



Journal of Globalization, Competitiveness
& Governability / Revista de
Globalización, Competitividad y
Gobernabilidad / Revista de
Globalização, Competitividade e
Governabilidade

E-ISSN: 1988-7116

Fischer, Bruno; Tello-Gamarra, Jorge
Institutional Quality as a Driver of Efficiency in Laggard Innovation Systems
Journal of Globalization, Competitiveness & Governability / Revista de Globalización,
Competitividad y Gobernabilidad / Revista de Globalização, Competitividade e
Governabilidade, vol. 11, núm. 1, enero-abril, 2017, pp. 129-144
Portal Universia S.A.
Boadilla del Monte, España

Available in: <http://www.redalyc.org/articulo.oa?id=511854478006>

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Institutional Quality as a Driver of Efficiency in Laggard Innovation Systems¹

AREA: 1
TYPE: Application

Efectos de la Calidad Institucional en la Eficiencia de los Sistemas de Innovación en Países en Desarrollo
Efeitos da Qualidade Institucional na Eficiência dos Sistemas de Inovação de Países em Desenvolvimento

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This article works with the hypothesis that institutional conditions have an important role to play in shaping the performance of R&D expenditures in laggard innovation systems. We have assessed 51 developing countries over the period 1980–2008. Dependent constructs consist in (i) labor productivity; and (ii) patenting activity. Three different measures of institutional quality were used: control of corruption, democratic predominance, and political rights. Results support the proposition that institutional quality matters for the efficiency of innovation inputs. The main implication concerns the need for improved institutional frameworks within developing countries in order to generate appropriate outcomes from R&D investments.

En este artículo se analiza la hipótesis de que las condiciones institucionales afectan significativamente el rendimiento del gasto en Investigación y Desarrollo en sistemas de innovación relativamente rezagados. Se han analizado 51 países en desarrollo durante el período 1980–2008. El constructo dependiente consisten en: i) la productividad del trabajo; y ii) la generación de patentes. Fueron utilizadas tres medidas diferentes de calidad institucional: el control de la corrupción, la predominancia de sistemas democráticos y los derechos políticos. Los resultados empíricos proporcionan evidencia en favor de la proposición de que la calidad institucional es un factor importante en la eficiencia de los recursos aplicados con vistas a la innovación. Estos hallazgos ponen de manifiesto la necesidad de mejoras en los marcos institucionales en los países en desarrollo para que haya evolución en la relación entre el desempeño innovador y gastos en I+D en estos países.

Este artigo aborda a hipótese de que condições institucionais afetam significativamente o desempenho de gastos em Pesquisa e Desenvolvimento em sistemas de inovação relativamente defasados. Para tanto, foram analisados 51 países em desenvolvimento ao longo do período 1980–2008. Construtos dependentes consistem em: i) produtividade do trabalho; e ii) geração de patentes. Três diferentes medidas de qualidade institucional foram aplicadas: controle de corrupção, predominância de sistemas democráticos e direitos políticos. Os resultados empíricos oferecem evidências a favor da proposição de que a qualidade institucional é um fator relevante para eficiência dos recursos aplicados com vistas à inovação. Estes achados evidenciam a necessidade de melhorias nos arcabouços institucionais em países em desenvolvimento para que haja evolução na relação entre desempenho inovador e gastos em P&D nestes países.

DOI
10.3232/GCG.2017.V11.N1.06

RECEIVED
20.11.2016

ACCEPTED
27.01.2017

1. Introduction

The National Innovation Systems (NIS) concept dates back to the 80's (Freeman, 1987) and in the years that followed it has achieved widespread influence in the academic and policymaking domains (Sharif, 2006). As it is known, one of the building blocks of the NIS rationale resides on the role of institutions and its respective setup (Edquist, 1997). This is not a trivial proposition. For instance, institutional factors are precluded from the origins of endogenous growth approaches (Tebaldi and Elmslie, 2008).

Existing evidence supports the hypothesis that institutional arrangements affect knowledge accumulation (Rodrik, 2000). Consequently, unravelling the mechanisms through which institutions and innovation are linked represents a fundamental challenge in the field of innovation economics (Tebaldi and Elmslie, 2013). Nonetheless, even evolutionary assessments often fail to empirically address the role of institutions in shaping the performance of innovation systems. Illustratively, Kotsemir (2013), in an evaluation of specialized literature, presents a body of work that seldom includes institutional variables in the assessment of innovation systems' efficiency. Given the theoretical context in which these studies are embedded, this is an odd situation.

