UNIVERSITÀ DELLA CALABRIA

Dipartimento di Economia e Statistica
Ponte Pietro Bucci, Cubo 0/C
87036 Arcavacata di Rende (Cosenza)
Italy
http://www.ecostat.unical.it/

Working Paper n. 07 - 2012

UNIVERSITY AND FIRM PERFORMANCE IN THE ITALIAN MANUFACTURING SECTOR

Paola Cardamone
Dipartimento di Economia e Statistica
Università della Calabria
Ponte Pietro Bucci, Cubo 0/C
Tel.: +39 0984 492442
Fax: +39 0984 492421
e-mail: p.cardamone@unical.it

Valeria Pupo
Dipartimento di Economia e Statistica
Università della Calabria
Ponte Pietro Bucci, Cubo 0/C
Tel.: +39 0984 492456
Fax: +39 0984 492421
e-mail: v.pupo@unical.it

Fernanda Ricotta
Dipartimento di Economia e Statistica
Università della Calabria
Ponte Pietro Bucci, Cubo 0/C
Tel.: +39 0984 492445
Fax: +39 0984 492421
e-mail: f.ricotta@unical.it

Ottobre 2012

University and firm performance in the Italian manufacturing sector

Paola Cardamone, Valeria Pupo and Fernanda Ricotta

(p.cardamone@unical.it – v.pupo@unical.it – f.ricotta@unical.it)

University of Calabria - Department of Economics and Statistics
I-87036 Arcavacata di Rende (CS), Italy

Abstract. This paper analyses the influence of universities on Italian firm TFP at the provincial level separating the effects of main university functions, such as the creation of knowledge through research, the creation of human capital through teaching and the technology transfer.

Overall, results show that the presence of the universities does not seem to affect firm productivity. If, instead, we focus only on the most developed and productive area of the country, the North of Italy, the results change: we find that university activities significantly improve firm performance.

Key words: University, R&D activities, Total Factor Productivity
JEL code: O30, D24, C21.

1. Introduction

In recent years industrially developed nations have identified cooperation between industry and public research institutions as a policy priority (OECD, 2007a). As regards Italy, the collaboration between firms and universities is an imperative, given that public research plays a fundamental role in the R&D system. In 2008 R&D expenditure in Italy amounted to 1.2 per cent of GDP, below the EU average (1.8%) and very far from Sweden (3.8%), Germany (2.6%) and France (2%). The gap is almost entirely due to the R&D expenditure by firms. Indeed, R&D spending in the public sector is only slightly below that of the main European countries, while R&D spending in the private sector is significantly lower (0.5% of GDP compared to 1,5% in France and 2% in Germany) (OECD, 2010). Also data on patents and innovations consistently signal that Italy lags behind other OECD countries.

The literature has proposed several explanatory factors for the poor performance of Italian firms for instance: high incidence of small and micro enterprises, preponderance of family-owned firms, orientation toward traditional sectors and concentration of private research spending in the North of Italy (Bugamelli et al, 2012). Furthermore, in the past 40 years, the progressive demise of the Italian high-tech industry (Gallino, 2003) has contributed to an increase of the innovation deficit. Insufficient attention has been paid to the specific role that universities could play in this context. Indeed, universities embody a wider set of functions and organizational goals, ranging from traditional knowledge-based activities such as research and teaching, to the more recent technology transfer. These activities affect the economic system in different ways. For example some analyses have examined the effect of universities on innovation (among others, see Acs et al 1992; Anselin et al., 1997 and 2000; Audretsch et al., 2011; Autant-Bernard, 2001; Blind and Grupp, 1999; Del Barrio-Castro and García-Quevedo, 2005; Leten et al, 2007; Jaffe, 1989; Mansfield, 1991 and 1995; Piergiovanni et al, 1997) while others focus on regional economic growth (Carree et al, 2011; Duch et al 2011; Drucker and Goldstein, 2007; Goldstein and Ducker, 2006).

Despite the growing literature on this topic, surprisingly few studies have investigated the impact of university knowledge on private firm productivity. Almost all these studies focus on the effect of R&D collaboration with universities on firm performance and the results are ambiguous: Belderbos et al. (2004) for Dutch firms and Harris et al. (2011) for Britain show a positive impact; on the contrary, Medda et al. (2005) found that collaborative research undertaken between Italian manufacturing firms and universities had no significant effect on the growth of total factor productivity (TFP). The only study that considers a wide spectrum of knowledge and technology transfer (KTT) is Arvanitis et al. (2008). They consider an aggregate index which takes into account several KTT activities and provide evidence that these have on average a positive influence on the labor productivity of Swiss firms. However, they do not distinguish among the effects of each of the university activities considered on firms' performance.

We contribute to this empirical literature by estimating the individual effects of different academic activities on firms' TFP, namely basic and applied research, creation of human capital through teaching and technology transfer. In order to perform the analysis we need to estimate a proxy of university R&D and to build indicators for the different functions carried out by universities. These are then aggregated on a provincial basis (NUTS 3 units in the Eurostat classification of administrative units in Europe). In fact, the use of territorially disaggregated data allows us to better capture the transmission of tacit knowledge which cannot be easily transferred over large distances (Anselin et al., 1997; Audretsch and Feldman, 1996; Jaffe 1989). The construction of these indicators is a further contribution of this paper, since the Italian National Institute of Statistics (ISTAT) provides data on university R&D and even that is at the regional level only.

Finally, this study contributes to the debate on the difficulties of the Italian economy by assessing the relationship between firms and universities in explaining economic performance. The analysis focuses on TFP because many contributions have shown how the slowdown of Italy's productivity observed over recent decades can be attributed to the decline in TFP (amongst others OECD, 2007b; Van Ark et al., 2007).

TFP is estimated at firm level by employing the Levinshon and Petrin's (2003) approach using the UniCredit-Capitalia database (2008), while to obtain university indicators we employ data by the National Agency for Evaluation of Universities and Research Institutes (ANVUR), the Ministry of Higher Education and Research (MIUR) and the Italian Network for the Valorization of University Research (NETVAL).

