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A *RESPONSIVENESS-BASED* (COMPOSITE) INDICATOR WITH AN APPLICATION TO COUNTRIES' INNOVATIVE PERFORMANCE

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A *responsiveness-based* (composite) indicator with an application to countries' innovative performance

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ABSTRACT: The aim of this paper is twofold: on one hand, from a methodological-statistical perspective, it develops a *responsiveness-based* index for a series of input factors on a specific target variable (assumed to capture the phenomenon the analyst wishes to look at), by means of an extended version of a *random coefficient regression* approach; on the other hand, it applies this methodology to the case of countries' innovation performance, where the target variable is the country number of patents (as proxy of "innovativeness"), and where inputs are chosen according to the literature dealing with the measurement of country technological capabilities.
The novelty of the approach presented in the paper regards the possibility of extracting from data a country-specific "reactivity effect" or "responsiveness" (that is, mathematically, a derivative) to each single input feeding into the regression. Thus, the paper provides a promising approach for ranking countries according to their responsiveness to specific inputs, an approach that can be complementary to the analysis on "level" performed, for instance, in the canonical composite indicators' literature.
As for results on countries' innovation function, besides a (new) ranking of countries, this approach allows also for testing - in an original and straightforward way - the (possible) presence of increasing (decreasing) returns. Two years are considered and compared, 1995 and 2007, on 42 countries. Our tests conclude that in both years innovative increasing returns are at work, although in 2007 their strength drops considerably compared to 1995. According to a huge literature on the subject (both neoclassical and evolutionary), we conclude that a *self-reinforcing* mechanism in new knowledge production, absorption and diffusion is at the basis of these results. As for the structural change found between 1995 and 2007, we deem it to depend on the growing globalization of production and innovation processes and on the brilliant growth of some developing countries worldwide, with a remarkable role played – according to our results – by post-communist economies.

KEYWORDS: Responsiveness, Country indicators, Random coefficient regression, Innovation function

JEL-CODES: C21, O31, Q01

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CONTENTS

INTRODUCTION

A plethora of statistical indicators are currently used worldwide to capture specific socio-economic trends of cities, regions and countries (United Nations, 2007). They refer to various aspects of sustainable development relating to economic growth, innovative capabilities, technological achievements, social progress, level of democracy, environmental sustainability and so on. Normally, countries are ranked according to the value assumed by these indicators and - in this regard - "composite" indices are of special worth since they are aimed at catching, in a single number, multifaceted and complex realities (Bandura, 2008; OECD and EC, 2008).

Standard indicators, either single or composite, should be mainly interpreted as "descriptive" objects, as it is widely recognized that they are "snapshots" of the reality they refer to: given their nature, they cannot rely – when considered by themselves - on any "if-then" principle (or "causal" interpretation). In other words, while they may be able to describe well the magnitude and character (i.e., the "level") of certain realities, they are not informative on the "responsiveness" (or "reactivity") of regions, countries, etc. to those specific input factors thought of as affecting the phenomenon the analyst intends to measure.

Therefore, when responsiveness is the main concern, the knowledge of level indicators needs to be accompanied with some measure of how these indicators react to external stimuli and a new approach is thus needed. This paper proposes a method for building an index of country *reactivity* (or *responsiveness*) to specific inputs (suggested by a "theory") when a given target variable, thought of as capturing the phenomenon the analyst wishes to enquiry, is selected. This target variable could be in turn either a composite or a single indicator, depending on the context and data availability.

This proposal should be seen as *complementary* to the standard approach based on "level measurement". In this direction, it can be seen as a way to improve the informational set the analyst and the policymaker may have at his disposal, when a more comprehensive understanding of the phenomenon is demanded.

The approach proposed in this paper to measure responsiveness is based on a statistical tool, the "random coefficient regression", whose first applications have been made in the context of microeconometric program evaluation (or *treatment effect* literature), but that seems suitable and useful to apply also to a macro-context as that considered here. What distinguishes this approach to standard regression applications is the possibility to gauge *observation-specific responsiveness*, an aspect that standard regression models are unable to provide.

The study of responsiveness – as defined above – has a twofold usefulness: (i) it is able to inform policymakers not only on the (static) achieved levels of the countries' performance they wish to look at, but also on the (dynamic) responsiveness patterns that countries could exhibit on specific factors, by allowing a complementary analysis of "level" on one hand, and "reactivity" on the other; (ii) it conveys further statistical tests than those allowed by usual methods, such as the possibility to look at the (possible) presence of increasing (or decreasing) returns for the considered phenomenon, an aspect of the utmost importance especially from a policy perspective.

The application proposed in this work enjoys many of the advantages of this novel approach and, at the same time, it is a suitable example for elucidating its worth. We embed our analysis within the literature on the measurement of "country technological capabilities"[1], providing a new perspective on the subject, which is based on *responsiveness* measurement. Indeed, we are interested in estimating a *country innovation function* where an innovation target variable is regressed on a series of technological capabilities' inputs (such as, public and private R&D, number of researchers, material and immaterial infrastructures and so on). Our methodology allows for identifying, for each country, which is the input factor whose modification generates the highest modification in the innovative output. This produces scores that can be then aggregated and compared, thus providing a ranking of countries based on "overall reactivity". Ultimately, this procedure allows for getting, for each country, two basic information:

(i) the achieved level of technological capabilities, as measured by a composite index of the technological input factors considered (as done in the standard literature);

(ii) a (composite) index of "responsiveness" of innovation to the technological capabilities' index calculated in point (i);

Furthermore, the knowledge of these two indices allows also for studying the countries' innovation function, as they convey information on the level of the technological input(s) and on the reactivity (mathematically, the *derivatives*) of the function in that input point. As it will be clearer later, an important implication of this is the possibility of testing the presence of increasing (decreasing) returns in the innovation function by a novel method.

The consequences of the proposed approach for policymaking are striking. A policymaker may know not only what is the current state of country technological capabilities, but - as these capabilities are ultimately directed to foster "innovation" - he can also know which is the most reactive countries as well as - within a country - which are the most reactive factors. A simple example can better explain this aspect.

Suppose that Italy gets a certain level of innovativeness, as measured by some proxy-variable (either single or composite). Suppose we can observe on Italy *Q* factors characterizing the state of Italy's technological capabilities and that a composite indicators of these *Q* variables is calculated according to some aggregation rule. Given these data, our approach allows for calculating: (i) the position of Italy in terms of technological capabilities, by ranking it according to the technological capabilities' composite index; (ii) *Q* coefficients of *innovation reactivity* (one for each input factor), as well as a composite measure of these *Q* coefficients (aggregated, in turn, with a pre-specified aggregation rule). It may be the case, for instance, that Italy ranks in the 15th position according to the technological capabilities' composite index, but that it ranks in the 2th one according to the innovation responsiveness (composite) index. This information drastically changes the interpretation of results when just one dimension, that of the composite indicators of capabilities, is employed, thus offering additional insights to policymakers.

[1] See in particular: Fagerberg and Srholec (2008), Archibugi, Denni and Filippetti (2009), James (2006), Archibugi and Coco (2005), Archibugi and Pietrobelli (2003).

But our approach is able to go farther in-depth, as it is also able to detect which of the *Q* factors contribute more to Italy's innovation reactivity. Indeed, it could be the case, for instance, that Italy is particularly reactive to immaterial infrastructure than, let's say, businesses R&D, differently, for instance, from Germany that could be more reactive to the number of researchers. Both aggregate responsiveness and factor-specific responsiveness convey precious insights on how technological capabilities affect country innovation, as they mix both level and derivative information.