At the same time, a predominant argument in innovation policy concerns the relative amount of investment performed in R&D. This is a core indicator for the evaluation of innovation intensity and overall quality of innovation systems (Castellacci and Natera, 2013), even though its aggregate features offer an imperfect perception of innovative dynamics (Griliches, 1979). But, as previous research has demonstrated, overall changes in productivity and the rate of technological change cannot be entirely explained by levels of R&D expenditures (Griliches, 1998). In this regard, institutions, just as productive technologies, are closely related to rates of efficiency in economic systems (Sala-i-Martin, 2002). Recent literature shows that improving institutional quality can have a similar effect upon innovation systems as increasing the amount of investments in R&D (Rodríguez-Pose and Di-Cataldo, 2014).

This discussion is of particular interest for the analysis of developing countries. These nations struggle with deficient institutions that often harm conditions for economic growth (Grogan and Moers, 2001). These countries lack the adequate amount of resources that should be directed to knowledge-intensive activities and suffer from endemic problems related to institutional quality (Acemoglu and Johnson, 2005). Unfortunately, much of the innovation policy discourse is still very linear-oriented (Edquist, 2014), and the coordination of R&D policy with broader aspects of the political agenda is poorly understood.

We depart from the idea that the institutional side of National Innovation Systems stands for fundamental mechanisms through which developing countries can realize their full innovative potential, leading to the following research question: *To what extent does institutional quality affect the performance of R&D as an innovation input in developing countries' innovation systems?*

In order to address this inquiry a panel dataset of developing countries (1980-2008) is assessed using a R&D-productivity function with the introduction of multiplicative interaction terms. More specifically, we assess the moderating impacts of corruption, democracy and political rights upon the performance of R&D expenditures concerning labor productivity and patenting activity. Results indicate the significance of the institutional context as a lever for R&D efficiency. Particular emphasis is put on the role of corruption control and existence of democratic systems.

KEY WORDS
National
Innovation
Systems,
Institutions,
Innovation
Policy, Systemic
efficiency.

PALABRAS CLAVE
Sistemas Nacionales
de Innovación,
Instituciones,
Políticas de
Innovación,
Eficiencia sistémica.

PALAVRAS-CHAVE
Sistemas Nacionais
de Inovação,
Instituições,
Políticas de
Inovação,
Eficiência
sistêmica.

JEL CODES:
B52, O3, O1, P5

The article is structured as follows: Section 2 develops an investigation of the extant literature on the relationship between innovation systems and the structural role of institutions. Based on this assessment we develop our research hypothesis. Section 3 depicts the formal structure of the empirical model. Section 4 consists in the presentation of data and estimation methods. Results are presented in Section 5. Section 6 concludes with some final remarks and implications for innovation systems' research and policy.

2. Institutional foundations of innovation systems

The concept of National Innovation Systems is rooted in the interplay between firms and institutions (e.g. Freeman, 1987; Nelson, 1993; Edquist, 1997; Asheim and Isaksen, 1997). The quality of these interactions is expected to affect aggregate levels of innovative capabilities within countries. While "firms" stand for a clear and straightforward representation of business units, "institutions" are a relatively vague term that can be associated with formal and informal aspects of the socioeconomic landscape (Freeman, 1995; Nasierowski and Arcelus, 2003).

On the one hand, institutions include public policies, research institutes, universities and other governmental agencies of interest. Under these assumptions, governmental actions represent a central piece of the institutional architecture of business systems (Whitley, 2007). On the other hand, institutions can be identified as '*rules of the game in a society [...]. In consequence they structure incentives in human exchange, whether political, social, or economic*' (North, 1990, 3). Johnson (1992) gives a similar definition, where habits, routines, rules, norms and laws lie at the heart of social interactions.

Instrumentally, the role of institutions, whether formal or not, is one of providing perennial and predictable grounds on which transactions take place, coordinating production and exchange (Ostrom, 2005; Pinto and Pereira, 2013). Within the National Innovation Systems' rationale, interest in these institutional dynamics are related to their respective capacity of affecting new knowledge production, diffusion and adaptation (Niosi, 2002). For these reasons, institutions have been referred to as "social technologies" (Nelson and Sampat, 2001). These observations provide support for the assertion that institutions represent the cornerstone of innovation systems. Their importance goes beyond offering 'hard' or 'soft' infrastructures for private parties: institutions set the stage for the desirable socioeconomic incentives to arise (Rodrik, 2000). Without such contributions, systemic flaws will likely take place and have negative impacts upon innovation systems' evolutionary paths.