Results show that firm R&D has a positive and significant effect on TFP, while R&D by external institutions does not affect firms' performance. Indicators which represent activities carried out by universities different from R&D (graduates in S&T areas, S&T researchers, Netval membership) do not seem to improve productivity. However, if we consider the North of Italy, the most industrialized area of country, we find that not only does internal R&D have a positive and significant effect on the productivity of firms, but also that R&D and the other activities carried out by universities play a fundamental role.

The paper is organized as follows. The following section describes data and indicators employed. We then illustrate methodology and results. The last section concludes.

2. Data and descriptive statistics

2.1 Firm data

Our firm-level data come from the Xth UniCredit-Capitalia survey (2008), which covers the period 2004-2006 and is compiled on the basis of the information collected using a questionnaire sent to a sample of Italian manufacturing firms.[1] The survey is complemented with balance sheet data for the period 1998-2006.

Information about our sample is reported in Table 1**.** Firms in the sample are mainly small-medium firms, family-owned, belonging to supplier-dominated sectors or specialized suppliers and located predominantly in Northern Italy. Table 1 also reports TFP average for 2006 estimated using the Levinsohn and Petrin (2003) approach (see Appendix A) and R&D intensity (R&D expenditure/Value Added) in 2006. Marked differences emerge across different groups. Productivity appears to be higher for large enterprises, non-family firms, firms belonging to the science based sector and located in the North. As far as the R&D intensity, 45% of the sample reported positive R&D expenditure with an average value of 1.94%. Firms that spend relatively more on R&D are small, not family-owned and operating in a scale intensive sector. Instead, for R&D intensity there is no difference in our sample between the two areas of the country.

[1] The survey design includes all firms with a minimum of 500 employees. A sample of firms with between 11 to 500 employees is selected according to three stratifications: geographical area, Pavitt sector and firm size. Although the survey covers the period 2004-2006, some parts of the questionnaire refer to 2006 only.

Table 1 - Characteristics of the sample

	Number of observations	TFP (2006)	Number of firms with positive R&D	R&D Intensity (2006)
ALL FIRMS	635	91049	288	1.94%
Pavitt Sectors				
Supplier dominated	318	79197	136	1.81%
Scale intensive	107	101734	42	2.31%
Specialised suppliers	188	101134	100	1.91%
Science based	22	124217	10	2.21%
Size				
Small (< 50 employees)	286	71373	122	2.28%
Medium (50-250)	298	98830	142	1.80%
Large (>250)	51	155923	24	1.16%
Territorial area				
North	467	93479	214	1.91%
Centre-South	168	84294	57	2.03%
Ownership				
Family firms	393	88086	186	1.75%
Non-family firms	242	95861	102	2.27%

Source: elaborations on data from UniCredit-Capitalia (2008)

2.2 University indicators

Past research points out as the main nature of the ‘‘spillover’’ of human capital and research from universities to industry is that of tacit knowledge (Acs et al. 1992; Jaffe 1989). Tacit knowledge cannot be easily transferred over large distances or bought via the market. Jaffe (1989) and Audretsch and Feldman (1996) provided evidence that knowledge spillovers are geographically bounded and located within spatial proximity to the knowledge source. Furthermore, Anselin et al. (1997) prove that the geographical scope of knowledge spillovers is restricted to a limited number of neighbouring regions or to regions within a given maximum distance from the region of interest.

Considering the relevance of geographic proximity for tacit knowledge, we choose the province (NUTS 3 level)[2] as the territorial unit for university variables. We use data collected from Italian universities, both public and private, to build university-related indicators. Universities contribute to the production of knowledge and knowledge inputs for the business sector in three major ways: i) basic and applied research, i.e. the creation of knowledge through research; ii)

[2] Provinces are one of the three different levels of government (regions, provinces and municipalities) introduced by Article 114 of the Italian constitution. According to the basic principles of the Nomenclature of Territorial Units for Statistics (NUTS) established by Eurostat and used by the European Commission, Italian provinces are NUTS 3 level.

teaching, i.e. creation of human capital and iii) transfer of existing know-how to businesses and other organisations.

For basic and applied research, we build two indicators: R&D expenditure and the number of professors and assistant professors in science and technology fields (S&T)[3] as a share of total academics.

Total research spending by university (RD_u) is given by:

$$RD_u = RDP_u + F_u + RDDEP_u \qquad [1]$$

with $u = 1\ldots\ldots 76$ universities and where RDP_u is the cost for personnel engaged in research activity, F_u represents the expenditure per doctoral and post-doctoral fellowships and $RDDEP_u$ is departments R&D expenditure.[4]

Expenditure for academic research personnel (RDP_u) is proxied by

$$RDP_u = \sum_{s=1}^{14}\left[\left(\sum_{p=1}^{2}\bar{S}_{pu}N_{psu}\right)t_s\right] \qquad [2]$$

with $s = 1\ldots\ldots 14$ S&T areas[5], p= position (1 for professors and 2 for assistant professors) and where:

$\bar{S}_{pu}$ is the average wage on personnel for position *p* and university *u*;

N_{psu} is the number of research staff for position *p*, scientific area *s* and university *u*;

t_s is the percentage of time spent on research activity by academics for each scientific area *s*.

The percentage of the time spent on research by university professors and assistant professors for each scientific area (t_s) is published by ISTAT (2007). These coefficients are the results of the survey on the distribution of working time of Italian academics, primarily the time devoted to teaching and research, for the academic year 2004-2005.[6]

---

[3] In the science and technology fields we consider the following faculties: Agriculture, Pharmacy, Engineering, Medicine and Surgery, Veterinary Medicine, Mathematical, Physical and Natural Sciences, Biosciences and Biotechnology, Industrial Chemistry, Environmental Sciences, Biotechnology, Science and Technology, Computer Science.

