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the effect of Italian universities' efficiency on local economic development 2006‒2012

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Abstract

We test whether there is a link between the performance of universities, measured through a concept of efficiency, and the economic development of the regions in which they operate. Indicators of teaching, research and third mission are considered as outputs. To handle endogeneity problems between the efficiency of universities and economic development, a system generalized method of moments and then an instrumental variable approach are used. Our findings reveal that the presence of efficient universities fosters local economic development. Knowledge spillovers occur to areas that are in close geographical proximity to efficient universities. Results are robust to different estimation strategies.

Keywords:
higher education; knowledge spillovers; local economic development; efficiency of universities

JEL Codes:
I21- Analysis of Education
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1. INTRODUCTION, MOTIVATION AND RESEARCH QUESTION

The assumption that universities should contribute to the social, economic and cultural development of the regions in which they operate is widely accepted nowadays. Several theoretical paradigms have been inspired by the positive role that higher education institutions (HEIs) can play in interactions with key stakeholders, with the final aim of transferring knowledge, disseminating culture and fostering economic competitiveness.

Among the first attempts at defining the 'external' role of HEIs, Clark's famous triangle (Clark, 1986) stands as a model for interpreting the performance of higher education systems. In Clark's view, the contribution of universities is not only the result of academic quality. The interplay with the 'state' (i.e. the government that regulates the system) and the 'market' (from students and their families to public and private entities in the region) is also important. The impact of a university's operations is not confined to the boundaries of academia, but has a positive/negative influence (depending on its quality) on wider society and the economy. In later literature, a clear indication of this emerges. It is possible to theoretically define a specific 'external' impact of teaching and research on the community, and this impact can be measured empirically[1]. Even more compelling is the notion that universities can contribute to the improvement of human capital, which in turn can stimulate and foster economic growth[2]. The most recent development in the field is the formalization of a new 'mission' to add to the two traditional roles of teaching and research. Researchers use the terms 'third mission' (Laredo, 2007) or 'knowledge transfer' (Bekkers & Freitas, 2008) to identify a new set of activities through which HEIs interact with their communities[3].

Reliable datasets and advanced theoretical frameworks are now available that allow for a more precise description of the channels through which HEIs influence regional social and economic development. First, measures of human capital development and research can be collected at the institution level, not just at the more aggregated district, province, region and country levels. This provides a great opportunity to integrate microeconomic insights into the analysis of a macroeconomic topic. Second, several databases now include indicators of the kind of actions that universities conduct with respect to the third mission. This allows activities in this area to form part of the wider picture of the performance of HEIs. Third, studies of higher education activities have highlighted how, in many cases, HEIs tend to operate inefficiently – in other words, they use more resources than should be required to achieve their observed levels of output (for a discussion, see Johnes, 2006). When considering the role of universities in developing human capital, their level of operational efficiency[4] should therefore be taken into account. There are few studies that take advantage of these developments in their empirical analyses. Barra and Zotti (2017), for example, use the number of graduates and university efficiency scores as indicators of human capital, demonstrating their positive effect on the areas in which HEIs operate. Their paper constitutes a natural key reference point for our study, which extends and improves the preliminary analysis presented by the authors.

We contribute to the literature by proposing an empirical analysis of the impact of the performance of Italian universities on local gross domestic product (GDP). Specifically, we address the following research question: *is there a statistical link between the performance of universities and the economic development of the geographical area in which they operate*? We answer this question by employing an econometric analysis, which uses a dynamic panel model for the period 2006-2012. The data cover 53 public universities, clustered into 46 Italian labor market areas (LMAs) (see Section 4 for more details on the geographical stratification). The performance of HEIs is conceptualized in terms of efficiency, which we estimate using an innovative and robust stochastic frontier analysis[5] that takes into account indicators of all three missions – teaching, research and the third mission. Our measurement of efficiency is more complete than that proposed by Barra and Zotti (2017), who ignore the third mission. To handle endogeneity problems between the efficiency of universities and economic development, a system generalized method of moments (Sys-GMM) and then an instrumental variable (IV) approach are used.

The topic addressed in this paper is of particular interest given the current state of the Italian economy. Italian governments have been searching for decades for policy interventions to make the country more competitive. Our findings point to the use of educational instruments to foster economic development, by reinforcing the nexus between human capital – which is related to university performance – and economic development. Furthermore, a recent public debate has centered on raising the efficiency of public spending (Agasisti, Arena, Catalano, & Erbacci, 2015). With public expenditure on higher education amounting to almost 1 percent of GDP (OECD 2016), the sector should be included in these efforts. Our empirical results show that it is not only the performance of universities that matters for the economy of regions, but especially their efficiency.

The remainder of the paper is organized as follows. The next section discusses the theoretical insights into the relationship between universities' activities and economic development. Section 3 outlines the various steps of our methodological approach to measuring the efficiency of universities. Section 4 describes the determinants of economic development. In Section 5 the main results from a system generalized method of moments, including a battery of robustness checks, are presented. Section 6 shows two-stage least-square estimates to deal with endogeneity issues. Finally, Section 7 concludes, and also presents some suggestions and implications for policy-making.

2. UNIVERSITIES' ACTIVITIES, THEIR EFFICIENCY AND ECONOMIC DEVELOPMENT

2.1 How universities' activities affect economic development – existing evidence

The impact of universities on regional development has been the subject of intense debate in the last few years. The main challenge is to provide evidence that the economic prosperity of a region can be partly attributed, either directly or indirectly, to the presence of a university. Universities can boost local economic development in various ways: via knowledge transfer through education and human resources development (i.e. the human capital of students and graduates); via knowledge creation and regional innovation through research (i.e. publications); and finally, via technology transfer activities (i.e. the third mission). These all lead to spillover effects and improved regional competitiveness

(Drucker & Goldstein, 2007)[6].

A key contribution of universities to local development relates to their teaching mission. HEIs play a role in providing knowledge spillovers through the human capital embodied in graduating students as they move from universities to firms. An important role of the university system is to improve human capital through education, first through attracting potential high-quality undergraduate human capital to a region (Faggian & McCann, 2006) and then by producing highly skilled graduates. Mostly driven by technological changes, employers seem to be increasingly demanding workers with a graduate qualification (Wößmann, 2008), and highly skilled and well-educated individuals are an important driver of economic development (Florida, Mellander, & Stolarick, 2008). They are also one of the most important channels for transferring knowledge from academia to local high-tech industry (Varga, 2000; Riddel & Schwer, 2003; Robert & Eesley, 2009; Stephan, 2009). Indeed, university graduates are among the main factors that allow some states having significantly higher per capita incomes than other states (Bauer, Schweitzer, & Shane, 2012). Graduates may decide to start up new firms that boost the dynamics of the local economic environment (Florax, 1992; Goldstein, Maier & Luger, 1995), and they also increase the innovativeness, creativity and productivity of existing local firms (Rothaermal & Ku, 2008). Full-time highly skilled employees are key factors for increasing the number of spin-offs which, in turn, positively affect local development (Algieri, Aquino, & Succurro, 2013). As a consequence, regions that increase the average level of education of their employees tend to become more innovative (Gumbau-Albert & Maudos, 2009; Chi & Qian, 2010) and competitive (Haapanen & Tervo, 2012).

Knowledge spillovers from universities to firms also involve research published in scholarly journals (i.e. codified knowledge). Scientific research results in knowledge that can spur innovation by firms (Autant-Bernard, 2001; Bercovitz & Feldman, 2007) and lead to local economic growth (Goldstein & Renault, 2004). The higher the quality of the academic research, the larger the contribution to industrial innovation (Mansfield, 1995), although considerable variation across industries has been identified (Leten, Landoni & Van Looy, 2014). While this knowledge can be easily transferred at low cost (i.e.

downloaded from the Internet) and therefore is not tied to a firm's location, proximity to high-output universities may be important for accessing research networks (Audretsch & Lehmann, 2005). University research thus has a positive impact on the regional distribution of innovation (Del Barrio-Castro & García-Quevedo, 2005), through new product development, industry formation, job creation and access to advanced professional and management services (Walshok, 1997). HEIs should therefore focus more on research activities in order to respond to regional needs (Chatterton & Goddard, 2000)[7].

In addition to their traditional teaching and research activities, universities also aim to build links between research and business as part of their 'third mission', including through patents (Henderson, Jaffe & Trajtenberg, 1998), business incubators, collaboration agreements and spin-offs (Shane, 2002). The contribution of universities to local development is increasingly focused on the transfer of technology, hence the importance of HEI services in boosting the innovation activities of firms. Due to the role played by technological progress in the economic development of a region, the university−industry relationship has become more important (Guldbrandsen & Smeby, 2005; Muscio, 2010; Algieri et al. 2013) and universities have become key elements in building regional innovation systems (Caniëls & van den Bosch 2010). For example, the establishment of new companies, based on technologies derived from university research, is a well-recognized driver of regional economic development (Hayter, Lubynsky & Maroulis, 2017). Incubators developed by higher education institutions are effective in supporting new entrepreneurial initiatives (Auricchio et al. 2014). Innovative start-ups are also an effective way to facilitate technology transfer from universities to the economy (Boh, De-Haan & Strom, 2015). For a description of the channels through which university–firm research and development (R&D) collaboration impacts firms' product and process innovations, see Maietta (2015).

2.2 Why university efficiency is important for local economic development: a conceptual framework

In this section, we illustrate the importance of considering the concept of 'efficiency' in the context of our study. Following the literature in this field (Johnes, 2006), we categorize a university as efficient if it is able to produce maximum output (teaching, research and third mission) given the available inputs (such as human and financial resources)[8]. In Section 3 we provide details of how we operationalize this measurement from an econometric perspective, but it is worthwhile clarifying some theoretical aspects first. Whilst the measurement of output is linked to an absolute level of performance (i.e. how much output is produced), efficiency is a ‘relative’ concept. It calculates how far from optimal the production of outputs by an institution is in comparison with similar institutions and/or with a predefined optimal production function. Measuring efficiency is therefore theoretically very distinct from the straight measurement of performance. The former involves productivity considerations, with an assessment based on making the most of the available resources (for example, by fostering innovation and improvements in the technology of production). The latter takes into consideration the rate at which universities are able to convert inputs into outputs, but is instead concerned with the absolute level of output produced.

The first argument for considering efficiency is that different universities that produce the same amount of output can have different impacts on local development. This impact may depend on the intensity of their input usage. If a university employs fewer individuals for their operations for a given level of output, then those individuals not required by the university could be employed in the same region in alternative occupations that are more productive in terms of generating GDP. Some Italian universities have acted as ‘social welfare interventions’ in the past, hiring more people than necessary (especially in the south) with the implicit aim of sustaining the local economy by reducing unemployment. Paradoxically, this approach could have the opposite effect if employing these people reduces the opportunity for them to work more productively for local companies.

A second aspect to the efficiency of universities is reputational. Institutions may be well respected by society due to their reputation for being ‘efficient organizations’, which can induce positive relationship mechanisms with the activities of important stakeholders in the region. This positive climate can result in the generation of new partnerships, ideas and collaborations, creating new economic opportunities for local companies. If, instead, an academic institution is deemed to be ‘inefficient’, companies and local entities may be more reluctant to explore partnerships with it.

