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TOTAL FACTOR PRODUCTIVITY HETEROGENEITY: CHANNELLING THE IMPACT OF INSTITUTIONS

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ABSTRACT

This paper aims to contribute to the debate on the determinants of differentials in firms' productivity. We test the hypothesis that macro factors, especially the quality of local institutions, play a role in explaining firm productivity in Italy. To this end, following Färe et al. (1994), we decompose the Malmquist index of total factor productivity (TFP) change for approximately 7,500 manufacturing small and medium-sized firms, and we proxy province-level institutional quality using the IQI index (Nifo and Vecchione, 2014). The results of our estimations suggest that better local institutions might help firms better combine inputs, approach the optimal size, and ultimately be more productive.

Keywords: TFP, Malmquist index, Institutional quality, Italian manufacturing SMEs
JEL: O47, C31, O50, C33, D24, L60, O43, R11

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1. INTRODUCTION

Over the past couple of decades, considerable attention has been paid to the issue of heterogeneity in firms' productivity. Researchers in many fields have offered abundant empirical evidence attesting the magnitude of persistent and ubiquitous productivity differentials across businesses and provided insight into the way firms turn inputs into outputs. While the efficiency with which this conversion occurs has become a topic of particular interest, the central theoretical question on the main determinants of the observed heterogeneity remains under debate: Why do firms differ so much in their abilities to convert inputs in outputs? Is productivity just a "*manna from heaven*" for the luckiest or something (or many things) more systematic?

An interesting taxonomy of the determinants of productivity differentials is the one distinguishing between internal and external factors. The former label is used for factors connected to firms' features and managers' or owners' decisions, such as size (van Biesebroeck, 2005), industry (Sinkkonen, 2005), the adopted technology (Jorgenson et al., 2008; Bartelsman et al., 2008; Faggio et al., 2009), the endowment of human capital (Bandiera et al., 2007) and managerial skills (Bushnell and Wolfram, 2009; Bloom and Van Reenen, 2010), the amount of R&D (Doraszelski and Jaumandreu, 2013), the degree of international openness (Wagner, 2002). The second source of inter-firm productivity differences typically concerns the macroeconomic context in which firms operate, such as more competitive and contestable markets (Knittel, 2002; Nicoletti and Scarpetta, 2005; Brown et al., 2006; Arnold et al., 2008; Bridgam et al., 2009), a context more favourable for innovation (Griffith et al., 2007; Bloom et al., 2007; Bartelsman et al., 2008; Arrighetti and Lasagni, 2011), inter-firm cooperation and positive spillovers (Chanda and Dalgaard, 2008; Syverson, 2011).

A large body of literature recognizes as a positive and important external factor the good quality of institutions in the geographical area where the firm is located, arguing that it enhances the ability of a region to capture development opportunities (OECD, 2001), a mechanism that may emerge through increases in local firms' productivity.

When firms' productivity differentials are evidently connected to different geographical locations, external factors, such as local institutional quality, are expected to be even more significant to explain the observed inter-firm diversity. The case of Italy, in this respect, looks particularly interesting due to the substantial and long-lasting productivity gap between industrial firms located in the regions of the relatively backward South *vis-à-vis* those in the rest of the country.

That institutions affect economic outcomes is well established. As noted by North (1990), the formal and informal institutions that a given society develops (or fails to develop) are crucial instruments to facilitate economic growth, international investment and trade by reducing opportunism in transactions among people largely unknown to one another and providing a framework for the creation of multilateral reputation and mutual trust. An extensive body of empirical literature has emphasized the role of institutions[1] in affecting both input (physical and human capital) productivity and total factor productivity (TFP), showing the existence of a distinct direct effect of institutions on per capita income through TFP changes, in addition to the indirect effect through capital accumulation. However, all studies estimating firms' TFP (levels and growth/ changes) are built on variants of Solow's (1957) accounting technique, assuming that economic agents instantaneously adjust choices and behaviours to altered market conditions. If these assumptions do not hold, conventional estimates of TFP may be biased, and firms may be technically or allocatively inefficient in the use of inputs. This, in turn, implies that observed input-output combinations may lie below the production frontier. In such a case, TFP may change as a result of (dis)improved efficiency, that is, movements towards or away from the frontier. This is in stark contrast to the growth accounting approach, according to which observed output is equivalent to frontier output, and growth in TFP consists only of technological progress, that is, shifts in the frontier. Pinpointing

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[1] Cross-country regressions have shown that institution quality is highly correlated with income per capita and that institutions can explain up to 30-fold per capita income differences between developed and developing countries (Knack and Keefer, 1997; Hall and Jones, 1999; Acemoglu et. al., 2001; Easterly and Levine, 2003).

the exact channel through which institutional quality affects firms' productivity – i.e., whether institutions influence (more) the frontier or firms' relative efficiency – may facilitate a better understanding of the determinants of inter-firm TFP heterogeneity and provide policymakers a key tool for helping firms become more productive and the economy to grow faster.

This paper focuses on the effects of institutions on firms' productivity, aiming in particular at evaluating the impact on TFP change exerted by institutions' quality, which is proxied either using the Institutional Quality Index (IQI) proposed by Nifo and Vecchione (2014) or its single components. Our working hypothesis is that differences in local institutional quality endowments are crucial in shaping inter-firm productivity differentials in the Italian industry.

To test this hypothesis, we proceed in two steps. First, using a large sample of Italian manufacturing SMEs, we retrieve the dependent variables of our analysis, i.e., firms' efficiency, by decomposing the Malmquist TFP index. Second, we estimate a model of the determinants of efficiency, where the explanatory variable of interest is either the IQI index or a single component of it. To account for the hierarchal structure of our data, we model firm-specific characteristics and efficiency simultaneously with the higher-level geographical context, adopting a multilevel analysis.

In the first step, we follow Färe et al. (1994), decomposing productivity growth into two mutually exclusive and exhaustive components: changes in technical efficiency and shifts in the technology frontier. The latter effect basically reflects technical innovation undertaken by firms, while the former represents (dis)improvements in the means by which the known technology is applied in production. Then, we further decompose the former component into two sub-components to distinguish the contribution of scale efficiency from pure efficiency changes, arising from the best (or worst) combination of inputs.

In the second stage of our analysis, we provide evidence on the relationship between the endowment of institutional quality in Italian provinces and the single components of firm productivity described above. A number of previous studies (Del Monte and Giannola, 1997; Scalera and Zazzaro, 2010; Erbetta and Petraglia, 2011; Nifo, 2011; Aiello et al., 2014) have argued that even at the subnational level, productivity differences might be explained on the basis of differences in institutional quality. However, very few have tried to prove this relationship through an econometric investigation (Lasagni et al, 2015). Furthermore, we deepen our analysis by investigating the relevance of five dimensions of institutional quality (regulatory quality, rule of law, government effectiveness, corruption, and voice and accountability) rather than of only single aspects of it, as is customary in the previous literature (Kneller and Misch, 2010; Daveri et al., 2011; Haggard and Tiede, 2011; Solinas and Jimenez, 2011).

Our results, based on a sample of Italian manufacturing SMEs, are robust and consistent with most of the existing literature. We find that local institutional quality matters as it proves to be one driver of firms' productivity differentials, particularly through the channel of efficiency.

The paper is organized as follows: Section 2 provides an overview of the literature on macroeconomic factors as determinants of productivity levels, growth and differentials, and particularly the role of institutional quality. Section 3 illustrates the methodologies adopted. Section 4 discusses the results, hinging on specific robustness analysis. Section 5 summarizes the main conclusions.

2. MACROECONOMIC DRIVERS OF FIRM PRODUCTIVITY: A LITERATURE REVIEW

The economic literature has long considered the possibility that social, historical and cultural factors, institutions and the political and administrative context may play a role in conditioning and steering the development processes and the economic success or decline of countries, regions and individual firms. Indeed, on one hand, a broad strand of literature has explored the connections between the recalled macroeconomic factors and the economic growth of countries and regions (for example, La Porta et al., 1998; Hall and Jones, 1999; Acemoglu et al., 2001; Djankov et al., 2002; Easterly and Levine, 2003; Glaeser et al., 2004; Rodrick et al., 2004; Kwock and Tadesse, 2006). On the other hand, many other authors have been concerned with the influence of the macroeconomic environment and, more specifically, of institutional quality on firms' productivity. This section provides a short review of this latter body of literature.

The presence of spillovers and the degree of competition are singled out by Chanda and Dalgaard (2008) and Syverson (2011) as the main channels through which macroeconomic factors may impinge on the level of business productivity. In their interpretation, spillovers basically operate through *incentive mechanisms*: They encourage companies to innovate and to adopt new technologies (Nguyen et Jaramillo, 2014), to invest more in R&D (Griffith et al., 2007), to shorten the technology distance (Bloom et al., 2007), and to accelerate the process of convergence to the productivity levels of the leader in the domestic market (Bartelsman et al., 2008). Other related studies (Eslava et al., 2004, Bernard et al., 2006; Fernandes, 2007; Verhoogen, 2008; Bloom and Van Reenen, 2010) focus on the relationship between the *intensity of competition* and productivity. Greater competition allows the best companies to gain larger market shares at the expense of less efficient firms, according to the so-called "Darwinian selection of the market". Moreover, competition creates greater opportunities for comparing performance, making it easier for owners to monitor managers (Lazear and Rosen, 1981; Nalebuff and Stiglitz, 1983). In addition, improvements in productivity may generate higher revenues and profits in a more competitive environment, where the price elasticity of demand tends to be higher, and because more competition is likely to raise the likelihood of bankruptcy at any given level of managerial effort, managers have to work harder to avoid this outcome (Aghion and Howitt, 1998). An additional effect of stronger competition on firms' productivity may stem from the increased incentive for workers, provided that product market rents are shared with workers in the form of higher wages or reduced effort (Haskel and Sanchis, 1995). Another strand of studies focuses on the relationship between the intensity/quality of market regulation and productivity. In this view, poor or inadequate regulations can create perverse incentives that reduce productivity (Bridgam et al., 2009). By contrast, largely positive effects can be associated with the implementation of an incentive programme combining the gains of economic operators to obtain particular standards of operational efficiency (Knittel, 2002), similar to those of the programmes of product market regulations in OECD countries (Nicoletti and Scarpetta, 2005, Arnold et al., 2008) or privatization programmes in Eastern European countries (Brown et al., 2006).