[4] Specific university variables are provided by ANVUR. The ANVUR Annual survey database relative to 2004 includes 79 universities. Removing from the population two telematic universities and one university with no data on expenditure on personnel brought down the count of research universities to 76. Databases are available at: http://www.anvur.org/?q=content/rilevazioni-annuali.
Data from private universities have been collected from https://nuclei.cineca.it/cgi-bin/2005/sommario.pl.

[5] Scientific areas are: Mathematics and Computer Sciences, Physics, Chemistry, Earth Sciences, Biology, Medicine, Agricultural and veterinary sciences, Civil Engineering and Architecture, Industrial and Computer Engineering, Ancient History, Philology, Literature and Art History, History, Philosophy, Pedagogy and Psychology, Law, Economics and Statistics, Political and Social Sciences.

[6] The research activity includes the time spent on research, i.e. the creative work aimed at acquiring new knowledge, and the use of such knowledge in new applications. It also includes the time involved in the coordination of research projects carried out by researchers and PhD students and in conferences and seminars. For example, chemists spend, on average, 56% of their working time doing research, while academics in the field of medicine spend only 29%.

Data on post-doctoral fellowships, F_u, were available from ANVUR Annual Survey, while doctoral fellowships were calculated by considering the number of PhD students provided by ANVUR and the cost of a fellowship in 2004.[7]

The last component of our proxy of university research expenditure is departments expenses for research activity, that is

$$RDDEP_u = \sum_{d=1}^{n} Pay_{du} \qquad [3]$$

with $d=1 \ldots\ldots n$ departments and Pay_{du} represents total expenditure for research activities by department d of university u.[8]

As a proxy of applied research we use the number of professors and assistant professors (from now on "researchers") in S&T as a share of the total research staff of each university. This indicator comes from Netval Report (2006).

As regards the creation of human capital, we consider the S&T graduates as a share of the graduates in all fields. We focus on S&T since this type of training is most directly applicable to industry. Information on the number of students is provided by the MIUR and refers to the year 2004.[9]

In order to separate the technology-development element from the more traditional functions of universities in creating knowledge through research and teaching, we consider the more recent activities by universities aimed at technology transfer and commercial exploitation of research results. For this purpose a growing number of universities has promoted specific structures devoted to technology transfer (Technology Transfer Office - TTO). In Italy the network of TTO has b een created (Netval).[10] We consider that participation in Netval identifies the universities most engaged in entrepreneurial and technological development: Netval gathers 78% of the total number of public research spin-offs, 88.3% of the total number of university spin-offs and 94.9% of active patents owned by Italian universities.

[7] For the universities where information on postdoctoral fellowships were not available on the ANVUR Annual Survey database, we collect data at http://www.anvur.org/?q=content/rilevazioni-annuali.

[8] Department R&D expenditure could be considered as a proxy of applied research. However, the bundled nature of university research activities and the difficulty in disentangling basic and applied research, prevent us from considering the departmental expenditure on research separately from university R&D expenditure. Departmental expenditure for research activities represents 26.8% of our university R&D indicator.

[9] http://statistica.miur.it/scripts/IU/vIU0.asp .

[10] Netval (www.netval.it) was founded in November 2002 as a university network, in order to cope with a set of critical issues such as the reduction of public funding for research activities, the promotion of patenting as a tool for the protection of research results and several changes in the Italian regulations regarding patent ownership. In September 2007 it was transformed into an association. Netval gathers 49 universities that account for 76.9% of Italian university students and 79.5% of professors (Netval, 2006).

To pool university indicators with the company dataset, all university indicators are aggregated on a provincial basis[11] and then added to the company dataset based on its territorial location.[12] The 76 universities considered are located in 49 out of the 107 Italian provinces. In particular, 37 provinces have just one university, 8 provinces have 2 universities and 1 province (Pisa) has 3 universities; a strong concentration of universities exists in the provinces of Naples (5 universities), Milan (7) and Rome (8).

Table 2 reports statistics regarding the university indicators aggregated by territorial area. Interestingly, the S&T graduate and researcher shares vary slightly from one area to another, but, in terms of university R&D expenditure, Northern provinces spend on average 1.4 times the amount spent by Southern provinces. The Northern provinces are also characterized by a high participation in Netval: 77% of universities located in the North compared to 56% of universities in the Central-Southern provinces.

Tab 2 University indicators by territorial area

	North	Center	South	Italy
Number of universities	30	22	24	76
Number of universities participating in NETVAL (2006)	23	13	13	49
University R&D expenditure (thousands of euro) (2004)	1,384,302	879,032	932,946	3,196,280
Average by province (thousands of euro)	69,215	87,903	49,102	65,200
Average by researcher	57,247	55,991	50,693	54,836
S&T graduates (2004)	45,226	21,863	26,470	93,559
Average by province	2,261	2,186	1,393	2,161
Share of total graduates	35.9%	33.0%	34.6%	34.8%
S&T researchers (2005)[1]	11,834	8,900	6,559	27,293
Average by province[2]	657	1113	505	700
Share of total researchers	60.1%	58.9%	59.1%	59.5%

[1] Calculated on the sample of the 49 universities participating in Netval in 2006.
[2] The average is calculated considering the provinces with S&T academic staff.
Source: elaborations on data from ANVUR, MIUR and Netval (2006)

3. Empirical strategy and results

3.1 Empirical strategy

The baseline model considered in our analysis is the following:

[11] For the multi-campus universities with an organized central campus and several peripheral ones, we refer the data to the province of the central location of the multi-campus university, since in most cases teaching activity alone is performed locally, whereas research is retained at the central location.
[12] The correlation between the Istat data on university R&D expenditure available at regional level and our estimates aggregated on a regional basis is very high (0.98).

