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Economic Development and Logistics Performance. A Probabilistic Approach

Desarrollo económico y desempeño logístico. Un enfoque probabilístico

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Abstract

There is not a consensus about a complete set of explanatory variables that could ultimately explain the linkages behind achieving economic development. In spite of this, determinants of economic development and especially the linkages between economic development and logistics performance are topics of growing interest within the recent literature, both in economic growth theory and maritime studies.

In this paper our attention is focused on the importance of logistics performance as one of the explanatory variables for economic development. To this end, we have estimated different econometric models in an attempt to explain the probability of a country being economically developed, based on a number of traditional explanatory variables (including natural endowments, economic openness, and institutional framework, among others) along with logistics performance as the major theoretical innovation. The applied methodology follows the binary choice framework described in probit models.

In the next step the research is concentrated on the determination of possible endogenous causalities of the economic development. In the last section we estimate the logistics gap, measured as a probability of reaching economic development that varies due to differences in the levels of logistics performance.

Our main finding shows that logistics performance is closely related to the probability of a country being developed. Specifically, the probability of being a developed country increases when logistics performance is improved.

Keywords: Logistics Performance; Economic Development; Probabilistic Functions.

Resumen

En la literatura económica, no existe un pleno consenso acerca del conjunto de variables explicativas que inciden sobre el desarrollo económico. Por otra parte, la vinculación entre el crecimiento y desarrollo económico y el desempeño logístico son tópicos de creciente interés en la literatura especializada.

En este documento prestamos especial atención al papel del desempeño logístico como una de las variables explicativas del desarrollo económico. Para este fin, hemos estimado diferentes modelos econométricos que buscan explicar cómo se afecta la probabilidad de un país de ser desarrollado al considerar algunas variables explicativas tradicionales (la dotación de recursos naturales, la apertura económica, y variables institucionales, entre otras), junto con el desempeño logístico. La metodología aplicada se basó en la utilización de modelos probit.

El principal hallazgo del trabajo ha sido el de encontrar una incidencia positiva entre el desempeño logístico y la probabilidad de un país de ser desarrollado. Particularmente, la probabilidad de un país de ser desarrollado se incrementa cuando mejora el desempeño logístico.

Palabras clave: Desempeño logístico; Desarrollo económico; Funciones probabilísticas.

JEL Classification: F14, F19.

1. Introduction

Literature on economic development is constantly investigating the causes that support development. Although there are numerous theoretical and practical studies on the subject, economists have not agreed on a given set of variables that can explain the determinants of economic growth, which is an ongoing point of theoretical interest.

Within this area of economic research, the role of infrastructure in economic growth has also been examined. Rozas and Sánchez (2004) performed a review of economic literature which confirms the direct – and highly significant – relationship between infrastructure development and economic growth, achieved through improvements in productivity and competitiveness. A major part of the empirical evidence gathered shows that investment in infrastructure makes a direct contribution to the GDP growth, and usually leads to improvements in profitability and a reduction in costs for the different economic agents of the Society.

The *ibid* study also concludes that, in order to analyze the effect on economic development, it is necessary to consider infrastructure and its services as a whole (the "infrastructure services"). The direct effect derives from the intermediate services provided to private companies by infrastructure service providers, assuming that better service conditions lead to better productivity. The indirect effect results from the complementarity between private and public capital in production. Thus, a rise in social capital or public infrastructure increases the productivity of the private sector, boosting GDP growth at a national and domestic level.

Various studies have been carried out in this sense, such as Wang (2010), who studies the dynamic role of regional logistics in economic development, reaching the conclusion that there is a profound relationship between logistics development and economic development in a given region (at national or sub-national level). Previously, Zhang (2002) had also found a circular relationship: the better the logistics, the higher the level of development, which leads to yet better logistics and other additional positive impacts, e.g. "*At the same time modern logistics development also changed the regional economic growth ways and promoted the formation of new industries and optimizes the regional industrial structure*."