Regarding more specifically the role of institutions, at least since the work of North (1990, p. 3), for whom “institutions are the rules of the game in a society”, institutions have been acknowledged to crucially contribute to forming the set of incentives underlying behaviour and individual choices. The importance of institutional quality as a basic determinant of economic growth and TFP in the long term has been illustrated by many authors. The seminal paper by Hall and Jones (1999), for example, emphasizes the effects of the history of a people and the underlying institutional structures on countries’ economic performance. Mankiw et al. (1992) highlight the importance of the impact of institutions on investment in human and physical capital and thus on per capita income. In the same vein, Eicher et al. (2006) and Ketterer and Rodriguez-Pose (2012) note that institutions have a large impact on human and physical capital accumulation, which in turn affects firms’ productivity. In particular, Rodrik et al. (2004) highlight the important role that institutions play in preventing the expropriability of property.

Following Hall and Jones (1999), other contributions (Kaufman et al., 1999; Acemoglu, et al., 2001; Easterly and Levine, 2003; Grigorian and Martinez, 2002; Rodrik et al., 2004) note that in addition to affecting capital accumulation, institutions may affect firms’ TFP and output through other channels. For example, McGuinness (2007), Acemoglu and Robinson (2008), Chanda and Dalgaard (2008) show how better institutions create a favourable business environment and a legal structure that directs investments towards activities able to ensure higher and more rapid economic growth. Good institutions encourage firms to use better technology, invest in knowledge creation and transfer (Loayza et al., 2005), produce on a larger scale and operate with a long time horizon, with a positive impact on competitiveness and economic performance (Aron, 2000), thereby ensuring higher levels of efficiency and often a fairer distribution of income (Bowen and De Clercq, 2008). Many other studies, both for cross-country (Barro and Lee, 1993; Nugent, 1993; Mauro, 1995; World Bank, 1997; Brunetti, 1997; Knack and Keefer, 1997; Djankov et al., 2002) and inter-regional comparisons (Barro and Sala-i-Martin, 1995; Helliwell and Putnam, 1995; Arrighetti and Serravalli, 1999; Dall'Aglio, 1999), have found evidence of significant correlations between measures of institutional quality and various indicators of economic performance.

Regarding the specific case of Italy, many observers have explained the economic divide between the Northern and Southern regions with reference to the different regional endowments of institutional quality. For example, Di Liberto and Sideri (2015) find evidence of the significant role of past regional domination (i.e., rule over different areas from the 12th to 18th centuries) on the current regional public administration performance, further supporting the idea that old norms and institutions tend to persist over centuries, strongly conditioning the economic performance of Italian regions and explaining a significant part of the observed gap in regional productivity levels. In the same vein, Nifo (2011), Aiello et al. (2014) and Lasagni et al. (2015) and ascribe a crucial role to macroeconomic factors in accounting for the significant and persistent productivity dispersion across Italian firms. In particular, concerning institutions, Del Monte and Giannola (1997) claim that institutional factors have contributed to creating an unfavourable business environment; Scalera and Zazzaro (2010) argue that public policies have been undermined by a poor institutional context; and Erbetta and Petraglia (2011) emphasize the crucial role of institutions and public capital in determining Italian firms' productivity differentials.

3. METHODOLOGY

To verify the influence of institutional quality on firms' efficiency, our analysis is organized into two steps, similarly to a large number of other contributions investigating the impact of internal firm characteristics and external factors on DEA efficiency estimates or Malmquist indices (e.g., Alvarez and Crespi, 2003; Ariff and Can, 2008; Sufian, 2009; Cummins et al., 2010; Cummins and Xie, 2013). First, we retrieve our dependent variables (firms' efficiency) by decomposing the Malmquist TFP index. To allow different technologies in different sectors, we carry out separate computations at the 2-digit level of the ATECO classification. Second, we estimate a model of the determinants of firms' productivity, where the explanatory variable of interest is institutional quality defined at the provincial level. To account for the hierarchical structure of our data, we adopt a mixed estimator.

Before describing these steps in more detail, it is worth mentioning that Banker and Natarajan (2008) and Johnson and Kuosmanen (2012) show that the two-stage DEA estimator is statistically consistent under different conditions, providing theoretical justification for its use. Furthermore, "Unlike the regression methods such as stochastic frontier analysis (SFA), the DEA efficiency estimator is not subject to the omitted variable bias in the first stage if the effect of the contextual variables has a finite maximum and the sample size is sufficiently large" (Johnson and Kuosmanen, 2012, page 560). Because our estimation sample is large, in light of the considerations above, we adopt a two-stage DEA estimator.

3.1 First stage: The Malmquist productivity index decomposition

Following Färe et al. (1994), we compute (total) productivity change as the geometric mean of two output-oriented Malmquist productivity indexes.[2] These indexes, proposed by Caves et al. (1982), are based on the Malmquist (output) distance functions. Thus, we first define the latter and then illustrate the Malmquist TFP index.

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[2] Several empirical works adopt the same measure of productivity change. An output orientation is commonly adopted when it is fair to assume that firms seek to maximize output for given input combinations (as in the manufacturing case; see, for instance, Milana et al., 2013). By contrast, when producers have a statutory obligation to meet demand, and they also have to guarantee certain quality levels, it is proper to assume that firms attempt to minimize input for given output levels (see Saal et al., 2007, for water and sewerage services and Giuffrida, 1999, for primary care provision by Family Health Service Authorities).

Distance functions, which may be either output or input oriented, allow the measurement of firms' efficiency without imposing any assumption~~s~~ on firm behaviour, such as profit maximization or cost minimization. The basic idea underlying the notion of distance is that at any point in time, we can draw a production frontier, i.e., a locus of technically efficient input-output combinations, given the existing technology. Hence, the distance between this frontier and a given combination beneath the frontier can be regarded as a measure of technical inefficiency. More formally, an *output* distance function gauges the largest proportional expansion of the output vector, conditional on given input levels.[3] In other words, "we could think of deflating the output vector so that the resulting deflated output vector is just producible by the input vector x" (Diewert and Fox, 2010, page 76). Hence, an output distance function, in period t, may be defined as follows:

$$D^t(q_t, x_t) = min\{\delta: (q/\delta) \in P(x)\} \qquad (1)$$

where *P(x)* is the production possibilities set for the technology available in period t. The minimum value of parameter δ is equal to unity for all combinations on the frontier (when production is technically efficient, in Farrell's [1957] terminology), while it is lower than one for all other combinations belonging to production set *P(x).* Having specified the distance function (1), it is possible to measure the productivity change from a given period to another (say, from *t=0* to *t=1)* by computing the ratio between two distances as follows:

$$m^t(q_0, q_1, x_0, x_1) = \frac{D^t_{CRS}(q_1, x_1)}{D^t_{CRS}(q_0, x_0)} \qquad (2)$$

where both distance functions are defined relatively to the same (constant returns to scale, CRS) benchmark technology prevailing in period t. Because in our exemplification, *t* may be either 0 or 1, it is possible to compute two ratios (i.e., two Malmquist indexes). To avoid selecting an arbitrary

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[3] An *input* distance function provides the largest proportional contraction of the inputs, given an output vector. Both concepts allow the complete categorization of the technology, and when constant returns to scale prevail, the input distance function is the reciprocal of the output distance function.

reference technology, the two indexes may be combined, as suggested by Färe et al. (1994), by computing the following geometric mean:

$$m(q_0, q_1, x_0, x_1) = \sqrt{(m^0 m^1)} = \sqrt{\frac{D^0_{CRS}(q_1,x_1)}{D^0_{CRS}(q_0,x_0)} \frac{D^1_{CRS}(q_1,x_1)}{D^1_{CRS}(q_0,x_0)}} \tag{3}$$

Hence, to retrieve the output-oriented Malmquist index (3), we need to calculate four distance functions, which requires knowledge of the production technologies in the two time periods. The main approaches applied to estimate production frontiers and thus firms' inefficiency measures are data envelopment analysis (DEA) and stochastic frontier analysis (SFA).[4] In this study we adopt the DEA approach because it does not require any a priori hypotheses on the frontier functional form or on the distribution of the regression error terms. Furthermore, several contributions suggest that the two methodologies tend to yield consistent results (Cummins and Zi, 1998; Casu et. al., 2004; Din et al. 2007; Elling and Luhnen, 2010; Cummins and Xie, 2013; Milana et al., 2013).

In applying the DEA approach, we adopt the conventional notation, indicating with N the number of firms (or decision making units, DMUs) belonging to each sector. If the *ith* firm employs K inputs to produce M outputs (represented by vectors x_i and q_i, respectively), the (K×N) input matrix, X, and the (M×N) output matrix, Q, represent the data of all N firms in each sector. Assuming constant returns to scale, the general linear programming problem that has to be solved for each firm is:

$$max\lambda,\phi \ \ \phi \qquad s.\ t.: \ Q\lambda - \phi qi \ \geq 0; \ \ Xi - X\lambda \geq 0; \ \ \lambda \geq 0 \tag{4}$$

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[4] While DEA is a linear programming-based methodology (introduced by Charnes et al., 1978) providing non-parametric measures of efficiency relative to the sample employed, SFA is an econometric method based on the assumption of a specific production function (typically a Cobb-Douglas or a Translog function) generating absolute measures of efficiency (Aigner et al., 1977; Meeusen and Broeck, 1977). For a more detailed description of these two methodologies, we refer to Coelli et al. (2005).

where ϕ is a scalar, and λ is an N*1 vector of constants. Optimal value ϕ^* is the efficiency score for the *ith* firm, which is greater than or equal to unity, with a value of 1 corresponding to a point on the frontier. Recalling that Farrell's (1957) output-based measure of technical efficiency is reciprocal to the output distance function (Färe et al., 1994), it is possible to retrieve $[D^t(q_t, x_t)] = \phi^{*-1}$. Therefore, the four distance functions that enter the Malmquist index are obtained by solving four linear programmes. Two of them are obtained considering both the technology and input-output combination from the same period. The other two letting the reference technology to be constructed from data in one period, whereas the input-output combination is from the other period.