$$\ln \omega_{ij} = \beta_0 + \beta_1 RD_{ij}^{INT} + \beta_2 RD_{ij}^{EXT} + \beta_3 S_{ij} + \eta_1 D\_small_{ij} + \eta_2 D\_pav3/4_{ij} + \eta_3 D\_fam_{ij} + \eta_4 D\_North_{ij} + \varepsilon_{ij} \quad [4]$$

for *i=1,…,N* firms and *j=1,2,…,P* provinces. ω indicates the firm TFP in 2006 estimated by using Levinsohn and Petrin's (2003) approach, RD^{INT} is the internal R&D intensity of firms in 2005, RD^{EXT} indicates the external R&D intensity (research projects with universities, other research centers, and other companies) in 2005,[13] *S* stands for the average level of education of the labour force in each firm.[14] Moreover, we have included a set of binary variables which allow us to take into account dimensional, industrial and geographical effects. In particular, we have considered *D_small* which takes the value 1 if the firm is small (less than 50 employees) and zero in the other cases, *D_pav3/4* which is equal to one if the firm is in the specialized or science based sector according to the Pavitt taxonomy,[15] and *D_North* which assumes the value of one if the firm is located in the North of Italy and zero otherwise. We have also included the dummy *D_fam* which takes the value of one in the case of a family-owned firm.[16] Finally, ε_{ij} is the error term.

In order to address the effect on TFP of basic and applied university research, we augment equation [4] by considering two indicators of R&D carried out by universities. Hence, we estimate also the following model:

$$\ln \omega_{ij} = \beta_0 + \beta_1 RD_{ij}^{INT} + \beta_2 RD_{ij}^{EXT} + \beta_3 S_{ij} + \beta_4 RD_j^{UNIV,PROV} + \beta_5 RD_j^{UNIV,REG} + \eta_1 D\_small_{ij} + \eta_2 D\_pav3/4_{ij} + \eta_3 D\_exp_{ij} + \eta_4 D\_North_{ij} + \varepsilon_{ij} \quad [5]$$

were $RD^{UNIV,PROV}$ indicates the intensity of R&D universities located in the same province as the firm in 2004, while $RD^{UNIV,REG}$ is the intensity of R&D universities located in the other provinces of the same region as each firm in 2004.

13 In the Unicredit-Capitalia questionnaire, firms are also asked to indicate the share of external R&D due to collaboration with universities, research centers and other companies, separately. However, since around 38% of firms that have indicated the amount of external R&D do not give any information about the institution with which they collaborate, we feel that the data on collaborative research with universities may not be reliable. For this reason we decided to consider only aggregate external research. Moreover, we have lagged the R&D variables (both internal and external) because it is likely that there is a time lag between when the investment is carried out and when it produces effects on the firm's performance. In this way problems due to the endogeneity of R&D variables should be limited.

14 The average level of education (Si) of the workforce of the firm is given by the following relation: Si=[8*Oi+13*Mi+18*Li]/Ni, where Oi indicates the number of employees that have attended compulsory education, Mi is the number that have completed secondary education, Li is the number of graduates, while Ni is the total number of people employed by the firm.

15 We have considered the specialized and the science based sectors together since the latter has only 22 firms.

16 According to the literature we can expect, ceteris paribus, on average a higher level of TFP for exporting firms (Melitz, 2003; ISGEP, 2008), and hence we have also run estimations with the inclusion of a dummy *D_exp* which is equal to one if the firm exported in 2006. Results regarding the other variables do not change while the coefficient of *D_exp* is never significant. As pointed out by Cassiman et al (2010), one potential underlying mechanism for the selection of more productive firms in the export market could be that successful innovation improves the firm's productivity and, hence, these more productive firms go into the export market. As a result, omitting an innovation variable from the analysis may lead to the overestimation of the productivity-export association. Therefore, the presence of innovative indicators in our specifications could explain the low significance of the dummy for exporters.

Finally, in order to evaluate the role of the other academic activities, that is applied research, teaching and formal technological transfer, we have added to eq. [4] other indicators of University activities and estimated the following model:

$$\ln \omega_{ij} = \beta_0 + \beta_1 RD_{ij}^{INT} + \beta_2 RD_{ij}^{EXT} + \beta_3 S_{ij} + \gamma UnivActiv_j + \eta_1 D\_small_{ij} + \\ + \eta_2 D\_pav3/4_{ij} + \eta_3 D\_fam_{ij} + \eta_4 D\_North_{ij} + \varepsilon_{ij} \qquad [6]$$

where *UnivActiv* stands for the proportion of researchers in S&T faculties in 2004 (*share_ResST*) out of total number, or the share of graduates in S&T faculties in 2004 (*share_gradST*),[17] or a dummy *D_netval* equal to one if in 2006 at least one university participating to Netval is located in the same province of the firm.[18] Similarly to university R&D, these variables refer to universities located in the same province as the firm. [19]

As regards the estimation method, since firms from the same province are likely to be more similar than firms from different provinces (because of socio-economic factors for expample) the assumption that the errors are independent might be violated. For this reason we control for the potential downward bias in the estimated errors by clustering firms at provincial level. The regression with the cluster option relaxes the assumption of independence and, therefore, compared with the OLS without clustering, increases the error term to accommodate the lack of independence of firms within each province. We have also verified if there is any significant spatial dependence in the TFP or in the disturbances across firms. Results based on the Moran, LM and robust LM tests (see Appendix B table B.3) show that there is no evidence of spatial lag or spatial error models.[20]

3.2 Results

Estimation of equations [4] and [5] are reported in columns (1) and (2) of Table 3, respectively.

Results show that higher average level of education increases firms' TFP. Moreover, firms in the specialized or science based sector have, on average and *ceteris paribus*, a higher TFP. A similar result is obtained for firms located in Northern italy , while small firms have a lower TFP. Regarding the impact of family ownership on productivity our results show that family firms are

---

[17] We have lagged university indicators of basic and applied research (university R&D and researchers in S&T) two years because it is likely that there is a temporal lag between the time when the new knowledge becomes available and when it is identified, absorbed and used by firms. Moreover, we have also lagged graduates in S&T two years to account for the transition to the labour market.

[18] We do not include the three variables at the same time in the estimations because they are highly correlated with each other (see Table B.2 in the Appendix B).

