regions with higher R&D and gross domestic product (GDP) levels appear to be efficient in knowledge transfer activities, implying the existence of regional spillovers. Friedman and Silberman (2003) find that in regions with a concentration of high technology firms, more patent exploitation and co-patenting can be expected. However, in our case, the presence of business innovators in the immediate vicinity of the university does not foster business funding of university research. Apparently, collaboration is not confined to the local industry: departments are capable of looking beyond their own regions to find potential business partners. On the other hand, a department's private funding is positively affected by company size (LOCAL_SIZE_MAN). The presence of larger manufacturing companies - which are more likely to carry out formalized R&D activities and interact with scientific institutions - fosters the capability of university departments to raise business funding. In fact, firm size and industrial sector are major factors explaining the type and level of interaction (Laursen and Salter 2004; Mohnen and Hoareau 2003; Fontana et al., 2006), with larger firms generally having spare resources to invest in various types of interactions with university researchers.

Mansfield (1995) provides evidence that universities conducting higher quality research, and which are located close to innovating companies, make a greater contribution to industrial innovation. Firms tend to trade off faculty quality against geographic proximity, particularly in the case of applied R&D. There is also evidence that innovative firms favour research produced by high quality research universities and published in peer reviewed journals (Bruno and Orsenigo, 2003; Pavitt, 2001; Hicks et al., 2000). In the present study we use a research performance indicator to control first for whether high quality research generates valuable intellectual property that can be passed to industry and second for whether research performance provides a signal to industry of the best university departments. We find that research performance (RES_RATING) has no significant impact on business funding to universities but we have no information to allow us to test the impact of research quality on the frequency of interactions and the applicability of the research, on funding.[8]

Bruno and Orsenigo's (2003) findings for the impact of department size on industry funding are confirmed. The variables measuring number of research staff and other research staff (research officers, PhDs, etc.) are positive and significant confirming that departments need to develop critical mass in research activities in order to attract business. Departments with larger numbers of research staff, will benefit from greater visibility, greater specialization of departmental research and more efficient procedures for the establishment and management of collaborations.

<INSERT TABLE 5 HERE>

The results of the panel data estimation suffer from some obvious data limitations. Given the short time dimension of our database, the panel data estimations use only 1-year time lags for the independent variables. However, public funding could be used to support basic research (e.g. in the case of the MIUR FIRB projects in Italy or the EC Framework Programmes) and the commercial returns of basic research typically need more time to be developed. We investigated in more depth what determines a department's capability to raise private funding by estimating standard cross-section Tobit and probit regressions and using the entire time length of our database to introduce up to three lags in the independent variables related to public funding. The probit regression estimates the probability of accessing private funding in 2008 and

[8] We also proxy research quality by MIUR "PRIN" projects granted to departments: the econometric results do not change significantly.

takes into account the effects of other sources of financing in the previous three years. The Tobit regression accounts for the volume of private funding in 2008 and also takes account of the amount of public and university financing in 2005, 2006 and 2007. We introduced a regressor of a 1-year lag of the dependent variable, in order to account for persistence in the process of collecting private finance.

The results of this second set of regressions are reported in Table 6. As expected, there is some path dependency to accessing private funding. For both the probit and Tobit regressions the parameters for the lagged variable measuring past private funding levels (F_PRIVATE_07) are positive and highly significant. In other words, accessing private funding greatly increases both the probability of further funding from business and the volume of this future funding.

Even in this case, location in a medium-sized university (SIZE_UNI2) only decreases the probability of earning business funding, not its volume. Location in a polytechnic university and existence of an office to manage European patents have no effect on funding and we find no evidence of a significant effect of research performance on business funding to universities. The impact of geographical location is confirmed in the majority of cases. However, we find no evidence of a negative impact of location in southern Italy and the results of the Tobit regression show that the coefficient of the variable LOCAL_EPO is negative and, therefore, the impact of geographic location on business funding is negative.

Analysis of the impact of the variables for funding provides the most interesting results in the context of this paper. In the Tobit regression, EU funding continues to have a positive impact on business funding, but only after three years (F_EC_05). The overall effect over the three years considered is positive and significant at the conventional level. These results are consistent with the theoretical predictions and can be explained by the fact that EU research funding schemes are primarily targeted at basic research. The results of basic research activities require relatively more time to be developed into commercializable output. Similarly, the second lag for MIUR funding (F_MIUR_06) has a positive and significant effect on private funding. To quantify the estimated static effects, for every euro of domestic public support (MIUR) the department receives around 0.08 euro of private funding. The overall coefficient of EU funding is slightly higher.[9]

Not surprisingly, the overall effect of internal university transfers is not significantly different from zero. This is because internal transfers in the main are aimed not at promoting research. They are used to provide general purpose resources or represent funding already allocated to departments for the next year/s.[10]

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[9] Note that our static model allows us to estimate the short run effects of a change in public funding on private funding. Given the strong persistence of the dependent variable, the long run response of private funding to a change in public funding (both MIUR and EU) may be considerably larger.