After outlining how the Malmquist index is retrieved, it is crucial to remark that TFP changes, gauged by the index, can be driven not only by improvements in technical efficiency (moving closer to the production frontier) but also by outward shifts of the technology frontier (technological progress) and movements along the frontier (returns to scale). Therefore, as proposed by Färe et al. (1994), we decompose the Malmquist index into three components: pure technical efficiency change (PEFF), technological change (TECH), and scale efficiency change (SE).[5] Formally,

$$m(q0\ q1,\ x0\ x1) = PEFF * TECH * SE \tag{5}$$

A value of PEFF greater than 1 indicates efficiency progress, indicating that the firm is catching up to the best-practice frontier (i.e., it is closer to the frontier in period 1 than it was in period 0). On the other hand, a value lower than 1 signals efficiency regress. Analogous considerations apply to the other TFP change components. Finally, to obtain decomposition (5), one needs to compute

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[5] The literature presents different approaches, based on different assumptions, for decomposing the Malmquist index. For instance, Ray and Desli (1997) criticize Färe et al. (1994) and advocate for an alternative decomposition, where the pure technical efficiency change term is the same, but the other two terms are differently computed. We refer to Balk (2001), Lovell (2003) and Pastor et al. (2011) for a review of the different decompositions.

additional distance functions, using a variable returns to scale (VRS) reference technology $[D_{VRS}^{0}(q_0, x_0);\ D_{VRS}^{1}(q_1, x_1)]$.[6]

3.2 Second stage: the determinants of firms' efficiency

In this section, we empirically investigate the impact of institutional quality on different components of firm efficiency, controlling for individual firm characteristics and other contextual variables conditioning firms' performance.

As section 2 above highlights, underlying our empirical question is the idea that firms' efficiency may depend not only on internal firms' characteristics and capabilities but also, crucially, on the environment within which firms operate (Fazio and Piacentino, 2010; Raspe and Van Oort, 2011; Nerozzi et al., 2015; Aiello and Ricotta 2016). As examples, recent research on the geography of innovation highlights that: "spatial concentration of relevant actors, their interactions, and other environmental factors conducive to learning determine the propensity of firms to generate innovations as much as their individual characteristics, resources, and capabilities" (Srholec, 2010, page 1210). More generally, studies investigating the determinants of firms' performance and survival highlight the remarkable importance of regional conditions, such as the access to specialized services and differentiated job markets and the proximity to a large number of suppliers, consumers and research centres (Vernon Henderson et al., 2001; Fritsch et al., 2006; Falck, 2007, Ottaviano, 2008). In this work, we argue that contextual effects, particularly the institutional quality effects on which we focus, may influence all components of efficiency: the ability of firms to organize their inputs, their propensity to innovate and their capacity to reach their optimal scale of production.

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[6] The overall efficiency change component (EFFCH=SE x PEFF) is calculated under constant returns to scale, while SE is the ratio of the scale efficiency measures in the two periods (scale efficiency in each period being the ratio between the distance function from a VRS frontier and the distance function from the CRS frontier).

Since different drivers of firms' efficiency operate at different levels, we need to adopt a technique that takes into account the hierarchal structure of the data and relates a dependent variable to explanatory variables defined at different levels. Hence, we model firm-specific characteristics and efficiency simultaneously with the higher-level geographical context, adopting a multilevel analysis. Multilevel (or mixed-effects) models have been widely adopted in social and medical sciences when handling hierarchical or clustered data to overcome some methodological limitations of the traditional single-equation models, based on the restrictive assumption of independence among errors.[7] As an example, in medical research, patients can be clustered in hospitals, while in educational research, pupils can be nested within classes and schools. Furthermore, in economic research, firms can be nested within geographical areas (such as regions or provinces) or productive sectors. Neglecting clusters leads to inference problems because the estimated parameter variance will be underestimated, entailing a higher probability of rejecting the null hypothesis when it is, in fact, true (Hox, 2013).[8]

Multilevel models allow correlation among the residuals of observations belonging to the same cluster, yielding more efficient estimates. Furthermore, hierarchical models allow deepening the understanding of the phenomenon under investigation, capturing the complexity characterizing the real world. In our study, they allow properly investigating the influence of specific provincial characteristics on firm efficiency. In other words, we can gauge the influence of specific higher-level factors (such as the provincial institutional quality) and the interplay between micro and macro determinants of firms' performance. Indeed, multilevel models are increasingly applied by research investigating the determinants of firms' performance to account for micro-and macro-level

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[7] For a more detailed illustration of the multilevel approach, we refer to De Leeuw and Meijer (2008).

[8] On the other hand, considering clusters (regions or sectors) as statistical units may entail the so-called "ecological fallacy" (Robinson, 1950) because correlations that are valid at the aggregated level do not necessarily hold true at the individual level.

heterogeneity and interrelationships (Fazio and Piacentino, 2010; van Oort et al. 2012; Nerozzi et al., 2015; Aiello and Ricotta 2016).

In our sample, firms represent level one units, clustered within administrative provinces, which represent the second level. Formally, a baseline equation for level one can be written as:

$$y_{ij} = \beta_{0j} + \beta_{1j}x_{ij} + \varepsilon_{ij} \tag{6}$$

where *i* refers to firms, and *j* refers to provinces; y is a measure of efficiency, and *x* is an explanatory variable defined at the first level of analysis. At level two, both intercept β_{0j} and coefficient β_{1j} may be modelled to allow random components defined at the provincial level:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + e_{0j} \\ \beta_{1j} &= \gamma_{10} + e_{1j} \end{aligned} \tag{7}$$

where γ_{00} and $\gamma_{10}$are second-level means, and e_{0j} and e_{1j} are normally distributed random effects. Embedding model (7) in equation (6) yields a mixed equation:

$$y_{ij} = \gamma_{00} + \gamma_{10}x_{ij} + \left(e_{0j} + e_{1j}x_{ij} + \varepsilon_{ij}\right) \tag{8}$$

where the dependent variables are explained by a deterministic part and a stochastic part, in parentheses, which accounts for the hierarchical structure of data.

To specify model (8), we build on a large body of research that has investigated the determinants of firms' efficiency, suggesting the interplay of firms' characteristics and external factors. Among the most investigated and established determinants are firm size, age, ownership structure, labour quality, export orientation, access to credit and market competitive pressure (Caves and Barton, 1990; Caves, 1992; Frydman et al., 1999; Aw et al., 2000; Djankov and Murrell, 2002; Alvarez and Crespi, 2003; Sinani et al., 2007). In what follows, we briefly illustrate the determinants of firm efficiency, which enter our estimating equation as controls, along with our key variable (IQI). It is worth noting from the outset that our choices have been inevitably conditioned by data availability.

Considering firm-level characteristics, firm size, age, indebtedness and liquidity are taken into account. Since the AIDA database does not provide information on importing/exporting activity, on the quality of labour or on credit rationing, size and age are bound also to proxy for these factors. Indeed, the size control (SIZE) may capture not only economies of specialization resulting from larger dimensions but also other potential effects of size on the ability of firms to successfully manage their input combinations. For instance, larger firms may have better access to finance, attract employees with higher skills, and be more export oriented and thus more exposed to international competition and "learning by exporting" effects. To gauge non-linear effects, we also include the squared term of SIZE. As far as age is concerned (AGE), older firms might exploit "learning by doing" effects and be more able to access credit, given their longer records. On the other hand, younger enterprises may be more motivated to build their reputation, more inclined to internationalization and more capable of absorbing new technological knowledge. Furthermore, firms' indebtedness (INDEBT) may have contrasting effects on efficiency. Indeed, greater liquidity may smooth the production process, helping firms optimally utilize their productive capacity. However, debt may also entail agency costs as shareholders can behave opportunistically, at the expense of debt holders, by making decisions that do not necessarily enhance firm value or efficiency.[9] Additionally, soft-budget constraint problems may arise when banks or suppliers keep financing customers even when undertaking inefficient projects to avoid their default and recuperate past loans (Carletti, 2004). Finally, liquidity (CASHFLOW) should enhance firms' capability to optimally manage their production process, decreasing the completion time of projects (and hence their relative costs).

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[9] We do not emphasize organization inefficiencies due to agency costs connected to the separation between ownership and control (Jensen,1986; Jensen and Meckling, 1976) because they may be largely negligible for Italian SMEs, featuring a strongly concentrated ownership structure (e.g., Giacomelli and Trento, 2005; Costi and Messori, 2005).

The provincial characteristics for which we control are local development (provincial per capita gross domestic product, GDPPC), agglomeration economies (population density, DENSITY), diversification economies (Jacob index, JACOB, defined as the number of sectors in each province, with more than 10 firms), local generation and diffusion of knowledge (patent applications, PATENT, and research and development expenditure, R&D). All these provincial variables are expected to positively affect firms' efficiency.

Moreover, we control for the degree of industry concentration (proxied using the Herfindahl-Hirschman Index, HHI, based either on sales or total assets), as higher competitive pressure should stimulate firms' efficiency.[10]

Finally, we limit potential simultaneity bias by assuming the lagged values of all regressors. We also control for level 2 endogeneity adopting the Mundlack (1978) correction (see section 4).

3.3 Data

Our estimations are based on data drawn from the Bureau Van Dijk AIDA database, which provides balance sheet information on Italian firms belonging to all productive sectors, and the Italian National Institute of Statistics (ISTAT). Our analysis considers all Italian manufacturing sectors, with the exception of the tobacco industry, characterized by too few observations. Table 1 shows the summary statistics of the variables employed to retrieve our measure of technical efficiency for a sample of 7,766 firms observed over 9 years (from 2004 to 2012). The nominal values of output (total sales) and inputs (capital assets, personnel costs and raw materials costs) have been

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[10] Higher HHI values are not necessarily synonymous with lower competition in an industrial sector. Indeed, while according to the Structure-Conduct-Performance paradigm, concentration may foster collusive behaviour among firms and therefore a reduction in the degree of competition, the Efficient-Structure Hypothesis claims that a greater concentration emerges as a consequence of higher competition in the market, as the most efficient firms might increase their market shares at the expense of their less efficient competitors.

deflated by means of (sector and output/input-specific) deflators, which are available for Italy in the OECD database (ISIC Revision 4, base-year 2005).

[TABLE 1]

To compute the Malmquist index described above, a balanced data panel is required. Hence, our results are conditional on firms' survival.[11] Further, to rule out potential outliers, all variables' distributions have been trimmed, excluding observations belonging to the top and bottom 1%.

Table 1 also presents summary statistics concerning the variables entering our efficiency model determinants. The IQI index, the focus of our analysis, is built by Nifo and Vecchione (2014) on a yearly basis, at the provincial (NUTS3) level. Inspired by the WGI framework (Kaufmann et al., 2011), it derives from the aggregation of 5 indexes of a lower rank and is constructed following the hierarchy framework illustrated in Figure 1.[12]

[FIGURE 1]

Each item of the IQI will be further described in section 4 when investigating the relationship between TFP change and each institutional dimension.