[19] See appendix B for descriptive statistics of variables and correlation matrix between regressors (Tab B.1. and B.2. respectively).

[20] We have used the *spatdiag* command provided by Pisati (2001) for the STATA software. The weighting matrix is computed by using the *spmat* command by Drukker et al (2011) and considering row standardized inverse distance matrix. Distances are computed by using the latitude and longitude coordinates of each province (downloadable from http://worldgazetteer.com) in which each firm or each university is located and considering the Haversine formula.

less efficient and confirm those obtained by Cucculelli and Marchionne (2012) for Italy, by Barth et al (2005) for Norwegian firms and by Chiang and Lin (2007) for Taiwan's manufacturing firms. As regards the specific variables of interest, the results show that internal R&D has a positive and significant effect on TFP. This is in line with results obtained by other authors in the literature on the productivity of Italian manufacturing firms (e.g., Aiello and Pupo, 2004; Matteucci et al., 2005; Matteucci and Sterlacchini, 2009; Medda et al, 2006; Medda et al, 2005). However R&D activity developed in cooperation with external institutions does not affect firms' TFP.[21]

If we consider equation [5], results do not change. As regards university R&D, results show that research carried out by universities does not significantly affect firms' TFP.[22]

Results of equation [6] are reported in columns 3, 4 and 5. Estimates regarding the control variables do not substantially change, and confirm that the internal R&D of each firm positively affects productivity, while the impact of the different University activities on firms' TFP is never significant.

In order to investigate the results on the relation between Universities and firms' TFP further, we have estimated equations [5] and [6] by considering only Northern firms. Indeed, it is reasonable to assume that university activities could affect firms' performance only in an industrialized context, such as the North of Italy. Results of these estimations, reported in Table 4,[23] confirm our expectations.

In general, throughout Italy we find that internal R&D has a positive and significant impact on productivity. However, for Northern firms we also observe a positive and significant impact on TFP of R&D by Universities located in the same province, while R&D university in other provinces of the region does not seem to affect firms' TFP. The latter result could be due to the fact that the knowledge flows from universities to firms are clearly localized (Anselin et al, 1997, Audretsch and Feldman, 1996, and Jaffe, 1989). Moreover, the other university indicators, that is the share of researchers and graduates in S&T and the participation in Netval, have a positive and significant effect on Northern firms' TFP. Hence, all the activities performed by universities in the North, such as basic and applied research, teaching and the transfer of existing know-how to firms, play a

[21] This is in contrast with results obtained by Medda et al. (2005) which claim the effect on TFP of external R&D is significantly larger than the internal one. However, it is worth mentioning that they considered a different model, based on the growth in TFP computed as Solow residual; moreover, their dataset refers to a different period from the one considered in our analysis. When they split the external R&D expenditure in expenditure on research with universities, other research centers and other companies they found that engaging in external projects with research centers and other firms enhances firms productivity while collaboration with universities does not.

[22] We have also verified whether there is a spatial spillover effect on TFP of firms' R&D and university R&D by including the spatial lag of both variables in the model. Results show that spatially lagged variables have no significant effect on firms' TFP.

[23] Estimates regarding equation [5] are reported in column (1) while those regarding model [6] with the inclusion of the variables *share_ResST*, *share_gradST* and *d_netval* are reported in columns (2), (3) and (4) of table 4, respectively.

relevant role for firms located nearby. These results are in line with those obtained by Carree et al (2011), who measuring the contribution of teaching, publication and intellectual property rights on the growth of value added for Italian provinces between 2001 and 2006, show that universities play a key role when they are associated with sustained entrepreneurial activities in the province. Similarly to our findings, Arvanitis et al. (2008) found that university knowledge and technology transfer involving firms imply, *ceteris paribus*, higher labour productivity for a sample of 2,428 Swiss firms over the period 2002-2004.

To sum up, while for the Italian sample as a whole we do not find a significant relationship between universities and firms' productivity, if we consider Northern firms only we learn that all the activities carried out by universities foster TFP. This could be due to the fact that the high concentration of companies and industries in this area of the country creates more demand for university products providing better infrastructure for developing innovation. Moreover, because of Northern universities have more opportunities to cooperate with local companies, conduct joint research and consultations, train students through internships, and exchange ideas between academics and entrepreneurs.

Table 3 – Estimation results. Dependent variable: (logarithm of) TFP, 2006.

	(1)	(2)	(3)	(4)	(5)
RD^{INT}	0.099*	0.098*	0.121**	0.099*	0.099*
	(0.053)	(0.053)	(0.059)	(0.053)	(0.053)
RD^{EXT}	-0.338	-0.380	-0.195	-0.331	-0.333
	(0.900)	(0.930)	(0.995)	(0.903)	(0.902)
S	0.027***	0.027***	0.028***	0.028***	0.028***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
D_small	-0.383***	-0.383***	-0.377***	-0.383***	-0.383***
	(0.031)	(0.031)	(0.034)	(0.031)	(0.031)
$RD^{UNIV,PROV}$		-4.966			
		(13.313)			
$RD^{UNIV,REG}$		-0.021			
		(26.915)			
share_ResST			0.020		
			(0.063)		
share_gradST				0.030	
				(0.096)	
D_netval					0.011
					(0.040)
D_pav3/4	0.104***	0.106***	0.098***	0.103***	0.102***
	(0.031)	(0.031)	(0.032)	(0.031)	(0.031)
D_fam	-0.075**	-0.076**	-0.069*	-0.075**	-0.076**
	(0.036)	(0.036)	(0.039)	(0.036)	(0.036)
D_North	0.114**	0.106**	0.092	0.114**	0.113**
	(0.054)	(0.053)	(0.065)	(0.054)	(0.054)
Constant	6.463***	6.482***	6.462***	6.455***	6.458***
	(0.104)	(0.158)	(0.123)	(0.107)	(0.106)
Observations	635	635	580	635	635
R-squared	0.208	0.209	0.202	0.208	0.208
F-test	31.00	23.83	24.65	27.23	27.42
p-value	*0*	*0*	*0*	*0*	*0*

Robust standard errors clustered at provincial level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4 – Estimation results for firms located in Northern Italy only. Dependent variable: (logarithm of) TFP, 2006.