However, there are scant efforts that aim at including institutional variables within formal empirical appraisals of innovation dynamics (Tebaldi and Elmslie, 2013). This is particularly relevant in a moment in which there is a call for thorough evaluations of NISS' efficiency in terms of innovation diffusion, generation, and appropriation (Edquist and Zabala-Iturriagagoitia, 2015). Even though we acknowledge that institutions can be highly idiosyncratic, some basic structural aspects behind the economics of institutions can (and should) be the target of international comparison. By no means institutions can be taken as given:

A clearly delineated system of property rights; a regulatory apparatus curbing the worst forms of fraud, anti-competitive behavior, and moral hazard; a moderately cohesive society exhibiting trust and social cooperation; social and political institutions that mitigate risk and manage social conflicts; the rule of law and clean government - these are social arrangements that economists usually take for granted, but which are conspicuous by their absence in poor countries (Rodrik, 2000, 4).

As highlighted by Rodrik (2000), the lack of institutional quality seems to afflict more strongly those countries that are in adverse economic situations. There are enough reasons to believe that these conditions are applicable to the dynamics of National Innovation Systems, posing a challenge for the possibilities of long-term growth and development.

2.1 Institutional quality and systemic efficiency

The institutional framework is often perceived in heterodox economics literature as a primary driver of performance (Acemoglu and Johnson, 2005). This is a function of the institutional importance in terms of coordinating transactions, individual behavior and the production of knowledge within any given production system. As a result, institutional backwardness is bound to hamper the potential of absorbing available productive technologies. This can happen via internal market protection regulations, organizational inertia, poor contractual frameworks, persistent information asymmetries, and a lack of learning routines among agents (Niosi, 2002). Such a scenario raises substantially the existing levels of transaction costs (Matthews, 1986), ultimately compromising long run rates of output growth (Tebaldi and Elmslie, 2008).

We can conclude that - within the existing interactions happening in innovation systems - the role of institutions is not limited to shaping the knowledge infrastructure; it also has pervasive effects upon the behavior of agents: *"institutions are not neutral and they show different missions and efficiency levels"* (Niosi, 2002, 300). In a similar vein, some authors highlight the different degrees of institutional quality that can be observed across nations, as well as its implications in terms of understanding economic performance heterogeneity (Pinto and Pereira, 2013; Nelson and Sampat, 2001).

Hence, the amount of economic resources invested in a given policy initiative is a poor measure of its effectiveness (Edquist, 2014). When thinking of institutions as platforms on which economic activity is based, previous approaches have pinpointed its importance in facilitating evolutionary trends. Hall and Jones (1999) defend that the social infrastructure (combination of institutions and public policies) has pervading impacts upon nations' labor productivity growth rates. Tebaldi and Elmslie (2013) found that institutional quality matters for patenting activity. Furman, Porter and Stern (2002) have empirically demonstrated the importance of R&D productivity (over R&D expenditures) as a driver of national innovative capacity in OECD countries. They also have derived R&D productivity as a function of policy, incentives, and quality of linkages among agents. Guan and Chen (2012) have also found support for institutional quality as a fundamental driver of efficiency in National Innovation Systems.

Nonetheless, most of these analyses draw their conclusions from developed countries. We believe that these perceptions are not only applicable to the context of laggard innovation systems: they are likely to show even more pronounced returns. As Acemoglu and Robinson (2012) and Glaeser et al. (2004) have discussed, there is a high degree of endogeneity in the interaction between economic evolution and

institutional quality. Thus, institutional traits can be more sensitive for developing countries, considering most of these nations have not achieved the same level of institutional quality as developed countries.

This condition can negatively affect even basic innovation efforts in backward economies. This issue has been verified empirically in Castellacci and Natera (2013). These authors found that while R&D investment is a fundamental aspect of national innovative capacity in developed countries, its role seems to be of decreasing relevance in laggard innovation systems. This phenomenon can be associated with less efficient uses of R&D efforts in these nations (Nasierowski and Arcelus, 2003).

However, scant attempts have taken place concerning the role of institutions as a moderating vector of the efficiency in innovation efforts. Some recent attempts have targeted this issue. Goedhuys et al. (2016) have addressed this issue at the firm level, finding that corruption exerts negative effects on innovative behavior. Barasa et al. (2017) and Seitz and Watzinger (2017) find that institutional quality moderates the amount of resources dedicated by firms to innovative endeavors. Krammer (2015) identifies that ease of doing business has a positive moderating effect on developing countries' productivity levels. Paunov (2016) does not find negative effects of corruption as a moderator in firm-level patenting activity.

