Efficiency and economic growth in Latin America: The case of Colombia

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Outline

Outline

Introduction

- Our study has two main starting points:
  - The literature that analyzes the links between institutions and long-run economic growth.
  - The literature on activity analysis that measures the efficiency and productivity of decision making units (DMUs).

Introduction

Institutions and growth

- Institutions have been identified as the fundamental cause of long-run economic growth:
  - Some of the most influential contributions in the field have thousands of citations.
  - Nobel Prize winners are among the contributors to this field.
  - Prominent contributions include:
    - Williamson (1985).
    - North (1990).
    - Acemoglu et al. (2005).
    - Menard and Shirley (2005).
    - Easterly and Levine (2003).
    - Rodrik et al. (2004).
    - Glaeser et al. (2004).
    - Acemoglu and Robinson (2012).
    - Etc.

Introduction

Institutions and growth

- According to this literature, institutions are viewed as the legal and social rules that govern economic systems.
- Because of this intrinsic nature, they embody the structure of incentives in societies.
  - Accordingly, the institutional theory of development tries to understand how different rules and norms reward the creation of markets and growth-enhancing activities.

Introduction

Institutions and growth

- Whereas most of these contributions favor the institutions view, some critical views exist as well:
  - For instance, Glaeser, La Porta and López-de-Silanes (J Ec Growth, 2004) found that growth and human capital is what leads to institutional improvement.

Introduction

Efficiency and productivity of Decision Making Units (DMUs)

- There is a voluminous frontier production function literature that has been measuring the efficiency and productivity of DMUs.
- This literature is based on the pioneering work of Michael J. Farrell (1957) and Sydney Afriat (1972).
- Since these early contributions, the number of developments in the field has grown exponentially, to the point that there is a specialized journal in the field (*Journal of Productivity Analysis*).

Introduction

Efficiency and productivity of Decision Making Units (DMUs)

- The number of contributions has increased from both methodological and empirical perspectives.
  - It includes applications in fields such as banking, environmental and energy economics, health, local government and the public sector in general, macroeconomic convergence, etc.
  - Papers have therefore been published in a wide range of journals (*AER, IER, EER, JBF, JME, JMCB, JPE, RSUE...*)
- However, since contributors have different backgrounds (economics as well as O.R.), contributions also exist in the areas of engineering, physics, etc.

Introduction

Efficiency and productivity of Decision Making Units (DMUs)

- From an economics point of view, the interested reader can revise, for instance:
  - Murillo-Zamorano, L. R. (2004). Economic efficiency and frontier techniques. *Journal of Economic Surveys*, 18(1), 33-77.
- Although many other surveys and relevant books exist, which focus on different methodologies to measure efficiency (mainly DEA, Data Envelopment Analysis, and SFA, Stochastic Frontier Analysis).

Introduction

Efficiency and productivity of Decision Making Units (DMUs)

- We will focus on the contributions to this field whose DMUs were either countries or regions, using either parametric or nonparametric methods:
  - Färe, R., S. Grosskopf, M. Norris and Z. Zhang (1994), "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries?, *American Economic Review*, 84(1), 66?83.
  - Kumar, S. and R.R. Russell (2002), "Technological Change , Technological Catch-up , and Capital Deepening: Relative Contributions to Growth and Convergence", *American Economic Review*, 92(3), pp.527?548.
  - Henderson, D. J., R.R. Russell (2005), "Human Capital and Convergence: A Production?Frontier Approach", *International Economic Review*, 46(4), 1167-1205. ISO 690
  - Angelopoulos, K., A. Philippopoulos and E. Tsionas (2008), "Does public sector efficiency matter? Revisiting the relation between fiscal size and economic growth in a world sample", *Public Choice*, 137(1?2), 245?278.

Introduction

Aims and context

- The objective of this article is to determine the efficiency levels of Colombia from an international perspective, and how this might affect growth.
- For this, we will estimate frontier production functions with an output (GDP) and two inputs: physical capital and human capital.