[10] Internal transfers of resources seem to have no effect on a department's capability to

In terms of the results of the probit regression however, EU funding appears to be negatively related to the probability of attracting private resources, while the effect of MIUR remains positive and significant. This may be due to the fact that departments that are specialized mainly in basic research have less or no access to private funding and concentrate on obtaining EU funding. This may lead to a negative effect of EU funding on the probability to get private resources. However, for those departments, engaged in both basic and applied research, the more EU funding they attract, the higher will be their capability of obtaining private funding for the reasons already discussed..

<INSERT TABLE 6 HERE>

4 DISCUSSION AND CONCLUSIONS

This paper investigates the impact of different forms of public funding for university departments on their ability to attract private funding. We provide empirical evidence that public funding enhances a department's capability to collect external resources, refuting the hypothesis that private funds are crowded out by public support to research activity. We find instead robust and significant evidence of complementarities between public and private funding with an estimated private/public funding elasticity (both EU and domestic) of about 5%. Also, the strong persistence of private funding suggests that the long run effects may be significantly higher than the estimated impact effects, and the impact of a change in public financing on private external sources may be understated in a static analysis.

We can formulate some concluding remarks and related policy implications to contribute to the on-going debate in Italy on the public/private funding of universities. This debate is founded on from several recent statements issued by MIUR, which underline the need (common to other European countries) for greater efforts by universities to increase private funding of research. This is in line with, and is aimed as justifying politically, the more pragmatic aim of a cut in public funding to universities, thus indirectly implying that public and private funding to universities are substitutes.

The empirical analysis in this paper does not support this policy objective. Public funding and private funding are generally positively linked, meaning that these two forms of funding are complementary. In other words, provided that publicly

attract funding from industry because apart from any budget formally assigned to research activities, in most cases this funding is designed to cover expenses such as purchase of hardware and software, and researchers' subsistence for attendance at conferences and scientific meetings. The per capita amounts of these transfers are typically capped at well below the amount required to finance structured research activities which are likely to attract firms and promote collaboration.

financed research programmes are well designed and do not generate a scheme of perverse incentives for researchers, public funding can play an important role in signalling best departments. Thus, initiatives aimed at cutting public funding to universities are totally inconsistent with the objective of increasing private funding opportunities to universities. Furthermore, as explained, the econometric analysis supports the hypothesis of a persistence of private funding over time. This implies that a reduction in public funding to universities would probably result in a further widening of the currently existing gap between those departments that are capable of attracting private funding and those that are not. The latter, sooner or later, will occupy a very marginal role in the national academic system.

Policy measures should be addressed to strengthening and rationalizing the system of public funding to universities through an increase in the amount of public competitive resources for academic research. Research funding should contribute to consolidating the signalling and reputational effects of public research programmes, stimulating industry funding to universities (e.g. by offering fiscal incentives to firms) and fostering the creation of a virtuous circle of university/industry collaboration.

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Tables

Table 1 Sample composition filed by scientific area

Code	Scientific Area	Frequency	Percent
1 MAT-INF	Mathematics & Computer Science	88	7.14
2 FIS	Physics	54	4.38
3 CHIM	Chemistry	82	6.66
4 GEO	Geology	38	3.08
5 BIO	Biology	127	10.31
6 MED	Medicine	450	36.53
7 AGR-VET	Agriculture & Veterinary	126	10.23
8 ICAR	Civil Engineering & Architecture	124	10.06
9 ING IND-INF	Industrial Engineering	143	11.61
TOTAL		1232	100.00

Source: Authors' calculations on MIUR data.