In the paper, we consider the case of countries' innovative performance as captured by the number of patents per 100,000 inhabitants: we will look at the relation between this target variable and a number of input factors usually assumed by the literature as those driving innovative performance. As dataset, we make use of the GloCap indices, an already existing set of indicators of technological capabilities measured on 42 countries. Although we are aware of the limits of patents as appropriate indicators of innovativeness, we deem our exercise to be a valuable first step to analyse this phenomenon within a "responsiveness" approach, and that further improvements will be provided in the near future.

Two important caveats related to our approach are worth to stress before closing this introduction: (i) this approach asks for establishing *ex-ante* which is the variable (or the set of variables) able to measure the "target" of the analysis. In our example, *innovativeness* is approximated by patents, but this choice could be questionable to some extent. Of course, one could uses a composite indicator of innovative outputs if available, but this does not solve completely the problem of capturing in a comprehensive way a complex phenomenon such as country "innovativeness"; (ii) the analyst needs to have a clear-cut *causal understanding* of what factors affect the target (innovativeness), as the choice of input factors could modify substantially the results. A theory-driven approach is no doubt requested, although it is well acknowledged how passing from theory to application generally brings complications, especially in terms of availability of good data and proxies; (iii) Simultaneity can be at work, as sometimes input variables could be in turn affected by output variables, thus generating estimation distortions. This is distinctive of the case of innovation as *success-breeds-success*'s effects are typically present in this field of study.

Although important, these caveats are to be taken as "cautionary notes". Answers to them depend on the specific context of application the analyst has to cope with. Of course, simultaneity is probably the most complex aspect to address. Nevertheless, as we are working within the indicators' literature, where figures take the form of "descriptive statistics", this problem is a little more attenuated compared to an inferential setting, as we will try to explain later on in the text.

The paper is organized as follows: section 2 discusses the rationale and usefulness of measuring "responsiveness" within our framework; section 3 presents the proposed index of responsiveness and the statistical approach and protocol for its construction. Section 4 provides a description of the data used for the application. Section 5 shows the main results. Section 6, finally, comments the results and concludes the paper.

1. RATIONALE AND USEFULNESS OF MEASURING "RESPONSIVENESS"

Providing statistical indicators expressed in "level" is the usual practise to describe a certain phenomenon and no doubt it is felt as the basic (and fair) means to inform policymakers and other stakeholders on the magnitude and character assumed by the phenomenon they are interested in (as well as on its temporal pattern, when more than one single measure over time is provided). Composite indicators, being them a synthesis based on some aggregation rule of single sub-indicators, add the advantage of capturing in a unique number (the score) a generally complex, multi-faceted and heterogeneous realty. It is what happens in many different contexts of sustainable development, where a plethora of indicators have been proposed and are continuously improved, updated and developed.

In this sense "level" indicators, both in a single or composite form, are snapshots of the phenomenon they wish to capture, useful to measure and compare across units and over time how phenomena distribute and evolve.

Borrowing metaphorically the case of medicine, previous practice shares some similarities with the case in which a physician uses the levels assumed by temperature, blood tests or electrocardiography figures as indicators to inspect into the general health of a human being. Yet, although these indicators are at the basis of any correct diagnosis, thus being highly informative on the current state of the patients' wellbeing, physicians are subsequently interested in knowing how patients will react to drugs, environmental factors, life-style etc., that is, on how previous indicators will modify according to a series of external stimuli. In this case, after getting a clear picture of the problem, patient "responsiveness" becomes the main concern.

We can extend this reasoning to socio-economic contexts. At country level, for instance, scholars and policymakers could want to complement information on the "level" assumed by the phenomena they look at, with the knowledge on how they change according to a series of factors that previous literature and/or common sense suggest to have some significant importance in affecting them. Furthermore, they could be interested not only in "aggregate" responsiveness, but rather on country-specific reactivity, as well as a physician's objective would be more that of detecting patient-specific resilience to external stimuli than general population's average effects. In other words, idiosyncratic unit-specific responses - if estimable – would be more informative and useful than average assessments, as they convey a substantial additional understanding of the phenomena considered. In this regard, as suggested in the introduction, the study of *responsiveness* should be seen as *complementary* to the study of *level*, as both are carrying different yet related information on the same phenomenon.

The definition, statistical measurement and use of the concept of "responsiveness", has its roots in epidemiology and in the so-called literature on "treatment-effect" estimation (Angrist, 1991; Rothman et al., 2008; Husted et al., 2000). In its basic conceptualization, responsiveness is defined as the effect of a specific treatment variable (generally defined) on a specific target variable, once any potential confounder is ruled out. The treatment variable may be, according to the disciplinary context, a new drug or chemical compound, a new type of physiotherapeutic method, as well as, in the economic context, a monetary support to firms' investment decision and so on.

In experimental or quasi-experimental design, treatment effects are generally estimated by a "counterfactual" approach, i.e., by comparing the outcome of a treated group with that of a non-treated one (the so-called *control group*), being the last one formed by those non-treated units that are as more similar as possible to the treated ones in terms of observable characteristics (Rosenbaum and Rubin, 1983). In this case the treatment variable is binary, assuming value one if the unit is "treated" and zero otherwise ("untreated"), and the "causal effect" takes the form in this case of the Average Treatment Effect (ATE) (Rubin, 1974). But when the treatment variable assumes, as in many cases, a *continuous* form, dose-response methods are more suitable (Angrist and Imbens, 1995). In this case the analyst is interested in the response to different intensity (or *dose*) of exposure to treatment, and the effect of treatment in this case is known to be, within a linear setting, the so-called Average Partial Effect (APE).

Another distinction within treatment models is that based on the presence of *observable* and/or *unobservable heterogeneity*, that is, the idea that each individual can get a different effect according to a bundle of personal characteristics, such as age, sex, income, presence of previous diseases, etc. that can be observed or unobserved by the analyst. In the first case, individual-specific effects depend on a set of observable factors characterizing individuals and Random Coefficient Models are suitable tools for estimating heterogeneous specific effects. Nevertheless, in the second case, when the idiosyncratic effect could depend also on unobservable-to-analyst characteristics and they are assumed to be correlated with the treatment variable, some bias in the estimation could arise (Heckman, Urzua and Vytlacil, 2006). In this case statistical methods such as Instrumental-Variables estimation can restore correctness (Wooldridge, 1997).

Our analysis is embedded within a *dose-response setting*, assuming a Random Coefficient approach and observable heterogeneity. We hold that, in our case, unobservable factors are irrelevant for the consistent estimation of the treatment effect[2]. Thus, we provide an individual-specific treatment (or responsiveness) effect, where the outcome variable is country "innovativeness" and the treatment variable is any other factor our theoretical framework (see section 4) assumes to have some role in determining country innovative performance.

Two important aspects still need to be outlined before going on by presenting the proposed indicator of responsiveness: the first relies on "country" as unit of observation; the second on the "descriptive" use we do of the Random Coefficient Model.

As for the first point, we are aware of the fact that country is an aggregate whole and that speaking about "treatment effect" in case of so large geographical, economical and cultural aggregations could seem – to say the least – questionable. It is for this reason that we prefer to speak more about "reactivity" than "treatment" effect, although in principle the proposed model incorporates both the concepts.

As for the second point, we wish to highlight that – at least at this stage of analysis – we will use our model to extract an index (or score) of responsiveness meant as a "descriptive statistical figure", as it occurs in the case of Principal Components scores and related approaches. We do not provide any test

[2] This assumption can be relaxed but, as suggested above, Instrumental-Variables are then needed in order to restore consistency. Nevertheless, as we use country level data, this requirement should be less bounding than in microeconomic contexts.

of statistical significance of our responsiveness-effects, as our goal is primarily that of ranking countries by responsiveness scores. Although traditional econometric tests of significance are available for such a kind of model, we prefer to direct our attention to countries' responsiveness scores to better embed our work in the traditional literature on (sustainable) descriptive indicators used for ranking observations.