At a nationwide level, the results from Rozas and Sánchez (2004) indicate that the provision of basic infrastructure is a key differential factor

in the explanation of growth gaps. For instance, the better provision of basic infrastructure, the better behaviour of the economic growth, because the reduction in transport costs and the enhancement of operations in each economic activity allow economic agents to access input and output markets more efficiently, while consequently reducing transaction costs. In a similar way, Gillen (2003) presents a review of the empirical literature investigating the relationship between transportation infrastructure and services, and economic growth. The author concludes that a better endowment of infrastructure may reduce inventory and transportation costs, improve logistics and facilitate smooth relationships with customers and suppliers.

A related matter present in the literature is that, when trying to identify growth sources and reach political recommendations, it is vital to know the structural relationships underlying the growth, specifically the quality of institutions and of management, both private and public. In this sense, the existence of weak institutions and infrastructure when a decade begins can obstruct economic growth in that decade.[1]

In summary, the literature shows that infrastructure services contribute to national product growth and have an impact on four aspects of economic development: the expenditure structure of businesses, factors of productivity, connectivity and accessibility, and the general welfare of the population. Costs drop while investment improves accessibility to input and service markets, and improves the efficiency of input supply chains and the storage and marketing of goods: that is, logistics.

The quantity, quality and efficiency of infrastructure services are determined by the interaction of the key components of the markets: physical infrastructure, conditions created by sectoral policies, regulation and the characteristics of the market. In the case of transport infrastructure services, the concept that arises is logistics, which is associated with two basic ideas: *"a) that it is supported by infrastructure and transport services, key elements to its purpose of providing inventories in an efficient manner; and b) that such conception implies the idea of integration, allowing an efficient disposition of transport infrastructure and related services, maximizing their contribution to the improvement of productivity and competitiveness"* (Cipoletta *et al.*, 2010)[2], and hence to economic development.

For the aforementioned reasons, it is necessary to incorporate "logistics" in the study of the determinants of economic development. Two recent papers (Sánchez *et al.*, 2012; and Coto-Millán *et al.*, 2013) have incorporated "logistics" as a key determinant of economic development (the first one) and economic growth (the second one). In both cases the results were in favour of a positive incidence between logistics and economic performance.

Particularly, in Coto-Millán *et al.* (2013) authors showed that in a framework of aggregate global production function expanded with the Logistics performance index, logistics activity "is estimated to have a significant, positive and important impact on the generation of economic growth for the world's countries in the period 2007–2012. The contribution by logistics in 2007–

2012 means that increases from 1% in logistics performance provide global economic growth ranging between 0.011% and 0.034%".

Based on these considerations, this paper will focus on highlighting the importance of logistics performance as one of the main explanatory variables of economic development. To this end, this introductory section has the aim of providing a preliminary approach to the literature on the determinant variables of economic development in order to find the main ones generally agreed in different studies and take them into account for our own econometric model.

1.1. Brief revision of the empirical literature on the determinants of economic development

Despite the previously mentioned lack of consensus in the economic literature in establishing a set of variables that explain development, it is possible to recognize some overlap between various empirical papers on the subject.

Before creating a list of possible causes of economic development, it is necessary to clarify what such a concept means. To achieve this purpose, we will provide a definition given by Herschel (1962) and Olivera (1959) in which growing signifies the expansion of the social product over time and economic development signifies the increase in the ratio between the actual social product and the potential social product over time.

In practice, the term "economic development" is used to assess and compare the capacity of countries or regions to generate wealth, with the purpose of improving and maintaining the economic and social welfare of its population. Thus, economic development can be seen as the result of well-being upgrades in a given economic system, which could be achieved because growth rates remained high, capital accumulation processes were strengthened, and social-economic prosperity showed a sustained improvement. In development economics it has been sufficiently proven that such qualitative leaps are not produced by quantitative improvements in a single variable. Instead, there are several variables affecting those increases or decreases in the social and economic welfare levels, and such variables can be determined by domestic as well as external factors.