Further analyses usually assess direct impacts of institutions upon outcomes (e.g. DiRienzo and Das, 2014). In the case of laggard innovation systems, even such assertions have yet to be tested in more detail. Based on the conceptual and empirical frameworks that have been addressed so far we expect that institutional conditions can have detrimental/beneficial effects upon innovation systems' outcomes by mediating the efficiency of R&D efforts. This leads us to the following research hypothesis:

H₁: Institutional quality moderates the economic impacts of R&D efforts within the context of developing countries' National Innovation Systems.

The next section is focused on the development of the empirical model dedicated to approach this proposition.

3. Empirical model

In order to verify the research hypothesis we have developed regression models that take into account the expected moderating effects played by institutional vectors within the dynamics of innovation systems. We depart from a R&D productivity function (Griliches, 1979) which can be estimated as:

Equation 1

$$Y = f(X, K, \Omega, \mu)$$

Where Y is an output vector, X represents conventional inputs (labor and capital), K is the level of technical knowledge (approximated by R&D), Ω represents the set of ancillary variables, and μ is a vector of unobserved determinants of output. However, this model offers an incomplete form for the appreciation of institutional conditionality upon innovation efforts, which is our primary goal. To deal with this limitation we have developed an augmented R&D productivity function through the application

of a multiplicative interaction model. The main advantage of this procedure is related to its capacity of capturing information on “context conditionality” (Aiken & West, 1991)³. Operationally, the interaction term is added to the constitutive variables (plus other regressors) in the following way:

Equation 2

$$Y = \alpha + \beta_1 X + \beta_2 Z + \beta_3 XZ + \beta_k Q + \varepsilon$$

Where α is a constant, $\beta_{1,2,\dots,k}$ is the k^{th} coefficient of predictors, Q is a representation of predictors that do not constitute the interaction term, ε is the error term, X is a continuous variable of interest, and Z is a binary variable of context (moderator). The binary character of this moderator is often achieved through transformations on the original variable for ease of interpretation. Differently from standard regressions, β_1 does not represent the average effect of X upon Y , but rather the effect of X upon Y *only* when condition Z is absent. When Z is present ($Z=1$), the actual effect of X is the composition of two parameters, i.e., $(\beta_1 + \beta_3)$. Based on these definitions, the generic regression model that is estimated in our empirical approach takes the following structure:

Equation 3

$$Y = \alpha + \beta_1 GERD + \beta_2 INST + \beta_3 GERD*INST + \beta_k Q + \varepsilon$$

Where the basic conditions observed in previous equations remain. GERD is a representation of Gross Expenditure in R&D (as a percentage of GDP), INST is a binary measure of institutional quality, and GERD*INST is the interaction term between these two dimensions. The operational indicators that represent each of these constructs (plus Y and the set of control variables, Q) are introduced in section 4. The use of GERD in our model represents not only its direct function as an innovative input, but also an approximation of overall National Innovation Systems' stage of development (as evidenced by Castellacci & Natera, 2013). Hence, this approach offers a novel for the evaluation of R&D productivity when conditional upon the context of institutional quality. Further remarks on the dataset and estimation procedures of Equation 3 are outlined in the upcoming section.

4. Data and estimation method

The complete sample comprehends 51 cross-section units (countries) classified as low-income, lower-middle-income, and upper-middle-income countries according to the World Bank⁴. We take this sample as a representation of developing economies, which stand for laggard innovation systems (the list of countries can be found in Appendix I). These nations were observed over 29 years (1980-2008). This timeframe avoids undesirable fluctuations derived from the 2008 financial crisis. As global financial markets' shocks may distort the prevalence of fundamental forces of economic activity and innovation, including more recent data could distort theoretical and policy implications of our analysis. Because of missing data issues in variables of interest, this panel is unbalanced.

Analytical variables are depicted in [Table 1](#), where they are also sorted as per their respective function in the regression model outlined in [Equation 3](#). The first vector of Y (dependent variable) is a measure of labor productivity. This variable functions as a proxy for innovative capabilities' impact upon productive efficiency. Moreover, it is a construct that is closely connected with the macroeconomic development path, affecting wages, income and competitiveness of firms. Because of missing data issues for several countries of our sample, estimations of regression models using "Prod" comprehend only 21 cross-section units, with timeframes varying between 6 and 29 years over the period 1980-2008. The second indicator we have used as a dependent representation of innovation systems is the usual measure of USPTO patenting activity per capita. Although we recognize the weaknesses inherently related to the complex relationship between patents and innovation, the international character of USPTO patents grants a widely acceptable verification of innovative capabilities. For "Pats", data is available for the whole sample of 51 developing countries with cross-section timeframes varying between 1 and 29 years.

