Productivity and growth: the relevance of the national system of entrepreneurship

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Abstract

In this study we evaluate how country-level entrepreneurship—measured via the national system of entrepreneurship—impacts total factor productivity, and how the national system of entrepreneurship triggers productivity by increasing the beneficial effects of different types of entrepreneurship, namely Kirznerian and Schumpeterian entrepreneurship. Using a comprehensive database for 73 countries during 2002-2013, we employ a non-parametric technique—Data Envelopment Analysis—to build the world technology frontier and compute the Malmquist total factor productivity index and its components. The results are consistent with the notion that the national system of entrepreneurship is positively associated with total factor productivity at the country level. Additionally, the findings reveal that the national system of entrepreneurship enhances efficiency change via enhanced Kirznerian entrepreneurship in the short-run, while the positive effect on total factor productivity of Schumpeterian entrepreneurship prevails in the long run. The results suggest that public policies promoting Kirznerian entrepreneurship—e.g., increased business formation rates—may be conducive to productivity in periods of economic growth. In contrast, policy interventions targeting Schumpeterian entrepreneurship objectives—e.g., innovative entrepreneurship and the development of new technologies—yield to technical progress and, consequently, productivity growth, regardless of the state of the economic cycle (growth of stagnation).

Keywords: National system of entrepreneurship, GEI, total factor productivity, efficiency change, technical change

JEL classification: C4; O10; L26; M13

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1. Introduction

What explains the large disparities in productivity across economies? Furthermore, to what extent can these productivity gaps be explained by reasons other than the countries' factor endowments? Productivity growth—for example, resulting from enhanced resource allocation policies or the development and implementation of technological advances—has been invoked as a critical component of economic development (Barro, 1991; Acemoglu and Zilibotti, 2001). Echoing the seminal work by Solow (1957), economists have devoted a great deal of efforts on evaluating the sources of productivity growth between and within countries over time. Prior studies have documented significant differences in total factor productivity across countries (Hall and Jones, 1999; Acemoglu and Zilibotti, 2001; Caselli and Coleman, 2006). Various reasons have been proposed to explain productivity discrepancies at country level, including slow diffusion of technology or barriers to technology transfer (Mankiw et al., 1992; Parente and Prescott, 1994; Barro and Sala-i-Martin, 1997), and differences in endogenous technical change associated with the limited access to technological knowledge and human capital (Lucas, 1988; Romer, 1990; Prescott, 1998; Young, 1998; Caselli and Coleman, 2006).

Nevertheless, countries do not materialize the generally positive effects of the exploitation of both factor endowments and technological advances at the same intensity. In this discussion, since the contribution of Schumpeter (1934), the role of entrepreneurship on national performance has increasingly drawn scholarly attention. Entrepreneurship has been shown to be important for countries' economic performance in various ways (Van Praag and Versloot 2007; Acs et al., 2009; Braunerhjelm et al., 2010; Prieger et al., 2016). The specific analysis of the role of entrepreneurship on country-level total factor productivity has recently started to attract attention (see, e.g., Lafuente et al., 2016; Erken et al., 2016).

This is the core of our analysis. In this study we argue that, besides the differences in technology and the allocation of production factors (i.e., capital and labor), the national system of entrepreneurship—i.e., the institutional setting backing entrepreneurship at country level—plays a decisive role in shaping total factor productivity across countries. More concretely, we evaluate if country-level entrepreneurship is conducive to productivity growth by triggering the beneficial effects of entrepreneurship which we link to different sources of productivity.

Underlying our approach to the relationship between entrepreneurship and productivity at the country level are three elements that constitute the cornerstones upon which we built the study. The first critical aspect deals with the definition of entrepreneurship at the country level.

Entrepreneurship is an attractive concept that has been mostly analyzed from the perspective of the individual (Acs et al., 2016). As a national phenomenon, entrepreneurship is much more than mere business formation rates and its operationalization should incorporate the regulating effect of context-related factors on individual actions (Acs et al., 2014). Countries cover a range of different institutional settings (Acemoglu et al., 2005), which suggests that entrepreneurial entry decisions are governed by complex interactions. Thus, a systemic approach to entrepreneurship seems appropriate to obtain a more realistic picture of entrepreneurship at the country level and its effects on total factor productivity. To better understand entrepreneurship at the country level, we adopt the concept of national system of entrepreneurship developed by Acs et al. (2014). The national system of entrepreneurship provides a richer framework that contributes to better understand how entrepreneurship fuels national productivity through the efficient allocation of resources in the economy (Acs et al., 2014; Lafuente et al., 2016).

Entrepreneurship is not only heterogeneous between countries, but also in terms of its effects on productivity. Thus, the second cornerstone of our study relates to the analysis of the effects on total factor productivity of different types of entrepreneurship, namely Kirznerian and Schumpeterian entrepreneurship. By scrutinizing how the national system of entrepreneurship triggers different sources of total factor productivity, we can assess if a healthy entrepreneurial ecosystem yields to a more efficient mobilization of resources and exploitation of available technologies—a process that we link to Kirznerian entrepreneurship (Kirzner, 1997)—and, consequently, to higher output levels. Also, our analysis permits us to evaluate whether the national system of entrepreneurship enhances the role of the entrepreneurs responsible for the 'creative destruction' (Schumpeter, 1934; Aghion and Howitt, 1992) on country-level productivity by replacing incumbents with higher-quality versions of existing products[1], and by promoting technological innovations that translate in higher technical change rates.

The distinction between Kirznerian and Schumpeterian entrepreneurship forces us to rethink the way we establish the link between entrepreneurship and total factor productivity. The third key element of this study—closely related to the second one addressing the role of Kirznerian and Schumpeterian entrepreneurship—deals with the computation of total factor productivity at country level. Building on Solow's model (1957), underlying most research is the assumption of zero waste and 100% efficiency.[2] This implies that total factor productivity changes are exclusively attributed to variations in technical change (see, e.g., Acemoglu and

[1] The Romer (1990) and Grossman and Helpman (1991) expanding variety models are in that sense more Schumpeterian in nature. In these models the introduction of new ideas erodes the profitability of the incumbent businesses. Also, the creative destruction process is not explicit in these models as they do not incorporate the possibility of business exit.

[2] This assumption is built into most mainstream economic models, simply because it would be irrational for the (representative) firm to allow such wasteful inefficiencies to persist and free competition would eliminate any inefficient firms. Still, in reality we know wasteful inefficiencies exist and persist in many industries and countries.

Zilibotti, 2001; Caselli and Coleman, 2006). Despite the relevance of these rigorous efforts, the assumption of full efficiency is innocent enough when the focus is on a group of countries shifting the world frontier under which a second (likely larger) group of countries operate.

To accurately capture the effects on productivity of Kirznerian and Schumpeterian entrepreneurship, we employ non-parametric techniques—i.e., Data Envelopment Analysis—to compute the Malmquist total factor productivity index (Färe et al., 1994; Kumar and Russell, 2002). This methodological approach allows us to split total factor productivity into two components: efficiency change (i.e., catch-up effect) and technical change (i.e., innovation effect). By separating the effect of changes in the countries' position relative to the technology frontier from the shifts of the world frontier, we can evaluate if the national system of entrepreneurship improves the role of Kirznerian entrepreneurship by helping economies to move closer to the technology frontier. Additionally, we can test if the national system of entrepreneurship is conducive to technical progress by increasing the effect of disruptive technologies—which we link to Schumpeterian entrepreneurship—on total factor productivity.

The empirical application considers a sample of 73 countries during the period 2002-2013. Our results corroborate that the national system of entrepreneurship is positively associated with changes in total factor productivity. Additionally, we find that the positive effect of Kirznerian entrepreneurship on efficiency change only holds in periods of sustained economic growth. On contrary, the results reveal that the positive effect of the national system of entrepreneurship on productivity via Schumpeterian entrepreneurship (technical change) consistent in the long run, regardless the economic cycle.

The following section presents the theory that underpins this work and our hypotheses. Section 3 describes the data and the methodological approach. Section 4 presents the empirical findings, while Section 5 presents the implications and concluding remarks.

2. Background theory and hypotheses development

Within the economic literature there are two dominant approaches dealing with the role of entrepreneurship on national performance, namely Kirznerian and Schumpeterian entrepreneurship. The first approach theorizing the role of entrepreneurship comes from the work of the 'Austrian' economists such as Von Mises, Hayek, and Kirzner. This approach underlines the relevance of market processes over economic equilibrium analysis. Kirzner (1973, 1997) emphasizes the function of entrepreneurship as a market discovery process in which entrepreneurs—defined as 'entrepreneurially alert' individuals—discover and exploit failures in the market pricing mechanisms by reacting to others' competitive actions (Kirzner 1997, p. 71). Kirznerian entrepreneurs create market profits by using available technologies in the context of the existing production function. Instead of shifting the country's production function, Kirznerian entrepreneurship primarily focuses on efficient market processes and business operations. Therefore, the contribution of this type of entrepreneurship to national performance mostly comes from enhanced operating efficiency levels, that is, the efficient mobilization and allocation of resources to achieve superior output levels. In this case, Kirznerian entrepreneurship helps economies to move closer to their technology frontier.