[TABLE 2]

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[11] When sample is limited, rather than excluding decision units with incomplete observations, some authors resort to interpolation (Giuffrida, 1999) or a "fake unit" approach (Yang and Pollitt, 2012). In the present analysis, we prefer to avoid potential measurement errors (to which the DEA approach is particularly sensitive) as the number of observations available is large.

[12] The IQI index is also available at the regional (NUTS2) level. The full dataset can be downloaded at: sites.google.com/site/institutionalqualityindex/home.

Table 2 reports the average values of the IQI index and the Malmquist index components by province in the period 2004-2011. Provinces are sorted in ascending order of IQI; thus, the institutional quality divide between the country's North and South clearly emerges. Indeed, the lowest (22) IQI scores are associated with Southern provinces, and vice-versa, the highest (30) ones refer to the provinces located in Central and Northern Italy. Furthermore, most provinces occupying panel A of Table 2 (i.e., those characterized by lower IQI values) tend to display a decline in terms of TFP, which seems mainly determined by a lack of gains in pure efficiency. By contrast, most provinces displaying higher IQI levels (panel B) appear characterized by progress in terms of TFP, which seems mainly driven by positive technological change and pure efficiency change. To further explore the relationship between the variables of interest across the provinces, Figures 2-5 report the mean values of the IQI index and one Malmquist component at a time, both computed at the province level. A positive association with institutional quality seems to characterize all components, except the scale efficiency change.

[FIGURES 2-5]

4. RESULTS

The estimation outcomes of our benchmark model are reported in columns 1 to 4 of Table 3. Looking first at the control variables, we find a non-linear relationship between SIZE and firms' efficiency; it is U-shaped for TFP and PEFF (and for TECH, but not statistically significantly) and inverse U-shaped for SE. This evidence seems to indicate that beyond a size threshold, firms' dimension positively impacts TFP. The estimated coefficients of AGE turn out to be negative and statistically significant in the TFP and PEFF cases, suggesting that total efficiency decreases as firms become older and that this effect is driven by negative changes in pure efficiency. Concerning the two financial variables, INDEBT and CASHFLOW, the results seem to be in line with the view that higher liquidity may facilitate firms' management of their production process. Indeed, the estimated coefficients of both regressors are always positive and mostly statistically significant. At the provincial level, we find that agglomeration (DENSITY) and diversification economies (JACOB) may play a role in favouring firms' total and scale efficiency (DENSITY is also positive and statistically significant in the PEFF regression). Finally, the coefficients of GDPPC and PATENT appear to be significant only once, in the pure efficiency and the scale efficiency cases, respectively.

Focusing on the main variable of interest, i.e., IQI, the first column of Table 3 provides support for our research hypothesis: the estimated coefficient of our proxy of institutional quality is positive and statistically significant in the TFP regression. When IQI increases by 10%, the TFP change increases, on average, by 4.6%.

Furthermore, the figures in columns from 2 to 4 suggest that the influence of IQI on firms' total efficiency is determined mainly by the impact of institutional quality on firms' pure efficiency (0.309) and, at a lower magnitude, by the effect on scale efficiency (0.164).

Our main findings remain qualitatively unaltered when we perform several robustness checks. First, we modify the benchmark specification by adding the square of AGE (Table 3, columns 5-8) or inserting a dummy for the recent crisis years (Table 3, columns 9-12). Furthermore, we change the estimation technique by adopting a random coefficient model rather than a random intercept model (Table 3, columns 13-16). Finally, as suggested by Snijders and Berkhof (2007), we control for cross-level endogeneity (between the level 2 error terms and the level 1 regressors) adopting Mundlak's (1978) correction, i.e., we add to the benchmark model the provincial means of the firm-level explanatory variables (Table 3, columns 17-20).

[TABLE 3]

4.1 Which institutional quality dimension drives our findings?

To provide more insight, we investigate the relevance of each dimension of institutional quality encompassed in the overall IQI index: the degree of corruption of those performing public functions in terms of both illegal gains and private proceeds acquired to the detriment of society (Control and Corruption, CORR); the quality of public service and the policies formulated and implemented by the local government (Government Effectiveness, GOV); the ability of government to promote and formulate effective regulatory interventions (Regulatory Quality, REG); the degree of legal certainty, in terms of contract fulfilment, property rights, incidence of crime, tax evasion, shadow economy, law enforcement and effectiveness in the administration of justice (Rule of Law, RUL); and the degree of freedom of press and association (Voice and Accountability, VOI).

Each of these facets of institutional quality has been separately analysed by the literature. The relationship between corruption and regional or national productivity has long been discussed from both theoretical (Krueger 1974; Rose-Ackerman 1978; Baumol 1990; Acemoglu and Verdier, 2000) and empirical perspectives (Méon and Sekkat, 2005; del Mar Salinas-Jiménez and Salinas-Jiménez, 2011). While the specific relationship between corruption and firm productivity remains almost unexplored (a relevant exception being De Rosa et al., 2010), both theory and empirical evidence highlight the negative consequences of corruption for resource allocation, entrepreneurship, investment and innovation (Baumol, 1990). Other studies emphasize how the entry of new firms is made more difficult in the presence of greater corruption and larger unofficial economies (Djankov et al., 2002); how investment decisions are discouraged by de facto entry barriers into otherwise competitive markets (Alesina et al., 2005); and how corruption directly affects the sources of productivity enhancements, technological progress and investment (Krusell and Rios-Rull, 1996; Svensson, 2005).

Concerning the issue of “Government Effectiveness”, some studies have highlighted the impact of the history of peoples and the connected institutional structures on the economic performance of countries (Hall and Jones, 1999), focusing, for example, on the role of political institutions in steering entrepreneurial efforts towards more productive activities and supporting business (Baumol, 1990; Murphy et al., 1991). Arrighetti and Lasagni (2011) argue that private firms are more abler to innovate and to push technological change where the intermediate government bodies (local political and administrative institutions) play a more active and positive role, also influencing firms' productivity. More effective public policies in health, transport and education (Kneller and Misch, 2010), transport (Shirley and Winston, 2004; Datta, 2008), and public electricity services (Reinkka and Svensson, 2002) are found to positively affect firms' productivity.

Regarding "Regulatory Quality", other contributions show the positive impact of liberalization and privatization policies in the OECD area on productivity in all sectors (Nicoletti and Scarpetta, 2005) and document the negative relationship between entry barriers and services' productivity in France and Italy (Daveri et al., 2011). An investigation of micro data from Bangladesh, China, India and Pakistan (Dollar et al., 2003) shows that the impact of the investment climate on firms' TFP is systematically positively related to the "Regulatory Quality" indicators.

Theoretical and empirical literature widely acknowledges the role of "Rule of Law" in fostering economic development and firms' performance. It discusses the negative effects of crime on the course of economic development (Ayres, 1998; Buvinic and Morrison, 2000); the negative correlations between the homicide rate and the increase in per capita GDP (World Bank, 2006) and between premature adult mortality from all sources, including crime, and the profound effect on time horizons, investment, and economic activity (Lorentzen et. al, 2008); the positive correlation between court efficiency across provincial courts and greater access to credit, showing that "larger more efficient firms are found in states with better court systems", leading to the conclusion that better courts "increase the firms' willingness to invest more" (Dam, 2006); evidence of a positive correlation between the efficiency of the Mexican court systems and faster growth of small firms (Islam, 2003). This view holds that the economic environment and firms' performance depend upon a legal system in which contracts between private parties are enforced, the property rights of foreign and domestic investors are respected, and the executive and legislative branches of government operate within a known framework of rules (World Bank 1992, 1994, 1997; Sherwood 1995; Shihata 1995; Dakolias 1996;).

In the literature on institutional quality, there is a large number of contributions on institutional thickness (Amin and Thrift, 1994) and social capital (Putnam, 1993a; Narayan and Pritchett, 1997; Woolcock, 1998). Both of these concepts are connected to a wide combination of factors, including the presence of virtuous local institutions and inter-institutional links that can create a sharing culture and a set of values that help construct the so-called "social atmosphere", generate mutual trust, enhance innovative capacity, expand common knowledge and strengthen local economic activity. Empirical evidence has clarified the roles social cohesion (Rodrik, 1997; Ritzen et al., 2000) and the spread of collaborative and associative practices (Putnam, 1993a and 1993b; Narayan, 1999) may have as drivers of economic development, showing that growth is favoured by greater social peace, political stability and a better quality of institutions and public services. The item "Voice and Accountability" of IQI fits into the debate on social capital *à la Putnam* while representing a dimension of social capital that is more consistent with the focus of the present work: a fair picture of the degree of citizens' participation in social and public life, represented by their willingness to act as volunteers, the presence of non-profit organizations and social cooperatives, and the number of books published. The literature focused on the relationship between social participation and firm performance suggests that knowledge flows are geographically bound as they tend to stream through social networks (Sorenson, 2003; Powell and Owen-Smith, 2004; Tallman et al., 2004).

According to our estimates, reported by Table 4, RUL is always positive and significant, except in the technological change case, while REG is significant only in the TFP change case. Thus, institutional contexts characterized by a relatively high incidence of crime, tax evasion, shadow economy, poor law enforcement and higher judicial costs seem to negatively affect firms' pure technical efficiency and scale efficiency.

[TABLE 4]

5. CONCLUDING REMARKS

Using a large sample of Italian manufacturing SMEs observed from 2004 to 2012, this paper investigates the relationship between institutional quality, defined at the province level, and firms' TFP growth, which is disentangled into three components: technological, pure technical efficiency and scale efficiency change.

Controlling for both firms' characteristics and contextual effects in a hierarchical model, we find that better institutions seem to favour a more efficient use of inputs by firms and stimulate the adoption of an operational scale more suitable to obtain good productivity performances. On the other hand, institutional quality never turns out to affect technological change, i.e., the capacity of firms to generate innovations.

Additionally, according to our findings, the most relevant institutional dimension is the one summarizing aspects related to legal certainty. In other words, institutional contexts characterized by a relatively low incidence of crime, good law enforcement and higher effectiveness in the administration of justice seem to positively influence firms' capacity to move both towards the benchmark frontier and towards the optimal productivity scale.