Introduction

Aims and context

- The estimated production functions allow determining the position of Colombia in relation to the variables derived from the technology, i.e.:
  - efficiency levels, returns to scale, technical change, and specific technical change of Colombia.
- In a second stage we will consider countries' government quality levels
  - Then we will be able to ascertain if the quality of government are related to the country's efficiency levels.

Introduction

Aims and context

- In this sense, we hypothesize that countries with a quality institutional framework will be those obtaining higher relative efficiency values.
  - This link would operate through the use of formal rules (common laws, regulations), informal norms (conventions, norms of behavior and self-imposed codes of conduct), or coercive characteristics of both, of each country.
- If this were the case, the consolidation of a political and public framework that generates quality institutions would be essential for economic growth and improving a country's efficiency levels.

Introduction

Aims and context

- We will conclude with a final exploration linking economic growth with variables that are representative of the importance and quality of public sector management.
  - In this sense, if results are statistically significant, it will be possible to determine the importance of public sector inefficiency on economic growth.

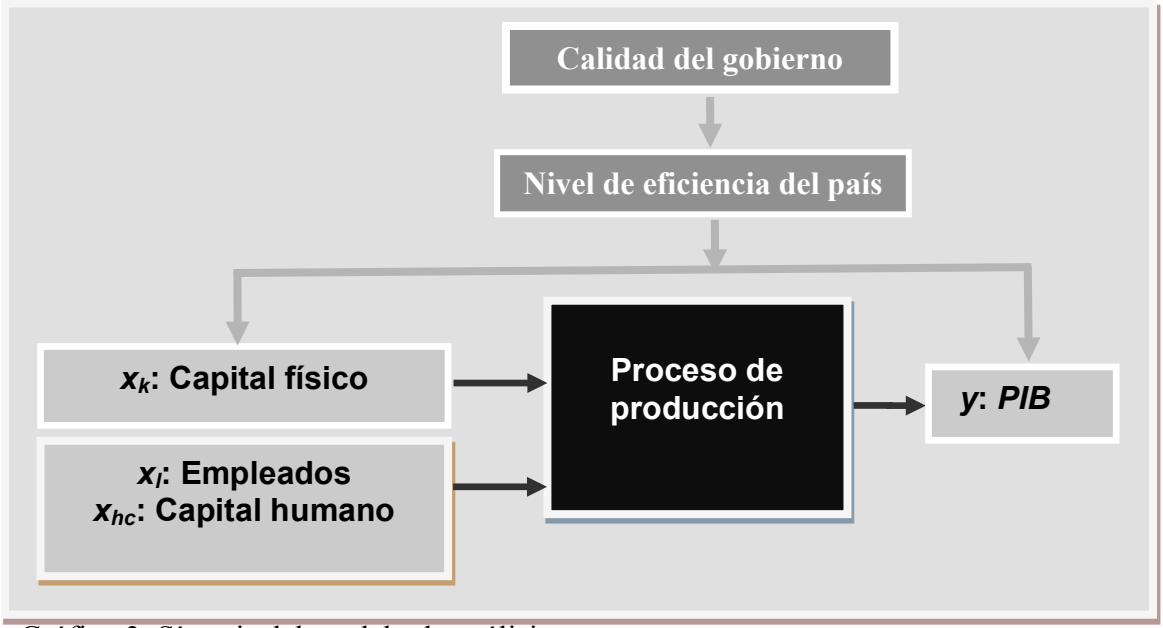

Gráfico 3. Síntesis del modelo de análisis

Fuente: elaboración propia

Outline

Methodology: efficiency concept and frontier production functions

- Starting from the modern theory of production, the concept of efficiency is derived from productivity estimates.
  - Having a specific productivity level, we try to ascertain how DMUs fare w.r.t. their competitors.
- The systematic comparison (benchmarking) between the productivity of DMUs in the same sector underlies the concept of technical efficiency.

Methodology

- Our study is based on standard parametric methodologies.
- We will consider several specifications for robustness reasons, including Cobb-Douglas as well as Translog.
- Regarding the estimation methods, we will consider OLS, panel data techniques as well as parametric frontier estimation.