The second approach is rooted in the Schumpeterian system (1934) that stresses the decisive role of innovation-driven market mechanisms on shifts in countries' production function. Under this line of thought entrepreneurship is a critical factor that sparks economic development by creating disequilibrium. For Schumpeter (1934) entrepreneurs introduce radical innovations to the market that create new combinations of inputs and outputs. In this case, Schumpeterian entrepreneurship contributes to national performance by promoting changes in the countries' production function.

Figure 1 illustrates the effect of both types of entrepreneurship on performance. The figure shows a standard production frontier (T) in which one output (y)—e.g., GDP per capita—is produced by two inputs: capital (K) and labor (L). The described technology in the figure represents the maximum output that can be produced for given input levels.

Following our line of argument, Kirznerian entrepreneurship will contribute to national performance if entrepreneurs adopt existing technologies and/or mobilize resources to the economy more efficiently than before. Countries can at any time operate below their maximum efficiency level (Kumar and Russell, 2002) and for a fictitious economy (A) Kirznerian entrepreneurship would translate in higher efficiency levels if the country uses its recourses more efficiently and move closer to the technology frontier in subsequent periods (A^{t+1}). The effects of Kirznerian entrepreneurship over national performance are closely related to the catch-up effect (convergence) analyzed from an economic perspective by, among others, Barro and Sala-i-Martin (1992) and Kumar and Russell (2002).

--- Insert Figure 1 about here ---

Alternatively, the productivity of countries may be shaped by actions linked to the development of innovations that improve (expand) the countries' technology function, that is, via technical change. In the context of the analysis of countries' factor endowments, the term technical change was first coined by Hicks (1939). Literature addressing the role of technical change on country-level productivity includes, among other, the work by Acemoglu and Zilibotti (2001), Caselli and Coleman (2006), and Acemoglu et al. (2012).

It should be kept in mind that Schumpeter (1947) noted that entrepreneurship is potentially conducive to technical change. The introduction of disruptive technologies in the economy helps to create new value-adding combinations of inputs that enhance the countries' productive capacity. In this case, such innovative entrepreneurship—linked to the development of new technologies—will be beneficial to the economy (e.g., country '*S*' in Figure 1) if we observe an upward shift in the technology function between two periods (in Figure 1: from S^t to S^{t+1}), that is, entrepreneurship contributes to technical change. It seems clear that in the long run the ultimate source of productivity growth is Schumpeterian entrepreneurship. In the short run, however, Kirznerian entrepreneurship may be more beneficial and effective in pushing countries' productivity up.

At this point, it is worth noting that the notion that entrepreneurship is good for the economy is widely accepted among economists (see, e.g., Acs and Audretsch, 1988; van Praag, 2007; Parker, 2009; Terjesen and Wang, 2013); however, the debate on how to accurately measure entrepreneurship at the country level is still open. Entrepreneurship as a national phenomenon is much more than the mere rate of business formation, and it should embrace the capacity of the entrepreneurial activity to dynamically optimize the allocation of resources in the economy (Acs et al., 2014). Regardless the level of economic development, the rate of business formation is heterogeneous across economies (Bosma et al., 2009), thus suggesting that complex and systemic interactions govern the effects that the business formation rate, which is often considered a measure of country-level entrepreneurial performance. Thus, a systemic approach to country-level entrepreneurship seems appropriate to obtain a more holistic picture of entrepreneurship at the country level and its effects on total factor productivity.

From the perspective of the national system of entrepreneurship (Acs et al., 2014), the essential aspect of entrepreneurship is not the number of new businesses created in the economy, but how entrepreneurial activity contributes to channel resources to the economy. We therefore propose to use the Global Entrepreneurship Index (GEI) as our proxy for the quality of the national system of entrepreneurship (Acs et al., 2014; Lafuente et al., 2016).

By connecting the quality of countries' entrepreneurial ecosystem to its different sources of productivity change (operating efficiency and technical change), we can gauge the relative importance of Kirznerian and Schumpeterian entrepreneurship for total factor productivity at the national level. Also, the analyzed temporal horizon allows us to zoom in on these relative contributions over different stages of the economic cycle. The next sub-section presents a simple model that describes the points raised above more formally. Then we derive our hypotheses.

2.1 Modeling country-level total factor productivity

A relevant question in macroeconomics is how to accurately describe the relationship between inputs and outputs—i.e., the aggregate production function—at country level. Most research addresses this issue by employing the standard Solow-Swan model:

$$Y = K^{\alpha}(AL)^{1-\alpha} \tag{1}$$

where Y denotes gross domestic product, K is physical capital, L is labor, $0<\alpha<1$, is the output elasticity of capital and A an index of labor augmenting productivity. The production function in (1) is allowed to vary across countries via the total factor productivity (TFP) term $A^{1-\alpha}$. Additionally, note that A can be expressed as $A = E \times T$, where $T>0$ is the current state of technology, often linked to technical change (TC) (Caselli and Coleman, 2006), and $0<E<1$ is the country's inefficiency level with respect to the global technology frontier. The change in efficiency over time will be represented by EC. To obtain the steady state we should divide the terms in equation (1) by $T \times L$ to obtain:

$$y = k^{\alpha} E^{1-\alpha} \tag{2}$$

where $y = Y/(T \times L)$ and $k = K/(T \times L)$. By introducing the usual laws of motion for the relevant state variable k we obtain $\dot{k} = s_k y - (n + g + \delta) k$, where a dot over a variable indicates a time derivative, s is the saving rate for accumulating physical capital, n and g are the exogenous growth rates for the population $(L_t = L_0 e^{nt})$ and the world technology frontier $(T_t = T_0 e^{gt})$ respectively, and δ is the depreciation rate for the capital stock. Setting the laws of motion equal to 0 and solving for y yields $y = \left(\frac{n+g+\delta}{s_k}\right) k$. By introducing this latter expression in equation (2) and multiplying both sides of (2) by T_t we obtain the steady state output per worker:

$$\frac{Y}{L} = T \times E \times s_k^{\frac{\alpha}{1-\alpha}} \times (n + g + \delta)^{\frac{-\alpha}{1-\alpha}} \tag{3}$$

or in natural logarithms:

$$\ln \frac{Y}{L} = \ln T_0 + gt + \ln E + \frac{\alpha}{1-\alpha} \ln s_k + \frac{-\alpha}{1-\alpha} \ln(n + g + \delta) \tag{4}$$

For a steady state efficiency level of E=1 (100% efficient and positioned on the production frontier)—this specification reduces to the standard Solow-specification, where the time trend would capture the rate of TFP-growth. The assumption of full efficiency in steady state is quite common in models where the focus is on countries shifting the world frontier under which all countries operate (Caselli and Coleman, 2006). However, when the objective is to relate countries' productivity growth to entrepreneurship, this simplification brings about important consequences. By ignoring the possibility of operating inefficiency (E<1) our model, by construction, attributes all productivity growth to genuine technical progress associated with Schumpeterian entrepreneurship, thus neglecting the possibility of Kirznerian entrepreneurship.

Furthermore, under the assumption of full efficiency, we interpret all countries to be normally i.d.d. distributed along the world technology frontier and interpret deviations below the frontier as random noise. Instead, a model that allows for inefficiency (*E*<1) permits the accurate analysis of the role of both Kirznerian and Schumpeterian entrepreneurship on productivity changes at the country level.

To do this so, we can use equations (2) to (4) to develop a growth regression that involves the linearization around the steady state. Given that $\dot{k} = s_k y - (n+g+\delta)k$, equation (2) can be expressed as $\frac{\dot{y}}{y} = \alpha\left(s_k \frac{y}{k} - \; n+g+\delta \;\right) + \; 1-\alpha \; \frac{\dot{E}}{E}$. By using $e^{\ln x} = x$ and $\frac{\dot{E}}{E} = \frac{\partial \ln E}{\partial t}$ we obtain:

$$\frac{\dot{y}}{y} = \alpha(s_k k^{\alpha-1} E^{1-\alpha} - (n+g+\delta)) + (1-\alpha)\frac{\dot{E}}{E} \tag{5a}$$

$$\frac{\dot{y}}{y} = \alpha(s_k e^{(\alpha-1)\ln k + (1-\alpha)\ln E} - (n+g+\delta)) + (1-\alpha)\frac{\dot{E}}{E} \equiv \varphi(\ln k, \ln E) \tag{5b}$$

The linearization around the steady state yields:

$$\frac{\dot{y}}{y} = \varphi(\ln k^*, \ln E^*) + \varphi'_{\ln k}(\ln k^*, \ln E^*)(\ln k - \ln k^*) + \varphi'_{\ln E}(\ln k^*, \ln E^*)(\ln E - \ln E^*) \tag{6}$$

By assuming that the steady state is stable so that $\varphi(\ln k^*, \ln E^*) = 0$, we obtain a two-factor specification for a country-specific growth regression that allows for inefficiency and variations in technical change over time:

$$\begin{aligned} \ln\frac{Y_i(t)}{L_i(t)} - \ln\frac{Y_i(0)}{L_i(0)} &= \beta_0 + \beta_1 t + \beta_2 s_{ki} + \beta_3 \ln(n+g+\delta) + \beta_4 \ln\frac{Y_i(0)}{L_i(0)} \\ &\quad + \beta_5(\ln E_i(t) - \ln E_i(0)) + \varepsilon_i \end{aligned} \tag{7}$$

The model specification in equation (7) proposes two sources of TFP growth at the country level: β_1 and β_5. The term β_1 captures the country-specific rate of technical change (*TC*). In other words, that is the rate at which Schumpeterian entrepreneurship shifts the country's technology frontier. In specifications that assume $\beta_5 = 0$ all countries are considered efficient—i.e., positioned on the production frontier—and all country-specific variation is absorbed by ε_i , the Solow-residual. But, our model proposes that variations in TFP can partially be explained by country-specific changes in efficiency $(EC = \ln E_i(t) - \ln E_i(0))$ over time. That is, the coefficient β_5 measures the impact of Kirznerian entrepreneurship on TFP changes.