Our first dependent variable of interest is GERD. As already exposed, this indicator assesses a key innovation input and it also functions as a proxy for National Innovation Systems' level of development. This variable is a core issue of interest in our empirical approach, as we try to assess if the productivity of aggregate investments in R&D can be boosted by the institutional context in which it is embedded.

On the institutional side, three variables of interest are included: corruption, democracy and political rights. These variables represent approximations of the institutional quality of countries, i.e., traditional indicators found in literature concerning the efficiency of functioning in countries' sociopolitical frameworks. A common problem with variables representative of institutional settings is that they often represent outcomes rather than actual indicators of context (Glaeser et al., 2004). Nonetheless, institutional quality indexes *per se* are rather difficult to be obtained, so we take these variables as robust proxies of the institutional environment in developing nations' innovation systems for the sake of measurement. It must be highlighted that binary transformations follow an intuitive approach based on the natural structure of original data: values closer to high (low) levels of institutional quality are assumed to represent the presence (absence) of sufficiently positive institutional conditions.

The set of control variables (Ω) comprehends dimensions of macroeconomic interest in the evaluation of National Innovation Systems. "K" stands for investments in physical capital, a common feature in production functions. Instead of adding the usual variable of labor quantity, we have resorted to a measure of labor quality via the inclusion of "School". "Open" stands for a vector of trade policy regimes that is closely related to the innovative environment by driving demand's level of sophistication (Alonso & Garcimartín, 2011). The share of Foreign Direct Investment in each economy controls for inflows of productive knowledge arising from the presence of multinational companies (Fischer, 2015). Lastly, "Inflation" is a proxy for overall economic stability within economic systems, a potential source of shocks upon output indicators.

Models follow the generic form outlined in [Equation 3](#) with the use of natural logs for all of the variables with the exception of binary predictors. This allows the interpretation of results in terms of elasticities. Estimations are carried out via fixed-effects methods for panel data, allowing consistent estimates of time-constant omitted variables upon dependent constructs (Wooldridge, 2000), a desirable feature for the assessment of National Innovation Systems. Additionally, we have applied Panel-Corrected Standard Errors (PCSE) to the regressions. This allows dealing with contemporaneous correlations across units and heteroscedasticity by unit (Beck & Katz, 1995).

Table 1. Analytical variables

Code	Function	Description	Source
<i>Prod</i>	Y	Labor productivity per hour worked in 2014 US\$ (converted to 2014 price level with updated 2011 PPPs).	<i>Conference Board</i>
<i>Pats</i>		Number of utility patents granted by the USPTO by year and Inventor's Country of Residence per capita.	<i>CANA Dataset</i>
<i>GERD</i>		R&D expenditures as a percentage of GDP.	<i>CANA Dataset</i>
<i>CorruptionCtrl</i>	INST	Transparency International Index, ranging from 0 (High Corruption) to 10 (Low Corruption). For the binary transformation, if index >5, it takes the value of 1, 0 otherwise.	<i>CANA Dataset</i>
<i>Democracy</i>		Democracy: political participation is full and competitive, executive recruitment is elective, constraints on the chief executive are substantial. Autocracy: it restricts or suppresses political participation. The index ranges from +10 (democratic) to -10 (autocratic). For the binary transformation, if index >0, it takes the value of 1, 0 otherwise.	<i>CANA Dataset</i>
<i>PoliticalRights</i>		People's free participation in the political process. It ranges from -7 (low freedom) to +1 (total freedom). For the binary transformation, if index >4, it takes the value of 1, 0 otherwise.	<i>CANA Dataset</i>
<i>K</i>	Ω	Gross capital formation (% of GDP).	<i>World Bank</i>
<i>Open</i>		(Import + Export)/GDP. PPP, 2000 USD.	<i>CANA Dataset</i>
<i>FDI</i>		Foreign direct investment, net inflows (% of GDP).	<i>World Bank</i>
<i>Inflation</i>		Inflation, consumer prices (annual %).	<i>World Bank</i>
<i>School</i>		Average number of years of school completed in population over 14.	<i>CANA Dataset</i>

Each institutional variable (Corruption, Democracy and Political Rights) is used to develop the interaction terms with GERD for the two dependent variables of interest (Productivity and Patenting Activity). Moreover, as we understand that simultaneous effects of GERD, institutional variables and interaction terms may have non-immediate results, lagged versions of these variables are tested for robustness examinations. However, finding a proper lag structure for each predictor in the model can be challenging (Nasierowski & Arcelus, 2003). To respect the limits of our dataset and gather a medium-term perspective on potential non-simultaneous effects of institutional quality upon GERD efficiency, we have applied a 2-year lag structure on these variables of interest. Control variables are kept in their original structure. As a result of these procedures, twelve regression models were estimated. Their respective results are presented in the next section.