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TABLE 1 - Description and summary statistics

VARIABLE	DESCRIPTION	Mean	Std. Dev.	Min	Max	Obs
Employed to retrieve the Malmquist index						
TOTREV (a)	Total revenue	9,843	7394	3.28	45,031	69,894
KAP (a)	Tangible plus intangible assets (including depreciation)	2,748	2720	0.09	15,007	69,894
RAWM (a)	Expenditure for raw materials	734	814	0.07	5,440	69,894
EMPLO (a)	Personnel expenditure	1,579	1156	0.02	6,081	69,894
Entering the second stage model						
TFP	Malmquist index, TFP change	1.42	1.36	0.13	8.31	58,667
TECH	Technological change	1.04	0.23	0.60	1.79	58,667
SE	Scale efficiency change	1.18	0.79	0.20	4.78	58,667
PEFF	Pure technical efficiency change	1.40	1.27	0.14	7.55	58,667
IQI	Provincial IQI (Instituional quality index)	0.70	0.13	0.00	1.00	56,631
CORR	Corruption - IQI dimension	0.87	0.13	0.20	0.99	56,631
GOV	Government effectiveness - IQI dimension	0.46	0.10	0.06	0.65	56,631
REG	Regulatory quality - IQI dimension	0.58	0.12	0.10	0.93	56,631
RUL	Rule of law - IQI dimension	0.56	0.12	0.13	0.86	56,631
VOI	Voice and accountability - IQI dimension	0.52	0.13	0.15	0.70	56,631
SIZE (a)	Total assets	10,164	7334	401	35,109	58,667
AGE (b)	Current year minus firm’s year of establishment	45.50	29.23	8.00	112.0	58,659
INDEBT (c)	Total debt to total assets	58.47	20.63	10.93	94.09	58,667
CASHFLOW (c)	Firm's cashflow	5.72	-5.91	12.01	26.30	58,667
GDPPC (a)	Provincial per capita GDP	30.59	7.40	11.81	49.43	49,261
DENSITY	Provincial population/provincial surface (sq. km)	504.9	597.1	31.0	2,603	58,667
HHI	Herfindahl-Hirschman index on firms' assets	0.05	0.09	0.01	1.00	58,667
JACOB	Jacob index: number of sectors (2-digit level) in each province, with more than 10 firms	12.09	10.46	0.00	23.00	58,667
PATENT	Patent applications (per million inhabitants) to the EPO by priority year by NUTS 3 regions	127.4	68.30	0.25	487.8	58,569
R&D	Total intramural R&D expenditure (Euros per inhabitant)	360.8	116.2	58.50	656.9	51,399

(a) in thousands of Euro; (b) in years; (c) in percentage

FIGURE 1 – Institutional quality dimensions

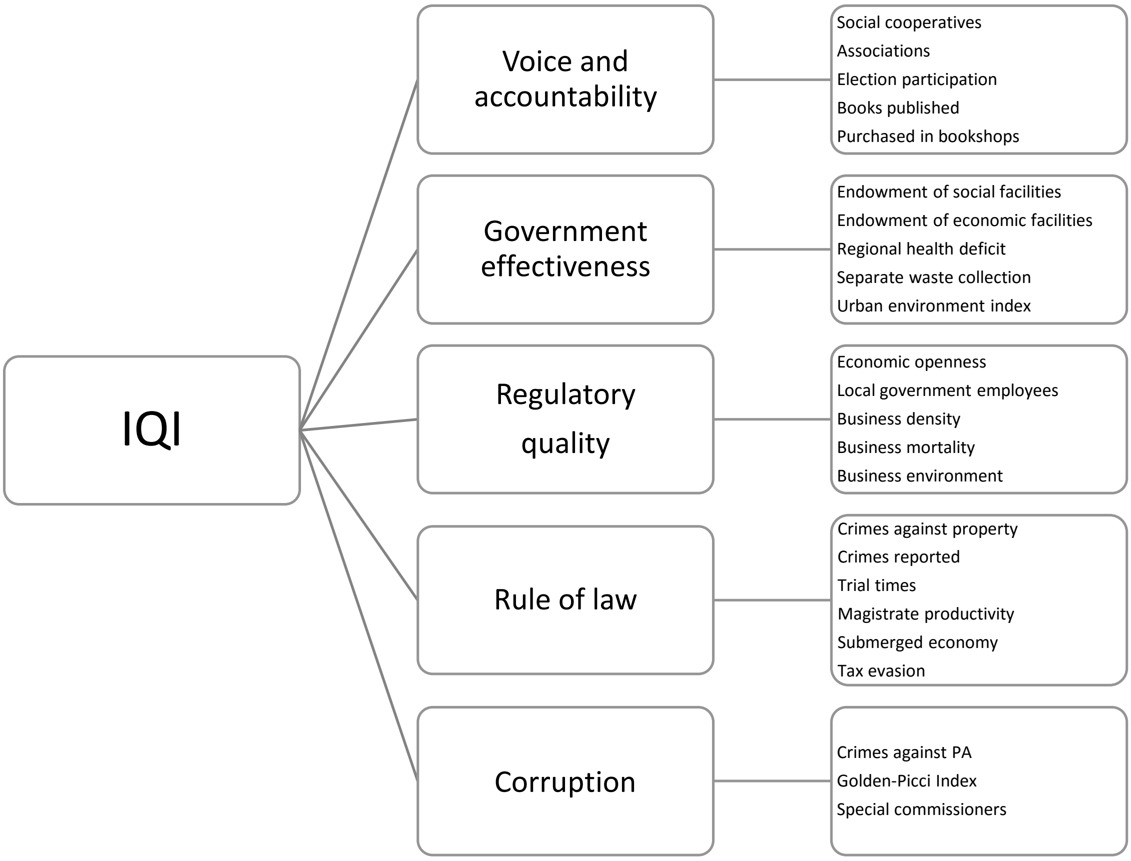

TABLE 2 - Malmquist index components and IQI by province in the period 2004-2011

Province	Region	TFP	TECH	SE	PEFF	IQI
Crotone	Calabria	0.584	0.963	0.765	0.746	0.003
Vibo Valentia	Calabria	0.663	0.989	0.894	0.767	0.071
Catanzaro	Calabria	0.632	0.988	0.950	0.678	0.088
Reggio di Calabria	Calabria	0.839	0.986	0.771	1.105	0.145
Caltanissetta	Sicilia	0.879	1.009	1.164	0.722	0.149
Cosenza	Calabria	0.537	0.968	0.948	0.586	0.182
Agrigento	Sicilia	0.709	0.972	1.119	0.650	0.191
Trapani	Sicilia	0.743	0.993	1.007	0.761	0.215
Isernia	Molise	0.855	1.011	1.046	0.817	0.234
Enna	Sicilia	0.672	1.105	1.183	0.507	0.239
Palermo	Sicilia	0.743	0.992	0.942	0.796	0.262
Catania	Sicilia	0.786	0.980	1.217	0.654	0.263
Napoli	Campania	0.942	1.013	0.953	0.984	0.263
Ragusa	Sicilia	1.193	0.975	1.216	1.023	0.286
Caserta	Campania	0.922	1.002	0.983	0.939	0.325
Messina	Sicilia	0.845	0.973	1.069	0.795	0.330
Siracusa	Sicilia	0.940	1.007	1.231	0.760	0.331
Campobasso	Molise	0.959	1.051	1.147	0.811	0.337
Nuoro	Sardegna	0.516	0.982	1.230	0.460	0.359
Foggia	Puglia	0.722	1.006	0.981	0.721	0.403
Benevento	Campania	0.803	0.992	1.186	0.698	0.408
Avellino	Campania	0.949	1.018	1.048	0.892	0.417
Imperia	Liguria	0.686	1.002	1.066	0.646	0.424
Sassari	Sardegna	0.885	0.981	1.186	0.757	0.439
Taranto	Puglia	1.381	1.022	0.915	1.450	0.442
Brindisi	Puglia	0.763	1.009	1.042	0.735	0.444
Potenza	Basilicata	1.052	0.989	1.267	0.824	0.456
Cagliari	Sardegna	0.727	1.001	1.047	0.712	0.460
Salerno	Campania	0.911	0.992	1.029	0.894	0.462
Matera	Basilicata	0.769	0.997	1.052	0.730	0.462
Lecce	Puglia	0.605	1.013	0.845	0.709	0.476
Bari	Puglia	0.826	1.020	1.024	0.796	0.493
Viterbo	Lazio	0.833	0.995	0.977	0.856	0.501
Latina	Lazio	0.999	1.022	0.990	0.981	0.508
Genova	Liguria	1.000	1.005	1.009	0.984	0.514
Rieti	Lazio	0.799	1.019	1.307	0.655	0.521
Frosinone	Lazio	1.065	1.021	0.931	1.106	0.525
Oristano	Sardegna	0.894	0.991	0.514	1.843	0.530
La Spezia	Liguria	1.007	1.002	1.284	0.766	0.554
Pescara	Abruzzo	0.779	0.999	1.278	0.611	0.593
Ascoli Piceno	Marche	1.037	1.008	1.009	1.016	0.598
Savona	Liguria	0.847	0.978	0.988	0.882	0.617
Pordenone	Friuli-Venezia Giulia	0.946	0.999	0.978	0.969	0.627
L'Aquila	Abruzzo	0.636	0.983	0.980	0.672	0.628
Belluno	Veneto	0.963	1.001	0.980	0.976	0.633
Vercelli	Piemonte	0.852	1.015	0.912	0.923	0.636
Rovigo	Veneto	0.904	0.992	0.889	1.018	0.644
Udine	Friuli-Venezia Giulia	0.902	1.003	1.004	0.895	0.651
Ferrara	Emilia-Romagna	0.861	1.011	0.949	0.893	0.659
Torino	Piemonte	0.953	1.011	1.006	0.936	0.661
Verona	Veneto	1.040	1.011	0.932	1.103	0.664
Pesaro e Urbino	Marche	1.009	1.010	0.912	1.093	0.665
Teramo	Abruzzo	0.877	1.015	0.964	0.892	0.666
Alessandria	Piemonte	0.888	0.997	1.050	0.846	0.666
Pavia	Lombardia	0.866	1.014	1.060	0.810	0.669
Terni	Umbria	0.860	1.034	0.863	0.962	0.670
Macerata	Marche	0.836	1.019	0.885	0.926	0.675
Modena	Emilia-Romagna	1.125	1.021	0.946	1.155	0.676
Lodi	Lombardia	1.139	1.009	1.013	1.116	0.678
Sondrio	Lombardia	0.888	0.990	0.835	1.050	0.683
Vicenza	Veneto	0.992	1.018	0.922	1.055	0.685
Asti	Piemonte	0.959	1.017	0.888	1.065	0.689
Bologna	Emilia-Romagna	1.030	1.017	1.005	1.005	0.689
Roma	Lazio	1.104	1.011	0.967	1.125	0.696
Venezia	Veneto	1.007	1.014	0.998	0.994	0.697
Como	Lombardia	0.928	1.021	0.870	1.046	0.697
Perugia	Umbria	0.940	1.021	1.001	0.918	0.700
Rimini	Emilia-Romagna	1.054	1.014	0.880	1.156	0.706
Piacenza	Emilia-Romagna	1.036	1.002	0.919	1.124	0.708
Brescia	Lombardia	1.129	1.014	0.986	1.131	0.711
Ancona	Marche	0.918	1.008	0.899	1.001	0.713
Reggio nell'Emilia	Emilia-Romagna	1.097	1.014	1.058	1.019	0.714
Chieti	Abruzzo	0.870	1.025	0.944	0.898	0.716
Biella	Piemonte	0.918	1.059	0.938	0.932	0.722
Lecco	Lombardia	1.031	1.016	0.869	1.162	0.732
Forlì-Cesena	Emilia-Romagna	0.959	1.008	0.888	1.065	0.733
Parma	Emilia-Romagna	1.204	0.994	1.012	1.195	0.734
Treviso	Veneto	1.038	1.013	0.989	1.031	0.734
Mantova	Lombardia	1.042	1.013	0.914	1.126	0.738
Valle d'Aosta	Valle d'Aosta	1.123	0.986	1.035	1.082	0.742
Padova	Veneto	1.021	1.005	0.971	1.041	0.743
Gorizia	Friuli-Venezia Giulia	0.863	1.011	0.918	0.937	0.744
Verbano-Cusio-Ossola	Piemonte	0.834	1.005	0.913	0.907	0.749
Massa-Carrara	Toscana	0.956	1.041	1.145	0.815	0.754
Bergamo	Lombardia	1.053	1.008	0.932	1.117	0.759
Novara	Piemonte	0.975	1.020	0.992	0.959	0.764
Cremona	Lombardia	1.052	0.991	0.798	1.330	0.768
Pistoia	Toscana	1.024	1.032	0.982	1.013	0.776
Grosseto	Toscana	0.933	0.981	0.962	0.987	0.776
Ravenna	Emilia-Romagna	0.942	1.002	0.958	0.979	0.782
Varese	Lombardia	0.950	1.020	0.972	0.957	0.795
Cuneo	Piemonte	1.047	1.007	0.993	1.048	0.797
Milano	Lombardia	1.055	1.008	1.012	1.034	0.812
Bolzano/Bozen	Trentino-Alto Adige	0.975	1.006	0.933	1.042	0.815
Arezzo	Toscana	1.144	1.028	0.955	1.161	0.819
Prato	Toscana	1.531	1.064	1.173	1.239	0.819
Lucca	Toscana	1.232	1.024	1.191	1.008	0.829
Trento	Trentino-Alto Adige	1.027	1.012	0.982	1.038	0.851
Pisa	Toscana	1.117	1.043	1.046	1.023	0.879
Trieste	Friuli-Venezia Giulia	1.023	1.010	0.831	1.203	0.897
Livorno	Toscana	2.001	1.042	1.336	1.394	0.898
Siena	Toscana	0.970	0.993	0.966	1.001	0.900
Firenze	Toscana	1.168	1.029	1.036	1.083	1.000
Barletta-Andria-Trani	Puglia	0.844	1.068	1.082	0.720	N/A
Carbonia-Iglesias	Sardegna	3.189	0.974	1.783	1.836	N/A
Fermo	Marche	0.992	1.036	0.953	1.004	N/A
Medio Campidano	Sardegna	0.670	0.938	0.969	0.737	N/A
Monza e della Brianza	Lombardia	1.040	1.013	1.000	1.024	N/A
Ogliastra	Sardegna	0.746	0.970	1.342	0.594	N/A
Olbia-Tempio	Sardegna	0.477	1.027	1.051	0.443	N/A