Similar to prior work (e.g., Färe et al., 1994; Kumar and Russell, 2002; Kerstens and Van de Woestyne, 2014), in this study we employ non-parametric techniques to compute country-level TFP and its components (section 3). This way, we do not make any assumption on the sample distribution of noise and the inefficiency terms. Our contribution lies in connecting both residual productivity changes (efficiency changes) and technical change to the national system of entrepreneurship. Before turning to our technical section on how we derive the inefficiency scores, the next sub-section advances the study hypotheses.

2.2 The study hypotheses

The theory that underpins this study allows us to investigate two distinct ways through which entrepreneurship impact total factor productivity at the country level. On the one hand, the Kirznerian channel that links entrepreneurship to efficiency improvements, relative to the world frontier. On the other hand, the Schumpeterian effect that connects entrepreneurship to upward shifts in the technology frontier, that is, positive variations in technical change. In both cases, a healthy national system of entrepreneurship is conducive to higher total factor productivity levels, and confounding these two processes may well obscure the effects of entrepreneurship on total factor productivity.

An example relates to the commercialization of semiconductors. This technological development—which constitutes a clear act of Schumpeterian entrepreneurship—generated productivity effects rippling from Silicon Valley to the rest of the US and throughout the world in ways one could never imagine to be traced back to the quality of the Silicon Valley's entrepreneurial ecosystem. This technological advance is a relevant component of technical change in the US that contributed to improve many production processes and develop a wide array of consumer goods. But, the speed at which other countries absorbed this new technology in their local economies once it was made available (technology diffusion or catch-up effect) most likely depended on how the local entrepreneurial ecosystem contributed to the effective exploitation of the new market opportunities (Kirznerian entrepreneurship).

The relevance of the national systems of entrepreneurship flows from the recognition that entrepreneurship is a vital component present in any economy to a larger of lesser extent. Therefore, the systematic analysis of countries' productivity including variables that account for the effects of entrepreneurial activity—i.e., through the national systems of entrepreneurship—helps not only to enhance the analysis of the factors that contribute to explain national performance, but also to provide scholars and policy makers with valuable information on the contribution of entrepreneurship to country-level productivity. We therefore hypothesize:

H1: *At the country level, improvements in the national system of entrepreneurship are positively associated with changes in total factor productivity*
H2: *At the country level, improvements in the national system of entrepreneurship are positively associated with changes in efficiency change*
H3: *At the country level, improvements in the national system of entrepreneurship are positively associated with changes in technical change*

Additionally, one would expect that efficiency drops in economic slumps as fixed costs and sunk capital investments cannot be adjusted downwards in the short run. In this sense, we hypothesize that this reduction is smaller when country-level entrepreneurship is well developed and supported. On the one hand, Kirznerian entrepreneurship drives the adjustment to shocks (Sobel, 2008). However, in periods of economic downturn—characterized by lower demand levels and increased uncertainty—new and incumbent organizations have no incentives to be more efficient, and their short-term behavior will likely prioritize the access to resources for sheer survival. Thus, the contribution of Kirznerian entrepreneurship to total factor productivity—which we link to its capacity to promote the efficient function of markets given the countries' technology (Kirzner, 1997)—is conditioned by the stage of the business cycle.

Schumpeterian entrepreneurship, on the other hand, depends crucially on long run processes of knowledge accumulation and commercialization. Schumpeterian entrepreneurship—which constitutes the driving force of knowledge creation and innovation—will materialize in enhanced productivity if the institutional mechanisms governing the selection and commercialization of knowledge by entrepreneurs remain unchanged over time (Acs et al., 2013). We argue that innovation processes that shift the countries' technology frontier may well be less susceptible to fall in periods of economic crisis. This is not a new idea. Building on Schumpeter's proposition of innovation long waves, prior work has documented that some innovation clustering occurs over time (Kleinknecht, 1990), and that economic recession may trigger and accelerate innovation (Mensch, 1979). Nevertheless, as Mansfield (1983) proposes, the hypothesis that the business cycle conditions the rate of innovations is questionable. Innovation flows are not constant over time, and the analysis of such temporal discrepancies should take into account 'the effect of macroeconomic conditions and policies on innovation and technological change' (Mansfield, 1983, p. 144). Recourses (e.g., capital and labor) are freed-up in periods of economic downturn for investments in new initiatives and key aspects of a healthy entrepreneurial ecosystem, such as appropriate entrepreneurship support policies jointly with a good innovation climate that encourages long-term investments in R&D, will likely continue to affect innovation processes in periods of growth and recession. We share the view of Mansfield (1983) that innovation waves result from a combination of factors where technical links (i.e., innovation chains) and policy elements play a key role. Schumpeterian entrepreneurship is, therefore, conducive to increased productivity by promoting technical change at the country level (i.e., upward shifts in the countries' production function), regardless of the state of the economy. Consequently we can derive two secondary hypotheses from hypotheses 2 and 3:

H2a: *The positive relationship between efficiency change and the quality of the national system of entrepreneurship is moderated by the state of the economy, such that this relationship is stronger in periods of economic growth.*

H3a: *The positive relationship between technical change and the quality of the national system of entrepreneurship is not moderated by the state of the economy.*

3. Sample, variable definition and estimation strategy

3.1 Sample

The data used in this study come from two sources of information. First, data on the macroeconomic figures of the analyzed countries were obtained from the World Development Indicators available from the World Bank datasets. Second, variables related to the country's demographic, educational and economic conditions, as well as to the entrepreneurial activity used to estimate the Global Entrepreneurship Index (GEI) were obtained from different sources, including the Global Entrepreneurship Monitor (GEM) adult population surveys, the Global Competitiveness Index (GCI), and the Doing Business Index.

We compute total factor productivity growth and its components on a sample 73 countries over the period 2002-2013. Given our interest in evaluating productivity patterns at the world scale, we work with an unbalanced panel so that the final analyzed sample comprises 470 country-year observations. The full list of countries included in the analysis is presented in Table A1 of the Appendix. Note that the representativeness of the sample is ensured insofar as it includes 32 European countries (Belgium, Bosnia and Herzegovina, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and United Kingdom), 18 American countries, including both North America and Latin America and the Caribbean islands (Argentina, Barbados, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Panama, Peru, Trinidad & Tobago, United States, Uruguay, and Venezuela), 11 Asian countries (China, India, Iran, Japan, South Korea, Malaysia, Pakistan, Saudi Arabia, Singapore, Thailand, and United Arab Emirates), 11 African countries (Algeria, Angola, Botswana, Ghana, Malawi, Namibia, Nigeria, South Africa, Tunisia, Uganda, and Zambia), and one Oceania economy (Australia).

According to the figures made available by the World Bank, note that for 2013 our sample of 73 countries represents 73.97% of the global population and 88.19% of the world's economic output, in terms of GDP.

3.2 Dependent variable: Total factor productivity

The approach adopted in this study to construct the world production frontier and associated inefficiency levels of each analyzed economy is non-parametric. When dealing with multiple inputs yielding multiple outputs, the efficiency literature often makes use of data envelopment analysis (DEA) frontier methods (see e.g., Cooper et al., 2011). This data-driven method approximates the true but unknown technology through linear programming without imposing any restrictions on the sample distribution (Grifell-Tatjé and Lovell, 2015). DEA is a benchmarking technique that yields a production possibilities set where efficient units—in our case, countries—positioned on the efficient surface shape the frontier. For the rest of the countries the DEA computes an inefficiency score indicating the countries' distance to the best practice frontier. The fundamental technological assumption of the proposed DEA model is that, in a focal period (t), countries (i) use two inputs ($\mathbf{x}$)—capital (K) and labor (L) $(\mathbf{x} = K, L)$—to produce one output, namely gross domestic product (GDP); and that this input-output set forms the technology (T): $T = \{(\mathbf{x}, \text{GDP}, t) : \mathbf{x} \text{ can produce GDP at time } t\}$. Our technology design is in line with previous studies evaluating country-level efficiency (see, e.g., Färe et al., 1994; Kumar and Russell, 2002; Boussemart et al. 2003; Färe et al., 2006; Mahlberg and Sahoo, 2011).