2. A RESPONSIVENESS-BASED INDEX: CONSTRUCTION PROTOCOL

The index proposed in this paper is based on a Random Coefficient Regression, an approach rarely used in macro-settings, but with a promising capacity of being of great usefulness in this context. Random coefficients models are normally applied in microeconomic settings, while few extensions to meso and macro environments were done (Wooldridge, 2002, Ch. 18). Yet, with some modifications to its standard use, our context enjoys all the virtues of this approach as it allows, differently from standard regression, for estimating the unit (country, in our case) specific parameter of interest instead of just an average value across observations. It means that each observation, i.e. each country, gets its own regression parameter that can be assumed to be the *idiosyncratic responsiveness-effect* of this country on a specific input factor. To more easily understand how our approach works, we propose to follow this simple protocol, taking as example the case of country innovative performance we will develop later on in the paper :

1. Define the specific object of the analysis: *what one wants to look at* (for instance, "country innovation performance")
2. Define a measure of this phenomenon: *how to gauge it* (for instance, "number of patent per 100,000 inhabitants") and indicate it by y.
3. Define a set of Q factors that a certain theoretical framework (for instance, the "linear model of innovation", the "national systems of innovation" or the "knowledge-based/capabilities" approach) identify as the leading factors affecting country innovative performance, and indicate the generic factor with x_q.
4. Define a "responsiveness model" - by means of a random coefficient regression - linking y to the various x_q, and extract a country-specific measure of "reactivity effect" of y to the all set of $\{x_q , q=1, ..., Q\}$.
5. Aggregate results on reactivity effects across the Q inputs according to some rule and rank countries according to this new generated variable.

The *responsiveness-effect* we are interested in, is defined as the "partial effect" of a random coefficient regression (Wooldridge, 1997; 2001; 2002). Define a random coefficient setting of this kind:

$$\begin{cases} y_i = a_{i,q} + b_{i,q} x_{i,q} + e_i \\ a_{i,q} = \gamma_0 + \mathbf{x}_{i,-q}\boldsymbol{\gamma} + u_i \\ b_{i,q} = \delta_0 + \mathbf{x}_{i,-q}\boldsymbol{\delta} + v_i \end{cases}$$

where e_i, u_i and v_i are error terms with $E(e_i \mid x_{i,q}) = E(u_i \mid x_{i,q}) = E(v_i \mid x_{i,q}) = 0$.

It is easy to see that the regression parameters, a and b, are both non constant as depending on all the other inputs x except x_q (this is, in fact, the meaning of the vector $\mathbf{x}_{-q}$). Observe that δ_0 and γ_0 are on the contrary constant parameters.

According to this model, we can define the *regression line* as:

$$E(y_i \mid x_{i,q}, a_{i,q}, b_{i,q}) = a_{i,q} + b_{i,q} x_{i,q}$$

We define the *responsiveness-effect* of $x_{i,q}$ on y_i as the *derivative* of y_i relative to $x_{i,q}$, that is:

$$\frac{\partial}{\partial x_{i,q}} \left[E(y_i \mid x_{i,q}, a_{i,q}, b_{i,q}) \right] = b_{i,q}$$

where $b_{i,q}$ is called the *partial effect* of $x_{i,q}$ on y_i. We can repeat the same procedure for each $x_{i,q}$ (q=1, ..., Q), so that eventually it is possible to define, for each country i =1 ..., N and factor q=1, ..., Q, the N x Q matrix **B** of "partial effects" as follows:

$$\mathbf{B} = \begin{pmatrix} b_{11} & \cdots & b_{1Q} \\ \vdots & b_{i,q} & \vdots \\ b_{N1} & \cdots & b_{NQ} \end{pmatrix}$$

If all the variables are normal-standardized (getting *z-scores*), *partial effects* are *beta coefficients*, so that they are independent of the unit of measurement, and then can be compared and summed[3]. Thus, a *Composite Partial Effects* (CPE) indicator for a country i based on these responsiveness-effects (partial effects) could be, for instance:

$$CPE_i = \sum_{q=1}^{Q} w_q b_{i,q}$$

It can be interpreted as a weighted average of the single inputs x_q responsiveness-effects. The higher this level for a country, the higher the capacity of this country of taking advantage of the increment of its input components. It can be proved (see, for instance, Wooldridge, 2002, p. 638-642) that the estimation of $b_{i,q}$ can be achieved, *under no endogeneity problems*, by an Ordinary Least Square (OLS) estimation of this regression:

$$y_i = \gamma_0 + \mathbf{x}_{i,-q}\boldsymbol{\gamma} + (\delta_0 + \overline{\mathbf{x}}_{-q}\boldsymbol{\delta})x_{i,q} + x_{i,q}(\mathbf{x}_{i,-q} - \overline{\mathbf{x}}_{-q})\boldsymbol{\delta} + \eta_i$$
$$\eta_i = u_i + x_{i,q}v_i + e_i$$

where $\overline{\mathbf{x}}_{-q}$ is the vector of the sample means of $\mathbf{x}_{i,-q}$. Once previous regression parameters have been estimated by OLS, we can get for the generic county i an estimation of the partial effect of variable x_q on y as:

$$\hat{b}_{i,q} = \hat{\delta}_0 + \mathbf{x}_{i,-q}\hat{\boldsymbol{\delta}}$$

By repeating this procedure for each q, we can finally obtain $\hat{\mathbf{B}}$, that is, the OLS estimation of the *partial effects matrix*. As we will see in section 5, the analysis by row and by column of this matrix is the core of our application.

3. AN APPLICATION TO COUNTRIES' INNOVATION PERFORMANCE

This section presents the indicators used in our application. We exploit a new and updated set of variables capturing country technological capabilities – the GloCap set – developed in Filippetti and Peyrache (2010)[4]. It includes nine va-

[3] As beta-coefficients are all measured in standard deviations, instead of the units of the variables, they can be compared to one another. The meaning of this coefficient is straightforward: suppose that in a regression of y on x the beta is found to be equal to 0.3, then it means that one standard deviation increase in x leads to a 0.3 standard deviation increase in the predicted y with all the other variables in the model held constant.

[4] The complete dataset is freely available on request to the authors. See also Cerulli and Filippetti (2010)

riables (or sub-indices) over 42 countries, and it is calculated relative to the years 1995 and 2007. Variables are grouped into three main categories or pillars: *Business and Innovation, Knowledge and Skills, Infrastructures*. Table 1 presents the three pillars and the nine variables considered along with their sources.

The GloCap set was primarily thought for building a composite indicator of the nine variables feeding into it. But our methodology takes on another perspective, as we have to assume one dependent and eight independent variables (input factors) within the GloCap. Indeed, what we want to estimate is - to some extent - an *innovation function*, where the dependent variable is a measure of country innovativeness, and all the remaining factors are assumed to explain the level of this performance. The logic of this choice seems a reasonable one, as the GloCap captures quite well those basic elements the literature largely consider to be the main drivers of innovation performance. Let us briefly comment on the *output* and *input* indicators considered in this application in the light of innovation and technological capabilities literature.

OUTPUT VARIABLE

Number of patents

Patents have been largely used for accounting commercial purpose generated technological innovation (Griliches, 1990). As such, they can be considered a "tolerable assumption" (Schmookler, 1962) of the innovative activities of firms. We use the "triadic patents" which correspond to patents filed at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO), for the same invention, by the same applicant or inventor (OECD, 2004; OECD, 2008). The advantage of using this particular family of patent is twofold. First, they are a reliable tool for cross-country comparison, given that they include the three more important and natural patent office in the world. Second, the underlying innovation related to a patent filed in the three most important offices across the world is more likely to be valuable (in commercial terms, loosely defined) with respect to an innovation protected only in one single office.