Note: TFP is the Malmquist index; TECH is technological change; SE is scale efficiency change; PEFF is pure technical efficiency change; TFP=TECH x SE x PEFF. Figures for TFP, TECH, SE and PEFF are geometric means, while those for IQI are arithmetic means. Percentage increases or decreases for each province and Malmquist component are obtained as (TFP-1)*100, (TECH-1)*100, (SE-1)*100 and (PEFF-1)*100. Provinces are sorted in ascending order of IQI.

FIGURE 2 – TFP change and IQI across the Italian provinces: 2004-2011 mean values

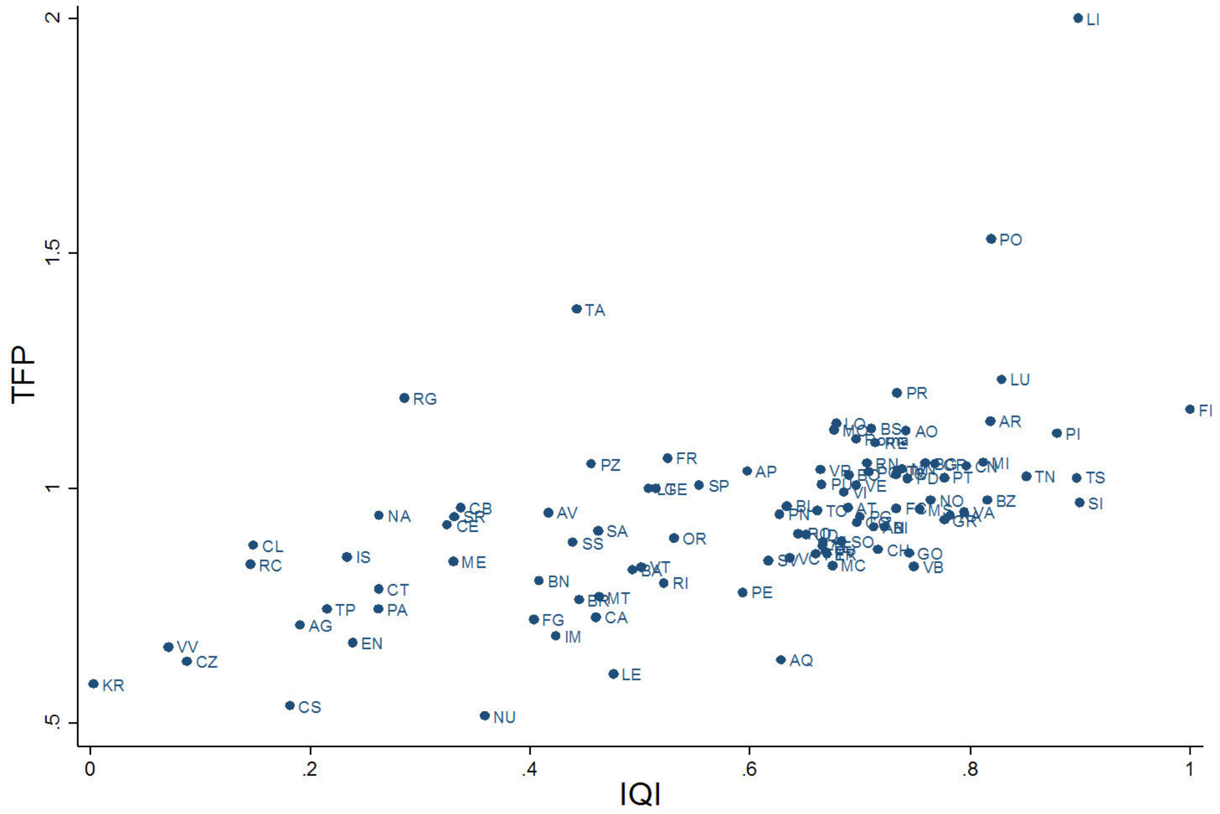

FIGURE 3 – Technological efficiency change and IQI across the Italian provinces: 2004-2011 mean values

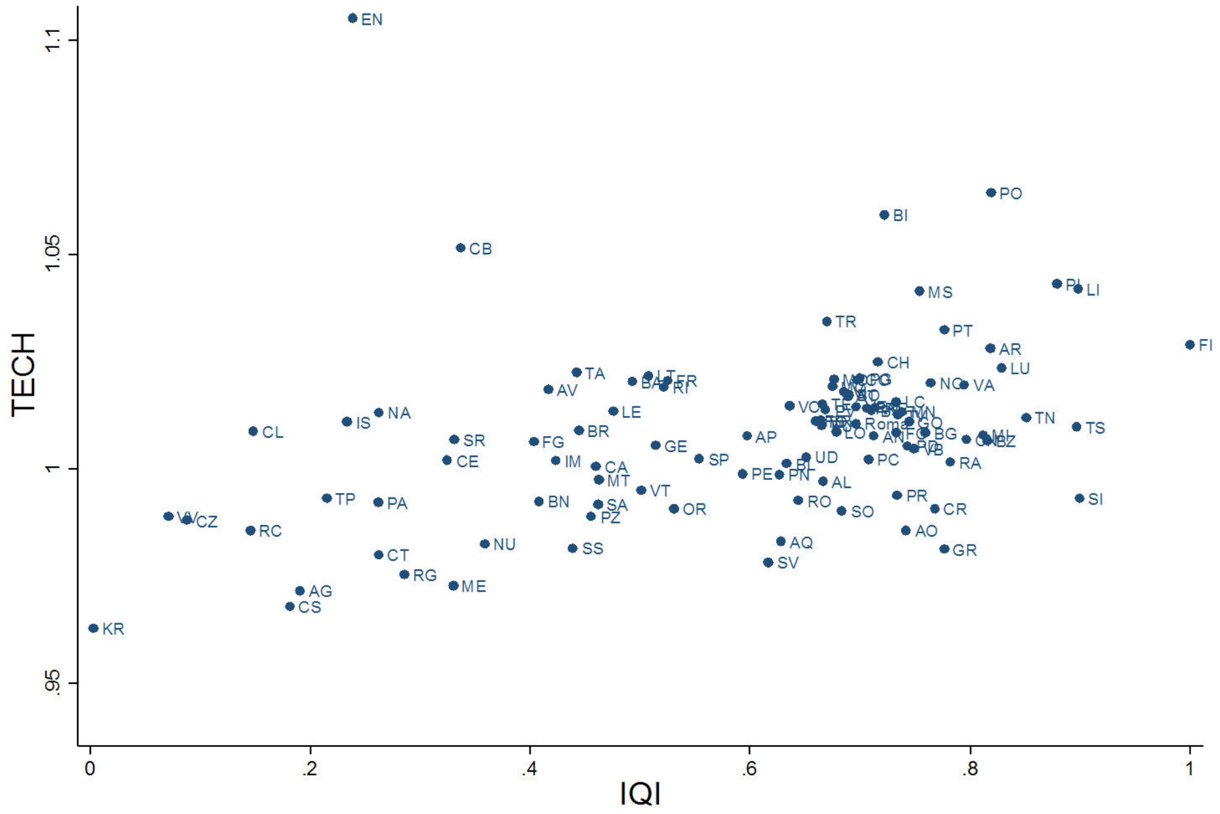

FIGURE 4 – Scale efficiency change and IQI across the Italian provinces: 2004-2011 mean values