A third relevant consideration concerns incentives for efficiency among other institutions that interact with a university. If a university's productivity is at its maximum level (i.e., it is efficient in the technical sense), it will encourage efficiency in the other institutions with which it interacts. If the economic and social activity that is mediated by the university is relevant enough, then its stakeholders will also necessarily act in an efficient way. Following one of the points above, this can free up human and financial resources (inputs) to be used in alternative productive activities, with a direct positive effect on the local economy.

In summary, universities that are efficient, by definition, can produce more output for a given amount of inputs, all else being equal. This higher rate of production can have a positive effect on local development, particularly in comparison with areas in which universities operate in a less efficient way. Part of this effect can be captured in empirical models by employing university output levels in a regression for economic development. However, efficiency indicators provide a more valuable and direct measure of the 'productivity mechanism' that is behind that production.

3. EFFICIENCY OF UNIVERSITIES

We calculate a university's relative efficiency at converting inputs into a production set while maximizing outputs. Two main methods have been extensively applied in the literature for measuring efficiency – non-parametric[9] and parametric[10] – and no consensus has been reached on which should be adopted to measure the efficiency of higher education institutions. Both approaches have advantages and disadvantages (Lewin & Lovell, 1990). Both construct a theoretical production frontier, but they do so in a different way. The non-parametric method does not impose a specific functional form and it is based on a priori hypotheses about the technology (free-disposability, convexity, constant or variable returns to scale). However, if these assumptions are too weak, the level of inefficiency could be systematically underestimated in small samples, generating inconsistent estimates. Furthermore, this method is very sensitive to the presence of outliers. The parametric method instead requires the imposition of a specific functional form. It is not sensitive to extreme values because it imposes some assumptions on the error distribution, but must deal with the necessary assumptions for decomposing the error term.

In this paper, we opt for a parametric method – specifically, a stochastic frontier approach (SFA) – because it provides useful information on the underlying education production process, as well as information on the extent of inefficiency. We perform our analysis in two stages. First, we use an SFA to calculate an index of efficiency for each university. Second, a growth model is tested, through a system generalized method moment (sys-GMM) estimator, to measure the effects of the human capital development on local development. The fact that the GMM is a parametric method is a key reason behind our decision to also use a parametric measure (i.e., the SFA) for higher education institutions. In order to calculate the performance of universities, we apply the recent innovative model suggested by Kumbhakar, Lien, and Hardaker (2014) (see the Appendix for more technical details).

3.1. Inputs

Referring to the literature on this subject, the production technology is specified with one input: the number of academic and non-academic staff divided by the total number of students weighted by the quality of freshmen. The total number of academic and non-academic staff[11] – which we refer to as equivalent personnel ($EQUIV_{PERS}$) – is a measure of a human capital input that captures the human resources used by a university for teaching activities[12] (see Agasisti & Dal Bianco, 2009; Johnes, 2014). The total number of students is simply the number of undergraduates in each university. Finally, one input that is known to have an effect on student performance is the quality of the students on arrival at university. There is strong evidence that pre-university academic achievement is an important determinant of students' performance (Boero, Mcnight, Naylor & Smith, 2001; Smith & Naylor, 2001;

Arulampalam, Naylor, Robin, & Smith, 2004; Lassibille, 2011). The underlying theory is that greater ability reduces students' educational costs and increases their motivation (DesJardins, Ahlburg, & Mccall, 2002). Therefore, we weight the number of students using a proxy of ability when entering tertiary education, namely, the percentage of enrolments with a grade higher than 9/10 at secondary school (STU_{WEIGH})[13]. This input thus aims to capture both the quantity and the quality of students[14].

3.2. Outputs

Three measures of outputs are included in the model, reflecting the teaching, research and 'third mission' functions of HEIs: (1) the number of graduates; (2) the number of academic publications; and (3) spin-offs.

The first output is the number of graduates weighted by their degree classification ($GRAD_{MARKS}$), in order to capture both the quantity and the quality of teaching[15] (see Agasisti & Perez-Esparrells, 2010; Kuah & Wong, 2011; Thanassoulis, Kortelainen, Johnes, & Johnes, 2011; Duh, Chen, Lin, & Kuo, 2014). The task of a university is to produce graduates by using and combining different resources. An increase in the human capital stock generates positive effects on the regional economy, as highly skilled and well-educated individuals are considered an important driver of economic development.

The second output is a measure of the research performance of universities (PUB). Various proxies have been used in the literature to measure academic performance, including the number of citations (Bonaccorsi, Daraio, & Simar, 2006; Agasisti, Catalano, Landoni & Verganti, 2012), the number of publications (Lee, 2011; Wolszczak-Derlacz & Parteka, 2011; Duh et al. 2014) and amount of research grants (Johnes, Johnes, & Thanassoulis, 2008; Thanassoulis et al. 2011). We use the number of publications on Web of Science as a proxy for the overall quality of research, which in turn can have an effect on regional propensity to innovation.

Finally, the third output, which aims to measure the third mission of universities, is the number of university spin-offs established ($SPIN_{OFFS}$). Spin-offs have an important role in the transfer of frontier knowledge from university to society (Laredo, 2007; Bathelt, Kogler, & Munro, 2010; Caldera & Debande, 2010; Berbegal-Mirabent, Lafuente, & Solè, 2013). Although they are the most complex way of commercializing academic research – more complicated than patents and R&D collaborations, for example – spin-offs have the greatest potential impact in a local context (Iacobuzzi & Micozzi, 2015). They are one of the main ways of transferring research results to the market as well as an important driving force in renewing industrial structures (Calcagnini, Favaretto, Giombini, Perugini, & Rombaldoni, 2016). While we are aware that the third mission of universities includes several other activities, including various forms of knowledge transfer and public engagement, the number of spin-offs appears to be a good proxy in the context of this study.

All the outputs are normalized by the total number of students weighted by the quality of freshmen.

3.3. Composite index of efficiency: benefit of doubt approach

To rank universities, we construct a composite index consisting of the three output variables described above. Our main aim here is to avoid the common subjectivity on the weight selection by proposing an endogenous weighting mechanism. Variables in which a university has a comparative advantage are more heavily weighted than variables in which a university has a lower comparative advantage, or even a comparative disadvantage. As the strengths of universities differ, the weights on the performances should differ as well. For example, University X might perform relatively poorly in the production of graduates. Therefore, in an endogenous weighting, the output 'number of graduates' will be assigned a lower weight in the weighting scheme. In contrast, outputs where the university performs relatively well, for instance the number of publications, will obtain a higher weight. In a similar model the weights are observation-specific, which contrasts with previous literature and practices. The idea corresponds to the benefit-of-doubt (BoD) model, a concept that was first developed by Melyn and Moesen (1991)[16]. Using BoD, each university gains its own weights that maximize (or minimize) the impact of the criteria in which the university performs relatively well (or poorly) compared to others[17]. In this paper, the BoD scores are used as composite output in measuring the efficiency of universities, while the estimation of efficiency scores is conducted using a parametric method (SFA)[18].

3.4. Variability of efficiency

It seems inappropriate to assume that efficiency would vary for each university in the same way. Institutions can react in very different ways to the contexts in which they operate. To take into account the effects of factors affecting the performance of universities, we include a vector of exogenous variables (z) in the variance of the efficiency term - see the Appendix for technical notation.

According to Wolszczak-Derlacz and Parteka (2011), HEIs with a longer tradition are often perceived as having a better reputation. However, younger HEIs could well have more flexible and modern structures, leading to more efficient performance. The years of existence of the university ($YEAR_{FOUND}$) is used as a proxy for the level of tradition of a given HEI.

Universities with medical schools may be more efficient than those without. For example, it might be easier for them to conduct clinical trials and to produce a large number of university licenses related to biomedical inventions (Kempkes & Pohl, 2010)[19]. To take this possibility into account, a dummy variable (MED_{SCHOOL}) equal to 1 if the university has a medical school and 0 otherwise has been used.

Universities' technology transfer offices are used as proxies for academic policies that are oriented towards the commercial exploitation of research results (see Muscio & Nardone, 2012, and Maietta, 2015 for previous use of such variable). We use the number of years since a technology transfer office was opened in a university (TTO_{AGE}) to control for the knowledge context in which local firms operate (in terms of research, education and technology transfer-related activities at local universities).

In the last few decades, the problem of interrupted careers (i.e. dropouts) has become an increasing concern in tertiary education. The Italian context is particularly interesting as the reduction of dropout rates is at the core of recent reforms of the national university system. To take this into account, the percentage of dropouts by the end of the first year ($INACT_{STU}$) is also included (see also Zoghbi, Rocha, & Mattos, 2013).

The ordinary financing fund (FFO), a global lump-sum that the central government transfers to each university, can be managed by universities autonomously. This variable is included to take into account the budget transferred for teaching and research activities. The amount and the criteria for its allocation can have an effect in terms of incentivizing the productivity of institutions.

Finally, dummy variables associated with the size of the universities' student bodies (DIM1, DIM2, DIM3 and DIM4) have also been added. These are obtained by splitting the number of students into quartiles, in order to control for the size of the institutions influencing their own technology. Time dummies (T1−T7) have also been included to capture two different effects: (i) change in technology over time when they are included in the production function, and (ii) change in inefficiency over time when they are included in the variance of inefficiency term. Table 1 contains the descriptive statistics of the variables used in the production set. Table 2 specifies the outputs, inputs and the exogenous factor combinations in the empirical models.

(Tables 1 & 2 to be inserted around here)

4. MODELLING THE DETERMINANTS OF LOCAL ECONOMIC DEVELOPMENT

In order to analyze the relationship between the efficiency of universities and local economic development, we specify the following dynamic panel model (Barra & Zotti, 2017):

$$ln\,GDPC_{i,j,t} = \alpha lnGDPC_{i,j,t-1} + \beta_1\, lnEFF_{i,j,t} + \beta_2 \sum_{i=1}^{56} ln\,EFF_{i,k,t} * W + \beta_3 \sum_{i=1}^{56} lnGDPC_{i,k,t} * W + \beta_4 lnMS_{i,j,t} + \beta_5 LG + \mu_{i,j} + \tau_t + \varepsilon_{i,j,t} \quad (1)$$

where ln is the natural logarithm, $GDPC$ is gross domestic product per capita (measured as the sum of the gross values added of all units divided by workers in each labor market area in which the university is located[20]) and $GDPC_{t-1}$ is its lagged value. EFF refers to the efficiency of universities. MS is market share, measured as the ratio between the number of enrolments at university i and the total number of enrolments in universities located in the same region. This is included to capture the potential effects of competition between universities. LG is the number of employed individuals at time t minus the number of employed individuals at time $t-1$. This controls for various local influences such as changes in the job market[21]. μ is the unobserved university and labor market area-specific effect, τ are year dummies controlling for time-specific effects, and ε are the disturbance errors. Subscripts i, j and t refer to the unit of analysis (universities), the area where the university is located (labor market areas) and time periods (years), respectively.