Concerning the variables used to build the technology frontier, note that the gross domestic product (GDP) is expressed at 2011 prices in million of PPP international dollars. Labor is measured as the country's number of employees (expressed in millions of workers). Similar to prior studies (Kumar and Russell, 2002; Mahlberg and Sahoo, 2011; Lafuente et al., 2016), capital is defined as the gross capital formation, which represents the investments in fixed assets by resident producers, the outlays on additions to the economy's fixed assets (public infrastructures, and commercial and residential buildings) plus net changes in the level of inventories held by firms in the economy.[3] This variable is expressed at 2011 prices in million of PPP international dollars. Table 1 presents the descriptive statistics for the input-output set.

--- Insert Table 1 about here ---

[3] According to the World Bank, gross capital formation consists of value of the resident producers' investments in fixed assets, the outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and 'work in progress.'

In this study, the best practice technology (*T*) is modeled for each country (*i*) in the sample (*N*) via an output distance function $D^t(\mathbf{x}^t, \text{GDP}^t) = \inf(\theta > 0 : (\mathbf{x}^t, \text{GDP}^t/\theta) \in T^t)$. The drawn technology exhibits constant returns to scale, is homogeneous of degree +1 and is convex in the output (GDP). The following linear program models the described technology and computes, for each country (*i*) and each period (*t*), the output distance function $(D^t(\mathbf{x}^t, \text{GDP}^t))$:

$$
\begin{aligned}
& D^t(\mathbf{x}^t, \text{GDP}^t) = \max \theta_i \\
& \text{subject to} \quad \textstyle\sum_{i=1}^{N} \lambda_i^t \text{GDP}_i^t \geq \theta_i \text{GDP}_i^t \qquad i = 1, \ldots, N \\
& \qquad \textstyle\sum_{i=1}^{N} \lambda_i^t K_i^t \leq K_i^t \\
& \qquad \textstyle\sum_{i=1}^{N} \lambda_i^t L_i^t \leq L_i^t \\
& \qquad \lambda_i^t > 0
\end{aligned} \tag{8}
$$

The solution value of θ in equation (8) is the inefficiency score computed for the country *i* at time *t*. Note that for efficient countries $\theta = 1$, while for inefficient countries $\theta > 1$ and $1 - \theta$ points to the degree of inefficiency. The term λ_i^t is the intensity weight used to form the linear combinations of the sampled countries (*N*).

Next, the distance functions can be used to compute changes in total factor productivity (TFP) between two periods through the Malmquist index ($M(\cdot)$). The Malmquist TFP index—first introduced by Malmquist (1953) and formally developed in the pioneering work by Caves et al. (1982)—measures TFP variations between two periods. In a multiple input-output setting, this index reflects changes (progress or regress) in productivity along with changes (progress or regress) of the frontier technology over time. By using distance functions, the output-oriented Malmquist TFP index $(M(\mathbf{x}^{t-1}, \text{GDP}^{t-1}, \mathbf{x}^t, \text{GDP}^t))$ is computed for each country (*i*) on the benchmark technologies in periods *t*-1 and *t* as follows (Färe et al., 1989):

$$
\begin{aligned}
& M(\mathbf{x}^{t-1}, \text{GDP}^{t-1}, \mathbf{x}^t, \text{GDP}^t) = \left[\frac{D^t(\mathbf{x}^t, \text{GDP}^t)}{D^{t-1}(\mathbf{x}^{t-1}, \text{GDP}^{t-1})} \right] \times \left[\frac{D^{t-1}(\mathbf{x}^t, \text{GDP}^t)}{D^t(\mathbf{x}^t, \text{GDP}^t)} \times \frac{D^{t-1}(\mathbf{x}^{t-1}, \text{GDP}^{t-1})}{D^t(\mathbf{x}^{t-1}, \text{GDP}^{t-1})} \right]^{0.50} \\
& M(\mathbf{x}^{t-1}, \text{GDP}^{t-1}, \mathbf{x}^t, \text{GDP}^t) = EC \times TC
\end{aligned} \tag{9}
$$

In equation (9), productivity growth (progress) yields a Malmquist index greater than unity, while values lower than one point to productivity decline. Analogous interpretations hold for the components of the Malmquist TFP index. The term inside the first square bracket measures the effect of efficiency changes (*EC*), that is, whether the operating efficiency of a focal country is moving closer (catching-up) or farther from the efficiency frontier between periods *t* and *t*+1. The geometric mean of the term inside the second square bracket captures the effect of technical change (*TC*), that is, the shift in the country-specific technology function between the two periods. Improvements in the technical-change component are considered to be evidence of innovation (Färe et al., 1994; Kumar and Russell, 2002).

Table 2 presents the summary statistics of the total factor productivity measure and its components for the full sample. Also, and for illustrative purposes, Figures 2 and 3 plot the Malmquist TFP index and its components (*EC* and *TC*) between 2003 and 2013, respectively.

The data reveal that, on average per year, the analyzed economies experienced a productivity progress of 0.10% between 2003 and 2013. The reported productivity growth was mainly driven by improvements in technical change (*TC*) which was, on average, 0.80% per year. The average yearly rate of efficiency change (*EC*) was –0.59%; however, this negative result is explained by the drastic fall in efficiency associated with economic downturn that hit most economies (Figure 3): the average efficiency change was 1.38% during the 2003-2007 period, while efficiency change between 2008 and 2013 was, on average, –1.62% (Table 2).

--- Insert Table 2 about here ---

--- Insert Figures 2 and 3 about here ---

3.3 Independent variables

National system of entrepreneurship (NSE). To achieve the core objective of this study—the analysis of the relationship between productivity and entrepreneurship at the country level—we need a good proxy for the quality of the entrepreneurial ecosystem at the national level. We use the Global Entrepreneurship Index (GEI), developed by Acs et al. (2014), to capture the multidimensional nature of the National System of Entrepreneurship. The GEI index measures the dynamic and institutionally embedded interaction between entrepreneurial attitudes, entrepreneurial abilities and entrepreneurial aspirations by individuals, which drive resource allocation through new business venturing (Acs et al., 2014). The GEI index, which ranges between zero and 100, is built on 14 pillars which result from 14 individual-level variables properly matched with selected institutional variables related to the country's entrepreneurship ecosystem.

The novelty of the GEDI index lies on the systemic view of countries' entrepreneurship in which the harmonization (configuration) of the analyzed pillars through the penalty for bottleneck (PFB) determines the country's systems of entrepreneurship (Acs et al., 2014). Through the PFB method the system performance is mainly determined by the weakest element (bottleneck) in the system. The magnitude of the country-specific penalty depends on the absolute difference between each pillar and the weakest pillar. Also, pillars cannot be fully substituted through the PFB method, i.e. a poorly performing pillar can only be partially compensated by a better performing pillar. More details on the methodology and data used to build the GEI can be found in Acs et al. (2014). Table 3 presents summary statistics and correlations for the variables used to evaluate the effect of the national system of entrepreneurship on TFP.

Capital deepening. Similar to other studies on country-level efficiency and economic performance (see, e.g., Kumar and Russell, 2002; Färe et al., 2006), our model specifications include the effect over total factor productivity of capital deepening, defined as the ratio of gross capital formation (GCF) divided by the number of workers. Keep in mind that in the input set used for computing the inefficiency scores and the Malmquist index both capital and labor are introduced individually. Furthermore, in DEA models, more or less of one output or input does not imply higher or lower inefficiency. In this case, the capital deepening variable only captures the effect on total factor productivity of movements along the frontier.

Crisis. We introduced a dummy variable that accounts for the effects caused by the economic meltdown that affected most economies after 2008. This dummy variable takes the value of one for the period 2008-2013, and zero otherwise.

Control variables. We control for economic performance, access to credit, OECD membership, and time in all model specifications. Economic performance is defined as the annual variation in GDP, while the domestic credit to the private sector divided by GDP measures the capacity of financial institutions to channel financial resources and finance the growth of organizations. We included a dummy variable taking the value of one for OECD countries. Finally, we introduced a set of time dummies to rule out the potential effects of time trends as well as economic and other environmental conditions that may affect the total factor productivity level of the analyzed countries.

--- Insert Table 3 about here ---

3.4 Estimation strategy

In line with the arguments that underpin this study, we employ panel data techniques to estimate the proposed model which emphasizes a relationship between total factor productivity and its components and entrepreneurship at the country level. Pooling repeated observations on the same countries violates the assumption of independence of observations, resulting in autocorrelation in the residuals. First-order autocorrelation occurs when the disturbances in one time period are correlated with those in the previous time period, resulting in incorrect variance estimates, rendering ordinary least squares (OLS) estimates inefficient and biased (Wooldridge, 2002). Therefore, we estimate fixed-effects panel data models with robust standard errors to take into account the unobserved and constant heterogeneity among the analyzed countries. Also, the use of fixed-effects models controls for the potential endogeneity problems that result from the correlation between the explanatory variables and the time-invariant country-specific unobserved heterogeneity (Greene, 2003).