	(1)	(2)	(3)	(4)
RD^{INT}	0.114*	0.118*	0.112*	0.111*
	(0.060)	(0.061)	(0.059)	(0.059)
RD^{EXT}	0.790	0.730	0.650	0.627
	(0.887)	(0.962)	(0.909)	(0.909)
S	0.022**	0.021*	0.022**	0.023**
	(0.010)	(0.011)	(0.010)	(0.010)
D_small	-0.387***	-0.383***	-0.385***	-0.386***
	(0.030)	(0.031)	(0.029)	(0.030)
$RD^{UNIV,PROV}$	22.178***			
	(7.625)			
$RD^{UNIV,REG}$	-4.417			
	(24.856)			
share_ResST		0.138**		
		(0.058)		
share_gradST			0.212**	
			(0.084)	
D_netval				0.093**
				(0.036)
D_pav3/4	0.096***	0.110***	0.102***	0.098***
	(0.031)	(0.032)	(0.031)	(0.031)
D_fam	-0.097**	-0.091**	-0.092**	-0.097**
	(0.039)	(0.040)	(0.039)	(0.038)
Constant	6.612***	6.599***	6.589***	6.588***
	(0.133)	(0.121)	(0.115)	(0.115)
Observations	467	443	467	467
R-squared	0.227	0.227	0.225	0.227
F-test	30.26	31.62	34.93	35.52
p-value	*0*	*0*	*0*	*0*

Robust standard errors clustered at provincial level in parentheses;
*** p<0.01, ** p<0.05, * p<0.1

4. Conclusions

Empirical evidence documenting the disappointing performance of the Italian economy highlights the role of TFP as a key factor in explaining the decline of labor productivity in Italy over recent decades. We contribute to this debate by assessing the role of universities in fostering productivity of Italian firms. In particular, we distinguish several key university activities, including research, teaching and technological transfer in order to explore the impact of each on Italian firm TFP.

Overall, results show that the presence of universities does not seem to improve firm productivity. This result is consistent with the empirical evidence produced for Italy by Medda et al (2005) who found research collaboration with universities had no effect on firm performance, but not with the positive effect identified by Arvanitis et al. (2008), Belderbos et al. (2004) and Harris et al. (2011) for other countries. The results of these studies are indicative but not completely comparable, since many of the observed differences can be traced back to differences in the specification of university-related variables.

Furthermore, to fully understand the nature of the firm-university relationship in Italy, we must take into account a particular feature of the Italian economy, that is the pronounced geographical disparities: the regions of the North are as prosperous as those of Central and Northern Europe, but the South is the largest backward region within the EU-15 (Iuzzolino et al, 2011). Therefore, it is reasonable to suppose that universities may have a positive effect on the performance of Northern firms alone, since only in the North there is an efficient productive system, able to take advantage of the presence of a university in the same area.

Empirical analysis for Italy shows, for example, that technological transfer from universities to firms is complementary to intra-mural research and to the use of other external sources of innovation. The hypothesis that public research can fully compensate for the lack of internal research is rejected (Fantino et al, 2012). If we consider the regional distribution of spending on R&D, the key role of the North which accounts for 58.3% of total national spending, is clear (ISTAT, 2011). Consequently, we decided to focus our analysis on Northern firms, and have found that all the different activities carried out by universities play a fundamental role for firms located in this part of the country.

In a nutshell, the results show that the presence of universities does not affect the Italian economy uniformly: only where there is a dynamic industrial system, as in the North of Italy, do universities have a positive effect on firm productivity.

These results provide grounds for a cautious optimism for the future, since if, on the one hand, collaboration between universities and firms in Italy appears to be problematic (DPS, 2009), on the other, many national and regional programs aim to provide the tools for promoting cooperation between public research institutes and the private sector. Besides, Italian universities have only begun to make contact with companies relatively recently and, thus, some time is required before we can begin to see the fruits of such collaboration on the competitiveness of the industrial system.

Acknowledgments The authors gratefully acknowledge comments from Francesco Aiello and Giovanni Anania on an earlier version of the paper. This work benefits of the financial support from Regione Calabria within the CALCOM project on "Regional Competitiveness and Innovation" (L.R. 10/1998).

References

Aiello F., Pupo V., 2004, Il tasso di rendimento degli investimenti in Ricerca e Sviluppo delle imprese manifatturiere italiane, Rivista di Politica Economica, 94, pp. 81-117.

Aiello F., Pupo V., Ricotta F. , 2012, Un'analisi territoriale della produttività totale dei fattori in Italia", Scienze Regionali / Italian Journal of Regional Science, Vol. 11 – n. 2, pp. 23-46.

Acs Z. J., Audretsch D. B., Feldman M. P., 1992,. Real Effects of Academic Research: Comment, The American Economic Review, 82 , 363-367.

Anselin L., Varga A., Acs Z., 1997, Local geographic spillovers between university research and high technology innovations, Journal of Urban Economics, 42, 422–448.

Anselin L., Varga A., Acs Z., 2000, Geographical spillovers and university research: A spatial econometric perspective, Growth & Change, 31(4), 501–515.

Arvanitis S., Sydow N. ,Woerter M., 2008, Is there any impact of university-industry knowledge transfer on innovation and productivity? – An empirical analysis based on Swiss firm data, Review of Industrial Organization, 32, 77–94.

Audretsch D. B., M. Hülsbeck, E. E. Lehmann, 2011, Regional competitiveness, university spillovers, and entrepreneurial activity, Small Business Economics DOI 10.1007/s11187-011-9332-9.

Audretsch D. B., Feldman M. P., 1996, R&D spillovers and the geography of innovation and production, American Economic Review, 86, 630–640.