To examine whether geographical space has an impact on the relationship between the efficiency of universities and local economic development, we specify a spatial-lag model such that the efficiency levels of HEIs can spill over to area j. In other words, we take into account that development in area j depends systematically on the human capital development in neighboring areas $k \in J$, where J is the set of all areas (Anselin, 1988). We use an inverse distance weighted matrix to weight the EFF of all neighboring areas. In matrix notation, $EFF_{ikt} * W$ is the weighted average of university efficiency proxies across J_j areas neighboring area j. The spatial weight matrix is assumed to reflect the geographical structure of the knowledge spillover mechanisms operating at the local level. The two parameters we are most interested in are:

- β_1, which measures how economic development at the labor market area level is *directly* influenced by the efficiency of universities that operate in the labor market area of influence; and
- β_2, which measures whether economic development at the labor market area level *indirectly* benefits from ($\beta_2 > 0$), suffers from ($\beta_2 < 0$) or is independent ($\beta_2 = 0$) of the efficiency of universities in

neighboring areas.

$GDPC_{ikt} * W$ is the weighted average GDPC proxies across J_j areas neighboring area j. It is included to control for spillovers due to the economic development of neighboring areas.

Due to the importance of capturing the contribution of HEIs to economic development at the local level, we use highly regionally disaggregated data based on labor market areas (LMAs). These are sub-regional geographical areas where the bulk of the labor force lives and works, and where establishments can find the largest amount of the labor force necessary to occupy the jobs they offer (see Destefanis, Barra, & Lubrano Lavadera, 2014 for a similar use). LMAs offer deeper regional disaggregation than the Nomenclature of Territorial Units for Statistics level 3 (NUTS 3) subdivisions. In order to underline the importance of the area under analysis in the paper, Figure 1 (in Appendix) reports the locations of universities across the whole of Italy (Panel A) and in our data set (Panel B); Figure 2 (in Appendix) shows the locations of provinces across Italy (Panel A) and of the provinces in which at least one university included in our data set is located (Panel B); and finally, Figure 3 (in Appendix) illustrates the locations of the labor market areas across Italy as well those in which at least one university contained in our data set is located. Exploiting this disaggregation, GDPC and LG are not measured at the national level as in previous studies, but at the labor market area level. There are two main advantages to using data at such a disaggregated level. First, we are able to better highlight economic performance across the country. Second, most universities are assigned a unique value for environmental variables[22].

Table 1 above provides a description of the variables used for modelling the determinants of local economic development. In estimating the GMM model, we rely on STATA 13[23].

4.1. A system generalized method of moments (Sys-GMM) approach

The main threat to the correct estimation of the effect of HEIs' performance on local economic development stems from the likely endogeneity of the relationship due to omitted variables or reverse causality. In particular, areas may show higher levels of economic development (and dynamics in this variable) for reasons other than university efficiency that are still somehow correlated to our measure of performance. Results may also be confounded by reverse causality problems. Regional economic development may influence the efficiency of universities if we imagine that increased efficiency in the commercial sector has a spillover effect on the public sector.

This eventuality is absorbed, in our specification, by the effect μ_{ij}, and can make our estimation invalid if not taken properly into account (only other time-invariant characteristics correlated to regional development and efficiency are absorbed by the effect μ_{ij})[24]. To eliminate μ_{ij} in the dynamic panel specification of the model, we use the two-step system GMM estimator with Windmeijer's (2005) corrected standard error (Holtz-Eakin, Newey, & Rosen, 1990; Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998).

We instrument EFF by including lagged levels and differences until orthogonality is reached (the efficiency level of the universities is specified as an endogenous variable). More specifically, we first difference the regression equation to remove any omitted variable bias created by unobserved university-specific effects. Then, we instrument the right-hand-side variables using differences of the original covariates to eliminate potential parameter inconsistency arising from simultaneity bias (this is the difference dynamic-panel estimator, developed by Arellano & Bond, 1991 and Holtz-Eakin et al. 1990). As shown by Alonso-Borrego and Arellano (1996) and Blundell and Bond (1998), when the explanatory variables are persistent over time, the lagged levels of these variables are weak instruments for the regression equation in differences. In order to reduce these potential issues when using the difference estimator, the system GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998) is employed. This improves the quality of instruments also using the regression in levels (in addition to the regression in differences). In other words, first-differencing is exploited to eliminate the unobserved effect. Then differences and lags two and beyond are used as instrumental variables for the differenced lagged dependent variable (i.e. as instruments for EFF).

It could be argued, however, that time-lagged variables may not be exogenous at all, because it takes a considerable amount of time for the output of universities to result in economic development. This establishes a direct link between past efficiency and current development. However, what we are considering through our measure of efficiency is whether universities are using more resources than should be required to obtain their observed levels of output. So we are not measuring performance per se, more the ability to transforming inputs into outputs. We believe that a lagged variable measuring this ability is only related to the current local economic development of the area in which a university is located indirectly, through that university's current efficiency.

Consistency of the GMM estimator depends on the validity of the instruments used. We check the accuracy of the model through the Sargan test of overidentifying restrictions for the overall validity of the instruments. The Arellano−Bond test is used to test the autocorrelation between the error terms over time (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998). All the tests confirm the validity of the approach proposed here[25].

4.2 Data sources and descriptive statistics

The data set refers to 53 Italian public universities over the years 2006 to 2012. We exclude all private sector universities due to the absence of comparable data on various dimensions. Each of the 53 universities in our sample yields data for each year, so we have a total of 371 observations[26].

The variables included in the production set of the universities, such as $EQUIV_{PERS}$, $STUD_{WEIGH}$, $GRAD_{MARKS}$, $YEAR_{FUND}$, MED_{SCHOOL}, $INACT_{STU}$, and FFO, were collected from the National Committee for the Evaluation of the University System (CNVSU). $SPIN_{OFFS}$ and as TTO_{AGE} were obtained from the Italian Network of Technology Transfer Offices of Universities and Public Research Organizations (NETVAL). The number of publications (PUB) was extracted from the Thomson Reuters

ISI Web of Science database (part of the ISI Web of Knowledge), which lists publications from quality journals in all scientific fields. We count all publications (scientific articles, proceedings papers, meeting abstracts, reviews, letters, notes etc.) with at least one author declaring an affiliation to the HEI under consideration. Finally, the environmental variables used to estimate the local economic impact of HEIs, such as GDPC and LG, are taken from the Italian National Institute of Statistics (ISTAT).

A glance at the descriptive statistics (see Table 1 above) reveals some interesting features of the Italian context that are worthy of comment. Let us consider first the variables for the estimation of economic development. GDP is much higher in the north than in the south of Italy. This well-known phenomenon influences various aspects of the country's economy and society. The market structure of the provision of higher education, as measured through MS (the market share of each university in its region), reveals more market power in southern areas. Universities in the north are more subject to within-region competition (on average, universities have less intra-regional market power – this is especially true for those located in the north-west).

Some additional information is needed to clarify our assumptions that provide the basis for using MS as a proxy for market power. The existence of competitive behavior by HEIs in the Italian system has been highlighted in previous academic contributions (Agasisti, 2009; Rossi, 2009). What we aim to measure through market share is a sort of 'market power' effect, rather than 'competition' in a more traditional sense. When two or more universities share the same market, they face the same level of competition (measurable, for example, through the Herfindahl index), but from very different positions. We are interested in the effect of competition on each university, which is measurable through their market power[27].

The dynamic of the Italian labor market appears to be broadly stable in the period under scrutiny (2006−12), with slight increases in northern and central Italy being offset by a reduction of the number of workers in the south. Turning our attention to the variables relating to the inputs and outputs of universities, the average number of employees in Italian universities is around 1,000, although there tend to be more personnel in the universities located in northern and central Italy. Universities in the south tend to have more students, and this leaves them with worse student–teacher ratios than their counterparts in the north. On the output side, universities in the north have a noticeably higher number of graduates. There are also substantial differences in the numbers of spin-offs and academic publications, with more than double the amount of both for universities in the north than for those in the south. These differences in the descriptive statistics strongly suggest that some important differentials in university efficiency do exist, and it is necessary to consider these when analysing the impact of universities on local economic development.

Lastly, the controls inserted in the empirical analysis of university efficiency also show a high degree of heterogeneity across macro-regions. For example, the lump-sum funding provided by the Ministry of Education (FFO) is much higher for the universities in the north. The same is true for 'experience' in the development of technology transfer activities (as measured by the 'age' of the university's technology transfer office). On the other hand, the number of inactive students is higher in the universities located in the south.

5. RESULTS

5.1 The efficiency of universities

The estimated parameters of the stochastic education frontier, employed to measure the efficiency of universities, are presented in Table 3[28]. The coefficients show that the input variable has a positive and statistically significant effect on the indicator for the composite output of the universities. The patterns of efficiency scores are worthy of comment. When looking at the (average) technical efficiency scores by geographical area (see Table 1 above) [29], the estimates reveal that HE institutions in central and northern areas (north-western, north-eastern and central) outperform those in southern areas. This result is consistent with previous evidence reported, for example, by Agasisti and Dal Bianco (2009), Agasisti, Barra and Zotti (2016) and Barra and Zotti (2017). Overall, universities should be able to expand their production of output by about 25 percent without increasing their inputs. This number is lower for universities located in the north (20 percent) and higher for those in the south (around 28 percent).

(Table 3 to be inserted around here)

5.2 The (direct) effect of university efficiency on local economic development

Let's first consider the direct link between the performances of universities and local economic development. The GMM estimates of the local economic growth model are presented in Table 4[30]. The empirical evidence shows that the lagged value of GDP per capita (GDPC) has a significant coefficient with positive sign in all models. Moreover, the efficiency of universities (EFF) has a positive and significant effect on local development. Indeed, a 1 percent increase in the technical efficiency of universities increases local development by about 0.051 percent when both GDPC and EFF are included as time-lagged predictors (see Table 4, Mod_1) and by about 0.013 percent when GDPC is the only time-lagged predictor (see Table 4, Mod_2). In other words, we find evidence that the presence of more efficient universities fosters local economic development through a direct channel of influence.

To take into account the role played by the socio-economic environment, we control for a measure of job market evolution (LG) and market power of the universities (MS). The negative and significant coefficient of the market share variable is particularly interesting. This means that the higher the market power of the universities (i.e. the less competition between them in attracting students), the lower the local economic development. In other words, we find evidence that productivity gains are greater in areas where universities have less market power. This finding suggests that differences in local economic development might be partly due to the market structure of the higher education sector. A more competitive environment could lead to greater human capital creation, which could in turn boost economic development. Multiple HEIs located in the same region, or HEI effects spilling across regions, could be seen as evidence of competition leading to greater efficiency and student choice. A further explanation is that the close proximity of multiple institutions permits collaboration, the sharing of resources, and a greater production of qualified labor with desirable knowledge and skill sets. This generates a positive impact on economic development compared with situations where there are no universities located nearby or only institutions that act in a monopolistic way. All these possible interpretations support the expansion of pro-competitive policies in the Italian higher education sector (see Barra & Zotti, 2017). Such policies can improve the efficiency of universities' operations which, in turn, are positively related to the positive effects on the local economy.

(Table 4 to be inserted around here)

5.3 Extending the analysis of the (indirect) relationship between university efficiency and local development: the role of spillover effects

We extend the analysis to consider the indirect link between the performances of universities and local economic development. Results are shown in Table 4, Mod_3 to Mod_8.