To evaluate the role of the national system of entrepreneurship empirically, we propose a full fixed-effects model based on equation (7) with the following form:

$$\begin{aligned}\text{Country-level}\\ \text{Performance}_{it} &= \beta_0 + \beta_1 \Delta\text{GEI}_{it} + \beta_2 \Delta\text{Capital deepening}_{it} + \beta_3 \text{Crisis}_{it} + \beta_{13} \text{Crisis} \times \Delta\text{GEI}_{it} \quad (10)\\ &+ \beta_{23} \text{Crisis} \times \Delta\text{Capital deepening}_{it} + \beta_4 \text{Controls}_{it} + \eta_i + \varepsilon_{it}\end{aligned}$$

The proposed regression models the countries' performance—i.e., TFP, EC, and TC—as a function of the national system of entrepreneurship (GEI index), capital deepening, and the set of control variables described in section 3.3 (variation in GDP, domestic credit divided by GDP, the dummy variable capturing OECD membership, and the group of time dummies). Note that our productivity measures (TFP, EC, and TC) are based on discrete time estimations and, for each country, their values are computed for every adjacent pair of years (*t*-1 and *t*). Also, all time varying independent variables are expressed as a variation rate between period *t*-1 and *t*.

In equation (10) β_j are parameter estimates for the *jth* independent variable, η is the time-invariant country-specific effect that controls for unobserved heterogeneity across economies (*i*) and that is uncorrelated with parameter estimates; and ε is the normally distributed error term that varies cross-countries and cross-time (*t*).

In terms of our hypotheses, we expect that $\beta_1 > 0$ to confirm that improvements in the national system of entrepreneurship positively impact TFP at the country level (**H1**). In the case of the models using efficiency change (**H2**) and technical change (**H3**) as dependent variable, hypotheses 2 and 3 will be confirmed if the coefficient linked to the GEI index is positive and statistically significant $(\beta_1 > 0)$. The parameter estimate for the interaction term between the GEI variable and the 'crisis' dummy (β_{13}) will be used to test our hypotheses **H2a** and **H3a**. In the regression that uses efficiency change as dependent variable, we expect that $\beta_{13} < 0$ and $\beta_1 > \beta_{13}$ to confirm our hypothesis **H2a** that the positive impact of the entrepreneurial ecosystem on efficiency change is stronger in periods of economic growth. To confirm **H3a** we expect that $\beta_{13} = 0$ in the model that uses technical change as dependent variable.

4. Empirical results

Table 4 presents the results for the fixed effects model emphasizing the relationship between the NSE and country-level productivity. The dependent variables are the percentage changes in the TFP index and its components (equation (9)), namely efficiency change (which we link to the effect of Kirznerian entrepreneurship) and technical change more related to the effects of innovations (Schumpeterian entrepreneurship). Specification 1 is the baseline model including the independent variables, while specification 2 is the full model including the interaction terms between the 'crisis' dummy, the GEI index and capital deepening.

The results for the control variables indicate that economic performance measured via GDP growth is positively associated with TFP. In the case of the technical change component, the lack of significance in the coefficient suggests that countries can experience technical progress irrespective of their economic performance. Technical change, which embraces different aspects related to the countries' capacity to generate and channel value-adding innovations to the markets, may well not be affected by economic performance measures, that is, technical change is not conditioned by the state of economy.

The key findings of the study indicate that variations in the GEI index measuring the national system of entrepreneurship are positively associated with TFP changes. Additionally, Figures 4 to 6 break the sample into the growth and crisis periods, and plot the estimated values for the dependent variables (variations in TFP and its components) and the national system of entrepreneurship, respectively. In terms of coefficients, results for the TFP model (model 2) show that in growth periods a 10% improvement in the national system of entrepreneurship increases TFP by 0.54 percentage points, while the effect of changes in the GEI index on TFP is –0.0202 (0.0536 + –0.0738 = –0.0202) in the crisis period. That is, a 10% increase in the GEI leads to a decrease in TFP of 0.20 percentage points (Figure 4). The estimated change in the slope for the effect of GEI in the crisis period, however, is not significant. This suggests that a healthy GEI helps alleviate the negative effects of the economic meltdown that affected most economies after 2008. These results are consistent with our first hypothesis (**H1**) that states that the national system of entrepreneurship is positively associated with changes in total factor productivity.

The model that uses efficiency changes (*EC*) as dependent variable evaluates if the national system of entrepreneurship captures mostly Kirznerian entrepreneurship moving the country closer to the efficient frontier. In the full model for the efficiency change component (model 2) we see that this effect only holds in growth periods: a 10% increase in GEI increases efficiency change by 1.47 percentage points, while the effect of the GEI index on efficiency changes is 0.0122 (0.1467 + –0.1345 = 0.0122) during the crisis period (that is, a 10% increase in the GEI rises efficiency change by 0.12 percentage points). The estimated change in the slope of the effect of GEI is significant. Therefore, the effect of the national system of entrepreneurship on efficiency changes linked to Kirznerian entrepreneurship is conditional on the economic cycle (growth or crisis). In periods of economic growth a healthy national system of entrepreneurship contributes to improve the productivity convergence of countries, while this effect vanishes in periods of economic uncertainty or slowdown (Figure 5). These results lead to partially confirm our second hypothesis (**H2**) that proposes that the national system of entrepreneurship increases the positive effect of Kirznerian entrepreneurship, which translates in greater rates of efficiency change. Additionally, the results support our hypothesis **H2a** that states that the positive effect of the national system of entrepreneurship on efficiency change is stronger in periods of economic growth.

--- Insert Table 4 about here ---

--- Insert Figures 4, 5 and 6 about here ---

Technical change is an accurate measure of the countries' capacity to develop and introduce innovations that enhance their production function. Results in Table 4 and Figure 6 show that the national system of entrepreneurship is conducive to technical change via the positive effects of Schumpeterian entrepreneurship. Additionally, we observe that this effect is positive and consistent in the long run, regardless the economic cycle (Figure 6). These results are consistent with our third hypothesis (**H3**) proposing that the national system of entrepreneurship increases the positive effect of Schumpeterian entrepreneurship in the economy, thus leading to higher rates of technical change.

In terms of coefficients, the findings indicate that in growth periods a 10% increase in the GEI index increases technical change by 0.71 percentage points. During the post-2008 period, the estimated effect of changes in the GEI on technical change is 0.0047 (0.0707 + – 0.0237 = 0.0047), that is, a 10% variation in the GEI increases technical change by 0.47 percentage points. The estimated change in the slope of the effect of the GEI, however, is not statistically significant. This result is in line with our hypothesis H3a that proposes that the effect of GEI on technical change is consistently positive in the long-run, regardless the state of the economic conditions.

Finally, it is worth noting that we conducted a robustness check to ensure estimation accuracy. Existing studies on the relationship between entrepreneurship and performance at the country level often employ the rates of business creation or aggregate business ownership rates to operationalize country-level entrepreneurship (see, e.g., Parker, 2009; Koellinger and Thurik, 2012; Van Praag and Van Stel, 2013). In line with these studies, one would be tempted to question whether the capacity of the proposed variable linked to the national system of entrepreneurship to explain differences in country-level variation in total factor productivity is different to that of conventional entrepreneurship metrics. To further corroborate the appropriateness of the GEI index as a measure of country-level entrepreneurship, we estimated equation (10) using the rate of rate of new businesses—with less than 42 months of market experience—as a proxy of entrepreneurship at the country level. Results in Table A2 of the Appendix reveal that, for all dependent variables, the coefficients linked to this variable are not statistically significant. This result confirms not only that the GEI index accurately measures the national system of entrepreneurship (country-level entrepreneurship), but also that business formation rates are merely quantity figures that do not have the capacity to explain differences in total factor productivity across economies.

6. Concluding remarks and implications

Existing studies underline the relevance of technological barriers and factor accumulation for explaining differences in total factor productivity across economies (e.g., Mankiw et al., 1992; Parente and Prescott, 1994; Romer, 1990; Caselli and Coleman, 2006).

In contrast, we have proposed in this study that, besides technology and the availability of production factors, the national system of entrepreneurship plays a decisive role in shaping total factor productivity across countries. Furthermore, we argue that country-level entrepreneurship is conducive to productivity growth by triggering the beneficial effect of different types of entrepreneurship that we link to different sources of productivity growth.

In this sense, the main contribution of this study relies on the comprehensive analysis of the relationship between country-level entrepreneurship and total factor productivity (distinguishing efficiency change from technical change), while acknowledging the differentiating effect on productivity of Kirznerian and Schumpeterian entrepreneurship. Our approach offers a compelling vision of how the national system of entrepreneurship impacts total factor productivity, through enhanced Kirznerian and Schumpeterian entrepreneurship.

Overall, we found that total factor productivity grew on average 0.10% per year during the analyzed period and that, coinciding with the economic slowdown that affected most economies, total factor productivity declined between 2009 and 2011. Breaking total factor productivity into efficiency change and technical change, we find that the former is largely responsible for the reported productivity fall, whereas the latter seems immune to the business cycle. Moreover, we find that both efficiency change and technical change are positively correlated with the quality of the national system of entrepreneurship as measured by the GEI.