Hence the process of economic development intends to turn "developing countries" into "developed countries"[3]. This implies a significant improvement of the variables that represent the population's income, the inhabitant's lifestyle, the production system, the government's institutionalism, education, health, investment rate, consumption levels, public policies, the system of goods and services distribution, and a wide variety of other factors.

In order to reach a consensus on the main variables that should be considered in our econometric model of development determinants, some empirical works were selected from the literature on development economy. The following list presents the variables, and their statistical series, that were considered for inclusion in the econometric analysis of our models in each case:

Calderõn *et al.*. (2004) utilized a panel to study the impact of infrastructure on growth. The variables used come from Loayza *et al.* (2005), a paper on growth in Latin America and the Caribbean.

The variables included in this case were: GDP per capita; human capital; financial development (private sector assets in banks and other financial institutions over GDP); governmental burden (government consumption over GDP); trade openness (exports and imports over GDP by area; population; access to sea; governance; inflation; evolution of real exchange rates; and terms of trade (see Table 1).

It is worth mentioning two more modern but well established measures of development as the UN Human Development Index (HDI) and the OECD Better Life Index (BLI), which shift the focus of development economics from national income accounting to people-centered policies in order to capture social progress; as well as one of the newest tools, the Social Progress Index (SPI) which measures the well-being by observing social and environmental outcomes.

Other authors have also taken into account other types of variables, such as policies, institutional factors, geography, and integration. For instance, Easterly (2005) authored a chapter of the economic growth manual that assesses the impact of different policies. The list of variables is quite similar to the previously mentioned case. In this model, the new included variables were: governmental deficit/superavit (surplus); difference between formal and informal exchange rates; private sector loans; and education (log).

Additionally, Rodrik *et al.* (2002) focused on the strength of the measures of institutional factors' impact versus geography and integration. Thus they utilized numerous variables that refer to each of these factors. Some of the strongest variables were: "rule of law"; distance from the equator; portion of the population that speaks English; portion of the population that speaks other European languages; Political Freedoms Index; and geographical area.

An interesting collection of variables and their effects can be seen in Loayza *et al.* (2005), whose list should be taken into consideration:

Category	Variable	Impact[1]
Transitional Convergence	Initial GDP	[-]: 1,3,4,5,6,7,8,9,10
Structural Policies and Institutions		
Physical Capital	Investment to GDP ratio	[+]: 1,2,3,4,9
		[0]: 5
Human Capital	Schooling (years, enrolment)	[+]: 2,3,4,5,7,8,10, [0]: 1,6,9
	Literacy	[+]: 1,5,9
	Fertility	[-]: 9
Financial Development	Credit to Private Sector (% GDP)	[+]: 7,8,10

	M2/GDP	[+]: 3,6
Trade Openness	Exports and Imports (% GDP)	[+]: 3,5,8,9,10
		[0]: 1,7
Governments Burden	Government Consumption (% GDP)	[-]: 1,2,3,5,6,7,8,9
Income Inequality	Income Shares	[0]: 1
Governance	Civil Liberties, Political Rights	[+]: 1,4,7,8,10
	Rule of Law	[+]: 5,9
Infrastructure	Telephones per capita	[+]: 8
	Energy per capita	[0/+]: 8
	Roads per area	[+]: 8
Stabilization Policies		
Inflation	CPI Inflation Rate	[-]: 1,2,3,5,6,7,8,10
	Inflation Volatility	[-]: 1
Real Exchange Rate (RER)	Degree of RER Overvaluation	[-]: 7,8,9
Overvaluation	Black Market Premium	[-]: 3,10 [0]: 2
Balance of Payments (BoP) Crisis	Frequency of BoP Crises Episodes	[0]: 9
External Conditions		
Terms of Trade Shocks	Changes in the terms of trade index	[+]: 2,3,5,6,7,8,9
		[0]: 1,10
Capital Flows	Private Capital Flows (% GDP)	[+]: 1,7
	Foreign Direct Investment (% GDP)	[+]: 7

Source: authors.