To address potential geographical spillovers, we consider two measures of spatial dependence. Efficiency*Spatial (EFF * W) is a spatially lagged regressor measuring whether average economic development is higher for those areas close to areas where the most efficient universities are located (see Table 4, Mod_3 and Mod_4). Economic development*Spatial (GDPC * W) is a spatially lagged dependent variable that tests the effects on an area, in terms of economic development, of being close to a prosperous area (see Table 4, Mod_5 and Mod_6).

When we introduce the specification of the spatially weighted covariates, the efficiency estimates do not change and remain statistically significant. Not only does the introduction of the spatial effects not alter our previous results, but we also detect a significant and statistically positive effect of the spatially weighted variables. In Mod_3 and Mod_4, we find evidence that average economic development is higher in areas that benefit from proximity to areas where universities contribute well with their missions. This suggests the presence of knowledge spillovers exerted by areas in which efficient institutions operate. Then the spatially weighted dependent variable has been included (Table 4, Mod_5 and Mod_6). We do not find evidence of a positive effect on the economic development of an area from being close to a prosperous area.

Results provide more information when the spatially weighted efficiency of the university and the spatially weighted dependent variable are simultaneously included (see Table 4, Mod_7 and Mod_8). The findings show that areas benefit, in terms of economic development, from being close to an area of high economic development. Additionally, and more importantly, the results show the presence of spillover effects indicating that when efficient universities operate in a certain area, other neighboring areas also indirectly benefit in terms of economic development. This result leads to the conclusion that labor market areas benefit from efficient universities located outside their administrative boundaries.

5.4 Sensitivity tests on the robustness of empirical results

We performed a number of sensitivity tests to check the robustness of our results.

Firstly, we examine whether the results depend on the distribution of the measure of the university performance, in other words, whether they are driven by the universities with the lowest or highest efficiency levels. To do this, we split the universities' efficiency scores (obtained through the procedure described in Section 3) into quartiles (see Tables 5 and 6). We then repeat the analysis after first removing those universities with an efficiency score in the first quartile (i.e., the least efficient universities) from the sample (see Table 5), and then those universities with an efficiency score in the fourth quartile (i.e., the most efficient universities) (see Table 6)[31].

Our results are generally confirmed. Starting from the models when spatial dependence is not taken into account (see Table 5, Mod_1 and Mod_2; Table 6, Mod_1 and Mod_2), we still find that the efficiency of universities has a direct positive and significant effect on local economic development (still significant at the 1 percent level). The effect is strong when the efficiency of universities is included as an additional time-lagged predictor. We then consider the case when potential geographical spillovers are used instead. Table 5, Mod_3 to Mod_8, summarizes the results when the least efficient universities are excluded from the sample. The empirical evidence shows the statistical significance of the spatially weighted efficiency of the university and the spatially weighted dependent variable when they are both used (Table 5, Mod_7 and Mod_8). Table 6, Mod_3 to Mod_8, summarizes the results when the most efficient universities are excluded from the sample. Both measures of spatial dependence are positive and highly statistically significant in all models. Overall, the relationship between efficiency and local economic development does not depend on the distribution of the efficiency measure.

(Tables 5 & 6 to be inserted around here)

Secondly, we examine whether the results depend on the distribution of the measure of economic development, in other words, whether the main results are driven by universities being located in areas characterized by high and low levels of economic development. To do this, we divide the territory according to the gross domestic product per capita (GDPC) in quartiles (see Tables 7 and 8). We repeat the analysis after first removing from the sample those areas with a GDP per capita in the first quartile (i.e., those areas with low economic development levels) (see Table 7). We then remove those areas with a GDP per capita in the fourth quartile (i.e., the areas that grow the most) (see Table 8).

Results still show that the efficiency of universities has a direct positive and significant effect on local economic development, particularly when it is included as an additional time-lagged predictor. Table 7, Mod_3 to Mod_8, and Table 8, Mod_3 to Mod_8, summarize the results when the areas with the lowest and highest levels of economic development are excluded from the sample, respectively. Geographical space has an impact on the relationship between university efficiency and local economic development. Interestingly, the effect is stronger when the analysis is performed after the areas with the lowest level of GDP have been excluded (Table 7). This suggests not only that economic gains are larger in areas neighboring those in which efficient universities are located, but also that this effect is stronger in areas that already have a good level of development. The findings point to the existence of virtuous circles, with economic development, coupled with the efficiency of universities operating in the region, boosting economic performance yet further.

(Tables 7 & 8 to be inserted around here)

Thirdly, we use the same composite index (see Section 3.3) as a measure of university performance (UNI_PERF) without calculating the rate at which they are able to convert inputs into outputs[32]. In other words, we do not calculate the level of efficiency at which universities operate, but only the association between their output levels and local economic performance. The idea is to examine whether a different measure of the performance of the university at the local level affects the main outcomes. The results, shown in Table 9, confirm that university performance has a positive and significant effect on local development (Table 9, Mod_1 and Mod_2). When we take the spatial dimension into account (Table 9, Mod_3 to Mod_8), the measure of university performance is still positive and significant. However, no evidence of potential geographical spillovers is found (e.g. the spatially lagged variable is insignificant). These findings confirm the need to focus on levels of the efficiency at which universities operate. Performance levels alone are not sufficient when measuring the role of universities in fostering local economic development.

(Table 9 to be inserted around here)

Fourthly, using the empirical approach explained in Section 4, the dependent variable GDPC of a labor market area occurs twice (three times) when the local market area contains two (three) universities. It is true that only a few labor market areas have more than one university (mainly in Rome, Naples and Milan). However, it could be argued that it is also the overall efficiency of HEIs that matters for regional development, not just the efficiency of the different constituents. Therefore, we collapse our variables at the labor market area level so we end up with only one GDPC for each labor market area and one measure of overall efficiency for all the HEIs in the area. The main results are reported in Table 12 in the Appendix and show that this alternative organization of the data set does not consistently affect the main outcomes.

Finally, competition among universities has been measured as an individual characteristic of the institution. We now also use a measure of concentration (the Herfindahl index) as a characteristic of the reference area. For enrolment, this is constructed as the sum of the square of the market share of the universities located in the same area. We use the province level as, in our opinion, this is the most appropriate geographical stratification for measuring market concentration. The closer to zero the index, the higher the competition in the higher education market; and the further the index is from 0, the closer the higher education market is to a monopoly – the index is bounded by 0 (full competition in the market) and 1 (full concentration of the market). Table 13 in the Appendix shows the results following the empirical specification used in the whole paper. In our final data set each university in the same labor market area is assigned the same value of labor market area GDPC. Table 14 in the Appendix reports the main results when we have only one GDPC for each labor market area and one measure of overall efficiency for all HEIs in the area. In neither case do the main results change substantially.

6. USING INSTRUMENTAL VARIABLE REGRESSIONS TO DEAL WITH ENDOGENEITY

So far, we have used a GMM dynamic panel estimator to handle endogeneity problems relating to the efficiency of universities. However, one of the most pressing concerns relates to the fact that time-lagged efficiency variables may not be considered as valid instruments. Indeed, it could still be argued that the effect of university efficiency on local economic development is not immediate but instead comes with some time lag. This would render the instruments invalid. Moreover, university efficiency affects local economic development, but at the same time, economic development may affect the ability of universities to transform inputs into outputs. To further address these issues, we estimate the model using an instrumental variable (IV) estimation strategy.

For the IV approach to be valid, we need to find a variable that is related to university efficiency (the variable to be instrumented) but not to local economic development (the outcome of interest). While there are a few variables in the Italian higher education setting that are candidates for this, we rely on some specific characteristics of the HE funding system. More specifically, we use, alternatively, the amount of grants that universities receive from foundations (GRANTS) and the revenue that universities receive in terms of student fees (FEES). To do this, we collect data from universities' balance sheets from the Ministry of Education, Universities and Research (https://ba.miur.it/index.php).

The share of government funding of universities in Italy fell from 57.8 percent in 2005 to 53.7 percent in 2012, with a corresponding increase in the relative importance of funding from private foundations and student fees. Both contribute significantly to the support of higher education expenditures and research (Geuna & Piolatto, 2016). Universities have also been encouraged to finance a greater share of their budgets from students' tuition fees in order to boost enrolment rates at little cost to public finances (Dima, 2004). A law in Italy establishes that the overall share of student fees cannot exceed the 20 percent of the state funds allocated to universities. However, several universities have found a way to collect higher levels of fees despite this regulation (Geuna & Labini, 2013).

These types of funds (grants and student fees) do not impact local economic development directly, but only by positively affecting the efficiency of universities. The mechanism that we have in mind relates to the way in which universities use the additional funds available from foundations and fees. When foundations provide money to universities, it is usually intended to stimulate additional research, teaching or institutional activities. Universities are therefore incentivized to demonstrate that they can use these resources in a productive manner in order to attract funding in subsequent years. A similar reasoning applies to the use of fees. When students are charged higher fees, they exert more control over the efficient use of resources. For example, students' councils monitor that funds are used to improve teaching and services. So while the level of funds coming from these sources is too small to have a direct effect on the economy of a particular local territory, the funds (both contributions from foundations and student fees) influence the local economy through incentives for university efficiency. From an econometric standpoint, the diagnostic tests clearly indicate that our instruments are valid.

We estimate the following equations:

$$ln\,GDPC_{i,j,t} = \alpha lnGDPC_{i,j,t-1} + \beta_1\,lnEFF_{i,j,t} + \beta_2 \sum_{i=1}^{56} ln\,EFF_{i,k,t} * W + \beta_3 \sum_{i=1}^{56} lnGDPC_{i,k,t} * W + \beta_4 lnMS_{i,j,t} + \beta_5 LG + \mu_{i,j} + \tau_t + \varepsilon_{1\ i,j,t} \quad (2)$$

$$ln\,EFF_{i,j,t} = (\gamma_1 lnGRANTS_{i,j,t}\ or\ \gamma_2 lnFEES_{i,j,t}) + \theta_1\,lnGDPC_{i,j,t} + \theta_2 \sum_{i=1}^{56} lnGDPC_{i,k,t} * W + \theta_3 lnMS_{i,j,t} + \theta_4 LG + \mu_{i,j} + \tau_t + \varepsilon_{2\ i,j,t} \quad (3)$$

The coefficient β_1, in equation (2), is the effect of interest to us (along with β_2). In equation (3), we formalize the effect that economic development has on the efficiency of universities, assuming that θ_1 is positive (e.g. higher economic development tends to increase the level of efficiency of universities). From (2) and (3) it is easy to verify that the efficiency of universities might be correlated with the error term $\varepsilon_{1\ i,j,t}$[33].