Table 2 University funding, 2005-08 (thousand of Euros)

Source of revenues	2008 %	2008	2007	2006	2005	2005-08 var. %	2005-08 var. % per capita
MIUR	13.74	138,294	162,979	188,269	179,107	-22.79	-30.95
European Commission	9.59	96,485	124,468	85,662	86,154	11.99	0.15
Public research institutions	2.96	29,805	35,867	25,821		15.43	8.82
Other public bodies	11.93	120,051	107,677	100,261		19.74	12.88
Enterprises	4.67	46,997	39,319	42,274	149,835*	11.17	4.81
Not-for-profit organizations	4.68	47,152	39,373	34,765		35.63	27.86
Foreign research institutions	0.74	7,483	9,325	6,383		17.23	10.52
Foreign private organizations (enterprises and not-for-profit organizations)	1.27	12,801	7,627	6,273		104.07	92.38
Own university	15.17	152,682	138,579	147,577	133,560	14.32	2.23
Other sources	6.62	66,593	75,674	31,403	51,035	30.48	16.68
TOTAL	71.37	718,343	740,554	668,688	650,458	10.44	-1.24
Research contracts and consultancies from public and private organizations**	28.63	288,216	248,902	285,637		0.90	-4.87
GRAND TOTAL	100.00	1,006,559	989,456	954,325	650,458	5.47	-0.57
TOTAL EXPENSES		799,211	790,268	665,417	638,839	20.11	13.23

Source: Authors' calculations on MIUR data.

Notes:

(*) Funding from other external organizations. Starting from 2006 MIUR adopted a more detailed classification of sources of funding.

(**) Research contracts and consultancies for public and private organizations are defined by the Law 382/1980

Table 3 Variable used in the regressions

Variable	Definition	Data source
Departments' source of revenue		
F_PRIVATE	Volume of funding from research contracts and consultancies from public and private organizations raised in the last financial year (2006-08). This source of funding does not account for funding from research programmes that do not allow income distribution to research staff	MIUR
F_PRIVATE_Y	F_PRIVATE (yes/no)	MIUR
F_EC	Research funding from the EC (2005-08)	MIUR
F_MIUR	Research funding from MIUR (2005-08)	MIUR
F_UNI	Research funding from own university (2005-08)	MIUR
Departments' characteristics		
P_ADM	Number of administrative staff	MIUR
P_RESEARCH	Number of research staff (full professors, associate professors, assistant professors)	MIUR
P_RESEARCH_OTHER	Number of other research staff involved in research activities (technical staff, PhDs, research officers)	MIUR
RES_RATING	Research rating published by MIUR in 2007, based on the evaluation of research output carried out over the period 2001-03. This composite indicator takes into account peer review evaluations of research activity carried out at academic institutions (patents, impact factor of journal articles, etc.)	CIVR VTR (MIUR, 2007)
- Scientific areas	Predominant departmental scientific research area	MIUR-CINECA
- a1	SA Mathematics & Computer Science	
- a2	SA Physics	
- a3	SA Chemistry	
- a4	SA Geology	
- a5	SA Biology	
- a6	SA Medicine	
- a7	SA Agriculture & Veterinary	
- a8	SA Civil Engineering & Architecture	
- a9	SA Industrial Engineering	
University characteristics		
SIZE_UNI1-4	Size of the academic institution where the department is located. University size is expressed in terms of number of students: 1 small (<10,000); 2 medium (10,000-15,000); 3 large (15,000-40,000); 4 mega (>40,000)	MIUR (2007)
POLYTECH	Location of the department in a polytechnic university (4 in Italy)	University website
EPO_MNGMT	Presence at the university of an office managing European patents. Normally this task is carried out by offices for valorisation of research results or by TTOs. These offices have the mission of supporting research staff in commercialising the results of scientific research establishing collaborations and mediating between agents.	MIUR
Indicators of local demand for technology		

GEO_S, GEO_C, GEO_N	Geographical location of the department respectively in Southern, Central and Northern Italy	
LOCAL_SIZE_MNF	Average size of manufacturing companies in the administrative province where the department is located	ISTAT 2001 Census
LOCAL_EPO	Number of European patents granted to industrial researchers resident in the administrative province where the department is located during the period 2000-06	PATSTAT database elaborated by Centro KITES, Università Bocconi