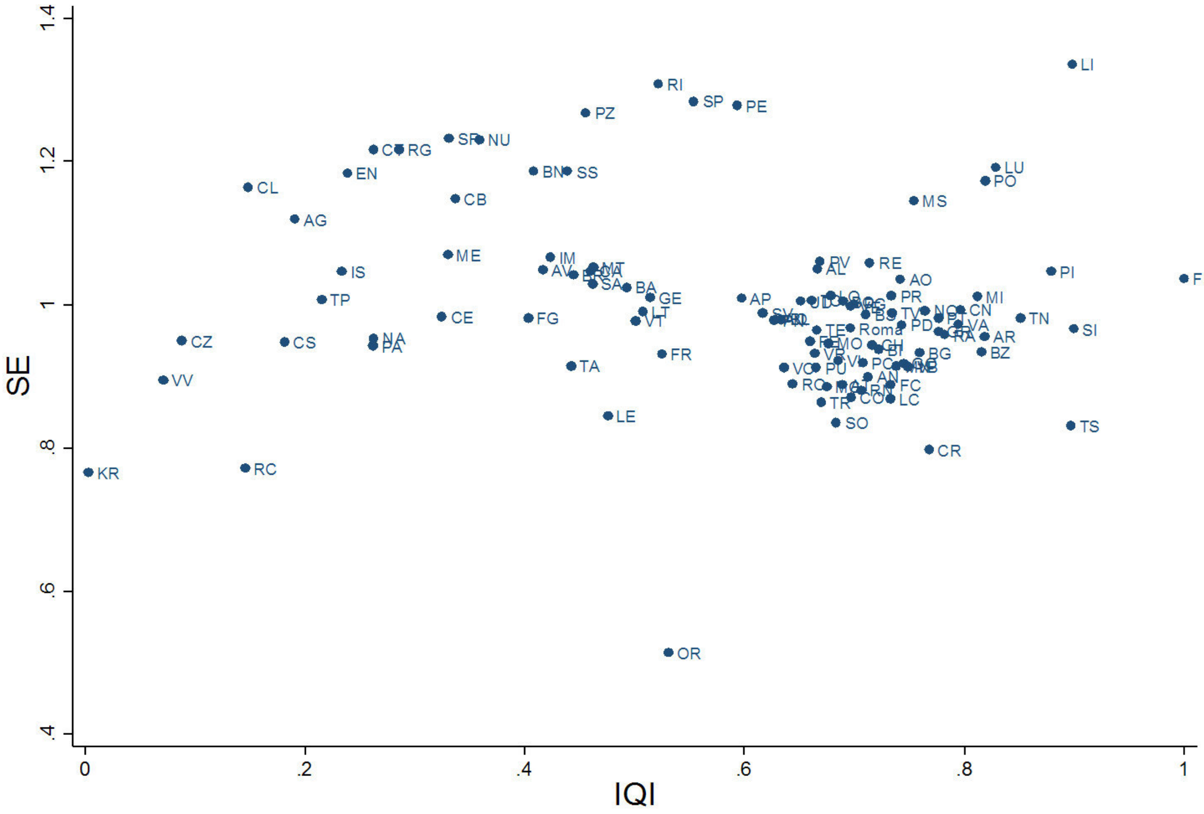

FIGURE 5 – Pure efficiency change and IQI across the Italian provinces: 2004-2011 mean values