Results are summarized in Tables 10 and 11, where grants from private foundations and revenue from students' fees are used, respectively, as instruments. The efficiency of universities has a positive effect on local development, confirming this direct channel of influence (Tables 10 and 11, Mod_1 and Mod_2). When we extend the analysis to address potential geographical spillovers, the results confirm the presence of knowledge spillovers exerted by areas in which efficient institutions operate (Tables 10 and 11, Mod_3 and Mod_4). When the spatially weighted dependent variable is included (Tables 10 and 11, Mod_5 and Mod_6), we also find evidence of a positive effect on economic development for an area that is closer to a prosperous area. This is net of the direct positive effect that efficiency of universities has on local economic development. Finally, we take into consideration simultaneously the spatially weighted efficiency of the university and the spatially weighted dependent variable (Tables 10 and 11, Mod_7 and Mod_8). The findings still show that the presence of efficient universities fosters local economic development. No effects of knowledge spillovers occurring through geographical proximity to efficient universities is found[34].

(Tables 10 & 11 to be inserted around here)

7. CONCLUDING REMARKS AND LESSON LEARNED

7.1. Conclusions

This article examines the role of universities in supporting local development, under the hypothesis that the presence of a university might have a positive influence on the economic activities of the area in which it is located. Academic institutions contribute to economic development through the production of highly skilled graduates and consequently of a highly educated workforce. Universities' research productivity transforms knowledge into economically relevant products. Moreover, transfer of knowledge, product development and services for the industry sector all play a role. The idea that universities could contribute to the social economic and cultural development of the area in which they are located has been widely discussed in the literature. However, to the best of our knowledge, only a few quantitative estimates of the 'external' impact of teaching, research and knowledge transfer on the community are available (see for instance Carree, Della Malva, & Santarelli, 2014; Calcagnini et al. 2016). Although our paper does not fully resolve all methodological concerns, it uses data and econometric procedures that directly confront the potential biases induced by simultaneity and omitted variables. These issues have not been fully taken into account in previous empirical work regarding the specific external impact of university activities on the community economic development. The insights that we are proposing here can be considered as illustrative of a tentative causal effect of HEI efficiency on local economic development.

We focus on the Italian experience and try to quantify the impact of university performances on local economic development using highly territorially disaggregated data. Following the approach proposed by Barra and Zotti (2017), we consider the level of efficiency at which universities operate as an indicator of quality of human capital production and of the transfer of knowledge and technology. We justify our conceptual approach by considering that more productive universities can exert a positive role in a region in several ways. First, efficient universities free up human and financial resources to be used for alternative economic activities. Second, they produce more teaching and research outputs for a given level of inputs. And finally, they stimulate the development of new ideas and opportunities in the region, where the university's reputation as an efficient organization is appreciated. Efficiency scores are estimated via an innovative SFA taking into account all the three university missions – teaching, research and knowledge transfer – and a growth model is tested. A Sys-GMM model estimator and then an instrumental variable approach are used to evaluate the link between performance of universities and the economic development of the geographical area in which they operate. We also highlight the importance of geographical spillovers in order to examine whether the effects of the presence of a university spill over into neighboring areas.

The results show that university efficiency is a positive and statistically significant determinant of economic development, with the presence of efficient universities directly raising local GDP per capita. Spillover effects from efficiency are also present. When efficient universities operate in a certain area, neighboring areas are also positively affected and benefit in terms of economic development.

We also show the presence of spillovers suggesting that the geography of production is affected. Indeed, we find evidence of a positive effect on the economic development of an area of being close to a prosperous area. Our results are robust to a battery of robustness checks, and our estimates are robust to different estimation strategies.

7.2 Discussion and implications for policymaking

Several implications can be derived from our analyses.

First, confirming the findings of Barra and Zotti (2017), the empirical evidence validates the use of university efficiency rather than performance. Efficiency captures the impact on the community of the ability of universities to make the most of the available resources. This is a specific contribution to the literature on economic growth that may represent a substantial improvement in understanding the mechanisms behind the role of academic institutions.

Second, results confirm the importance of measuring the development of human capital and skills, technology transfer activities, new product development and research activities. To better understand the mechanisms behind the local economic development, ‘third mission’ activities must be explicitly considered. This broader concept of the goals of universities should then be in kept in mind when developing incentives and funding models that acknowledge the multiple missions of universities. This is in line with the appreciation that universities not only supply knowledge outputs, such as graduates and research papers, but are also involved in collaborations with private firms through licensing and spin-offs (see Johnes et al. 2008; Thanassoulis et al. 2011; Carree et al. 2014; Shubert, 2014; Calcagnini et al. 2016).

Third, the results support the need to take into account the presence of spatial dependence when explaining regional income per capita and development differences. In other words, proximity to a university leads to an expansion of the available knowledge base for firms and strengthens the university–industry partnership (Carboni, 2013; Muscio, 2013; Cardamone, Pupo, & Ricotta, 2014). The importance of spatial effects gives credit to policy interventions and investments in tertiary education to the extent that the activities performed in such institutions foster economic competitiveness. Hence, there is an increasing interest in measuring the contribution that universities directly have on the area in which they are located and, indirectly, on neighboring areas.

Fourth, some issues arise in the specific case of Italy when policymakers must decide how to encourage positive collaborations between academia and local institutions and industries. Our findings reveal the presence of ‘virtuous circles’ – highly efficient universities are located in territories that grow more, which in turn stimulates the universities to reach higher levels of operational efficiency. Such conditions are very unevenly distributed across Italy, and they constitute another potential explanation for the north/south gap in the country. A policy devoted to improving the performance of universities in the south of Italy (e.g., ad hoc incentives or targeted funding) can be justified in the long run by the building of economic capacity at the local level. Nevertheless, this approach is also risky and could be wasteful if local industries are not culturally ready to benefit from the highly skilled human capital and innovative research being developed in neighboring academic institutions. The nature of this challenge is reinforced by our finding of positive (spillover) effects on the local economic development of neighboring areas. However, a positive move by a single university or local region would be insufficient. Instead, a more systemic approach based on bringing together different regions in a combined effort is needed. If there are no attempts made in this direction, however, the geographical patterns depicted here will lead to a widening of the gap between geographical areas. This is especially likely if areas are characterized by different starting points of local economic development, as is the case in Italy with its north/south gap.

Fifth, when turning to other determinants of local economic development, one other finding is worthy of particular attention. The variable that captures universities' market power (which can be interpreted as the local 'market share' of an academic institution) is positively correlated with local economic development. In other words, economic development at the local level benefits from an environment in which universities compete more with each other. This finding adds to existing evidence on the positive effects competition has on university performance (see Agasisti, 2009). Future research should be devoted to disentangling how much of the benefit to economic development arising from competition, as well as from other sources, is channeled indirectly through higher efficiency of universities.

Our research opens the way to future interesting extensions. One immediate extension would be to test the validity of the relationship between universities' activities and local economic development not only at the national level, but also at the European level. Can we assume that part of the regional differentials across Europe stem from the differences between universities' productivity and their geographical localization? The use of disaggregated EUROSTAT data at the regional level, together with recent data on individual European HEIs (https://www.eter-project.com), could be used for this purpose.

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TABLES

Table 1: Variables for estimating economic development and the production set for estimating universities' efficiency: descriptive statistics (mean values by geographical areas)

Variable	Definition	Mean values				
		North-Western	North-Eastern	Central	Southern	Italy
EFF	Efficiency of universities	0.8142	0.7808	0.7376	0.7269	0.7576
GDP	Gross domestic product normalized by workers (sum of the gross values added of all units)	61.102	58.776	56.116	52.751	56.383
MS	Market share (# of enrolments university$_i$/total enrolments region$_j$)	0.256	0.387	0.333	0.400	0.352
LG	Labor growth (# of employed individuals at time t minus the # of employed individuals at time t-1)	0.002	0.002	0.005	-0.005	0.0001
$EQUIV_{PERS}$	# of academic and non-academic staff	990.91	1064.43	1169.22	873.01	1000.66
STU_{WEIGH}	Number of total students weighted by the percentage of enrolments with a score higher than 9/10	14036.85	13605.46	17627.07	15238.35	15221.73
$GRAD_{MARKS}$	# of graduates weighted by their degree marks	3627.32	3873.38	4330.58	3120.26	3641.63
$SPIN_{OFFS}$	# of spin-offs	15.935	17.357	12.976	8.250	12.633
PUB	# of publications	1632.84	1469.07	1535.00	752.642	1247.639
$YEAR_{FOUND}$	Years of existence of university	205.812	403.1	404.166	180.65	278.452
MED_{SCHOOL}	Presence of medical school	0.727	0.800	0.583	0.700	0.698
$INACT_{STU}$	Percentage of inactive students	5020.182	4961.957	7392.036	6457.55	6088.62
FFO	University Ordinary Financing Funding	1.33e+08	1.36e+08	1.47e+08	1.09e+08	1.28e+08
TTO_{AGE}	Age of TTO's	5.727	4.400	5.166	2.5	4.132
GRANTS	Grants from private foundations (Instrument 1)	1936705	1492715	2074841	335657.5	1280041
FEES	Revenue from students' fees (Instrument 2)	3.83e+07	3.89e+07	3.42e+07	2.39e+07	3.21e+07

Note: All monetary aggregates are in thousands of Euros (at 2007 prices). GDP is expressed in million of euros. In order to get an easy and comprehensible measure, the total value of GDP is reported in the descriptive statistics. In the analysis, it is divided by the workers in each area where the university is located.

The variables EFF, GDP, MS and LG have been included in the two-step system GMM estimator and in the IV approach in order to analyze the relationship between the efficiency of universities and local economic development. $EQUIV_{PERS}$ and STU_{WEIGH} are used as inputs, $GRAD_{MARKS}$, $SPIN_{OFFS}$ and PUB as outputs in specifying the university production technology while the variables $YEAR_{FOND}$, $MEDICAL_{SCHOOL}$, $INACT_{STU,}$ FFO and TTO_{AGE} have been included in the variance of the inefficiency term in the stochastic frontier analysis when calculating the university's relative efficiency.

In order to get an easy and comprehensible measure, the total number of academic and non-academic staff is reported in the descriptive statistics. In the analysis, the total number of academic staff has been, instead, adjusted for their respective academic position (i.e. professors, associate professors and researchers). Descriptive statistics are reported separately for both $EQUIV_{PERS}$ and for STU_{WEIGH} while in the analysis the ratio between the two variables has been used.