The Cobb-Douglas production function

- As is well known, the Cobb-Douglas production function is defined as a linear function of output that depends on the inputs, with coefficients β that define the technology.

$$log(y_{it}) = \beta_0 + \sum_{j=1}^{2} \beta_j log(x_{jit}) + \theta t + \varepsilon_{it} \quad (1)$$

where

i:	unit under analysis
t:	time
ε_{it}:	error term, $\varepsilon_{it} \sim (N(0, \sigma_\epsilon^2))$.
θ:	technical change ($\theta > 0$ implies technical progress).

Stochastic frontier production function

- Introduced by Aigner et al. (1977) and Meeusen Van Den Broeck (1977), the estimation of the stochastic frontier is a generalization of the standard regression model.
  - Peculiarity: due to inefficiency, each firm i produces less output than its potential.
- This inefficiency is captured by a half-distributed error term $(0 < \xi_{it} \leq 1)$.
  - When $\xi_{it} = 1$ the analyzed DMU is obtaining its maximum possible level of output, given the inputs consumed x_{jit}
  - When $\xi_{it} < 1$, the unit is not producing its potential level.

Stochastic frontier production function

- In the Cobb-Douglas production function, $u_{it} = -log(\xi_{it})$ would correspond to the inefficiency term, and ν_{it} the error term. Therefore, the function to be estimated is:

$$log(y_{it}) = \beta_0 + \sum_{j=1}^{2} \beta_j log(x_{jit}) + \theta t + \nu_{it} - u_{it} \qquad (2)$$

- The interpretation of the coefficients ν_{it} and u_{it} is as follows:
  - ν_{it} represents the specification and measurement error, assumed to be i.i.d. $N(0, \sigma_\nu^2)$.
  - The term u_{it} is half-distributed (nonnegative) and represents inefficiency.

Panel data frontier estimation

- The model is described as follows:

$$log(y_{it}) = \beta_0 + \sum_{j=1}^{2} \beta_j log(x_{jit}) + \theta_t t + \nu_{it} - u_{it} \qquad (3)$$

where ν_{it} is the symmetric error term, u_{it} is the half-distributed (non-negative) inefficiency term.

Panel data frontier estimation

- Battese & Coelli (1992) propose two possible specifications for the inefficiency: i) time-invariant ($u_{it} = u_i$) and ii) time-variant efficiency, which would correspond to:

$$u_{it} = exp\{-\eta(t - T_i)\}u_i \tag{4}$$

where T_i corresponds to the last period, η is the time trend ($\eta > 0$ indicates inefficiency decreases over time, $\eta < 0$ indicates the opposite).

Determining the impact of environmental variables

- An extension that has received great interest is the search for the determinants of inefficiency.
  - The initial proposals are due to Pitt (1981) and Kalirajan (1981) who defined the so-called "two-stage model".
- Two-stage models have received severe criticisms because
  - They are inconsistent, contradicting the initial assumptions of i.i.d. inefficiencies;
  - They consider that environmental variables are separable from the technology to measure efficiency (Badin et al., 2014).

Determining the impact of environmental variables

- A possible solution: to simultaneously estimate the parameters of the production function and the inefficiency model.
  - In this sense, Battese & Coelli 1995 define the following specification:

$$u_{it} = z_{it}\delta + W_{it} \tag{5}$$

where W_{it} is distributed as a half-normal, and the truncation point $-z_{it}\delta(W_{it} \geq -z_{it}\delta)$.

- The simultaneous estimation of the parameters of the stochastic frontier and the model that explains the levels of inefficiency takes place from the following expression:

$$log(y_{it}) = \beta_0 + \sum_{j=1}^{2} \beta_j log(x_{jit}) + \theta_t t + \nu_{it} - (z_{it}\delta + W_{it}) \tag{6}$$

The Translog production function

- The Translog production function is an extension of the Cobb-Douglas function, which also gives the technology more flexibility. Its specification is as follows

$$log(y_{it}) = \beta_0 + \sum_{j=1}^{2} \beta_j log(x_{jit}) + (1/2) \sum_{k=1}^{2} \sum_{j=1}^{2} \beta_{kj} log(x_{kit}) \theta t + \varepsilon_{it} \tag{7}$$

- However, the greater flexibility also has negative aspects because, unlike the Cobb-Douglas function, the Translog function is not globally monotonic.