5. Results

A first step in the evaluation of the empirical assessment consists in the presentation of descriptive statistics for the main variables of interest (**Table 2**). It should be noticed that institutional variables (Corruption, Democracy and Political Rights) are analyzed in their untransformed format, providing more detailed information on the sample. As it can be gathered from the coefficient of variation (C.V.), the sample is highly heterogeneous concerning the variables under scrutiny, particularly so for "Democracy". Moreover, it is of great concern for this particular group of developing nations that the mean value in "Corruption" is below the established threshold for good institutional quality (>5.00). A similar situation, but not as extreme, is found for "PoliticalRights". These features of the sample suggest a high level of heterogeneity among developing countries in terms of innovation systems and institutional frameworks, offering support for the importance of this analytical exercise.

Table 2. Descriptive statistics of core variables of interest (original structures).

<i>Variable</i>	<i>Mean</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Std. Dev.</i>	<i>C.V.</i>
<i>Prod</i>	10	31	0,994	6	0,612
<i>Pats</i>	1,823E-06	2,13E-05	0	3,46E-06	1,8977
<i>GERD</i>	0,0035453	0,01805	5,99E-08	0,002911	0,82109
<i>Corruption</i>	3,4797	7,6722	1	1,1356	0,32633
<i>Democracy</i>	1,4406	-10	10	6,5079	4,5176
<i>PoliticalRights</i>	-4,1254	-1	-7	1,8125	0,43936

The first set of estimations is presented in **Table 3**. Overall adequacy of models can be deemed as satisfactory. The behavior of "GERD" is consistently positive and significant (for current and lagged versions), warranting the fundamental importance of R&D investments in the dynamics of developing countries' labor productivity. However, taking a closer look on the structure of each model, the strategic relevance of the institutional environment becomes evident.

The verification of "Corruption" and "LnGERD*Corruption" suggests that controlling for such opportunistic actions can have major impacts on the evolution of labor productivity. The multiplicative interaction term in model I highlights that overcoming a minimum threshold of corruption control renders R&D investment twice as efficient. This effect is even more pronounced in model IV, where "LnGERD*Corruption(t-2)" can roughly increase threefold the parameter for R&D efficiency. This finding offers support for our research hypothesis. We argue that these outcomes go beyond the problems of resource draining associated with corruption in developing countries. The magnitude of coefficients related to both "Corruption" and "LnGERD*Corruption" recommend perceiving structural damages for innovation systems when facing conditions of widespread corruption.

Table 3. Estimations of fixed-effects models VII-XII (LnProd dependent) with panel-corrected standard errors

	<i>Model I</i>	<i>Model II</i>	<i>Model III</i>	<i>Model IV</i>	<i>Model V</i>	<i>Model VI</i>
<i>LnK</i>	.109*** [.016]	.110*** [.015]	.115*** [.016]	.106*** [.016]	.111*** [.015]	.110*** [.016]
<i>LnOpen</i>	.179*** [.031]	.216*** [.027]	.183*** [.028]	.201*** [.031]	.226*** [.029]	.201*** [.028]
<i>LnFDI</i>	.021*** [.006]	.020*** [.006]	.020*** [.006]	.021*** [.006]	.020*** [.006]	.019*** [.006]
<i>LnInflation</i>	.006 [.006]	.008 [.005]	.009 [.006]	.009 [.005]	.011** [.005]	.013** [.005]
<i>LnSchool</i>	.199*** [.047]	.211*** [.051]	.200*** [.049]	.232*** [.052]	.234*** [.055]	.251*** [.053]
<i>LnGERD</i>	.064*** [.006]	.043*** [.010]	.060*** [.008]	-	-	-
<i>CorruptionCtrl</i>	.429*** [.098]	-	-	-	-	-
<i>Democracy</i>	-	.143* [.083]	-	-	-	-
<i>PoliticalRights</i>	-	-	.182** [.086]	-	-	-
<i>LnGERD*CorruptionCtrl</i>	.062*** [.014]	-	-	-	-	-
<i>LnGERD*Democracy</i>	-	.036*** [.012]	-	-	-	-
<i>LnGERD*PoliticalRights</i>	-	-	.028** [.012]	-	-	-
<i>LnGERD(t-2)</i>	-	-	-	.041*** [.006]	.031*** [.009]	.041*** [.007]
<i>CorruptionCtrl(t-2)</i>	-	-	-	.496*** [.102]	-	-
<i>Democracy(t-2)</i>	-	-	-	-	.152** [.072]	-
<i>PoliticalRights(t-2)</i>	-	-	-	-	-	.220*** [.073]
<i>LnGERD*CorruptionCtrl(t-2)</i>	-	-	-	.076*** [.015]	-	-
<i>LnGERD*Democracy(t-2)</i>	-	-	-	-	.032*** [.011]	-
<i>LnGERD*PoliticalRights(t-2)</i>	-	-	-	-	-	.031*** [.010]