[1] [+] indicates a positive and significant relationship with economic growth,
[-] indicates a negative and significant relationship with economic growth, and
[0] indicates that the variable has no robust association with growth.
The references to the results in the empirical growth literature are listed in chronological order:
[1] De Gregorio (1992). [2] Corbo and Rojas (1993). [3] Easterly, Loayza and Montiel (1997). [4] Campos and Nugent (1998). [5] De Gregorio and Lee (1999). [6] Fernández-Arias and Montiel (2001). [7] Calderón and Schmidt-Hebbel (2003). [8] Calderón and Servén (2003). [9] De Gregorio and Lee (2003). [10] Blyde and Fernández-Arias (2004).

1.2. Selection of variables and contents of the paper

The explanatory variables of economic development presented in these recent studies provided us with tools for the selection of the variables that will be included in the econometric model proposal that will estimate the determinants of development, which are integral to the objective of this paper. On that basis, a good starting point for the selection of the determinant variables of economic development for our model could be the following:

- GDP per capita,
- Human capital (demographics),
- Inflation,
- Financial development,
- Institutional level,
- Trade openness,
- Natural endowment,
- Terms of trade and
- Income distribution.

In this sense, the function to be estimated in our econometric model proposes that economic development be seen as a function of *natural endowments, demographics, economics, institutional, equity*, and of course the main contribution of this paper, *logistics* and *transport*. The following section evaluates the inclusion of these variables in the development of an economic model.

After this introduction, section II develops several different econometric model estimations to explain the probability of becoming a "developed country" (based on a set of explanatory variables). The methodological approach for modelling is done with a probabilistic function (a probit or logit framework) where the dependent variable is the characterization of the incumbent economy (i.e. developed or developing economy). This section includes econometric treatment, challenges and results.

In the last part of the paper, the determination of the logistics gap is made. It is measured as the difference between the countries' probabilities of achieving economic development, based on their different logistics performance. A comparison of the results of the previous steps is done so as to measure the gap, focusing primarily on the differences in the level of the logistics performance index that have influence over the probability of being a developed country.

The conclusions of the research emphasize that an appropriate and steady logistics supply may play a strategic role in the probability of a developing economy achieving the benefits derived from being a developed economy.

2. Econometric Estimations

2.1 Econometric Background

The previous sections presented different theoretical approaches that relate economic growth with some important explanatory variables. This section begins with similar causality relationships but considers a probabilistic approach, where it is assumed that the dependent variable, being a developed country or not, is verified with a specific probability of occurrence based on the set of explanatory variables. Such an approach assumes a particular functional form of probability density for the perturbation terms. The most common are the logistics function and the normal function.

Choosing between both types of function is somewhat arbitrary, considering that the estimated average for any of the methods predisposes the subsequent distribution of the perturbation terms. There is also a corresponding relationship between the parameters estimated by both probability density functions, which implies, to a certain extent, the independence of the initial choice between one method and the other.

Although the two functions lead – in general – to similar results, a possible method for selecting between them is to use the Akaike Information Criterion (AIC). Based on this criterion it was chosen the probit method which uses the normal probability distribution function.

The probit models have the following generic form:

$$P(y = 1|x) = G(x\beta) \equiv p(x)$$

Where x is a 1xK vector of explanatory variables and **β** is a vector of kx1 estimated parameters. Meanwhile, G is the cumulative distribution function whose specific form - within the probit model - is the standard normal distribution:

$$G(z) = \int_{-\infty}^{z} (2\pi)^{-\frac{1}{2}} \exp\left(\frac{-z^2}{2}\right) \delta z$$

The objective of this kind of model is to explain the effects of the explanatory variables x in terms of response probability

Moreover, in the selection of explanatory variables, the authors have grouped them into five major groups: natural endowments, demographics, economics, institutional, and equity related. These groups may cause some debate as to the accuracy of locating a variable in a particular group when it may also be connected with another group. The approach taken was to place the explanatory variable in the closest group membership by the authors' criteria (see below).