Outline

Data and variables

Macroeconomic data

- We use the Penn World Table (PWT) database.
- Other alternatives: OECD Productivity Database; Conference Board Total Economy Database, EU KLEMS, GGDC Productivity Level Database.
  - However, none of them allows to perform comparisons between countries with different levels of development.
- PWT 8.0 (edited in July 2013) offers indicators of capital stock and human capital, allowing multilateral comparisons of efficiency and productivity among countries with a very fine definition of inputs.
- Future research: use the most updated version of PWT (9.0), use other types of capital (social capital, intangibles...).

Data and variables

Macroeconomic data

- Previous studies that have used this database in a similar context:
  - Färe et al. (1994, to compare productivity of 17 OECD countries).
  - Chambers et al. (1996).
  - Ray & Desli (1997).
  - Färe et al. (2000).
  - Kumar & Russell (2002).
  - Henderson & Russell (2002).
  - Färe et al. (2004).
  - Angelopoulos et al. (2008).
  - Pires & García (2012).
  - Badunenko et al. (2013).
- With the exception of Angelopoulos et al. (2008) and Pires & García (2012), all of them use nonparametric estimation techniques.
- In contrast, we will use stochastic parametric techniques, since we are interested in determining if results are consistent with the axioms and postulates the production theory.

Table : Definition of the macroeconomic variables

Variable	Type of variable	Definition
y : *rgdpo*	Output	GDP, PPP adjusted, thousands 2005 $US
x_l	Input	Number of workers (millions)
x_{hc} : *hc*	Human capital	Human capital per person, based on school years (Barro and Lee, 2013), as well as returns on education (Psacharopoulos, 1994)
x_k : *rkna*	Physical capital	Capital stock, thousands 2005 $US

Data and variables

Government quality data

- We use the Worldwide Governance Indicators (2014), provided by the World Bank:
  - It offers government effectiveness data for the 1996–2012 period.
- Merging both databases, the final sample consisted of 133 countries and 16 years (1996–2012).

Table : Definition of the government quality data

Variable	Type of variable	Definition
VAA: voice and accountability	Government quality	Perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media
PSAV: political stability and absence of violence/terrorism	Government quality	Perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism.
GE: government effectiveness	Government quality	Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies
RQ: regulatory quality	Government quality	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development
ROL: rule of law	Government quality	Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
COC: control of corruption	Government quality	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests

Outline

Table : Estimation results for the production function, Cobb-Douglas

Variables	Parameters	PANEL DATA (Model I, Cobb-Douglas)	PANEL DATA (Model II, Translog)	PANEL DATA (Model III, Translog with govt.quality)	PANEL DATA (Model IV, Translog with govt.efficacy)
Inefficiency Trend	variable	0.0063906***	0.0142043***		
Mean inefficiency	$\bar{Z}$	0.427771	0.460832	0.7011875	0.6948282

Results for the production functions and inefficiency levels

Model I

- The first column corresponds to the Cobb-Douglas production function.
  - There is also positive technical change—albeit close to zero.
  - The inefficiency level is high (0.4277), implying that countries experience difficulties to reach their GDP full potential—given their endowments human and physical capital endowments.

Table : Estimation results for the production function, Translog

Variables	Parameters	PANEL DATA (Model I, Cobb-Douglas)	PANEL DATA (Model II, Translog)	PANEL DATA (Model III, Translog with govt.quality)	PANEL DATA (Model IV, Translog with govt.efficacy)
Inefficiency Trend	variable	0.0063906***	0.0142043***		
Mean inefficiency	$\bar{Z}$	0.427771	0.460832	0.7011875	0.6948282

Results for the production functions and inefficiency levels, Translog functions

Models II, III and IV

- Results are generally robust when considering results corresponding to a Translog production function (columns 2, 3, 4).
  - However, in this case, inefficiency levels are even higher.