Of course, patents present also some limitations as an innovation indicator. First, patenting intensity can largely differ across industrial sectors (Cohen et al., 2000). Consequently, cross-countries differences in terms of patenting activity can reflect a different industrial structure. Second, patents by definition are not capable to capture service innovation, while in advanced countries services have been dramatically growing in importance in terms of innovation investment and knowledge creation and exploitation. Third, patents captures especially product innovation, thus hiding process and above all organizational innovations that in modern economies are of increasing importance. Four, patents account for codified innovation, while in many industrial contexts innovations take the form of incremental quality changes of products that are rarely patented. Nevertheless, we may accept this variable as a proxy of innovation, although the abovementioned limits and shortcomings.

INPUT VARIABLES

(A) Business innovation effort: *(1) BERD*

As we are looking at the number of patents as our target indicator of innova-

for an application using these data.

tion, business R&D expenditures (BERD) should be expected to have a fundamental role as the main driver of private innovation performance. R&D activity is not only generally viewed as able to promote innovation via the so-called linear model of innovation (Godin, 2006; 2007), but also because it enlarges the so-called firm *absorptive capacity* (Cohen and Levintal 1989; Rosenberg 1990), thus promoting firm ability to exploit profitably external flows of knowledge and technological advancements. Including BERD is thus of the utmost importance for our purposes.

(B) Knowledge and Skills: *(2) Number of researchers, (3) Number of scientific articles,* and *(4) Public R&D (GOVERD+HERD).*

These variables aim at capturing the importance attached to R&D activities within the economy, the quality of the university and research system, and the public effort for R&D activities. These can be thought of as the knowledge-base of the country innovation system. The variable "total researchers in R&D" is expected to reflect the magnitude of human resources with high-skills involved in formal scientific-based and technological-based activities, both in the public and in the private sector (Howitt, 2000; World Bank, 1998). The variable "scientific and technical articles" represents the magnitude of the generation of codified knowledge. Specifically, it reflects the knowledge generated especially in the universities and public-funded research centres (Etzkowitz and Leydesdorff, 1997). However, it also reflects knowledge generated in the private sector which over the last years have been publishing an increasing share of scientific and technical articles. Finally, Public R&D (GOVERD+HERD) gives account of the resources devoted to formal research activities by the state, including both governmental institutions and higher education institutions.

(C) Infrastructures: *(5) Number of personal computers, (6) Number of fixed-line and mobile phones subscribers, (7) Number of internet users,* and *(8) Stock of fixed capital.*

The importance of material and immaterial infrastructures is also been recognised to be an important condition for countries to innovate and develop (World Bank, 1998). This has increasingly become a necessary requirement with the revolution of the new information and communication technologies (ICTs) which have profoundly changed the way people do things, leading to fundamental changing in the organizational structure of the firm, their business models, the channels for the sharing and diffusion of knowledge and so on (Castells, 1996). Within this environment, being connected has become a necessary condition for countries to access knowledge created and circulated across the globe through the worldwide web (Rifkin, 2000). Both personal computers, fixed-line and mobile phones and the number internet users should capture all together the quality of the network and immaterial infrastructures of a country to tap global knowledge[5]. Additionally, fixed capital accumulation aims at capturing the hard (material) infrastructure which can be key especially at the beginning of catching-up processes.

[5] Initially we also included broadband subscribers, but in this case we decided to rule it out because of a large overlapping with other variables within the same pillar.

4. RESULTS

Tables 2.A and 2.B set out the estimation of matrix **B** for 1995 and 2007 respectively. As suggested above, these partial effects are comparable as variables are normal-standardized. Both tables show a strong variability of results across countries, either in terms of magnitude of the effects or in terms of their sign.

The columns and rows with the heading "Total" and "Mean" have two different meanings if read by column or by row: by column, they are the sum by factors of the *b*-coefficients and their average respectively; by row, they are the sum by country of the *b*-coefficients and their average respectively. We comment our results first by column and then by row.

By column

The countries' rankings are visible in the tables and have been obtained by sorting by column on "Mean" (observe that sorting on "Total" brings to the same ranking). The meaning of these two measures is quite straightforward: the total effect is the sum of the single partial effects and represents the "global" responsiveness of the eight inputs on country patenting propensity; the mean effect represents the average of the eight inputs coefficients, and it represents an estimation of CPE_i where the weights are all put equal to 1/8 (i.e., the simple arithmetic mean). Both "Total" and "Mean" convey two different although really correlated information in terms of overall country responsiveness of innovation output to innovation inputs. Results on the rankings show important differences between 1995 and 2007. In 1995 more technologically advanced countries rank within the first positions, while in 2007 this conclusion is partially attenuated. Observe that, on average, some countries present a negative responsiveness of innovation to inputs both in 1995 and 2007. The Spearman correlation between these two rankings is significantly low (about 0.20), thus suggesting that a different pattern is at work in the two periods.

Apart from some evident variability in advanced countries (such as, for instance, the case of Ireland passing from position 34 in 1995 to 2 in 2007, Singapore passing from position 9 in 1995 to 43 in 2007, and UK passing from position 17 to 4), the great variability is found in the post-communist European countries: Estonia passes from position 39, where it got a negative sign, to position 13 with a positive sign; Poland passes from position 37 and a negative coefficient to position 21 and a positive coefficient; Slovak Republic passes from position 35 and a negative sign too, to position 8, and Slovenia from 38 to 9 (changing, also in this case, its sign). But also Romania and Bulgaria get higher positions, although still maintaining a negative sign. The so-called BRIC do not seem to have moved substantially: Russia passes from 43 to 41, India from 31 to 34, China remains stable at 32, while only Brazil passes from position 27 to 22 by changing sign. Also interesting is the movement of some developed countries changing signifycantly their sign from a positive to a negative one: Iceland and Singapore drop to position 42 and 43 respectively, Norway from 18 to 40, and France from 10 to 38. Generally speaking, what clearly emerges in moving from 1995 to 2007 is a pattern showing that some advanced countries lose momentum in their innovative reactivity to technological inputs, while a specific group of developing countries, the post-communist ones, gain considerable strength.

By row
In this case, the meaning of "Total" and "Mean" changes completely, as it becomes the sum and the mean of the partial effects across country. In this case it can be put into evidence which are the factors that contribute more to innovation responsiveness. In 1995, for example, both "Mean" and "Total" show – as expected – that the factor generating the highest reactivity to innovation is BERD, with a total value of 30.07 and a mean value of 0.70. It is followed by PUBRD (with a mean of 0.20) and "number of articles" (with a mean of 0.18), while it is interesting to observe the very high negative magnitude of the "number of PC" (with a mean of -0.74) and "internet users" (but with a very low level of just -0.05). The other factors, finally, have a positive impact. In 2007 something changes, although BERD remains the most reactive factor (with a total of 46.52 and a mean of 1.08). For instance, PUBRD and "total researchers" get negative signs, while "internet users" gets a positive one. Observe that both in 1995 and 2007 "capital stock" has a positive effect both in terms of total and mean partial effect.