Table 2: Estimating universities' efficiency – specification of outputs and inputs and exogenous factors

Models	Input	Outputs	Explaining the inefficiency
Model	$EQUIV_{PERS}/STU_{WEIGH}$	$GRAD_{MARKS}$; $SPIN_{OFFS}$; PUB	$YEAR_{FOUND}$; MED_{SCHOOL}; $INACT_{STU}$; FFO; TTO_{AGE}

Note:

$EQUIV_{PERS}$: Weighted # of academic staff and non-academic staff
STU_{WEIGH}: Number of total students weighted by the percentage of enrolments with a score higher than 9/10
$GRAD_{MARKS}$: # of graduates weighted by their degree classification
$SPIN_{OFFS}$: # of spin-offs
PUB: # of publications

$YEAR_{FOUND}$: Years of existence of university
MED_{SCHOOL}: Presence of Medical school
$INACT_{STU}$: Percentage of inactive students
FFO: University Ordinary Financing Funding
TTO_{AGE}: age of TTO's

Table 3: Estimating the universities' efficiency – result from Stochastic Frontier Analysis

Variables	
EQ_{PERS}/STU_{WEIGH}	**0.745***
	(2.55)
T1	-0.144
	(-1.62)
T2	**-0.280*****
	(-3.33)
T3	**-0.326*****
	(-4.29)
T4	**-0.357*****
	(-7.31)
T5	**-0.337*****
	(-6.61)
T6	**-0.247*****
	(-3.54)
DIM1	**1.466*****
	(16.49)
DIM2	**0.435*****
	(5.47)
DIM3	**0.114****
	(2.66)
VAR(U)	
$YEAR_{FOUND}$	**0.00122****
	(2.76)
MED_{SCHOOL}	**-0.822****
	(-2.86)
$INACT_{STU}$	**0.000117****
	(3.23)
FFO	-3.33e-09
	(-1.55)
TTO_{AGE}	**-0.101***
	(-2.28)
T1	**-2.420*****
	(-6.84)
T2	**-2.669*****
	(-5.35)
T3	**-2.122*****
	(-3.98)
T4	**-1.930*****
	(-3.65)
T5	**-1.730****
	(-2.86)
T6	-1.097
	(-1.64)
N	371

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: The effect of universities' efficiency on local economic development – Without and with spatial spillovers

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC(t-1)	**0.707***** (0.014)	**0.718***** (0.016)	**0.709***** (0.015)	**0.714***** (0.001)	**0.704***** (0.011)	**0.716***** (0.001)	**0.698***** (0.015)	**0.705***** (0.015)
EFF (t-1)	**0.051***** (0.005)		**0.047***** (0.005)		**0.055***** (0.005)		**0.049***** (0.005)	
EFF (t)		**0.013***** (0.003)		**0.010**** (0.004)		**0.016***** (0.004)		**0.011***** (0.003)
EFF*W (t-1)			**0.258***** (0.091)				**0.387***** (0.123)	
EFF*W (t)				**0.257***** (0.087)				**0.379***** (0.112)
GDPC*W (t)					0.317 (0.231)	0.195 (0.232)	**0.636**** (0.268)	**0.503*** (0.268)
MS (t)	**-0.007***** (0.001)	**-0.008***** (0.001)	**-0.008**** (0.001)	**-0.009***** (0.001)	**-0.007***** (0.001)	**-0.008***** (0.001)	**-0.008***** (0.001)	**-0.010***** (0.002)
LG (t)	**-0.054**** (0.026)	**-0.047*** (0.025)	**-0.049*** (0.027)	**-0.050*** (0.026)	**-0.061**** (0.027)	**-0.053**** (0.024)	**-0.056*** (0.028)	**-0.057**** (0.0269)
T3	**-0.033***** (0.002)	**-0.031***** (0.002)	**-0.032***** (0.002)	**-0.030***** (0.002)	**-0.033***** (0.002)	**-0.030***** (0.002)	**-0.035***** (0.002)	**-0.030***** (0.002)
T4	**-0.050***** (0.001)	**-0.050***** (0.001)	**-0.051***** (0.001)	**-0.050***** (0.001)	**-0.0511***** (0.001)	**-0.050***** (0.001)	**-0.051***** (0.001)	**-0.050***** (0.001)
T5	**-0.004***** (0.001)	**-0.003**** (0.001)	**-0.004***** (0.001)	**-0.003***** (0.001)	**-0.004***** (0.001)	**-0.002**** (0.001)	**-0.004***** (0.001)	**-0.003**** (0.001)
T6	**-0.050***** (0.002)	**-0.049***** (0.002)	**-0.050***** (0.001)	**-0.050***** (0.001)	**-0.050***** (0.002)	**-0.049***** (0.002)	**-0.050***** (0.001)	**-0.050***** (0.001)
T7	**-0.053***** (0.001)	**-0.052***** (0.002)	**-0.053***** (0.001)	**-0.054***** (0.002)	**-0.052***** (0.002)	**-0.052***** (0.002)	**-0.053***** (0.002)	**-0.053***** (0.002)
CONST	**1.213***** (0.057)	**1.159***** (0.066)	**1.282***** (0.073)	**1.250***** (0.071)	**2.505***** (0.949)	**1.952***** (0.954)	**3.926***** (1.140)	**3.350***** (1.135)
AB(2)	0.356	0.402	0.361	0.409	0.357	0.408	0.367	0.417
Hansen	0.317	0.334	0.274	0.334	0.270	0.299	0.218	0.264
N	318	318	318	318	318	318	318	318

Note: Standard errors in brackets; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 5: The effect of universities' efficiency on local economic development– Without and with spatial spillovers using quartile university efficiency scores – Excluding the lowest efficient universities

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.871***** (0.020)	**0.799***** (0.026)	**0.874***** (0.020)	**0.771***** (0.025)	**0.870***** (0.022)	**0.794***** (0.026)	**0.860***** (0.023)	**0.783***** (0.034)
EFF (t-1)	**0.043***** (0.014)		**0.056**** (0.021)		**0.066***** (0.020)		**0.074***** (0.023)	
EFF (t)		0.018 (0.022)		0.002 (0.022)		0.014 (0.025)		0.031 (0.027)
EFF*W (t-1)			0.058 (0.072)				**0.170**** (0.081)	
EFF*W (t)				0.146 (0.119)				**0.264***** (0.096)
GDPC*W (t)					0.330 (0.206)	0.199 (0.148)	**0.527**** (0.225)	**0.518**** (0.247)
MS (t)	**-0.005***** (0.001)	**-0.008***** (0.001)	**-0.005***** (0.001)	**-0.007***** (0.001)	**-0.004***** (0.001)	**-0.008***** (0.001)	**-0.005***** (0.001)	**-0.009***** (0.001)
LG (t)	-0.040 (0.028)	-0.041 (0.031)	-0.039 (0.028)	-0.010 (0.035)	-0.037 (0.029)	-0.045 (0.032)	-0.034 (0.029)	**-0.062*** (0.033)
T3	**-0.036***** (0.002)	**-0.032***** (0.001)	**-0.036***** (0.002)	**-0.032***** (0.001)	**-0.037***** (0.001)	**-0.032***** (0.001)	**-0.037***** (0.001)	**-0.031***** (0.002)
T4	**-0.057***** (0.001)	**-0.056***** (0.001)	**-0.057***** (0.001)	**-0.053***** (0.002)	**-0.056***** (0.001)	**-0.056***** (0.002)	**-0.057***** (0.001)	**-0.053***** (0.002)
T5	0.001 (0.002)	**0.004**** (0.002)	0.001 (0.002)	0.001 (0.001)	0.002 (0.001)	**0.004**** (0.002)	0.001 (0.001)	**0.004**** (0.002)
T6	**-0.053***** (0.001)	**-0.051***** (0.003)	**-0.054***** (0.002)	**-0.0513***** (0.003)	**-0.054***** (0.002)	**-0.050***** (0.003)	**-0.053***** (0.002)	**-0.049***** (0.003)
T7	**-0.055***** (0.003)	**-0.055***** (0.006)	-0.055*** (0.003)	-0.057*** (0.005)	**-0.053***** (0.003)	**-0.054***** (0.006)	**-0.054***** (0.003)	**-0.049***** (0.006)
CONST	**0.550***** (0.082)	**0.828***** (0.107)	**0.558***** (0.096)	**0.988***** (0.126)	**1.885**** (0.828)	**1.650***** (0.596)	**2.776***** (0.900)	**3.059***** (1.008)
AB(2)	0.680	0.838	0.664	0.750	0.649	0.842	0.645	0.835
Hansen	0.723	0.660	0.756	0.894	0.729	0.705	0.727	0.796
N	232	232	232	232	232	232	232	232

Note: Standard errors in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: The effect of universities' efficiency on local economic development – Without and with spatial spillovers using quartile university efficiency scores – Excluding the highest efficient universities

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.667***	**0.717***	**0.695***	**0.688***	**0.628***	**0.634***	**0.636***	**0.672***
	(0.017)	(0.010)	(0.0173)	(0.020)	(0.018)	(0.021)	(0.022)	(0.021)
EFF (t-1)	**0.048***		**0.043***		**0.058***		**0.0509***	
	(0.004)		(0.003)		(0.006)		(0.005)	
EFF (t)		-0.003		0.002		**0.015**		0.004
		(0.003)		(0.005)		(0.006)		(0.003)
EFF*W (t-1)			**0.139***				**0.534***	
			(0.082)				(0.157)	
EFF*W (t)				**0.164**				**0.449***
				(0.078)				(0.108)
GDPC*W (t)					**1.126***	**1.091***	**1.680***	**1.275***
					(0.186)	(0.186)	(0.335)	(0.320)
MS (t)	**-0.008***	**-0.011***	**-0.007***	**-0.009***	**-0.008***	**-0.011***	**-0.008***	**-0.0103***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LG (t)	-0.023	-0.008	-0.020	-0.014	-0.0206	0.001	-0.027	-0.016
	(0.027)	(0.014)	(0.025)	(0.026)	(0.032)	(0.030)	(0.029)	(0.023)
T3	**-0.032***	**-0.030***	**-0.037***	**-0.030***	**-0.033***	**-0.029***	**-0.034***	**-0.031***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
T4	**-0.047***	**-0.045***	**-0.048***	**-0.047***	**-0.046***	**-0.044***	**-0.046***	**-0.047***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
T5	**-0.009***	**-0.007***	**-0.009**	**-0.008***	**-0.009***	**-0.006***	**-0.008***	**-0.008***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
T6	**-0.050***	**-0.050***	**-0.050***	**-0.050***	**-0.048***	**-0.046***	**-0.047***	**-0.050***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
T7	**-0.053***	**-0.0549***	**-0.053***	**-0.055***	**-0.052***	**-0.050***	**-0.051***	**-0.053***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
CONST	**1.369***	**1.153***	**1.302***	**1.323***	**6.064***	**5.881***	**8.422***	**6.602***
	(0.069)	(0.040)	(0.084)	(0.099)	(0.764)	(0.791)	(1.464)	(1.378)
AB(2)	0.337	0.395	0.336	0.398	0.323	0.389	0.342	0.401
Hansen	0.259	0.604	0.258	0.289	0.316	0.334	0.358	0.558
N	244	244	244	244	244	244	244	244

Note: Standard errors in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: The effect of universities' efficiency on local economic development – Without and with spatial spillovers using quartile of GDPC – Excluding the areas with the lowest GDPC values