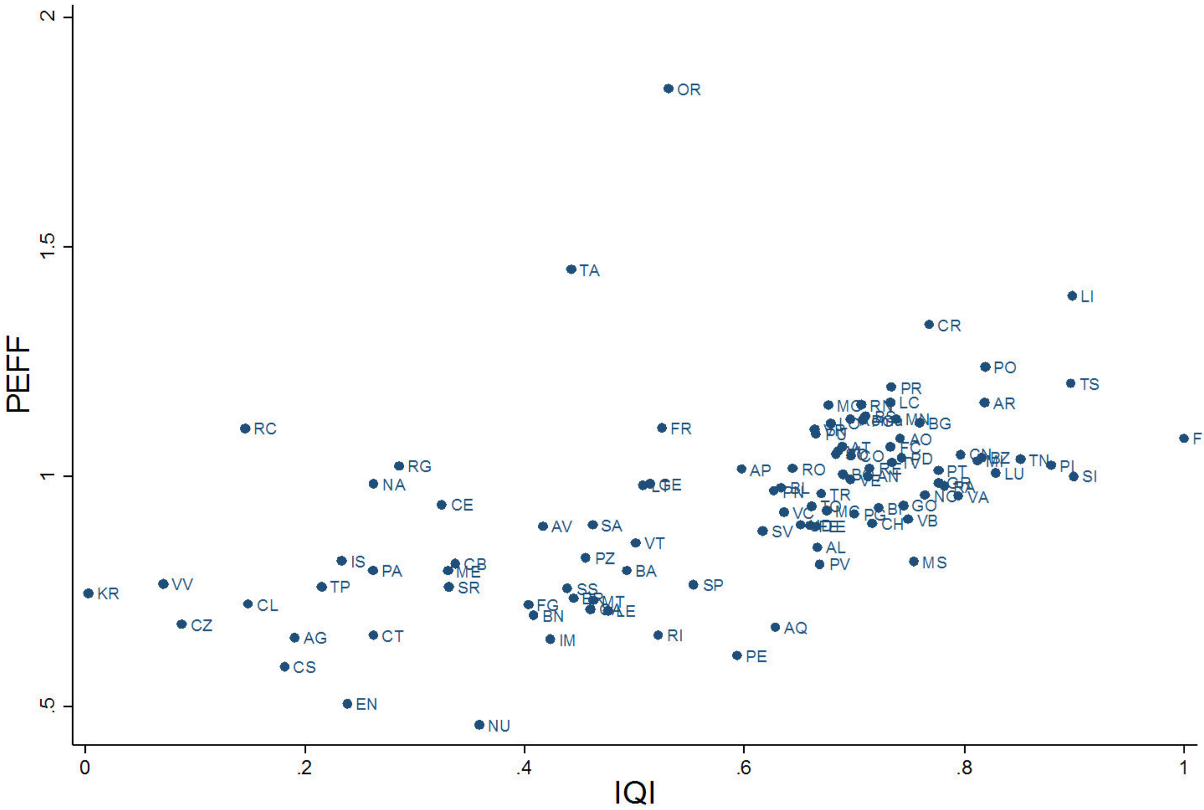

TABLE 3 - Estimation results

	BENCH				Adding AGE^2 in BENCH				Dummy CRISIS in BENCH				Random coefficient				Mundlack correction			
	TFP	TECH	SE	PEFF	TFP	TECH	SE	PEFF	TFP	TECH	SE	PEFF	TFP	TECH	SE	PEFF	TFP	TECH	SE	PEFF
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
IQI	0.464***	-0.007	0.164***	0.309***	0.464***	-0.007	0.164***	0.309***	0.464***	-0.007	0.164***	0.309***	0.470***	-0.007	0.153**	0.307***	0.374***	-0.011	0.150***	0.184*
	0.000	*0.541*	*0.007*	*0.003*	*0.000*	*0.535*	*0.007*	*0.003*	*0.000*	*0.541*	*0.007*	*0.003*	*0.000*	*0.541*	*0.015*	*0.003*	*0.002*	*0.364*	*0.007*	*0.055*
SIZE	-0.391***	-0.009	1.159***	-2.695***	-0.385***	-0.009	1.158***	-2.693***	-0.391***	-0.009	1.159***	-2.695***	-0.389***	-0.009	1.160***	-2.696***	-0.397***	-0.009	1.156***	-2.690***
	0.001	*0.455*	*0.000*	*0.000*	*0.001*	*0.473*	*0.000*	*0.000*	*0.001*	*0.455*	*0.000*	*0.000*	*0.001*	*0.455*	*0.000*	*0.000*	*0.001*	*0.453*	*0.000*	*0.000*
SIZE^2	0.022***	0.001	-0.085***	0.176***	0.021***	0.001	-0.085***	0.176***	0.022***	0.001	-0.085***	0.176***	0.022***	0.001	-0.085***	0.176***	0.022***	0.001	-0.085***	0.175***
	0.002	*0.343*	*0.000*	*0.000*	*0.002*	*0.354*	*0.000*	*0.000*	*0.002*	*0.343*	*0.000*	*0.000*	*0.002*	*0.343*	*0.000*	*0.000*	*0.002*	*0.346*	*0.000*	*0.000*
AGE	-0.062***	-0.001	-0.005	-0.049***	-0.234*	-0.014	0.023	-0.132	-0.062***	-0.001	-0.005	-0.049***	-0.062***	-0.001	-0.005	-0.049***	-0.059***	0.000	-0.002	-0.048***
	0.000	*0.712*	*0.486*	*0.000*	*0.098*	*0.357*	*0.749*	*0.245*	*0.000*	*0.712*	*0.486*	*0.000*	*0.000*	*0.712*	*0.507*	*0.000*	*0.000*	*0.814*	*0.764*	*0.000*
INDEBT	0.006***	0.000	0.001***	0.005***	0.006***	0.000	0.001***	0.005***	0.006***	0.000	0.001***	0.005***	0.006***	0.000	0.001***	0.005***	0.006***	0.000	0.001***	0.005***
	0.000	*0.117*	*0.000*	*0.000*	*0.000*	*0.139*	*0.000*	*0.000*	*0.000*	*0.117*	*0.000*	*0.000*	*0.000*	*0.117*	*0.000*	*0.000*	*0.000*	*0.149*	*0.000*	*0.000*
CASHFLOW	0.026***	0.000	0.001	0.024***	0.026***	0.000	0.001	0.024***	0.026***	0.000	0.001	0.024***	0.026***	0.000	0.001	0.024***	0.027***	0.000	0.001	0.024***
	0.000	*0.778*	*0.167*	*0.000*	*0.000*	*0.737*	*0.162*	*0.000*	*0.000*	*0.778*	*0.167*	*0.000*	*0.000*	*0.778*	*0.168*	*0.000*	*0.000*	*0.783*	*0.139*	*0.000*
HHI	-0.023	0.007	0.007	0.118	-0.024	0.007	0.007	0.117	-0.023	0.007	0.007	0.118	-0.024	0.007	0.007	0.119	-0.021	0.007	0.003	0.122
	0.853	*0.538*	*0.901*	*0.212*	*0.848*	*0.542*	*0.899*	*0.213*	*0.853*	*0.538*	*0.901*	*0.212*	*0.850*	*0.538*	*0.902*	*0.208*	*0.866*	*0.540*	*0.960*	*0.198*
GDPPC	0.146	-0.002	-0.047	0.173*	0.148	-0.002	-0.047	0.174*	0.146	-0.002	-0.047	0.173*	0.118	-0.002	-0.038	0.171*	0.186	-0.001	-0.039	0.187**
	0.214	*0.833*	*0.371*	*0.051*	*0.208*	*0.842*	*0.368*	*0.050*	*0.214*	*0.833*	*0.371*	*0.051*	*0.291*	*0.833*	*0.471*	*0.052*	*0.104*	*0.916*	*0.347*	*0.017*
DENSITY	0.085***	0.000	0.022**	0.045**	0.085***	0.000	0.022**	0.045**	0.085***	0.000	0.022**	0.045**	0.089***	0.000	0.020**	0.053***	0.069***	0.000	0.015*	0.029*
	0.002	*0.924*	*0.031*	*0.010*	*0.002*	*0.926*	*0.031*	*0.010*	*0.002*	*0.924*	*0.031*	*0.010*	*0.001*	*0.924*	*0.047*	*0.002*	*0.005*	*0.808*	*0.082*	*0.061*
JACOB	0.003*	0.000	0.001*	0.000	0.003*	0.000	0.001*	0.000	0.003*	0.000	0.001*	0.000	0.003*	0.000	0.001*	0.000	0.003**	0.000	0.001*	0.000
	0.096	*0.645*	*0.077*	*0.710*	*0.099*	*0.631*	*0.076*	*0.703*	*0.096*	*0.645*	*0.077*	*0.710*	*0.095*	*0.645*	*0.070*	*0.733*	*0.046*	*0.697*	*0.058*	*0.964*
PATENT	-0.029	0.001	-0.034***	-0.003	-0.029	0.001	-0.034***	-0.003	-0.029	0.001	-0.034***	-0.003	-0.026	0.001	-0.034***	-0.004	-0.027	0.001	-0.029***	0.003
	0.161	*0.677*	*0.001*	*0.842*	*0.162*	*0.666*	*0.001*	*0.845*	*0.161*	*0.677*	*0.001*	*0.842*	*0.197*	*0.677*	*0.001*	*0.823*	*0.169*	*0.696*	*0.001*	*0.869*
R&D	0.024	0.001	-0.009	0.031	0.025	0.001	-0.009	0.031	0.024	0.001	-0.009	0.031	0.025	0.001	-0.009	0.031	0.066*	0.003	0.015	0.071**
	0.558	*0.685*	*0.636*	*0.336*	*0.546*	*0.670*	*0.631*	*0.330*	*0.558*	*0.685*	*0.636*	*0.336*	*0.532*	*0.685*	*0.625*	*0.326*	*0.094*	*0.398*	*0.377*	*0.017*
AGE^2					0.025	0.002	-0.004	0.012												
					0.221	*0.373*	*0.694*	*0.464*												
CRISIS									0.044*	-0.045***	0.141***	-0.030								
									0.056	*0.000*	*0.000*	*0.168*								
Observations	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151
Model test	1382.8	13422.5	3856.4	2638.4	1384.4	13423.5	3856.4	2639.3	1382.8	13422.5	3856.4	2638.4	1383.4	13422.5	3852.1	2641.2	1417.8	13424.9	3923.6	2686.1
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

For the description of the variables see Table 1. Superscripts ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively. In italics are reported the p-values of the tests. The variables SIZE, AGE, GDPPC, DENSITY, PATENT and R&D are in natural logarithms.

TABLE 4 - Estimation results: decomposing IQI

	TFP					TECH					SE					PEFF				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
CORR	0.086					0.005					-0.064					0.012				
	0.499					*0.683*					*0.545*					*0.857*				
GOV		0.147					-0.018					0.178					0.092			
		0.277					*0.183*					*0.121*					*0.185*			
REG			0.158*					0.010					0.099					0.054		
			0.069					*0.246*					*0.177*					*0.223*		
RUL				0.311***					-0.008					0.225***					0.088**	
				0.000					*0.270*					*0.001*					*0.036*	
VOI					-0.012					0.006					-0.127					-0.023
					0.933					*0.513*					*0.210*					*0.713*
SIZE	-0.387***	-0.387***	-0.391***	-0.391***	-0.387***	-0.009	-0.009	-0.010	-0.009	-0.009	-2.693***	-2.692***	-2.695***	-2.699***	-2.694***	1.161***	1.162***	1.160***	1.159***	1.161***
	0.001	*0.001*	*0.001*	*0.001*	*0.001*	*0.452*	*0.446*	*0.436*	*0.470*	*0.455*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
SIZE^2	0.021***	0.021***	0.022***	0.022***	0.021***	0.001	0.001	0.001	0.001	0.001	0.176***	0.176***	0.176***	0.176***	0.176***	-0.086***	-0.086***	-0.085***	-0.085***	-0.085***
	0.002	*0.002*	*0.002*	*0.002*	*0.002*	*0.341*	*0.336*	*0.327*	*0.354*	*0.342*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
AGE	-0.062***	-0.062***	-0.062***	-0.062***	-0.062***	-0.001	0.000	0.000	-0.001	-0.001	-0.050***	-0.050***	-0.050***	-0.049***	-0.050***	-0.005	-0.005	-0.005	-0.005	-0.005
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.720*	*0.732*	*0.736*	*0.700*	*0.715*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.483*	*0.473*	*0.482*	*0.509*	*0.487*
INDEBT	0.006***	0.006***	0.006***	0.006***	0.006***	0.000	0.000	0.000	0.000	0.000	0.005***	0.005***	0.005***	0.005***	0.005***	0.001***	0.001***	0.001***	0.001***	0.001***
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.125*	*0.116*	*0.131*	*0.116*	*0.119*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
CASHFLOW	0.026***	0.026***	0.026***	0.026***	0.026***	0.000	0.000	0.000	0.000	0.000	0.024***	0.024***	0.024***	0.024***	0.024***	0.001	0.001	0.001	0.001	0.001
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.775*	*0.787*	*0.777*	*0.771*	*0.782*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.170*	*0.172*	*0.173*	*0.163*	*0.169*
HHI	-0.026	-0.026	-0.026	-0.026	-0.027	0.007	0.007	0.007	0.007	0.007	0.113	0.115	0.116	0.116	0.113	0.006	0.006	0.006	0.007	0.006
	0.837	*0.838*	*0.834*	*0.835*	*0.833*	*0.525*	*0.537*	*0.515*	*0.533*	*0.524*	*0.231*	*0.224*	*0.221*	*0.221*	*0.230*	*0.912*	*0.912*	*0.913*	*0.904*	*0.913*
GDPPC	0.286**	0.282**	0.228*	0.304***	0.314**	-0.005	-0.002	-0.010	-0.005	-0.009	0.306***	0.255***	0.230***	0.293***	0.350***	0.012	-0.002	-0.016	0.020	0.028
	0.016	*0.016*	*0.054*	*0.006*	*0.012*	*0.499*	*0.766*	*0.259*	*0.477*	*0.381*	*0.001*	*0.003*	*0.010*	*0.000*	*0.000*	*0.827*	*0.965*	*0.769*	*0.699*	*0.647*
DENSITY	0.085***	0.071**	0.084***	0.095***	0.077***	0.001	0.001	0.001	0.000	0.000	0.031	0.031*	0.043**	0.050***	0.041**	0.020	0.015	0.022**	0.025**	0.020*
	0.007	*0.016*	*0.003*	*0.001*	*0.008*	*0.665*	*0.597*	*0.534*	*0.943*	*0.982*	*0.138*	*0.083*	*0.016*	*0.004*	*0.019*	*0.113*	*0.152*	*0.042*	*0.027*	*0.071*
JACOB	0.002	0.003	0.002	0.003*	0.003	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	0.000	-0.001	0.001	0.001	0.001	0.001*	0.001
	0.105	*0.105*	*0.121*	*0.074*	*0.100*	*0.680*	*0.625*	*0.698*	*0.619*	*0.701*	*0.629*	*0.621*	*0.577*	*0.747*	*0.579*	*0.103*	*0.101*	*0.109*	*0.077*	*0.103*
PATENT	-0.017	-0.020	-0.017	-0.016	-0.014	0.000	0.002	0.000	0.001	0.001	0.009	-0.002	0.006	0.007	0.004	-0.030***	-0.034***	-0.030***	-0.029***	-0.030***
	0.429	*0.356*	*0.398*	*0.443*	*0.490*	*0.899*	*0.400*	*0.834*	*0.771*	*0.625*	*0.606*	*0.906*	*0.746*	*0.684*	*0.813*	*0.006*	*0.002*	*0.004*	*0.006*	*0.005*
R&D	0.046	0.046	0.059	0.027	0.048	0.001	0.001	0.002	0.002	0.001	0.047	0.046	0.052*	0.028	0.050	-0.001	-0.001	0.002	-0.009	0.000
	0.268	*0.267*	*0.151*	*0.518*	*0.246*	*0.749*	*0.728*	*0.630*	*0.610*	*0.782*	*0.137*	*0.150*	*0.100*	*0.378*	*0.110*	*0.975*	*0.969*	*0.925*	*0.668*	*0.997*
Observations	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151	42,151
Model test	1365.9	1366.3	1371.0	1382.1	1365.2	13422.2	13424.3	13423.7	13423.6	13422.5	2625.2	2627.4	2630.6	2643.0	2630.4	3840.9	3844.3	3847.3	3844.4	3839.3
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

For the description of the variables see Table 1. Superscripts ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively. In italics are reported the p-values of the tests. The variables SIZE, AGE, GDPPC, DENSITY, PATENT and R&D are in natural logarithms.