Table 4 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
F_PRIVATE_Y	1075	0.859	0.349	0.00	1.00
F_PRIVATE_08	1075	250.265	408.380	0.00	3707.00
F_PRIVATE_07	1075	218.967	364.532	0.00	3660.00
F_PRIVATE_06	1075	219.705	383.694	0.00	4743.00
F_EC_08	1075	84.509	248.800	0.00	3857.00
F_EC_07	1075	112.335	400.196	0.00	7585.00
F_EC_06	1075	75.231	220.824	0.00	4062.00
F_EC_05	1075	78.900	288.981	0.00	5721.00
F_MIUR_08	1075	116.490	220.494	0.00	2423.00
F_MIUR_07	1075	139.093	229.379	0.00	3295.00
F_MIUR_06	1075	165.024	311.214	0.00	4000.00
F_MIUR_05	1075	160.454	270.694	0.00	3064.00
F_UNI_08	1075	129.294	181.552	0.00	2268.00
F_UNI_07	1075	119.357	144.228	0.00	1214.00
F_UNI_06	1075	131.814	204.628	0.00	1984.00
F_UNI_05	1075	120.168	157.138	0.00	2020.00
P_ADM_07	1075	4.323	3.910	0.00	36.00
P_RESEARCH_07	1075	32.131	21.303	1.00	185.00
P_RESEARCH_OTHER_07	1075	35.339	29.694	0.00	221.00
RES_RATING	1075	0.790	0.079	0.20	1.00
a1	1075	0.075	0.264	0.00	1.00
a2	1075	0.049	0.217	0.00	1.00
a3	1075	0.073	0.260	0.00	1.00
a4	1075	0.032	0.175	0.00	1.00
a5	1075	0.102	0.303	0.00	1.00
a6	1075	0.344	0.475	0.00	1.00
a7	1075	0.100	0.301	0.00	1.00
a8	1075	0.103	0.304	0.00	1.00
a9	1075	0.121	0.326	0.00	1.00
SIZE_UNI1	1075	0.079	0.270	0.00	1.00
SIZE_UNI2	1075	0.068	0.252	0.00	1.00
SIZE_UNI3	1075	0.434	0.496	0.00	1.00
SIZE_UNI4	1075	0.419	0.494	0.00	1.00

POLYTECH	1075	0.059	0.235	0.00	1.00
EPO_MNGMT	1075	0.864	0.343	0.00	1.00
GEO_S	1075	0.311	0.463	0.00	1.00
GEO_C	1075	0.274	0.446	0.00	1.00
GEO_N	1075	0.415	0.493	0.00	1.00
LOCAL_EPO	1075	12.086	18.080	0.00	58.70
LOCAL_SIZE_MNF	1075	7.473	2.353	3.11	11.78

Table 5 Panel data tobit and probit regressions

Dependent variable: F_PRIVATE (t)	tobit	probit	marginal/impact effects (at the median)
F_EC (t-1)	0.045	0.001	0.00019
	(0.017)***	(0.000)*	(0.00012)*
F_MIUR (t-1)	0.007	0.000	0.00012
	(0.019)	(0.000)*	(0.00001)*
F_UNI (t-1)	-0.005	-0.001	-0.00014
	(0.032)	(0.000)	(0.00011)
P_ADM (t-1)	0.873	0.050	0.012146
	(2.384)	(0.022)**	(0.00638)*
P_RESEARCH (t-1)	4.675	0.016	0.00382
	(0.593)***	(0.005)***	(0.00174)**
P_RESEARCH_OTHER (t-1)	1.044	0.004	0.00098
	(0.322)***	(0.003)	(0.00078)
RES_RATING	-12.844	-0.115	-0.02788
	(158.777)	(0.922)	(0.22402)
a2	-75.621	-0.304	-0.08504
	(59.237)	(0.317)	(0.09312)
a3	154.870	1.709	0.15660
	(51.377)***	(0.343)***	(0.06997)**
a4	217.448	1.958	0.15845
	(65.496)***	(0.446)***	(0.07067)**
a5	124.460	1.045	0.139334
	(47.738)***	(0.277)***	(0.06415)**
a6	113.653	0.851	0.12753
	(41.478)***	(0.234)***	(0.06147)**
a7	241.781	1.860	0.15787
	(51.930)***	(0.330)***	(0.07053)**
a8	320.953	1.816	0.15756
	(49.050)***	(0.307)***	(0.07032)**
a9	551.365	2.284	0.15951
	(46.934)***	(0.339)***	(0.07133)**
SIZE_UNI1	4.765	-0.124	-0.032054
	(41.500)	(0.263)	(0.06877)
SIZE_UNI2	-59.515	-0.630	-0.19774
	(42.600)	(0.246)**	(0.09302)**