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.549*** **	**0.594*** **	**0.566*** **	**0.639*** **	**0.559*** **	**0.592*** **	**0.567*** **	**0.647*** **
	(0.026)	(0.032)	(0.024)	(0.026)	(0.027)	(0.036)	(0.023)	(0.030)
EFF (t-1)	**0.029*** **		**0.020*** **		**0.025*** **		**0.019*** **	
	(0.004)		(0.004)		(0.005)		(0.005)	
EFF (t)		0.0003		-0.003		**0.007** **		0.004
		(0.002)		(0.002)		(0.003)		(0.002)
EFF*W (t-1)			**0.343*** **				**0.459*** **	
			(0.073)				(0.135)	
EFF*W (t)				**0.335*** **				**0.351*** **
				(0.055)				(0.123)
GDPC*W (t)					-0.288	0.187	0.247	0.212
					(0.194)	(0.293)	(0.319)	(0.397)
MS (t)	**-0.014*** **	**-0.013*** **	**-0.013*** **	**-0.012*** **	**-0.012*** **	**-0.0138*** **	**-0.012*** **	**-0.010*** **
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
LG (t)	-0.006	-0.001	-0.017	-0.002	0.010	-0.011	-0.0005	-0.024
	(0.025)	(0.021)	(0.022)	(0.023)	(0.024)	(0.023)	(0.021)	(0.021)
T3	**-0.023*** **	**-0.025*** **	**-0.024*** **	**-0.027*** **	**-0.0244*** **	**-0.025*** **	**-0.026*** **	**-0.027*** **
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
T4	**-0.044*** **	**-0.0464*** **	**-0.045*** **	**-0.046*** **	**-0.045*** **	**-0.045*** **	**-0.047*** **	**-0.048*** **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.0009)	(0.001)
T5	**0.003***	**0.003** **	**0.002***	0.002	**0.003***	**0.003** **	**0.003***	**0.003** **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
T6	**-0.040*** **	**-0.044*** **	**-0.041*** **	**-0.047*** **	**-0.040*** **	**-0.043*** **	**-0.042*** **	**-0.046*** **
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
T7	**-0.040*** **	**-0.044*** **	**-0.041*** **	**-0.046*** **	**-0.041*** **	**-0.042*** **	**-0.043*** **	**-0.043*** **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CONST	**1.848*** **	**1.659*** **	**1.881*** **	**1.578*** **	0.647	**2.423** **	**2.907** **	2.409
	(0.106)	(0.130)	(0.113)	(0.115)	(0.736)	(1.257)	(1.316)	(1.711)
AB(2)	0.325	0.281	0.316	0.327	0.331	0.290	0.336	0.329
Hansen	0.421	0.555	0.390	0.685	0.315	0.592	0.252	0.544
N	241	241	241	241	241	241	241	241

Note: Standard errors in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: The effect of universities' efficiency on local economic development – Without and with spatial spillovers using quartile of GDPC – Excluding the areas with the highest GDPC values

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.530*****	**0.518*****	**0.522*****	**0.518*****	**0.544*****	**0.547*****	**0.549*****	**0.553*****
	(0.014)	(0.018)	(0.019)	(0.020)	(0.017)	(0.022)	(0.024)	(0.025)
EFF (t-1)	**0.023*****		**0.020*****		**0.024*****		**0.024*****	
	(0.005)		(0.006)		(0.005)		(0.006)	
EFF (t)		-0.006		-0.008		-0.006		-0.008
		(0.004)		(0.005)		(0.004)		(0.005)
EFF*W (t-1)			0.114				0.189	
			(0.115)				(0.177)	
EFF*W (t)				0.092				**0.263***
				(0.117)				(0.155)
GDPC*W (t)					**0.682*****	**0.736*****	0.397	**0.799*****
					(0.179)	(0.175)	(0.455)	(0.239)
MS (t)	-0.001	-0.003	-0.001	-0.002	-0.002	-0.003	-0.001	-0.003
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
LG (t)	**-0.064*****	**-0.043***	**-0.069*****	**-0.052****	**-0.072*****	**-0.052****	**-0.063*****	**-0.046***
	(0.021)	(0.021)	(0.021)	(0.022)	(0.024)	(0.023)	(0.023)	(0.023)
T3	**-0.031*****	**-0.029*****	**-0.031*****	**-0.030*****	**-0.033*****	**-0.032*****	**-0.030*****	**-0.029*****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
T4	**-0.045*****	**-0.044*****	**-0.045*****	**-0.045*****	**-0.046*****	**-0.047*****	**-0.046*****	**-0.047*****
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
T5	**-0.012*****	**-0.012*****	**-0.012*****	**-0.013*****	**-0.011*****	**-0.011*****	**-0.011*****	**-0.011*****
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
T6	**-0.049*****	**-0.049*****	**-0.049*****	**-0.050*****	**-0.050*****	**-0.051*****	**-0.049*****	**-0.051*****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
T7	**-0.054*****	**-0.058*****	**-0.055*****	**-0.059*****	**-0.054*****	**-0.058*****	**-0.053*****	**-0.058*****
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
CONST	**1.908*****	**1.942*****	**1.974*****	**1.972*****	**4.593*****	**4.792*****	**3.489***	**5.106*****
	(0.060)	(0.076)	(0.101)	(0.0986)	(0.710)	(0.692)	(1.900)	(1.016)
AB(2)	0.410	0.421	0.422	0.433	0.411	0.413	0.398	0.406
Hansen	0.440	0.425	0.454	0.427	0.369	0.341	0.535	0.483
N	238	238	238	238	238	238	238	238

Note: Standard errors in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: The effect of universities' performances on local economic development – Using the composite index consisting of the teaching, research and knowledge transfer missions

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.757*****	**0.768*****	**0.799*****	**0.797*****	**0.739*****	**0.753*****	**0.788*****	**0.784*****
	(0.018)	(0.008)	(0.015)	(0.008)	(0.021)	(0.010)	(0.017)	(0.010)
UNI_PERF (t-1)	**0.010*****		**0.006****		**0.013*****		**0.008*****	
	(0.003)		(0.002)		(0.003)		(0.002)	
UNI_PERF (t)		**0.011*****		**0.009*****		**0.014*****		**0.012*****
		(0.002)		(0.002)		(0.0024)		(0.002)
UNI_PERF *W (t-1)			0.018				0.040	
			(0.030)				(0.034)	
UNI_PERF *W (t)				0.0435				**0.075****
				(0.025)				(0.030)
GDPC*W (t)					0.251	0.295	0.253	**0.400***
					(0.261)	(0.206)	(0.233)	(0.201)
MS (t)	**-0.009*****	**-0.010*****	**-0.008*****	**-0.009*****	**-0.010*****	**-0.010*****	**-0.008*****	**-0.008*****
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LG (t)	**-0.063*****	**-0.045****	**-0.068*****	**-0.052****	**-0.066*****	**-0.050****	**-0.069*****	**-0.052****
	(0.021)	(0.020)	(0.020)	(0.020)	(0.022)	(0.020)	(0.020)	(0.019)
T3	**-0.032*****	**-0.032*****	**-0.034*****	**-0.034*****	**-0.031*****	**-0.031*****	**-0.033*****	**-0.033*****
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
T4	**-0.050*****	**-0.050*****	**-0.051*****	**-0.051*****	**-0.049*****	**-0.049*****	**-0.051*****	**-0.050*****
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
T5	-0.0007	-0.0002	-0.001	-0.0006	-0.000001	0.0004	-0.0009	0.00003
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
T6	**-0.048*****	**-0.050*****	**-0.050*****	**-0.051*****	**-0.047*****	**-0.049*****	**-0.049*****	**-0.050*****
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
T7	**-0.051*****	**-0.052*****	**-0.052*****	**-0.052*****	**-0.050*****	**-0.051*****	**-0.052*****	**-0.052*****
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
CONST	**0.900*****	**0.848*****	**0.610****	0.369	**1.958***	**2.067****	1.452	**1.713****
	(0.051)	(0.021)	(0.279)	(0.239)	(1.084)	(0.851)	(0.936)	(0.791)
AB(2)	0.462	0.386	0.435	0.389	0.484	0.389	0.449	0.386
Hansen	0.228	0.336	0.221	0.351	0.221	0.336	0.210	0.349
N	318	318	318	318	318	318	318	318

Note: Standard errors in brackets; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 10: Two-Stage Least Squares Estimates - The effect of universities' efficiency on local economic development – Without and with spatial spillovers – Using grants from foundations as an instrumental variable for the efficiency of universities

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.957*** **	**0.954*** **	**0.962*** **	**0.958*** **	**0.955*** **	**0.956*** **	**0.957*** **	**0.958*** **
	(0.008)	(0.007)	(0.007)	(0.004)	(0.003)	(0.007)	(0.005)	(0.008)
EFF (t-1)	**0.019*** **		**0.021*** **		**0.024*** **		**0.024*** **	
	(0.003)		(0.004)		(0.001)		(0.001)	
EFF (t)		**0.018*** **		**0.020*** **		**0.023*** **		**0.022*** **
		(0.004)		(0.005)		(0.003)		(0.003)
EFF*W (t-1)			**0.111*** **				0.026	
			(0.028)				(0.053)	
EFF*W (t)				**0.087*** **				0.0300
				(0.014)				(0.051)
GDPC*W (t)					**0.276*** **	**0.255*** **	**0.229** **	**0.207** **
					(0.061)	(0.068)	(0.104)	(0.104)
MS (t)	**-0.003*** **	**-0.003*** **	**-0.003*** **	**-0.003*** **	**-0.001** **	**-0.001** **	**-0.002** **	**-0.002** **
	(0.0008)	(0.0007)	(0.0007)	(0.0005)	(0.0008)	(0.0008)	(0.0008)	(0.0009)
LG (t)	-0.043	-0.045	-0.014	-0.040	-0.015	-0.048	-0.010	-0.045
	(0.044)	(0.044)	(0.049)	(0.050)	(0.048)	(0.045)	(0.048)	(0.046)
T3	**-0.029*** **	**-0.030*** **	**-0.030*** **	**-0.028*** **	**-0.031*** **	**-0.028*** **	**-0.030*** **	**-0.028*** **
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
T4	**-0.053*** **	**-0.053*** **	**-0.050*** **	**-0.051*** **	**-0.050*** **	**-0.051*** **	**-0.049*** **	**-0.051*** **
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
T5	0.005	0.006	0.007*	0.007*	0.005	0.005	0.005	0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
T6	**-0.051*** **	**-0.051*** **	**-0.051*** **	**-0.051*** **	**-0.050*** **	**-0.049*** **	**-0.050*** **	**-0.049*** **
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
T7	**-0.050*** **	**-0.046*** **	**-0.048*** **	**-0.044*** **	**-0.050*** **	**-0.046*** **	**-0.049*** **	**-0.045*** **
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
CONST	**0.202*** **	**0.212*** **	**0.146*** **	**0.172*** **	**1.324*** **	**1.232*** **	**1.118** **	**1.023** **
	(0.032)	(0.028)	(0.035)	(0.018)	(0.241)	(0.275)	(0.444)	(0.444)
Hansen J test	0.107	0.101	0.329	0.157	0.590	0.374	0.554	0.326
N	318	318	318	318	318	318	318	318

Note: Standard errors in brackets; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 11: Two-Stage Least Squares Estimates - The effect of universities' efficiency on local economic development – Without and with spatial spillovers – Using student's fees as an instrumental variable for the efficiency of universities