The findings are consistent with the notion that the national system of entrepreneurship is conducive to total factor productivity through different channels. The results corroborate that the national system of entrepreneurship contributes to enhance the positive effects of Kirznerian and Schumpeterian entrepreneurship on total factor productivity. Furthermore, we find that Kirznerian entrepreneurship is important in cushioning the negative effect of global crisis, while Schumpeterian entrepreneurship appears as a long run process.

The findings of this study have relevant academic and policy implications. Scholars increasingly acknowledge the need to harmonize the definition and operationalization of country-level entrepreneurship (Acs et al., 2014). In this sense, the debate is still open and this study provides further evidence on the value of the national system of entrepreneurship as an accurate variable to measure country-level entrepreneurship by incorporating in the analysis the complex and systemic interactions that govern entrepreneurial entry actions.

Policy makers often allocate large sums of public money in policies excessively oriented towards the stimulation of employment, capital accumulation and knowledge generation in the economy, such as subsidies to support self-employment and human capital formation and investments in research and development. These policies—rooted in the endogenous growth theory—are conducive to economic performance and undoubtedly have translated into significant economic outcomes linked to increased levels of employment and education (Braunerhjelm et al. 2010). Our results indicate that the national system of entrepreneurship is conducive to productivity both by improving the resilience of countries below the frontier, which translates in greater rates of convergence (efficiency change); and by helping those on the frontier to capitalize on their innovation efforts and shift the production frontier (technical change). Therefore, we suggest that policy makers should devote more attention to interventions aimed at enhancing the national system of entrepreneurship.

From a policy perspective, our comprehensive analysis fuels the notion that policy should shift from a focus on capital and labor towards designs that match knowledge and capital formation programs with policies that enhance the national systems of entrepreneurship. Entrepreneurship support programs would become sterile if entrepreneurs navigate in contexts that do not guarantee the effective exploitation of their knowledge. Thus, policy makers need to turn their attention to the development of appropriate national systems of entrepreneurship; and prioritize policies that seek to improve the way through which the national systems of entrepreneurship channel knowledge to the economy and create economic resilience in the short run and growth in the long-run. In the short-run, policies linked to the development of Kirznerian entrepreneurship—e.g., stimulation of business creation and self-employment—are beneficial to enhance the resilience of an economy, while successful productivity growth in the long-term should be grounded in the creation and/or consolidation of policies that support Schumpeterian entrepreneurship—e.g., via financing innovations and the development of new technologies.

It must, however, be mentioned a series of limitations to the present study that, in turn, represent avenues for future research. First, like other studies on productivity (Acemoglu and Zilibotti, 2001; Caselli and Coleman, 2006), the data do not permit the direct analysis of how technology development and adoption processes affect total factor productivity. Further research on this issue would be valuable. For example, future studies should evaluate the links between total factor productivity and the patterns of basic and major innovations, and determine both the effect of different types of innovation on total factor productivity and if the national system of entrepreneurship plays a role in these processes. Although its validity, future studies should also evaluate the potentially differentiating effect of the GEI sub-indexes on productivity. We present various interpretations of how the national system of entrepreneurship impacts countries' productivity; however, we do not evaluate how the sub-indexes that form the

GEI variable affect productivity, nor do we assess the specific effect on total factor productivity of policies that seek to improve the national system of entrepreneurship. Further research on this issue would be valuable. Finally, the analysis of the weak spots in the national system of entrepreneurship is an urgent task for policy makers and academics alike. Supported by the results of our study, the deep scrutiny of the national system of entrepreneurship is a relevant aspect that should enter the research agenda of scholars and policy makers.