LSDV Rsq.	.975	.976	.974	.977	.977	.977
Within Rsq.	.581	.594	.574	.577	.574	.571
Valid N	421	421	421	399	399	399

Std. Errors in brackets *sig. at 10% **sig. at 5% ***sig. at 1%

Similar results are identified for models II and V, where “Democracy” and “LnGERD*Democracy” are included. The reach of these results is of particular interest for countries like China and Vietnam, which still lack adequate democratic structures. On the other hand, Latin American countries have greatly evolved along the democratic processes over the period 1980-2008. As per our findings, achieving higher effective rates of social participation in political processes can significantly increase the efficiency in the input/output relationship of developing countries’ National Innovation Systems.

The assessment of “PoliticalRights” and “LnGERD*PoliticalRights” render more modest, but still significant results. The issue of sociopolitical freedom complements the view on democratic environments. Hence, our findings concerning the combined view on models I-VI offer evidence in favor of our research hypothesis in terms of the evolutionary dynamics of labor productivity in laggard innovation systems.

As per control variables, outcomes mostly have the expected behavior. Levels of openness to trade are strongly significant and positive. Further moderating effects of “LnSchool” are also consistently positive and significant. Capital investments are positive and significant. Inflation is only moderately significant in models V and VI, and surprisingly positive.

A complementary view in terms of input/output relationships in developing nations’ innovation systems is developed around the approach of “LnPats” as the dependent construct (Table 4). The overall fit of models VII-XII suffers a reduction in comparison to “LnProd” estimations. This seems to be largely attributed to the behavior of some of the control variables (namely “LnK”, “LnFDI” and “LnInflation”) rather than to individual results of the core variables of interest. However, “LnOpen” and “LnSchool” remain significant and even show a steep increase in their coefficients. Analyzed independently, the contribution of “GERD” is more pronounced than what was observed in models I-VI in terms of the magnitude of its parameters. Nonetheless, its impacts are not significant in models VIII and XI (lagged form).

Contributions observed for models VII and X shed additional light on the importance of corruption control as a key moderating vector for the competitiveness of laggard innovation systems. The evaluation of models VIII and XI show a more marked dependence of patenting activity concerning institutional quality than for the case of labor productivity. On the other hand, models IX and XII do not warrant the inclusion of “PoliticalRights” and “LnGERD*PoliticalRights” as significant influences in the patenting behavior of the sample under scrutiny. In these specific cases, contributions arising from “GERD” are taken as unconditional.

Table 4. Estimations of fixed-effects models VII-XII (LnPATS dependent) with panel-corrected standard errors.

	<i>Model VII</i>	<i>Model VIII</i>	<i>Model IX</i>	<i>Model X</i>	<i>Model XI</i>	<i>Model XII</i>
<i>LnK</i>	.098 [.118]	.083 [.121]	.084 [.119]	.066 [.117]	.055 [.120]	.049 [.117]
<i>LnOpen</i>	.529*** [.110]	.555*** [.112]	.534*** [.110]	.504*** [.110]	.555*** [.116]	.525*** [.112]
<i>LnFDI</i>	-.010 [.025]	-.006 [.025]	-.007 [.026]	-.005 [.025]	-.009 [.024]	-.002 [.025]
<i>LnInflation</i>	-.004 [.023]	-.001 [.024]	-.004 [.024]	-.002 [.024]	-.001 [.025]	-.001 [.023]
<i>LnSchool</i>	.646*** [.153]	.748*** [.158]	.686*** [.154]	.651*** [.184]	.832*** [.190]	.777*** [.185]
<i>LnGERD</i>	.086** [.038]	.036 [.048]	.113*** [.042]	-	-	-
<i>CorruptionCtrl</i>	1.066** [.486]	-	-	-	-	-
<i>Democracy</i>	-	.748** [.357]	-	-	-	-
<i>PoliticalRights</i>	-	-	.094 [.320]	-	-	-
<i>LnGERD*CorruptionCtrl</i>	.190** [.080]	-	-	-	-	-
<i>LnGERD*Democracy</i>	-	.147*** [.055]	-	-	-	-
<i>LnGERD*PoliticalRights</i>	-	-	.036 [.048]	-	-	-
<i>LnGERD(t-2)</i>	-	-	-	.086*** [.032]	.049 [.045]	.132*** [.034]
<i>CorruptionCtrl(t-2)</i>	-	-	-	1.454*** [.469]	-	-
<i>Democracy(t-2)</i>	-	-	-	-	.478 [.346]	-
<i>PoliticalRights(t-2)</i>	-	-	-	-	-	-.237 [.255]
<i>LnGERD*CorruptionCtrl(t-2)</i>	-	-	-	.257*** [.077]	-	-
<i>LnGERD*Democracy(t-2)</i>	-	-	-	-	.107** [.053]	-
<i>LnGERD*PoliticalRights(t-2)</i>	-	-	-	-	-	-.007 [.038]