4.1 Testing for the presence of increasing (decreasing) returns in countries' innovation function

Probably, the most attractive use of the proposed model is that of allowing for testing the potential existence of increasing (or decreasing) returns in countries' innovation function. This is possible since - by the estimation of the various partial effects b - we estimate the *derivatives* of the innovation output associated to different levels of innovation inputs. Figure 1 shows two patterns of the innovation function when just one input is at work: one under the case of decreasing returns (figure 1.a), and the other under the case of increasing returns (figure 1.b). It is quite clear to observe that in the first case (decreasing returns), as soon as the level of the input x rises, the level of the derivatives (b, i.e., the partial effects of our model) decreases accordingly, and the contrary occurs in the opposite case (increasing returns). Therefore, a test for detecting the presence of increasing (or decreasing) returns might be that of studying the relation between the derivatives of the innovation function and the level of the inputs considered. Nevertheless, as many inputs are involved, a synthetic measure of them is firstly needed.
To that end, we proceed as follows: we first calculate a simple composite index of the eight innovation inputs expressed in (standardized) level, thus obtaining a synthetic and unique input measure of innovation input, and then we regress the mean of the partial effects (CPE_i) on this synthetic input variable (we indicate by CI_i). It means that we assume as dependent variable the derivatives of the innovation function, and as the independent one a synthetic innovation input expressed in level. It is quite intuitive that, as soon as the relation between these two variables is significantly increasing, we can conclude that the innovation function shows "increasing returns" to innovation input and vice versa (decreasing returns) in the opposite case. As for the eight inputs composite indicator CI_i, we simply use the arithmetic mean of their normal-standardized levels.
We consider results both for 1995 and 2007 and we use both linear regressions and smoothing techniques to enquiry into the relation between CPE_i and CI_i. Results on linear regression are reported in table 3 for both 1995 and 2007, while figure 2 and 3 show the linear and Lowess fitting for the relation between these two variables.

Results on 1995 show an impressive significant increasing relationship between the composite indicators of partial effects and the composite indicators of input levels. The OLS linear coefficient is about 0.3 and it is significant at less than 1%. Also the Lowess smoother confirms this result, with a clear upward sloping form of the non-parametric curve. This leads to accept that in 1995 increasing returns to innovation are at work: countries that start with an already consolidated level of innovation inputs (or technological capabilities) are also more reactive (for the same increment of input level) than countries lagging behind in terms of input levels. It means that innovative capabilities have a *cumulative* and *self-reinforcing* effect that are able to generate an even more strengthening effect on the capacity to transform innovation inputs into innovative output.

Results on 2007 are a little less clear-cut. We present two estimations, one including the whole sample, the other dropping out three visible outliers (Iceland, Singapore e Switzerland). In this second case results are very similar to 1995, although less strong in magnitude than in that case. The regression coefficient, for instance, becomes about 0.1, three times lower than in 1995. But what seems more interesting is the non-parametric form of the curve: in this case it first increases until it reaches a maximum around 0.5 in the input axis, and then it assumes a decreasing pattern. At least roughly, it means that in 2007 the innovation function exhibits increasing returns for low input levels and decreasing ones after a certain threshold is achieved, i.e., for higher technological input levels.

These findings lead to the conclusion that some “structural change” in countries’ innovation function was probably at work between 1995 and 2007, and it might be explained by a drop of competitiveness in traditionally more advanced technological countries due to globalization and to the brilliant growth of some developing countries, such as Cina, India and Brazil and above all – as maintained by our comparison of rankings - post-communist countries. Nevertheless, given the limited size of the sample under which these smoothing techniques operate, and since the linear trend seems quite clear-cut in both datasets, that last conclusion should be taken with some care. What is no doubt true, is a general lower strength of the increasing returns in 2007 compared to 1995, a finding deserving anyways further investigations.

CONCLUSION

The methodology developed in this paper highlights new insights into the study of countries’ innovative performance. The capacity of this model to capture country-specific innovative output’s response to innovation inputs - the main original contribution of the paper – seems a useful step forward into a major understanding of how innovative efforts (technological inputs) feed innovation.

From our perspective, two main objectives have been achieved: one, more statistical-methodological in nature, regards the proposal of a new (composite) index of (country) responsiveness; the other, more in tune with the economics of innovation, allows for building a test detecting the presence of increasing (decreasing) returns in country innovation function.

In terms of results, the paper shows quite clearly the presence of increasing returns to scale. More specifically, while in 1995 increasing returns are strongly evident, they appear more attenuated in 2007, thus showing that a sort of "structural change" is at work, although future observations will be able to confirm (or disconfirm) this finding.

Which are the possible causes laying behind these results, and what consequences could they have in terms of innovation (and growth) policy implications? The first point is easier to answer than the second. There is a huge literature and a shared common sense suggesting that innovation processes are inherently cumulative, path-dependent and self-reinforcing, at least to some significant extent. According to Arthur (1994) and Nelson and Winter (1982) this is what basically makes innovation a process characterized by increasing returns. Innovation processes are indeed profoundly sensitive to all those elements the economic and management literature identify as carriers of increasing returns: path-dependence, threshold mechanisms and spreading costs' effects, increasing specialization and organizational upgrading, continuous movements along the experience and learning curves (*cumulativeness*), scope and diversification economies, network and agglomeration spillovers, market power. All these elements, with different strength depending on the context, contribute to *bandwagon effects* associate to the generation and diffusion of innovation, as also maintained by the New Growth Theory that, from a macroeconomic perspective, describes knowledge creation as having an intrinsic non-rival nature generating spillover effects able to compensate (socially) the high private costs of doing R&D activities (Romer, 1986; 1990). It is for these reasons that innovation processes are potentially more associated with increasing than decreasing returns, and are normally considered at the basis of long-run self-sustained economic growth (Grossman and Helpman, 1991; Aghion and Howitt, 1993). Nevertheless, it does not mean that innovation processes are exempt from potential deadlocks: the evolutionary perspective has widely recognized the risk connected to *lock-in* patterns and situations of diminishing technological opportunities, as in the case of saturated technological trajectories (Dosi, 1993; Malerba and Orsenigo, 1996; Levinthal, 1996). But these phenomena seem to appear more in micro rather than macro-contexts, where increasing returns seem to be the general rule.

Form a policy perspective, the presence of increasing returns to innovation open another relevant question regarding the capacity of less technologically advanced countries to converge to rates of growth and technological development comparable to those of richer ones (Barro and Sala-i-Martin, 1997). If we assume innovation to be the engine of economic growth, as the neo-Schumpeterian and New Growth Theory schools of thought firmly hold, then the presence of self-reinforcing mechanisms and scale economies in innovation processes lead to the conclusion that convergence might be - if not impossible - at least questionable, although some part of the literature is also suggesting that free trade, technology transfer, as well as the global redistribution of division of labour, could partially mitigate this process, thus allowing for a wider participation of developing countries to the benefits of increasing returns generated elsewhere (Rivera-Batiz and Romer, 1991; Ben-David and Kimhi, 2004). It is not the intention of this paper to go into this complex subject, but the reduced level of the increasing returns we have found in 2007 might be interpret also as a first signal of this change that is in turn linked, ultimately, to the wider and growing phenomenon of globalization of production and innovation. The problem is that this phenomenon might run the risk to be beneficial only for a few number of countries (nowadays, for instance, the so-called BRIC and the post-communist economies), thus generating a sort of *club-convergence*, while worldwide many other countries would be out of the fruitful effect of globalisation, being thus destined to a permanent backwardness unless suitable compensating policies were found and put at work.