Table : Estimation results for the production function, government quality variables

Variables	Parameters	PANEL DATA (Model I, Cobb-Douglas)	PANEL DATA (Model II, Translog)	PANEL DATA (Model III, Translog with govt.quality)	PANEL DATA (Model IV, Translog with govt.efficacy)
Inefficiency Trend	variable	0.0063906^{***}	0.0142043^{***}		
Mean inefficiency		0.427771	0.460832	0.7011875	0.6948282
Government quality	$\bar{Z}$			-0.6145916^{***}	
Government efficacy					-0.7566569^{***}

Results for the production functions and inefficiency levels, government quality variables

The role of the quality of government

- The results presented above do not explore the determinants of inefficiency, except for the time trend—which increases to 0.0142 for Model II.
- The last two columns correspond to the estimation including government quality variables.
  - Results corroborate the expectations, i.e., the coefficient is negative (-0.6146) and significant, indicating that countries with high government quality have low inefficiency levels.
  - Therefore, the favorable effect of the quality of public institutions on the real economy is evident—either by the direct participation of the public sector or by the government's ability to regulate private activities.

Table : Estimation results for the production function, government efficacy variable

Variables	Parameters	PANEL DATA (Model I, Cobb-Douglas)	PANEL DATA (Model II, Translog)	PANEL DATA (Model III, Translog with govt.quality)	PANEL DATA (Model IV, Translog with govt.efficacy)
Inefficiency Trend	variable	0.0063906^{***}	0.0142043^{***}		
Mean inefficiency		0.427771	0.460832	0.7011875	0.6948282
Government quality	$\bar{Z}$			-0.6145916^{***}	
Government efficacy					-0.7566569^{***}

Results for the production functions and inefficiency levels

The efficacy of public administration and public services

- In the last column (Model IV) we factor in the efficacy of the public administration and public sector in general.
  - This dimension has an even greater impact than the average value of government quality.
  - This confirms that, in fact, the behavior of the public sector and its efficacy levels directly affect the levels of efficiency of the country.

Results corresponding to the obstacles to growth

- It has become clear that poor quality institutions have an impact on the country's levels of inefficiency.
- However, we are now interested in the direct impact of public sector efficiency levels on the economic growth of the countries.
- To do this, we will take the model proposed by Angelopoulos et al. 2008 to explain the factors that affect the economic growth of a country:

$$growth_{it} = \beta_0 + \beta_1 public_{it} + \beta_2 public_{it} \times efic_{it} + \sum_{j=3}^{4} \beta_j X_{it} + \varepsilon_{it} \quad (8)$$

Results corresponding to the obstacles to growth

Table : Efficiency's impact on economic growth

	Parameter	POOLED DATA (Model I)	PANEL DATA (Model II)
Constant	β_0	0.071498^{***}	0.074824^{***}
public	β_1	-0.135340^{***}	-0.176622^{***}
(*public* $\times$ *eff*)	β_2	0.137599^{*}	0.166404^{*}
investment	β_3	0.059975^{*}	$0.056371^{\cdot}$
$log(GDP/pop)$	β_4	-0.005439^{*}	-0.005260^{*}
R^2 adjusted		0.046	0.058
# obs.		1976	1995

Results corresponding to the obstacles to growth

- As shown in the table, regardless of the method of estimation, the regressors' signs coincide with expectations:
  - the size of the public sector impacts negatively on growth;
  - but its efficiency (*public* $\times$ *efficiency*) impacts positively.
- It is also clear that investment favors growth and that there is a convergence process because countries with higher GDP per capita have lower growth rates.

Efficiency results for Colombia

- We focus the results now on the case of Colombia.
- For this, we compare our results with others found in previous studies employing nonparametric techniques.
  - Kumar & Russell 2002.
  - Henderson & Russell 2005.
  - Badunenko et al. 2013.