Consequently, the generic form of the function to be estimated is as follows.

$$P(developed|developed = 1) = f\,(natural\ endowments, demographics, economics, institutional, equity) + \mu$$

It is important to note that we analyze the probability of being a developed country from econometric models that have the commonly used variables in economic growth theory, but considering the main objective of this paper we add new economic variables that reflect the change of behaviour in the logistics indexes. In this sense, the "economics" group of variables includes "logistics performance" and "shipping connectivity" (see Table 2 for more details).

2.2 DATABASE

In order to estimate the above general specification we use the variables presented in Table 2 that were collected from the World Development Indicators database of the World Bank[4]. These variables were grouped by the authors in the categories explained in previous sections, and are also presented with their definitions.

The variables selected for estimation are based on the following criteria: 1) their inclusion in the traditional theoretical models of development; 2) information availability, frequency, reliability of the source and the grade of substitution between proxy variables; 3) the inclusion of the variables "logistics performance" and "liner shipping connectivity".

Variable name	Definition	Group
connectivity index[2]	Liner Shipping Connectivity Index (LSCI) indicates how well countries are connected to global shipping networks based on the status of their maritime transport sector. The LSCI is not a measure of shipping performance, but one of accessibility.	economics
fdi	Foreign direct investment is the net inflow of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.	economics
gdppc_k_2000	GDP per capita is gross domestic product divided by mid-year population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data is in constant prices (U.S. dollars of 2000).	economics

[2] It is very important to note here that the connectivity index is applied within this paper only as a proxy of the accessibility to global trade and a country's level of integration into the existing liner shipping network. The variable included does not reflect the maritime 'performance'.

gfkf	Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.	economics
LPI	Logistics Performance Index overall score reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time. The index ranges from 1 to 5, with a higher score representing better performance.	economics
LPI_infrastructure	Logistics professionals' perception of country's quality of trade and transport related infrastructure (e.g. ports, railroads, roads, information technology), on a rating ranging from 1 (very low) to 5 (very high). Scores are averaged across all respondents.	economics
LPI_reach	Logistics professionals' perception of how often the shipments to assessed country reach the consignee within the scheduled or expected delivery time, on a rating ranging from 1 (hardly ever) to 5 (nearly always). Scores are averaged across all respondents.	economics
gini_index	Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.	equity
natural_resources_rents	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	natural endowment
Rule_of_law	This index provides detailed information and original data regarding a variety of 9 dimensions of the rule of law: 1. Limited Government Powers; 2. Absence of Corruption; 3. Order and Security; 4. Fundamental Rights; 5. Open Government; 6. Effective Regulatory Enforcement; 7. Access to Civil Justice; 8. Effective Criminal Justice; 9. Informal Justice	institutional

Additionally, to complete the set of explanatory variables it was necessary to include a financial variable that was available for all the countries considered in the required dates. The selected variable is the following:

kaopen	The Chinn-Ito index (KAOPEN) is an index measuring a country's degree of capital account openness. The index was initially introduced in Chinn and Ito (2006). KAOPEN is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).	financial

Source: authors.

2.3 Econometric treatment, challenges and results

The estimation process faced some major difficulties. Firstly, as the main focus of the paper was to analyze logistics performance as one of the determinants of economic development, the only available data provided by Logistics Performance Index (LPI) was from 2006 and 2009. This situation implied a clear constraint of data that did not allow the application of alternative methodologies, such as panel data.

In the second term, and in order to mitigate short-term cycles, we estimated moving averages of the last ten years for all those variables that present growth rates or shares in aggregate variables, which are sensitive to the effects of the cycle.

Next, many of the explanatory variables did not have information for all the countries in the years for which logistics performance data were available. Consequently, there was no available information on some of the explanatory variables previously listed, due to a simultaneous lack of information from the LPI and the required variables.

In most cases, some of the explanatory variables – according to the literature – were available for the required period only in a partial set of countries associated to the interest groups (developed or developing). Thus its parametric estimation was impossible, and the totality of explanatory variables could not be used.