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TABLE 1. THE THREE PILLARS AND NINE VARIABLES FEEDING INTO THE GLOCAP INDEX, AND THE RELATIVE DATA SOURCES

Pillar		**Variable**	**Data Source**
Business innovation	y	Triadic patents	OECD
	x_1	Business R&D (BERD)	OECD, UNCTAD
Knowledge&skills	x_2	Total researchers in R&D (FTE)	OECD
	x_3	Scientific and technical artiche	WDI (World Bank)
	x_4	Public R&D (PUBRD): Government Intramural Expenditure on R&D (GOVERD) + Higher Education Expenditure on R&D (HERD)	OECD, UNCTAD
Infrastructures	x_5	Personnel computers	WDI (World Bank)
	x_6	Fixed-line and mobile telephones	WDI (World Bank)
	x_7	Internet users	WDI (World Bank)
	x_8	Fixed capital	WDI (World Bank)

TABLE 2.A. 1995 – OLS ESTIMATION OF THE COUNTRY PARTIAL EFFECTS FROM THE RANDOM COEFFICIENT MODEL

	Country	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	*Total*	*Mean*
1	Switzerland	1.61	1.37	0.99	1.34	0.09	2.16	1.16	0.85	**9.58**	**1.20**
2	Japan	1.70	0.18	0.29	1.67	-1.03	2.95	1.19	0.65	**7.60**	**0.95**
3	Israel	1.02	1.76	0.02	0.21	0.30	1.09	1.52	1.14	**7.06**	**0.88**
4	Sweden	0.86	0.67	0.60	0.21	-0.26	0.66	1.17	0.99	**4.90**	**0.61**
5	Netherlands	1.34	0.62	0.36	0.70	-0.41	1.08	0.44	0.59	**4.73**	**0.59**
6	Austria	1.35	-0.06	0.52	1.02	-0.41	1.17	-0.19	0.55	**3.97**	**0.50**
7	Finland	1.39	0.68	1.09	0.67	-1.18	0.77	0.31	-0.27	**3.45**	**0.43**
8	Germany	1.05	-0.22	0.30	0.77	-0.57	1.12	0.18	0.62	**3.26**	**0.41**
9	Singapore	1.29	-0.08	0.82	1.12	-0.72	1.09	-0.48	-0.16	**2.88**	**0.36**
10	France	0.93	-0.31	0.01	0.47	-0.52	0.81	0.26	0.89	**2.53**	**0.32**
11	Denmark	0.98	0.20	0.43	0.38	-0.32	0.25	0.13	0.38	**2.43**	**0.30**
12	Belgium	0.74	0.25	0.41	0.38	-0.45	0.56	0.15	0.22	**2.26**	**0.28**
13	Italy	1.09	-0.24	0.24	0.60	-0.52	0.66	-0.24	0.59	**2.17**	**0.27**
14	Spain	0.98	0.06	0.22	0.47	-0.58	0.59	-0.16	0.30	**1.89**	**0.24**
15	UE27	0.79	-0.03	0.16	0.30	-0.61	0.46	0.04	0.36	**1.46**	**0.18**
16	Greece	1.10	-0.32	0.33	0.52	-0.70	0.42	-0.47	0.38	**1.26**	**0.16**
17	United Kingdom	0.45	0.44	0.13	-0.23	-0.26	-0.19	0.41	0.41	**1.16**	**0.14**
18	Norway	1.04	-0.21	0.57	0.51	-0.82	0.24	-0.19	-0.05	**1.11**	**0.14**
19	Canada	0.61	0.25	0.12	-0.15	-0.45	-0.17	0.34	0.37	**0.93**	**0.12**
20	New Zealand	0.81	0.23	0.36	0.09	-0.48	-0.32	-0.40	-0.10	**0.19**	**0.02**
21	United States	0.52	-0.22	0.75	0.10	-0.99	0.00	0.08	-0.11	**0.13**	**0.02**
22	Czech Republic	0.55	0.06	0.12	0.07	-0.84	0.22	-0.19	-0.10	**-0.11**	**-0.01**
23	Korea, Rep.	0.70	-0.79	0.33	0.49	-1.00	0.49	-0.47	0.08	**-0.17**	**-0.02**
24	Portugal	0.88	-0.46	0.28	0.41	-0.93	0.26	-0.65	-0.03	**-0.23**	**-0.03**
25	Australia	0.81	-0.27	0.12	0.09	-0.06	-0.63	-0.82	0.31	**-0.46**	**-0.06**
26	Iceland	1.02	-0.46	-0.02	0.21	-1.41	0.16	-0.05	-0.08	**-0.62**	**-0.08**
27	Brazil	0.46	-0.14	-0.01	0.05	-0.82	0.15	-0.49	-0.09	**-0.88**	**-0.11**
28	Turkey	0.58	-0.32	0.12	0.11	-0.82	0.04	-0.63	-0.01	**-0.91**	**-0.11**
29	South Africa	0.44	-0.03	0.11	-0.01	-0.82	0.02	-0.52	-0.22	**-1.03**	**-0.13**
30	Hungary	0.42	-0.02	-0.02	-0.13	-0.83	-0.08	-0.27	-0.11	**-1.04**	**-0.13**
31	India	0.29	0.05	-0.08	-0.16	-0.86	-0.01	-0.41	-0.27	**-1.44**	**-0.18**
32	China	0.26	0.01	-0.09	-0.18	-0.92	-0.04	-0.38	-0.31	**-1.66**	**-0.21**
33	Mexico	0.36	-0.22	-0.01	-0.08	-0.83	-0.12	-0.61	-0.20	**-1.71**	**-0.21**
34	Ireland	0.29	-0.31	0.31	-0.10	-0.64	-0.46	-0.60	-0.24	**-1.75**	**-0.22**
35	Slovak Republic	0.18	0.10	-0.22	-0.39	-0.95	-0.24	-0.01	-0.30	**-1.83**	**-0.23**
36	Argentina	0.19	-0.16	-0.07	-0.21	-1.07	-0.05	-0.19	-0.35	**-1.91**	**-0.24**
37	Poland	0.23	-0.01	-0.19	-0.30	-0.98	-0.19	-0.21	-0.32	**-1.96**	**-0.25**
38	Slovenia	0.34	-0.45	-0.23	-0.18	-1.12	-0.15	-0.23	-0.19	**-2.21**	**-0.28**
39	Estonia	0.38	-0.16	0.08	-0.21	-1.16	-0.34	-0.40	-0.51	**-2.32**	**-0.29**
40	Bulgaria	0.24	-0.24	-0.15	-0.36	-1.05	-0.38	-0.23	-0.24	**-2.41**	**-0.30**
41	Romania	0.11	-0.14	-0.19	-0.37	-1.10	-0.25	-0.25	-0.41	**-2.60**	**-0.32**
42	Lithuania	0.15	-0.34	-0.30	-0.42	-1.23	-0.38	-0.20	-0.39	**-3.09**	**-0.39**
43	Russian Fed.	-0.46	0.08	-0.71	-1.07	-1.56	-0.75	0.46	-0.98	**-5.00**	**-0.62**
	Total	**30.07**	**0.82**	**7.89**	**8.42**	**-31.88**	**12.69**	**-2.10**	**3.66**		
	Mean	**0.70**	**0.02**	**0.18**	**0.20**	**-0.74**	**0.30**	**-0.05**	**0.09**		

TABLE 2.B. 2007 – OLS ESTIMATION OF THE COUNTRY PARTIAL EFFECTS FROM THE RANDOM COEFFICIENT MODEL.