Efficiency results for Colombia

Table : Aggregate efficiency estimates, Colombia, previous studies

Kumar and Russell (2002)	1965	1990
Colombia	0.41	0.45
Latin America	0.66	0.56
OECD	0.75	0.8
Total sample	0.64	0.65
Henderson and Russell (2005)	**1965**	**1990**
Colombia	0.48	0.54
Latin America	0.72	0.58
OECD	0.79	0.78
Total sample	0.68	0.67
Badunenko, Henderson y Russell (2005)	**Average 1965-2007**	
Colombia	0.39	
Latin America	0.48	
OECD	0.60	
Total sample	0.50	

Efficiency results for Colombia

Table : Aggregate efficiency estimates, Colombia, our study

Our results (Model II)	Average
Colombia	0.48
Latin America	0.42
OECD	0.65
Total sample	0.46

Efficiency results for Colombia

- In the previous studies, Colombia's relative efficiency levels were low–lower to any of the groups with which it is compared.
- However, in our case Colombia's efficiency levels almost coincide with the average value for the sample analyzed, outperforming the rest of Latin America countries.
  - But the gap with OECD countries is still remarkable.

Efficiency results for Colombia

- These results would point to a catching up process that would allow Colombia to approach the efficiency frontier, especially in recent years.
  - Improvements are still pending, though, because its level of efficiency does not even reach half of the full potential.

Efficiency results for Colombia: controlling for government quality

- A more detailed analysis will allow us to determine the impact of government quality on efficiency.
  - For this we compare the results of Models II, III and IV.

Efficiency results for Colombia: controlling for government quality

Table : Government quality and efficiency, Colombia

	Efficiency model II	Efficiency controlling for government quality	Impact of government quality on inefficiency (% increase)	Level of government quality
Model III				
Colombia	0.48	0.70	51.40%	-0.53
Latinamerica	0.42	0.68	55.43%	-0.15
OECD	0.65	0.85	62.27%	1.18
Total sample	0.46	0.70	54.06%	0.00
Model IV				
Colombia	0.48	0.73	57.12%	-0.17
Latinamerica	0.42	0.66	52.10%	-0.21
OECD	0.65	0.87	67.67%	1.35
Total sample	0.46	0.70	54.06%	0.04

Efficiency results for Colombia: controlling for government quality

- As shown for model II, it is clear that the existing inefficiency is considerable; except for the OECD countries, the level of efficiency does not even reach half of the potential level.
- However, when we control for government quality (model III), efficiency levels increase significantly.
  - In both cases, Colombia's efficiency level is around the average for all countries in the sample, slightly above the Latin American average and still far from the OECD average.

Efficiency results for Colombia: controlling for government quality

- As shown in column (3), in all cases, more than half of the inefficiency found is due to the respective levels of government quality.
  - This reiterates the importance of the efficiency of public management for any economy.
- Importantly, column (3) does not present the highest percentage for Colombia
  - Thus, in other geographical areas the impact of government efficiency is even higher.

Outline

Conclusions

- As claimed in relevant contributions (North 1994, Acemoglu & Robinson 2008), an essential determining factor explaining differences in prosperity among countries is related to their economic institutions.
- With this theoretical basis, we analyzed the efficiency differences for 134 countries, with a special focus on Colombia.

Conclusions

- Results show technical inefficiency levels are high, and growing over time.
- Introducing institutional variables (quality of government) affects significantly the levels of inefficiency.
- Results also indicated that higher levels of public efficiency translate into faster economic growth.
  - This implies that, in developing countries, a good growth strategy requires improving the quality of their institutions.

Conclusions

- The results for Colombia indicate that there is a long way to go because GDP per capita levels are still far below the OECD average.
- It has also been found that more than half of the country's inefficiency is related to relatively low institutional quality.
- Thus, improving the efficiency levels of the country requires improving the quality of government and, ultimately, the effectiveness of the public sector.