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List of Figures

Figure 1. Kirznerian and Schumpeterian entrepreneurship

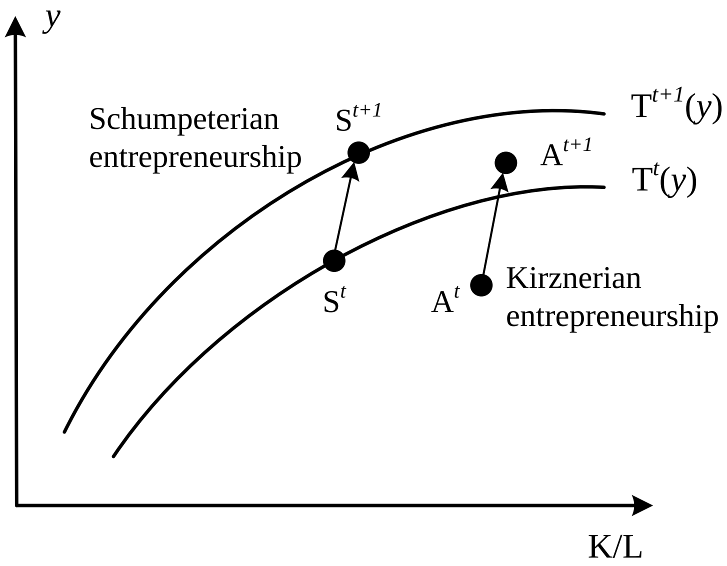


Figure 2. Evolution of total factor productivity between 2003 and 2013

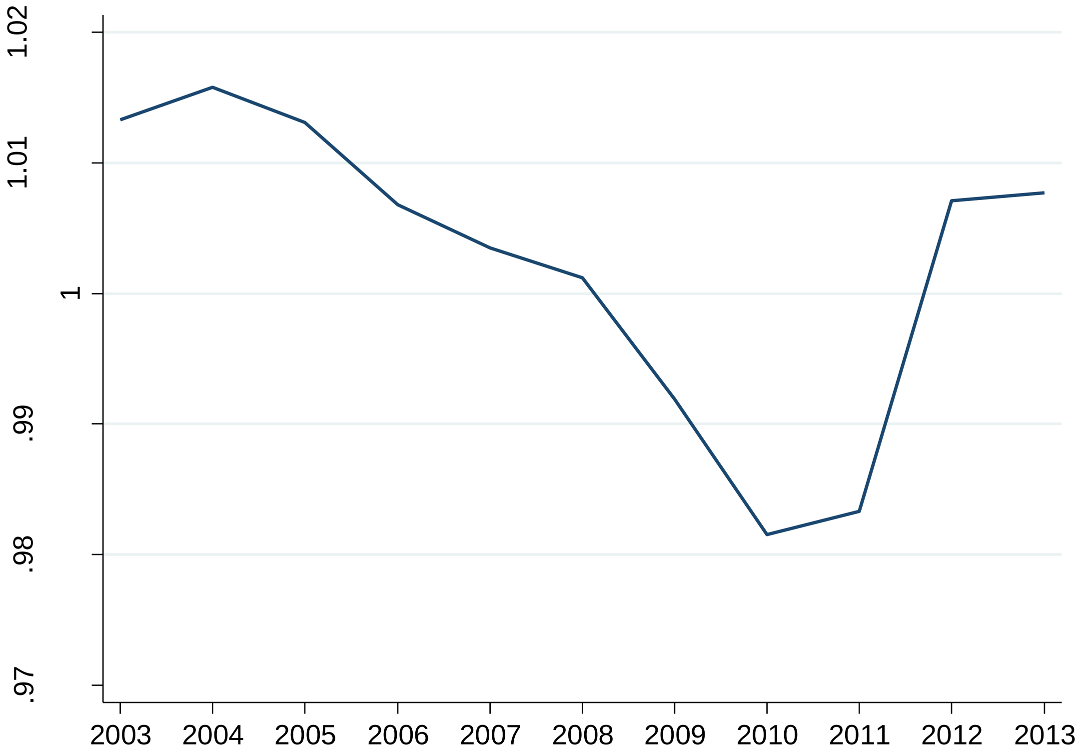


Figure 3. Efficiency change and technical change between 2003 and 2013

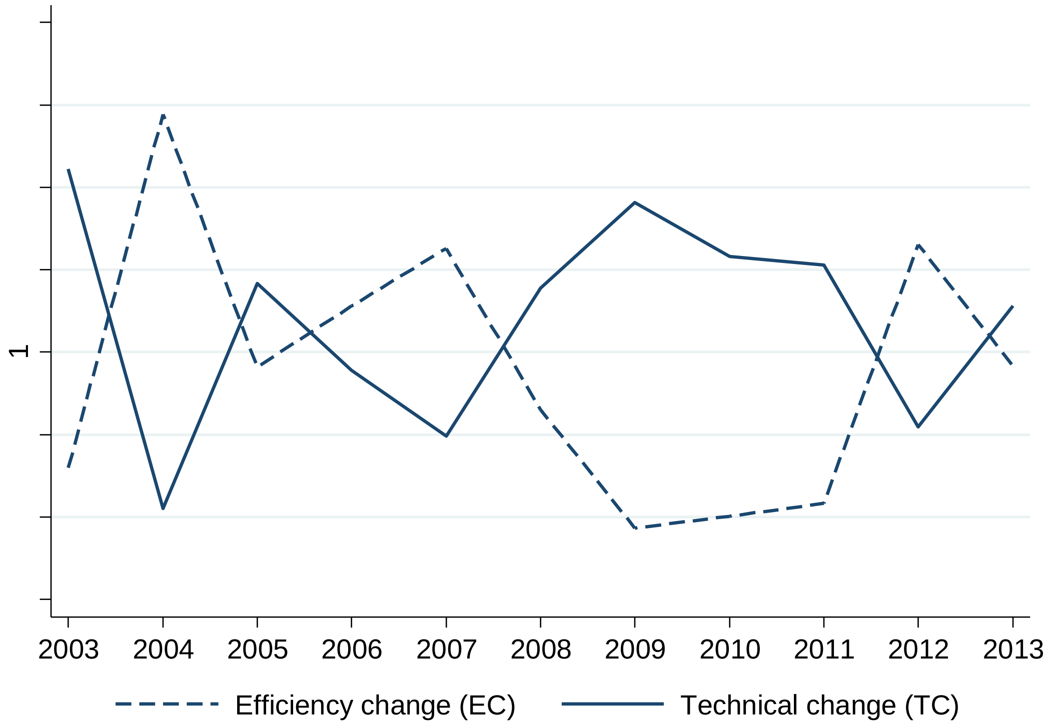


Figure 4. The relationship between GEI and TFP changes

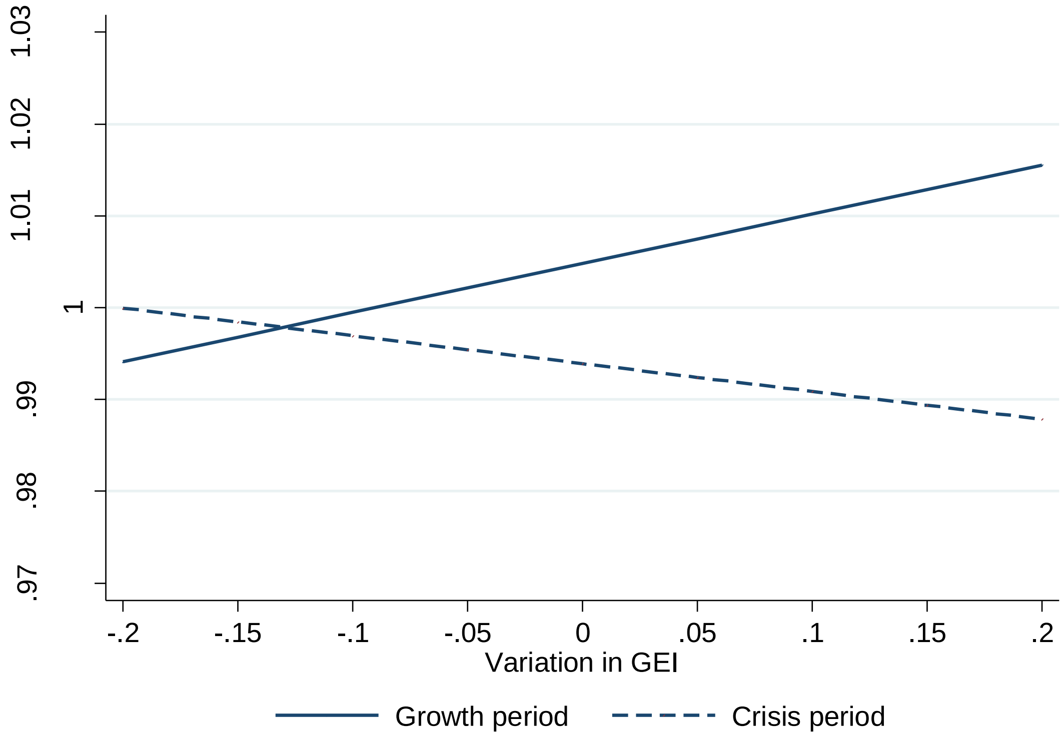


Figure 5. The relationship between GEI and Operating Efficiency Change

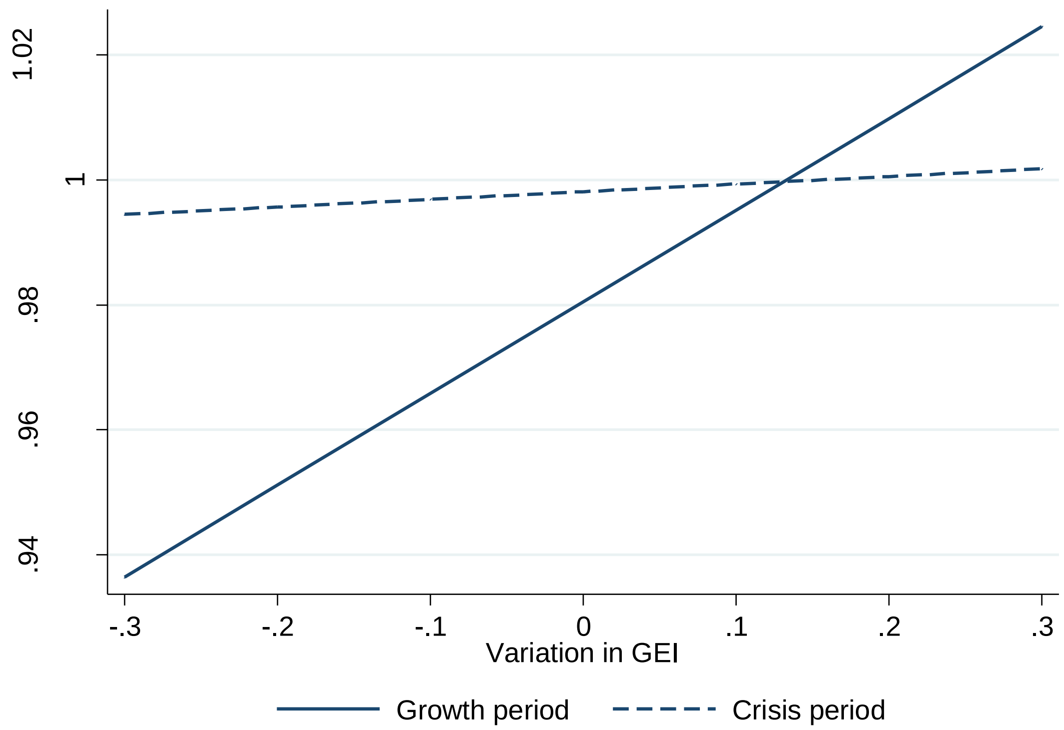
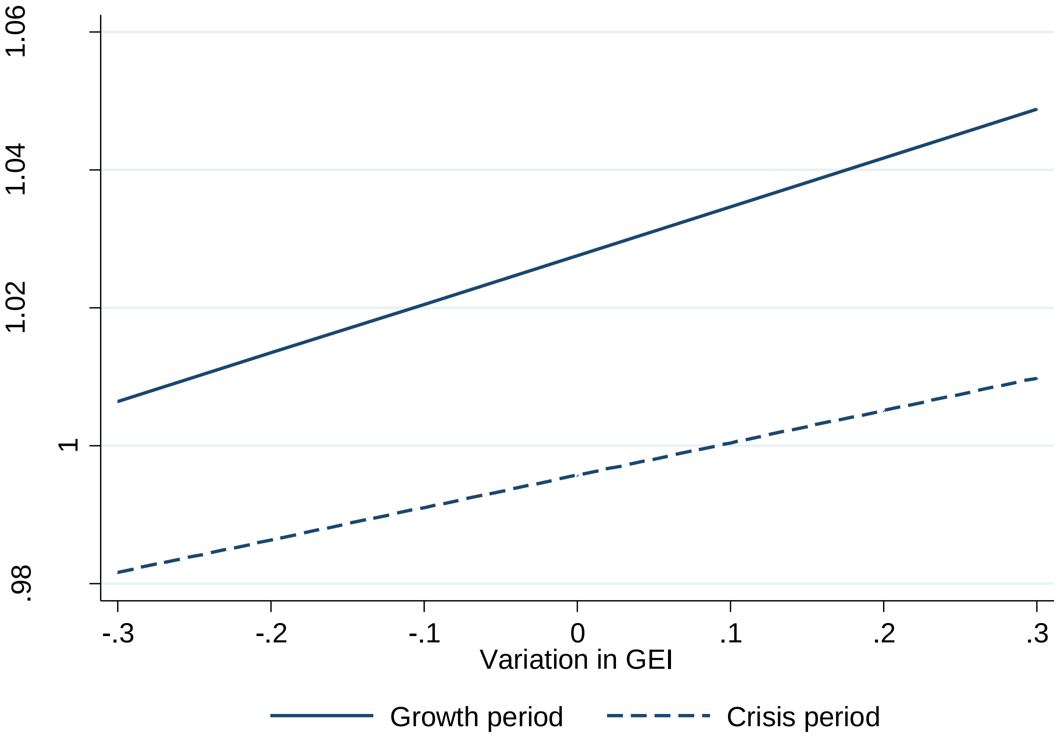


Figure 6. The relationship between GEI and Technical Change



List of Tables

Table 1. Descriptive statistics for the selected input-output set (period 2002-2013)

	Description	Mean (Std. dev.)	Q1	Median	Q3
Output					
Gross domestic product (GDP)	GDP equals the gross value added by country producers plus product taxes and minus subsidies not included in the products' value.	1,310,657 (2,681,693)	158,529	368,607	1,314,236
Inputs					
Labor force	The economically active population: people over 15 years old who supply labor for the production of goods and services.	38.96 (119.13)	2.74	8.23	24.57
Gross capital formation (GCF)	GCF consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.	340,195 (835,411)	32,152	88,454	339,004

Data on labor and the economic variables were obtained from the World Bank.