	Country	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	Total	Mean
1	Switzerland	1.55	0.63	0.67	-0.35	0.78	1.12	1.86	0.90	**7.15**	**0.89**
2	Ireland	2.02	0.91	0.65	-0.37	-0.28	-0.53	1.74	0.17	**4.31**	**0.54**
3	Belgium	1.45	0.23	0.40	-0.46	0.17	0.33	0.99	0.54	**3.64**	**0.45**
4	United Kingdom	1.24	0.11	0.37	-0.37	0.10	0.64	0.97	0.48	**3.53**	**0.44**
5	Netherlands	1.14	-0.09	0.43	-0.21	0.07	0.78	0.83	0.54	**3.49**	**0.44**
6	Denmark	1.59	0.16	0.13	-0.45	-0.44	0.07	0.69	0.65	**2.39**	**0.30**
7	Sweden	0.90	0.08	0.12	-0.55	-0.14	0.49	0.71	0.70	**2.32**	**0.29**
8	Slovak Republic	1.35	0.02	0.30	-0.55	0.03	0.03	0.73	0.25	**2.14**	**0.27**
9	Slovenia	1.21	-0.18	0.01	-0.63	-0.02	0.25	0.61	0.47	**1.71**	**0.21**
10	Israel	0.44	0.08	-0.06	-0.90	0.33	0.64	0.77	0.41	**1.70**	**0.21**
11	New Zealand	1.35	-0.38	-0.13	-0.58	-0.13	0.44	0.40	0.69	**1.65**	**0.21**
12	Spain	1.51	0.16	0.20	-0.50	-0.44	-0.34	0.80	0.15	**1.55**	**0.19**
13	Estonia	1.31	-0.05	0.20	-0.45	-0.30	0.20	0.40	0.17	**1.47**	**0.18**
14	Italy	1.19	-0.07	0.26	-0.37	-0.29	0.19	0.50	0.05	**1.47**	**0.18**
15	Japan	1.31	0.55	0.31	-0.72	-0.50	-0.86	0.86	0.36	**1.31**	**0.16**
16	Korea, Rep.	1.19	0.24	0.35	-0.59	-0.35	-0.39	0.51	0.33	**1.29**	**0.16**
17	Hungary	1.05	-0.28	0.20	-0.54	0.05	0.29	0.28	0.20	**1.24**	**0.16**
18	UE27	1.13	-0.05	0.15	-0.50	-0.34	0.00	0.51	0.20	**1.09**	**0.14**
19	Greece	1.32	-0.11	-0.04	-0.62	-0.27	-0.03	0.56	0.10	**0.92**	**0.11**
20	United States	0.97	0.17	0.17	-0.62	-0.52	-0.39	0.63	0.40	**0.82**	**0.10**
21	Poland	1.04	-0.32	0.10	-0.61	-0.00	0.16	0.25	0.15	**0.77**	**0.10**
22	Brazil	0.78	-0.48	0.19	-0.64	0.24	0.05	0.33	0.12	**0.59**	**0.07**
23	Austria	1.02	0.08	0.18	-0.50	-0.62	-0.32	0.49	0.20	**0.54**	**0.07**
24	Mexico	0.84	-0.37	0.09	-0.75	0.18	-0.17	0.53	0.06	**0.40**	**0.05**
25	Germany	0.92	-0.02	0.20	-0.43	-0.69	-0.15	0.17	0.10	**0.10**	**0.01**
26	Portugal	1.17	-0.15	-0.09	-0.70	-0.39	-0.14	0.29	0.09	**0.08**	**0.01**
27	Canada	0.84	-0.63	-0.26	-0.53	-0.55	0.13	0.30	0.61	**-0.09**	**-0.01**
28	Finland	1.17	-0.04	-0.27	-0.80	-0.75	-0.35	0.20	0.72	**-0.11**	**-0.01**
29	Romania	0.91	-0.26	0.01	-0.74	-0.14	-0.26	0.43	-0.08	**-0.12**	**-0.02**
30	Czech Republic	0.98	-0.26	-0.03	-0.66	-0.36	-0.12	0.18	0.14	**-0.12**	**-0.02**
31	Bulgaria	0.97	-0.26	-0.04	-0.72	-0.26	-0.11	0.17	-0.08	**-0.32**	**-0.04**
32	China	0.75	-0.48	-0.11	-0.90	0.14	-0.28	0.42	0.12	**-0.35**	**-0.04**
33	Argentina	0.93	-0.11	-0.07	-0.89	-0.21	-0.45	0.40	0.02	**-0.37**	**-0.05**
34	India	0.51	-0.75	-0.13	-0.92	0.41	-0.18	0.42	0.17	**-0.47**	**-0.06**
35	Australia	0.85	-0.95	-0.17	-0.24	-0.65	0.43	-0.16	0.29	**-0.60**	**-0.07**
36	Lithuania	1.08	-0.29	-0.00	-0.58	-0.57	-0.21	-0.08	-0.07	**-0.73**	**-0.09**
37	Turkey	0.70	-0.52	-0.15	-0.81	-0.10	-0.18	0.22	-0.03	**-0.88**	**-0.11**
38	France	0.95	-0.19	-0.15	-0.64	-0.82	-0.57	0.40	0.12	**-0.89**	**-0.11**
39	South Africa	0.62	-0.51	-0.18	-0.89	-0.04	-0.28	0.34	-0.07	**-1.01**	**-0.13**
40	Norway	1.53	-0.16	-0.07	-0.30	-1.55	-0.96	0.07	0.23	**-1.20**	**-0.15**
41	Russian Fed.	0.96	-0.31	-0.51	-1.03	-0.75	-0.74	0.07	-0.03	**-2.33**	**-0.29**
42	Iceland	1.53	-0.15	-0.68	-0.68	-2.35	-1.86	-0.17	0.06	**-4.28**	**-0.54**
43	Singapore	0.25	-0.86	-0.83	-0.77	-1.76	-0.68	-0.94	0.19	**-5.40**	**-0.68**
	Total	**46.52**	**-5.87**	**1.73**	**-26.06**	**-14.07**	**-4.32**	**19.66**	**10.78**		
	Mean	**1.08**	**-0.14**	**0.04**	**-0.61**	**-0.33**	**-0.10**	**0.46**	**0.25**		

FIGURE 1. INCREASING AND DECREASING RETURNS IN AN INNOVATION PRODUCTION FUNCTION.