Autant-Bernard C., 2001, Science and knowledge flows: evidence from the French case, Research Policy, 30, 1069–1078.

Barth E., Gulbrandsen T., Schone P., 2005, Family ownership and productivity: the role of owner–management, Journal of Corporate Finance, 11, 107–127.

Belderbos R., Carree M. , Lokshin B., 2004, Cooperative R&D and firm performance, Research Policy, 33, 1477–92.

Blind K., Grupp H., 1999, Interdependencies between the science and technology infrastructure and innovation activities in German regions: empirical findings and policy consequences, Research Policy, 28, 451–468.

Bugamelli M., Cannari L., Lotti F., Magri S., 2012, Radici e possibili rimedi del gap innovativo del sistema produttivo italiano, Bank of Italy,. Questioni di economia e finanza (Occasional Papers), n. 121.

Carree M., Della Malva A., Santarelli E., 2011, The Contribution of Universities to Growth: Empirical Evidence for Italy. Working Paper DSE N° 793, Department of Economics, University of Bologna, Italy.

Cassiman B, Goloso E., Martinez-Ros E., 2010, Innovation, export and productivity, International Journal of industrial Organization, 28, 372-376.

Chiang M.S., Lin J.H., 2007, The relationship between corporate governance and firm productivity: evidence from Taiwan's manufacturing firms, Corporate Governance, 15, 5, 768-779.

Cucculelli M., Marchionne F., 2012, Market opportunities and owner identity: Are family firms different?, Journal of Corporate Finance, 18, 476-495.

Del Barrio-Castro T., García-Quevedo J., 2005, Effects of university research on the geography of innovation, Regional Studies, 39, 9, 1217-1229.

DPS, 2009, Migliorare le politiche di Ricerca e Innovazione per le Regioni. Contenuti e processi di policy, Ministry of Economic Development, Rome.

Drukker, D. M., H. Peng, I. R. Prucha, Raciborski R., 2011, Creating and managing spatial-weighting matrices using the spmat command. Working paper, The University of Maryland, Department of Economics
(http://econweb.umd.edu/~prucha/Papers/WP_spmat_2011.pdf).

Drucker, J., Goldstein, H. (2007). Assessing the regional economic development impacts of universities: A review of current approaches. International Regional Science Review, 30, 20–46.

Duch N., García-Estévez J., Parellada M., 2011, Universities and Regional Economic Growth in Spanish Regions, IEB (Barcelona Institute of Economics) Working papers, n.6.

Fantino D., Mori A. , Scalise D., 2012, Geographic proximity and technological transfer in Italy, Proceedings of the Conference "The transformation of local production systems", University of Bologna, January 31 - February 1.

Gallino L., 2003, La scomparsa dell'Italia industriale, Einaudi, Torino.

Goldstein H., Drucker J., 2006, The Economic Development Impacts of Universities on Regions: Do Size and Distance Matter? Economic Development Quarterly, 20, 1, 22-43.

Jaffe A. B., 1989, Real Effects of Academic Research. The American Economic Review, 79 , 967-970.

Harris R., Li Q.C., Moffat J., 2011, The impact of higher education institution-firm knowledge links on firm-level productivity in Britain, Applied Economics Letters, 18:13, 1243-1246.

ISGEP, International Study Group on Exports and Productivity, 2008, Understanding Cross-Country Differences in Exporter Premia: Comparable Evidence for 14 Countries, Review of World Economics, 144, 4, 596 – 635.

ISTAT, 2011, La ricerca e sviluppo in Italia, Statistiche Report, 29 dicembre.

ISTAT, 2007, La Ricerca e Sviluppo in Italia nel 2005, Statistiche in breve, 11 ottobre.

Iuzzolino G., Pellegrini G., Viesti G., 2011, Convergence among Italian Regions, 1861-2011, Bank of Italy, Economic History Working Papers, n. 22.

Leten B., Landoni P., Van Looy B., 2007, Developing technology in the vicinity of science: do firms benefit? An overview and empirical assessment on the level of Italian provinces, FBE Research Report MSI_0711, K.U.Leuven - Faculty of Business and Economics, 1-24.

Levinsohn J., Petrin A., 2003, Estimating production functions using inputs to control for unobservables, Review of Economic Studies, 70, 317-341.

Mansfield E., 1991, Academic Research and Industrial Innovation, Research Policy, 20, 1, 1-12.

Mansfield E., 1995, Academic Research Underlying Industrial Innovations: Sources, Characteristics and Financing, The Review of Economics and Statistics, 77 , 55-62.

Matteucci N., O'Mahonynn M., Robinsonnn C., Zwick T, 2005, Productivity, Workplace Performance and I C T : Industry and Firm-Level Evidence for Europe and the Us, Scottish Journal of Political Economy, 52, 3, 359-386.

Matteucci N., Sterlacchini A., 2009, R&S, Innovazione e Produttività nelle imprese manifatturiere italiane, in Produttività e Cambiamento nell'industria italiana. Indagini Quantitative, L. Rondi e F. Silva (edited by). Il Mulino, Bologna, pp. 95-123.

Medda G., Piga, C., Siegel D. S., 2006, Assessing the returns to Collaborative Research: Firm-level evidence from Italy, Economics of Innovation and New Technology, 15, 1, 37-50.

Medda G., Piga C. , Siegel D. S., 2005, University R&D and firm productivity: evidence from Italy, Journal of Technology Transfer, 30, 199–205.

Melitz M. J., 2003, The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, Econometrica 71, 6, 1695–1725.

Netval, 2006, La valorizzazione della ricerca nelle università italiane. Quarto rapporto annuale (http://netval.it).

Netval, 2011, Potenziamo la catena del valore, Ottavo rapporto Netval sulla valorizzazione della ricerca nelle università italiane (http://netval.it)..

OECD, 2007a, OECD science, technology and industry scoreboard 2007. ISBN 978-92-64-03788-5.

OECD, 2007b, Economic Survey: Italy. OECD, Paris.