LSDV Rsq.	.893	.894	.893	.899	.898	.899
Within Rsq.	.174	.180	.173	.182	.177	.178
Valid N	713	713	713	680	680	680

Std. Errors in brackets *sig. at 10% **sig. at 5% ***sig. at 1%

6. Concluding remarks

This article has developed an assessment of the institutional role in shaping the efficiency of R&D efforts in developing countries' innovation systems. In orthodox approaches, the institutional environment is often taken for granted, and even in evolutionary empirical assessments there are scant efforts in qualifying the role of institutions as moderators of inputs in the dynamics of innovation systems.

Even though some recent attempts have been made to assess efficiency and institutional issues in innovation systems (Edquist and Zabala-Iturriagagoitia, 2015; Tebaldie and Elmslie, 2013), they still fall short in addressing the interactive dynamics of innovation-related investments and the institutional context. More than that, laggard innovation systems are widely left out of related studies, making empirical evidence strongly biased towards the context of developed nations.

As our findings demonstrate, institutional quality matters for the efficiency of innovation inputs. At least that seems to be the case for labor productivity and patenting behavior. Hence, it is hardly acceptable that catching-up processes will take place without the proper institutional conditions. Even though these institutional dimensions may not be connected directly with public and private routines of innovation systems, they represent the existence of inclusive institutions (Acemoglu and Robinson, 2012) that set benign incentives for business firms and entrepreneurs. A future research avenue in this regard might be directed towards addressing the propensity of business enterprises R&D expenditures (BERD) in inadequate institutional environments. There are enough reasons to believe that there might be a link between lower levels of BERD and a deficient structure of incentives for economic agents.

Furthermore, as we have observed, innovation policy in developing countries should be oriented towards solving institutional imbalances, rather than (just) pouring additional financial resources in the system. This is likely to represent a more effective strategy in shaping evolutionary trajectories in laggard innovation systems. We are not making a plea for lower or stagnant levels of R&D investment. Findings have highlighted the positive effects of these expenditures even in the absence of proper institutional conditions. Rather, we make a claim for the improvement of the quality of institutions to drive a more efficient appropriation of these resources. What appears to be the most compelling solution for this puzzle is a greater commitment to educational levels of the population. First, empirical evidence allows assuming that schooling levels drive institutional evolution (Glaeser et al., 2004; Tebaldi and Elmslie, 2008). Second, as the inclusion of the variable "Schooling" in our assessment (standing for mean years of schooling) has stressed, the investment in human capital pays off in terms of innovative output. Therefore, if developing countries' governments want to establish successful innovation policies, they might as well start by coordinating these initiatives with educational efforts.

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Notas

1. *Acknowledgments*: Bruno Fischer acknowledges support by the São Paulo Research Foundation (FAPESP – Project 2016/17801–4) established in the School of Applied Sciences of the University of Campinas (UNICAMP).

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3. *For an application of interaction models on innovation dynamics*, see Goedhuys et al. (2016).

4. *The 2016 classification can be found at*: <http://data.worldbank.org/about/country-and-lending-groups>.

Appendix I. List of Countries Included in the Analytical Exercise

Labor productivity estimations

Brazil, Bulgaria, Cambodia, China, Colombia, Costa Rica, Ecuador, India, Indonesia, Jamaica, Malaysia, Mexico, Pakistan, Peru, Philippines, Romania, South Africa, Sri Lanka, Thailand, Turkey, Vietnam.

Patenting activity estimations

Algeria, Armenia, Azerbaijan, Bolivia, Botswana, Brazil, Bulgaria, Cambodia, China, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Ethiopia, Georgia, Guatemala, Honduras, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Kyrgyz Republic, Lao PDR, Lesotho, Madagascar, Malaysia, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Nicaragua, Pakistan, Panama, Paraguay, Peru, Philippines, Romania, Senegal, South Africa, Sri Lanka, Tajikistan, Thailand, Tunisia, Turkey, Uganda, Ukraine, Vietnam.