	Mod_1	Mod_2	Mod_3	Mod_4	Mod_5	Mod_6	Mod_7	Mod_8
GDPC (t-1)	**0.955***** (0.008)	**0.954***** (0.007)	**0.960***** (0.007)	**0.957***** (0.004)	**0.953***** (0.003)	**0.955***** (0.007)	**0.956***** (0.006)	**0.956***** (0.009)
EFF (t-1)	**0.020***** (0.003)		**0.020***** (0.004)		**0.024***** (0.001)		**0.024***** (0.001)	
EFF (t)		**0.018***** (0.004)		**0.018***** (0.005)		**0.022***** (0.003)		**0.022***** (0.003)
EFF*W (t-1)			**0.107***** (0.023)				0.026 (0.054)	
EFF*W (t)				**0.089***** (0.021)				0.010 (0.056)
GDPC*W (t)					**0.255***** (0.004)	**0.244***** (0.065)	**0.215**** (0.098)	**0.228**** (0.102)
MS (t)	**-0.003***** (0.0008)	**-0.003***** (0.0007)	**-0.003***** (0.0006)	**-0.003***** (0.0006)	**-0.002***** (0.0006)	**-0.002***** (0.0008)	**-0.002***** (0.0008)	**-0.002***** (0.0009)
LG (t)	-0.032 (0.045)	-0.049 (0.040)	0.004 (0.053)	-0.035 (0.046)	0.003 (0.049)	-0.045 (0.042)	0.004 (0.051)	-0.045 (0.041)
T3	**-0.031***** (0.0054)	**-0.030***** (0.005)	**-0.031***** (0.005)	**-0.030***** (0.005)	**-0.032***** (0.005)	**-0.029***** (0.0057)	**-0.031***** (0.005)	**-0.028***** (0.005)
T4	**-0.051***** (0.003)	**-0.052***** (0.003)	**-0.050***** (0.003)	**-0.051***** (0.003)	**-0.051***** (0.003)	**-0.051***** (0.003)	**-0.050***** (0.003)	**-0.051***** (0.003)
T5	0.005 (0.004)	0.006 (0.004)	0.007* (0.004)	0.007* (0.004)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)
T6	**-0.051***** (0.004)	**-0.050***** (0.0040	**-0.051***** (0.004)	**-0.050***** (0.004)	**-0.049***** (0.004)	**-0.048***** (0.004)	**-0.049***** (0.004)	**-0.048***** (0.004)
T7	**-0.050***** (0.003)	**-0.046***** (0.004)	**-0.048***** (0.004)	**-0.045***** (0.004)	**-0.050***** (0.004)	**-0.0458** (0.004)	**-0.049***** (0.004)	**-0.045***** (0.004)
CONST	**0.208***** (0.034)	**0.214***** (0.027)	**0.155***** (0.032)	**0.172***** (0.022)	**1.247**** (0.440)	**1.193***** (0.263)	**1.068**** (0.425)	**1.124**** (0.439)
Hansen J test	0.192	0.122	0.335	0.230	0.587	0.465	0.541	0.405
N	318	318	318	318	318	318	318	318

Note: Standard errors in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[1] Bornmann (2013), for example, reviews two decades of studies attempting to estimating the 'societal impact' of research. He defines this impact as the ability to transform knowledge into economically relevant products, services and processes.

[2] See, for example, Benhabib and Spiegel (1994) and Barro (2001).

[3] In the remainder of the paper, we use 'third mission' as our preferred term to ensure homogeneity and univocal naming in the discussion of results.

[4] The ratio at which they are able to convert inputs (human and financial resources) into outputs (graduation rates, publications, technology transfer initiatives).

[5] Considering that academic institutions may eliminate certain sources of their short-run inefficiency over time, while other sources may have a more permanent nature.

[6] See Walckiers (2008) for a discussion on the multi-dimensional tasks of universities and on the joint production of science and teaching.

[7] Empirical evidence from firm surveys also confirms the importance of university research for corporate innovation performance (Mansfield, 1995, 1997; Cohen, Nelson, & Walsh, 2002; Veugelers & Cassiman, 2005).

[8] Or, conversely, which is able to minimize the inputs necessary for the production of a given amount of outputs.

[9] For example, data envelopment analysis (DEA) and free disposable hull (FDH), proposed by Charnes, Cooper and Rhodes (1978) and due to the original contribution of Farrell (1957), based on deterministic frontier models (see also Cazals, Florens, & Simar, 2002).

[10] For example, a stochastic frontier approach (SFA), a distribution-free approach (DFA) and a thick frontier approach (TFA), based on stochastic frontier models (see Aigner, Lovell, & Schmidt, 1977).

[11] We also consider non-academic staff to take into account the administrative staff who support the academic staff and the students.

[12] The academic staff is composed of professors, associate professors and researchers. We assign weights to each category according to their salary and to the amount of institutional, educational and research duties they have to deal with (Madden, Savage, & Kemp, 1997; Carrington, Coelli, & Rao, 2005). A lower weight has been assigned to non-academic staff. Similarly to Halkos, Tzeremes and Kourtzidis (2012), we use the following weighting system: 1*professors+0.75*associate professors+0.50*researchers +0.25*non-academic staff. For robustness, we also further test how alternative weights would change the results. In all cases the results (available on request) are similar, providing good evidence that alternative weighting does not affect the outcomes.

[13] A similar measure is also used in Agasisti and Dal Bianco (2009). For robustness, we also weight total number of students by the percentage of enrolments from a Lyceum (i.e. a non-vocational secondary school – more academically oriented and specialized in providing students the skills needed in order to enrol in the university). Results, available on request, are similar.

[14] There are no measures of capital inputs (such as libraries, computers buildings) that might have a role in determining university outputs. This is confirmed by a recent paper by De Witte and López-Torres (2017), who reviewed the literature on the efficiency in education. In describing the inputs in the education production function, a few included those inputs in the analysis of higher education.

[15] Students can graduate obtaining marks from 66 to 110 with distinction. In order to weight the graduates according to their degree marks, we apply the following procedure: $GRAD_{MARKS}$ =1* graduates with marks between 106 and 110 with distinction +0.75*graduates with marks between 101 and 105 + 0.5*graduates with marks between 91 and 100+0.25*graduates with marks between 66 and 90. For robustness, we have also used the number of graduates without weighting by their degree classification. Results (available on request) are similar, providing good evidence that alternative weighting does not affect the outcomes.

[16] See De Witte and Rogge (2011) and De Witte and Hudrlikova (2013) for an application of this method to higher education.

[17] Therefore, for each university, the BoD procedure searches for weights that maximize the impact of the strengths and minimize the influence of the relative weaknesses. This means that in absence of any other detailed information on the true weights, the BoD procedure assumes that representative weights can be inferred from looking at the relative strengths and weaknesses.

[18] It could be argued that a lot of arbitrary structure is imposed in how universities' three outputs are aggregated into a single measure to estimate efficiency. The fact that the weights used to aggregate these inputs differ across institutions based on their estimated comparative advantages may seem circular. If a university performs well in an area, that output gets more weight, but then the resulting higher output is going to make the university appear more efficient in that activity. For robustness, we have also replicated the main model without using the endogenous weighting schemes. The main results, available on request, are confirmed although differences in magnitude and on the statistical significance have been found. Therefore, we believe that the proposed endogenous weighting mechanism better exploits the differences among universities.

[19] The empirical evidence is controversial. Siegel, Wright, Chapple and Lockett (2008) show that the presence of a medical school has a statistically significant impact on efficiency. For a different perspective, see Thursby and Kemp (2002), Anderson, Daim, and Lavoie (2007) and Chapple, Lockett, Siegel and Wright (2005) who, instead, show that the presence of a medical school reduces efficiency, probably due to the heavy service commitments of medical schools or to differences in the health product market.

[20] GDP per worker is constructed by updating the LMA value-added data from ISTAT through the period of 2006 to 2012 with data from the Bureau van Dijk AIDA data set (similar to Barra & Zotti, 2017). AIDA is a database providing balance sheets and other information about Italian firms with a turnover of at least one million euro. See for further information: http://aida.bvdep.com/.

[21] See Hasan, Koetter, and Wedow (2009) and Destefanis et al. 2014.

[22] McHenry (2014), with the aim of investigating the geographic distribution of human capital in US, uses the 'commuting zone' – described as a collection of counties making up a coherent local economy – as the location measure.

[23] Coordinates of the areas where universities are located are taken from the ISTAT website (http://www.istat.it/it/strumenti/cartografia). The spatial weights matrix is constructed using the "spwmatrix" module by Jeanty (2010a). The spatial weights matrix is row-standardized, i.e. the elements of each row sum up to one. The spatial lagged variables used in the analysis are built using the "splagvar" module by Jeanty (2010b).

[24] Time-varying characteristics, instead, are absorbed by the error term and could eventually make the results biased. Nevertheless, given also the short period under analysis, it is hard to believe that there could be many time-varying variables in such a short time that will bias our results. It could be argued, however, that the financial crisis that happened around 2008 may play an important role. To take this into account we also include time dummies in the model capturing time-specific effects such as any variation in the outcome that happens over time (not attributed to our other explanatory variables).

[25] Passing the Hansen test of over-identifying restrictions may convey little information about the validity of instruments (Deaton, 2010). However, the test is still relevant to signal the feasibility of the adopted instrument approach and whether the estimates change when we select different subjects from a possible set of instruments. Therefore, the test provides useful information on the feasibility of the adopted instrument approach.

[26] Our sample is very representative of the higher education system in Italy, corresponding to almost 90 percent of the total number of public universities in the country. Confirming the representativeness of the sample used, in the 53 universities included in the empirical analysis is enrolled 88 percent of the students enrolled in the entire higher public education system in Italy.

[27] Competition among universities, of course, does not happen only on a geographical level, as various dimensions are considered by students when making their choices (disciplines, reputations, personal networks, cities' and regions' attractiveness). From this perspective, the kind of 'market power' effect that we are measuring in the analysis is a partial one that only relates to the pressures posed by geographical proximity with other institutions. In this case, the regional dimension appears to be an adequate one, given that the majority of students still opt to study in the region where they live. When interpreting the results, however, it must be kept in mind that the effect of universities competing for students should be considered comprehensive. Indeed, the geographical density of institutions also affects other factors at the university level, which react to competitive pressures.

[28] From a methodological perspective, the null hypothesis that there is no heteroscedasticity in the error term has been tested and rejected, at the 1 percent significance level. The likelihood ratio test supports the use of some exogenous variables in the variance of the efficiency term affecting the performance of universities.

[29] Due to space constraints, the efficiency estimates are presented by geographical areas and on average over the period 2006-2012. Estimates for each year and for each university are available on request.

[30] The results of the Arellano−Bond test confirm the appropriateness of the 2nd-order autoregressive specification while the Hansen test is always insignificant. Both corroborate the validity of the instruments and thus the accuracy of the model.

[31] Data constraints do not allow us to perform the analysis on each quartile.

[32] In order to examine the relative importance of efficiency versus absolute output, the possibility of estimating, simultaneously, both variables may also be taken into account. However, the two variables may be correlated with each other. Moreover, given inclusion in the model also of spatial lagged levels of the variables, there is a concern related to the number of observations available to perform the estimates.

[33] The variables selected as instruments meet the two essential conditions for their validity (relevance and exogeneity). Indeed, grants and student fees do influence the efficiency of the universities in (3), but they are not correlated with the error term $\varepsilon_{1\ i,j,t}$.

[34] We have also repeated the IV approach when using a measure of concentration as a characteristic of the reference area such as the Herfindahl index. The main results do not change and are reported in Tables 15 and 16 (respectively when grants from private foundations and the revenue from students' fees are used as instrument of efficiency of universities) in the Appendix.