SIZE_UNI3	18.801	0.007	0.00171
	(24.479)	(0.155)	(0.0376)
POLYTECH	25.314	-0.620	-0.19421
	(49.896)	(0.335)*	(0.13544)
EPO_MNGMT	-7.578	0.381	0.10984
	(31.816)	(0.183)**	(0.06742)*
GEO_S	-139.121	-0.774	-0.25284
	(42.361)***	(0.278)***	(0.09211)***
GEO_C	-16.801	-0.015	-0.00370
	(34.174)	(0.229)	(0.05607)
LOCAL_EPO	-0.025	-0.001	-0.00033
	(0.845)	(0.006)	(0.0014)
LOCAL_SIZE_MNF	3.343	0.132	0.03206
	(7.142)	(0.046)***	(0.01581)**
CONSTANT	-170.088	-0.969	
	(153.719)	(0.891)	
PseudoR2	0.73	0.32	
Observations	3391	3391	
Number of n	1181	1181	

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6 Cross-sectional tobit and probit regressions

Dependent variables: F_PRIVATE_08 (tobit) F_PRIVATE_Y (probit)	tobit	probit	marginal/impact effects (at the median)
F_PRIVATE_07	0.890	0.00546	0.001936
	(0.024)***	(0.00183)***	(0.00065)***
F_EC_07	0.024	0.00080	0.0002855
	(0.024)	(0.00071)	(0.00025)
F_EC_06	-0.005	-0.00136	-0.000482
	(0.049)	(0.00054)**	(0.00019)**
F_EC_05	0.061	0.00025	0.0000872
	(0.033)*	(0.00063)	(0.00022)
F_MIUR_07	0.034	0.00002	0.00000607
	(0.042)	(0.00053)	(0.00019)
F_MIUR_06	0.087	0.00086	0.0003057
	(0.029)***	(0.00041)**	(0.00014)**
F_MIUR_05	-0.045	-0.00015	-0.0000519
	(0.036)	(0.00038)	(0.00014)
F_UNI_07	0.038	0.00066	0.0002344
	(0.068)	(0.00080)	(0.00028)
F_UNI_06	-0.083	-0.00051	-0.0001807
	(0.049)*	(0.00054)	(0.00019)
F_UNI_05	0.134	0.00124	0.0004403

	(0.063)**	(0.00084)	(0.0003)
P_ADM_07	1.259	0.07446	0.0264108
	(2.553)	(0.02525)***	(0.00896)***
P_RESEARCH_07	0.349	0.00966	0.003428
	(0.570)	(0.00502)*	(0.00178)**
P_RESEARCH_OTHER_07	0.386	-0.00479	-0.0016985
	(0.404)	(0.00337)	(0.00119)
RES_RATING	55.374	-0.28593	-0.1014211
	(123.761)	(0.85183)	(0.30215)
a2	-99.627	-0.18045	-0.0665218
	(44.962)**	(0.28531)	(0.1063)
a3	4.005	0.61343	0.1778558
	(39.203)	(0.28994)**	(0.08564)**
a4	36.722	1.62650	0.2965341
	(49.094)	(0.50302)***	(0.08821)***
a5	-23.314	0.52082	0.1566083
	(37.000)	(0.25366)**	(0.07951)**
a6	22.933	0.41945	0.1309768
	(31.841)	(0.21195)**	(0.07191)*
a7	42.603	0.92243	0.2342284
	(40.021)	(0.29342)***	(0.08373)***
a8	64.610	0.56011	0.165876
	(37.689)*	(0.28815)*	(0.08726)**
a9	125.927	0.73945	0.2034787
	(36.994)***	(0.32246)**	(0.09039)**
SIZE_UNI1	-46.065	0.01458	0.0051544
	(31.762)	(0.24956)	(0.08817)
SIZE_UNI2	-45.886	-0.56205	-0.2168789
	(33.149)	(0.23677)**	(0.09413)**
SIZE_UNI3	-11.302	0.10017	0.0346241
	(18.889)	(0.14950)	(0.05228)
POLYTECH	23.861	0.41365	0.129437
	(39.292)	(0.38818)	(0.1010)
EPO_MNGMT	-8.410	-0.16729	-0.0567386
	(24.672)	(0.17240)	(0.05569)
GEO_S	-4.107	-0.22095	-0.0820397
	(32.101)	(0.25317)	(0.09415)
GEO_C	-19.204	0.32850	0.1058852
	(26.255)	(0.21086)	(0.07092)
LOCAL_EPO	-1.168	0.00495	0.0017551
	(0.640)*	(0.00593)	(0.0021)
LOCAL_SIZE_MNF	9.732	0.04932	0.0174948
	(5.569)*	(0.04602)	(0.01632)
CONSTANT	-136.487	-0.43462	
	(119.011)	(0.81679)	
PseudoR2	0.27	0.11	
Observations	1075	1075	

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%