Table 2. Productivity around the globe: Malmquist TFP index and its components (equation (9))

	Total factor productivity (Malmquist index)		Operating efficiency change (EC)		Technical change (TC)		Obs.
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
2003	1.0133	0.0399	0.9720	0.0527	1.0444	0.0511	29
2004	1.0158	0.0669	1.0577	0.0770	0.9621	0.0536	32
2005	1.0131	0.0352	0.9964	0.0341	1.0167	0.0080	30
2006	1.0068	0.0429	1.0112	0.0368	0.9956	0.0196	34
2007	1.0035	0.0568	1.0252	0.0578	0.9796	0.0397	37
2008	1.0012	0.0441	0.9860	0.0367	1.0155	0.0289	40
2009	0.9919	0.0734	0.9573	0.0556	1.0363	0.0463	44
2010	0.9815	0.0680	0.9602	0.0716	1.0232	0.0325	48
2011	0.9833	0.0600	0.9633	0.0606	1.0212	0.0224	55
2012	1.0071	0.0540	1.0261	0.0600	0.9818	0.0155	60
2013	1.0077	0.0472	0.9967	0.0459	1.0112	0.0214	61
Total	1.0010	0.0562	0.9941	0.0627	1.0080	0.0392	470

Table 3. Descriptive statistics and bivariate correlations

		Mean	Std. dev.	1	2	3	4	5	6	7	8
1	TFP	1.0010	0.0562	1							
2	Efficiency change	0.9941	0.0627	0.7793***	1						
3	Technical change	1.0080	0.0392	0.1709***	–0.4801***	1					
4	GEI	47.1154	17.4517	0.2100***	0.1315***	0.0791*	1				
5	Country size (ln GDP PPP)	12.8818	1.6131	–0.0435	–0.0196	–0.0202	0.1887***	1			
6	Domestic credit / GDP	0.8284	0.5346	0.1763***	0.1238***	0.0531	0.6617***	0.3273***	1		
7	Capital deepening (ln GCF / workers)	9.2252	0.7408	0.1202***	0.0774*	0.0320	0.7307***	0.2702***	0.5220***	1	
8	OECD (dummy)	0.5114	0.5003	0.2012***	0.1613***	0.0316	0.6744***	0.2674***	0.5231***	0.5920***	1
9	Crisis (dummy)	0.5272	0.4997	–0.1154**	–0.1964***	0.1450***	–0.1695***	–0.1140***	–0.1019**	–0.1741***	–0.1157***

*, **, *** indicate significance at the 10%, 5%, and 1%, respectively.

Table 4. Fixed-effects regression results: The relationship between total factor productivity and the National System of Entrepreneurship

	Total factor productivity (TFP)		Operating efficiency change (EC)		Technical change (TC)	
	(1)	(2)	(1)	(2)	(1)	(2)
Crisis (dummy)	–0.0194** (0.0094)	–0.0165* (0.0094)	0.0169 (0.0125)	0.0185 (0.0122)	–0.0318*** (0.0112)	–0.0321*** (0.0111)
Δ GEI index	0.0253* (0.0144)	0.0536** (0.0265)	0.0871* (0.0529)	0.1467** (0.0576)	0.0602** (0.0303)	0.0707* (0.0403)
Δ GEI index X Crisis		–0.0738 (0.0472)		–0.1345** (0.0534)		–0.0237 (0.0387)
Δ Capital deepening	–0.4086*** (0.0297)	–0.3505*** (0.0481)	–0.3827*** (0.0382)	–0.3248*** (0.0585)	–0.0196 (0.0305)	–0.0330 (0.0325)
Δ Capital deepening X Crisis		–0.0906* (0.0540)		–0.0916* (0.0566)		0.0209 (0.0443)
Δ GDP	0.4075*** (0.1151)	0.4074*** (0.1184)	0.3269** (0.1299)	0.3341** (0.1339)	0.0722 (0.0739)	0.0716 (0.0747)
Δ Domestic credit / GDP	–0.0001 (0.0001)	–0.0001 (0.0001)	–0.0003 (0.0002)	–0.0001 (0.0003)	–0.0002** (0.0001)	–0.0003* (0.0002)
OECD (dummy)	–0.0118 (0.0187)	–0.0126 (0.0183)	–0.0025 (0.0149)	–0.0039 (0.0141)	–0.0065 (0.0054)	–0.0063 (0.0055)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.0097*** (0.0108)	1.0083*** (0.0106)	0.9675*** (0.0130)	0.9658*** (0.0127)	1.4427*** (0.0102)	1.0446*** (0.0102)
F-test	17.80***	18.40***	23.25***	29.39***	42.20***	38.79***
R2 (within)	0.4622	0.4733	0.5472	0.5601	0.3805	0.3817
Observations	470	470	470	470	470	470
Number of countries	73	73	73	73	73	73

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5%, and 1%, respectively.

Appendix

Table A1. Countries included in the sample (period 2002-2013)

	Country	Number of observations			Country	Number of observations
1	Algeria	5		41	Malaysia	6
2	Angola	4		42	Mexico	10
3	Argentina	12		43	Namibia	2
4	Australia	7		44	Netherlands	12
5	Barbados	3		45	Nigeria	3
6	Belgium	12		46	Norway	12
7	Bosnia and Herzegovina	6		47	Pakistan	3
8	Botswana	2		48	Panama	5
9	Brazil	12		49	Peru	10
10	Canada	6		50	Poland	5
11	Chile	12		51	Portugal	6
12	China	12		52	Romania	7
13	Colombia	8		53	Russia	9
14	Costa Rica	3		54	Saudi Arabia	2
15	Croatia	12		55	Serbia	3
16	Czech Republic	4		56	Singapore	8
17	Denmark	12		57	Slovakia	3
18	Dominican Republic	3		58	Slovenia	12
19	Ecuador	7		59	South Africa	12
20	Estonia	2		60	Spain	12
21	Finland	12		61	Sweden	12
22	France	12		62	Switzerland	12
23	Germany	12		63	Thailand	7
24	Ghana	4		64	Trinidad & Tobago	4
25	Greece	11		65	Tunisia	4
26	Guatemala	5		66	Turkey	8
27	Hungary	12		67	Uganda	7
28	Iceland	9		68	United Arab Emirates	6
29	India	3		69	United Kingdom	12
30	Iran	6		70	United States	12
31	Ireland	12		71	Uruguay	8
32	Israel	10		72	Venezuela	9
33	Italy	12		73	Zambia	4
34	Jamaica	9				
35	Japan	12				
36	Korea, Rep.	7				
37	Latvia	9				
38	Lithuania	3				
39	Macedonia, FYR	6				
40	Malawi	2				

Table A2. The relationship between TFP components and the rate of new businesses (with less than 42 months of market experience)

	Total factor productivity (TFP)		Efficiency change (EC)		Technical change (TC)	
	(1)	(2)	(1)	(2)	(1)	(2)
Crisis (dummy)	–0.0118* (0.0062)	–0.0121* (0.0072)	0.0145 (0.0130)	0.0151 (0.0127)	–0.0301*** (0.0115)	–0.0302*** (0.0114)
Δ Baby business rate	0.0011 (0.0027)	0.0015 (0.0040)	0.0028 (0.0029)	0.0005 (0.0032)	–0.0015 (0.0032)	0.0010 (0.0047)
Δ Baby business rate X Crisis		0.0017 (0.0054)		0.0057 (0.0059)		–0.0051 (0.0058)
Δ Capital deepening	–0.4080*** (0.0297)	–0.3489*** (0.0475)	–0.3801*** (0.0377)	–0.3206*** (0.0570)	–0.0213 (0.0301)	–0.0352 (0.0320)
Δ Capital deepening X Crisis		–0.0914* (0.0531)		–0.0914* (0.0548)		0.0208 (0.0455)
Δ GDP	0.4055*** (0.1148)	0.3925*** (0.1185)	0.3207** (0.1275)	0.3017** (0.1313)	0.0759 (0.0718)	0.0843 (0.0715)
Δ Domestic credit / GDP	–0.0001 (0.0001)	–0.0001 (0.0001)	–0.0003 (0.0003)	–0.0001 (0.0002)	–0.0002* (0.0001)	–0.0003* (0.0002)
OECD (dummy)	–0.0119 (0.0184)	–0.0117 (0.0185)	–0.0024 (0.0137)	–0.0024 (0.0129)	–0.0066 (0.0063)	–0.0065 (0.0063)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.0102*** (0.0105)	1.0090*** (0.0106)	0.9694*** (0.0125)	0.9683*** (0.0124)	1.0430*** (0.0105)	1.0432*** (0.0104)
F-test	18.10***	17.77***	19.55***	22.27***	43.64***	36.83***
R2 (within)	0.4618	0.4694	0.5359	0.5424	0.3679	0.3696
Observations	470	470	470	470	470	470
Number of countries	73	73	73	73	73	73

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5%, and 1%, respectively.