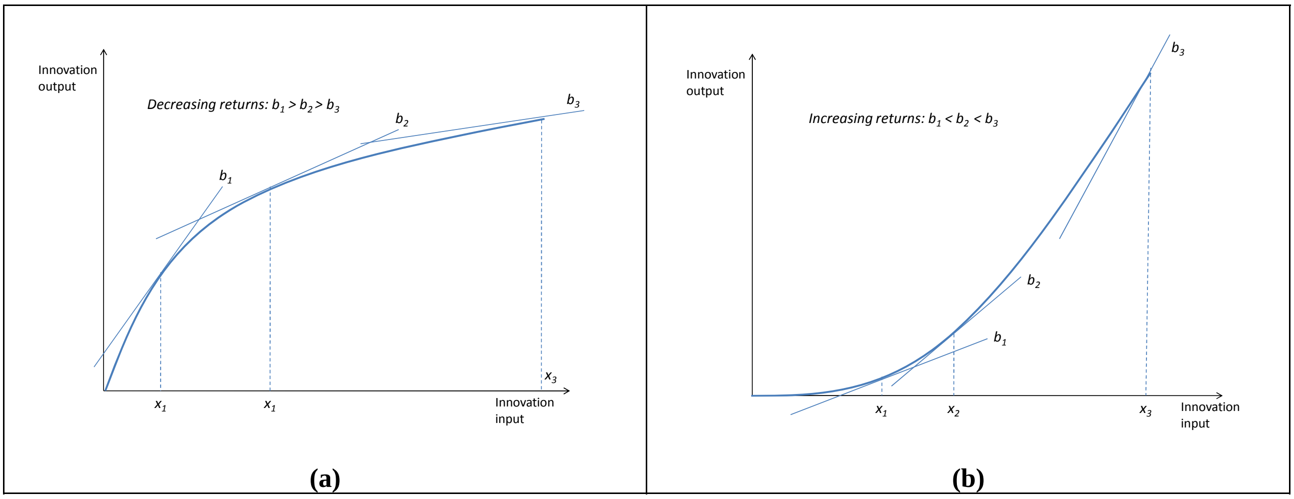
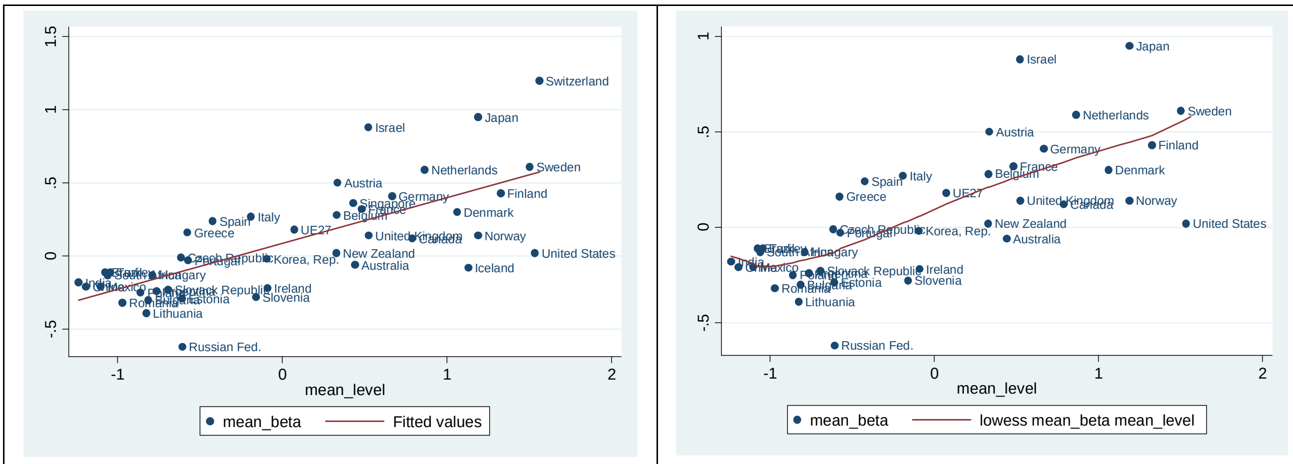


TABLE 3. REGRESSION LINE ESTIMATION.

Dependent variable: "Composite indicator of countries' innovation inputs in levels" (*CI*). Regressor: "Composite indicators of countries' partial effects" (*CPE*). Note: (1) = results on the overall 1995 sample; (2) = results on the overall 2007 sample; (3) results on 2007 sample excluding three outliers: Switzerland, Iceland and Singapore. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

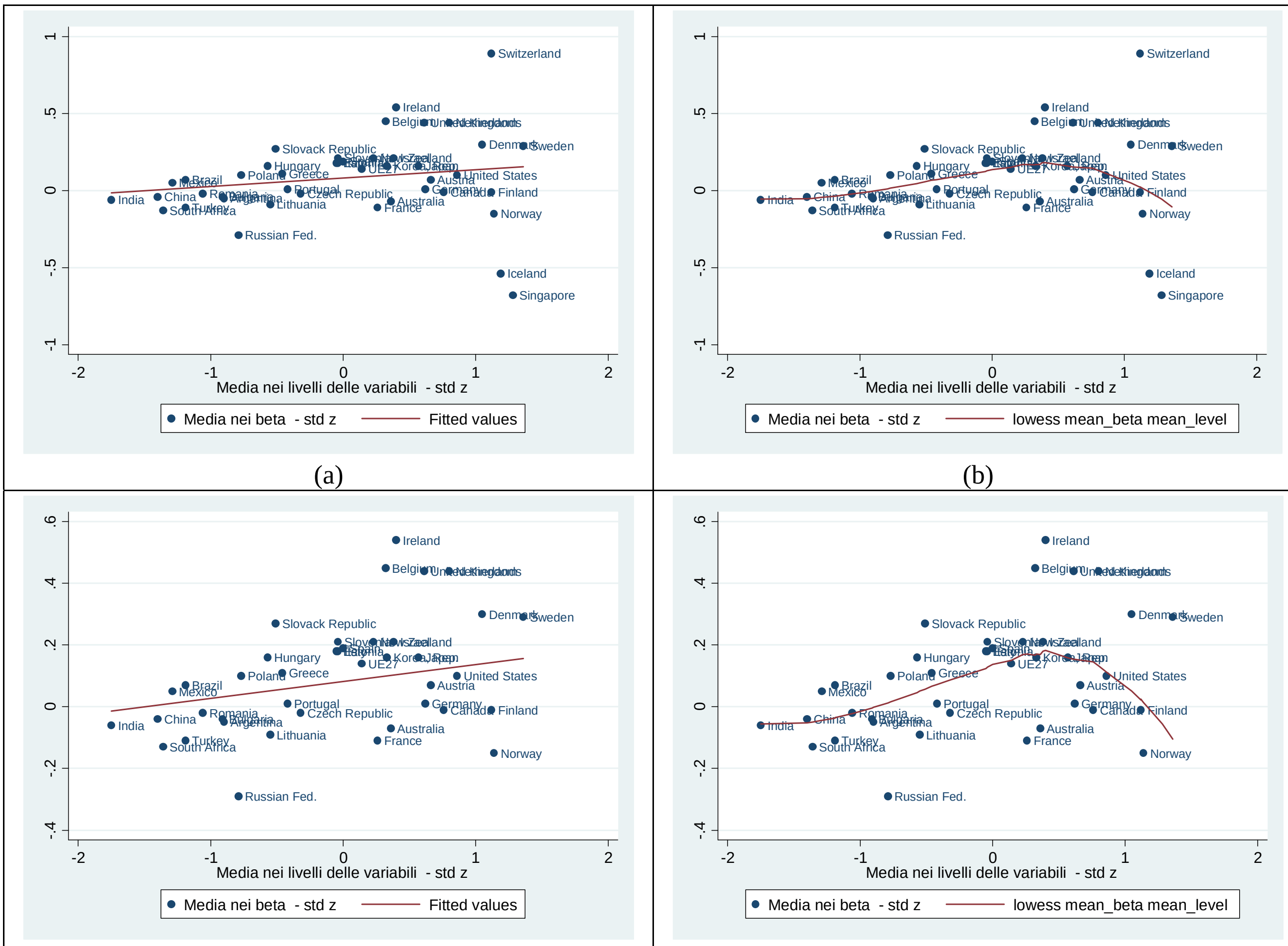
	(1) 1995	(2) 2007	(3) 2007
CPE	0.31^{***}	0.05	0.1^{***}
N	43	43	40
adj. R^2	0.49	0.03	0.17
F	42.89^{***}	0.255	8.92^{***}

FIGURE 2. 1995 – LINEAR (A) AND LOWESS (B) FITTING FOR THE RELATION BETWEEN THE "COMPOSITE INDICATOR OF COUNTRIES' INNOVATION INPUTS IN LEVELS" (*CI*) AND THE "COMPOSITE INDICATORS OF COUNTRIES' PARTIAL EFFECTS" (*CPE*).



(a) (b)

FIGURE 3. 2007 – LINEAR (A, C) AND LOWESS (B, D) FITTING FOR THE RELATION BETWEEN THE "COMPOSITE INDICATOR OF COUNTRIES' INNOVATION INPUTS IN LEVELS" (*CI*) AND THE "COMPOSITE INDICATORS OF COUNTRIES' PARTIAL EFFECTS" (*CPE*). FIGURES (C) AND (D) ARE DRAWN BY EXCLUDING THREE OUTLIERS: SWITZERLAND, ICELAND AND SINGAPORE.



(a) (b)

(c) (d)

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