OECD, 2010, Main Science and Technology Indicators, OECD, Paris.

Piergiovanni R., Santarelli E., Vivarelli M., 1997, From which source do small firms derive their innovative inputs? Some evidence from Italian industry", Review of Industrial Organization 12, 243-258.

Pisati M., 2001 spatwmat, spatcorr, spatgsa, spatlsa, spatdiag, spatreg – Tools for spatial data analysis, Stata Technical Bulletin, n. 60, 21-37.

Serti F., Tomasi C., 2008, Self-Selection and Post-Entry Effects of Exports: Evidence from Italian Manufacturing Firms, Review of World Economics, 144, 4, 660 – 694.

UniCredit-Capitalia, 2008, Decima indagine sulle imprese manifatturiere italiane. Rapporto Corporate, n.1.

Van Ark B., O'Mahony M., Ypma G., 2007, Productivity in the European Union: A comparative industry approach, The EU KLEMS Productivity Report, n. 1, March.

Appendix - A measure of TFP

The TFP used in this paper has been estimated in Aiello et al. (2012). Before estimating the TFP, a data cleaning procedure on Unicredit-Capitalia database has been carried out: firms with negative values of value added from the original archive and firms with a growth rate of value added and of employees below the first or above the ninety-ninth percentile of the distribution have been eliminated. Finally, firms for which data regarding employees was not available for at least 7 years were also excluded. In order to compute the TFP at firm level, we first estimate the following log-linear specification of a production function by using Levinshon and Petrin (2003) approach:

$$y_{it} = \beta_0 + \beta_K^{MAT} k_{it}^{MAT} + \beta_l l_{it} + u_{it} \qquad \text{[A1]}$$

with $i = 1, \ldots\ldots N$ firms, t = 1998, ……2006 and where y represents the value added, l the number of employees, k^{MAT} the stock of physical capital, β_0 measures the average efficiency and u_{it} represents the deviation of firm i from this average at time t. The error term can be decomposed into two parts:

$$u_{it} = \omega_{it} + \eta_{it} \qquad \text{[A2]}$$

where the term ω_{it} represents the productivity of firm i at time t and η_{it} is a stochastic term which includes not only the measurement error, but also the shocks which are unobservable to firms, and, therefore, do not correlate with inputs.

Productivity ω_{it} is known to the firm which, therefore, in the case of positive shocks, can decide to increase production by raising the level of inputs. This determines a problem of simultaneity which Levinshon and Petrin (2003) resolved by identifying in the demand for intermediate goods a proxy related to the variations in TFP known to firms.

Equation (A1) was estimated by utilizing as proxy for the stock of physical capital the tangible fixed assets and the demand for intermediate goods was measured by the operating costs. The value added has been deflated by using the ISTAT production price index available for each ATECO sector. As regards the tangible fixed assets, data have been deflated by using the average production price indices of the following sectors: machines and mechanical appliances, electrical machines and electrical equipment, electronics and optics and means of transport. For the operating costs, we adopt the intermediate consumption deflator calculated by using data from ISTAT.

Appendix B

Table B.1 Descriptive statistics of variables used in the estimations.

Variable	Obs	Mean	Std. Dev.	Min	Max
ln ω	635	6.676795	0.504432	4.628506	8.903166
RD^{INT}	635	0.040025	0.192001	0	4.220573
RD^{EXT}	635	0.007593	0.024035	0	0.224632
$RD^{UNIV,PROV}$	635	0.00219	0.002482	0	0.014444
$RD^{UNIV,REG}$	635	0.002041	0.001053	2.10E-06	0.005859
share_ResST	580	0.368258	0.317424	0	0.8536
share_gradST	635	0.229264	0.199935	0	0.659824
D_netval	635	0.56378	0.496306	0	1
S	635	11.40354	1.807575	8	18
D_small	635	0.450394	0.497925	0	1
D_pav3/4	635	0.330709	0.470839	0	1
D_fam	635	0.618898	0.486041	0	1
D_North	635	0.735433	0.44145	0	1

Table B.2 Correlation matrix between regressors included in the estimated models.

	RD^{INT}	RD^{EXT}	$RD^{UNIV,PROV}$	$RD^{UNIV,REG}$	*share_ResST*	*share_gradST*	D_netval	D_small	S	D_pav3/4	D_fam	D_North
RD^{INT}	1											
RD^{EXT}	0.0554	1										
$RD^{UNIV,PROV}$	-0.0177	-0.0743	1									
$RD^{UNIV,REG}$	0.0611	0.0505	-0.2719	1								
share_ResST	-0.0094	-0.0467	0.7234	-0.5088	1							
share_gradST	-0.0005	-0.0424	0.7065	-0.4249	0.9581	1						
D_netval	0.002	-0.0229	0.6833	-0.4809	0.8098	0.7676	1					
D_small	-0.0596	0.0231	-0.0052	0.0002	-0.0278	-0.0248	-0.019	1				
S	0.0329	-0.0004	-0.019	-0.0232	0.0156	0.0186	0.0215	-0.0743	1			
D_pav3/4	0.0751	0.0217	0.0515	-0.1483	0.111	0.1004	0.1194	-0.1244	0.2085	1		
D_fam	-0.0491	-0.0108	0.0008	0.02	0.0125	-0.0119	0.01	0.0214	-0.0425	-0.1306	1	
D_North	0.0418	-0.0096	-0.2238	-0.3945	-0.0128	-0.0167	0.0058	-0.0243	0.0507	0.1931	-0.1224	1

Table B.3 Spatial tests

	Model (1)		Model (2)	
	Statistic	p-value	Statistic	p-value
Spatial error:				
Moran's I	0.91	0.363	1.006	0.315
Lagrange Multiplier	1.632	0.201	1.467	0.226
Robust Lagrange Multiplier	0.189	0.664	0.332	0.565
Spatial lag:				
Lagrange Multiplier	1.945	0.163	1.841	0.175
Robust Lagrange Multiplier	0.503	0.478	0.706	0.401