The troubles previously mentioned were an obstacle not only for the estimation of a model that would consider all of the explanatory variables (once potential multicollinearity problems were solved), but also for the freedom levels in the selection of the other specifications.

As a result of all of the previous challenges, some combinations of explanatory variables used for estimating models have shown several failures. After adjusting some explanatory series, the combinations have reflect exclusively one of the two binomial possible outcomes (to be developed or undeveloped), meaning the lack of variability of the dependent variable 'y' and making the estimation unfeasible.

Table 3 shows the estimations of the models that solved the above mentioned difficulties, and also displays statistically significant parameters. It is composed of 15 models (among 48 estimated and tested) that meet the corresponding statistical tests, which will be explained below.

Table 3: Estimated Probit Models (source: authors)

Dependent variable: developed	Model_1	Model_2	Model_3	Model_4	Model_5	Model_6	Model_7	Model_8	Model_9	Model_10	Model_11	Model_12	Model_13	Model_14	Model_15
Regressors															
lpi	3.10	4.03	1.29	3.29	4.86				1.39		3.09	4.69	3.14	1.51	1.44
p-value	*0.00*	*0.00*	*0.05*	*0.00*	*0.00*				*0.04*		*0.00*	*0.00*	*0.00*	*0.02*	*0.00*
lpi_reach						2.24	1.58	1.81							
p-value						*0.02*	*0.03*	*0.01*							
lpi_infrastructure						2.82	1.73	1.66		2.74					
p-value						*0.00*	*0.01*	*0.00*		*0.05*					
connectivity_index		-0.03				-0.04				-0.12					
p-value		*0.04*				*0.01*				*0.00*					
gfkf									0.15						
p-value									*0.00*						
gdppc_k_2000			0.00						0.00	0.00					
p-value			*0.00*						*0.00*	*0.00*					
natural_resources_rents				0.02									0.02		0.04
p-value				*0.08*									*0.06*		*0.01*
gini_index					-0.23							-0.24			
p-value					*0.01*							*0.00*			
fdi								0.08							
p-value								*0.06*							
kaopen											0.42	*0.40*	*0.39*		
p-value											*0.01*	*0.06*	*0.01*		
rule_of_law														*1.76*	*1.86*
p-value														*0.00*	*0.00*
constant	-9.70	-12.01	-7.12	-10.47	-7.00	-15.38	-10.79	-11.71	-12.07	-11.12	-10.00	-6.35	-10.30	-5.43	-5.53
p-value	*0.00*	*0.00*	*0.00*	*0.00*	*0.04*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.02*	*0.00*	*0.00*	*0.00*
Number of Obs	*149*	*116*	*145*	*147*	*125*	*116*	*149*	*147*	*143*	*113*	*146*	*122*	*144*	*148*	*146*
LR Chi2	*112.98*	*93.00*	*18.04*	*114.87*	*109.20*	*105.35*	*121.18*	*47.19*	*15.69*	*15.20*	*117.02*	*26.50*	*50.84*	*128.88*	*28.07*
Pseudo R2	*0.65*	*0.65*	*0.86*	*0.67*	*0.82*	*0.73*	*0.70*	*0.70*	*0.89*	*0.91*	*0.69*	*0.84*	*0.70*	*0.76*	*0.78*

The above table shows that all of the estimated parameters in each of the models are statistically significant and show the expected signs (the only exception being the coefficient of connectivity, which shows a relationship contrary to expectation). The overall significance ratios also exhibit good behaviour, while the pseudo R squared is in all cases above 60%.

Sensitivity and specificity analysis

Sensitivity and specificity analyses are statistical measures of performance in a binary estimation. Sensitivity measures the proportion of actual positives which are correctly identified, while Specificity measures the proportion of negatives which are correctly identified. Table 4 presents the correctly classified ratio of each model and the correspondent sensitivity and specificity rates. It could be said that all models have a very high performance:

Table 4

Model #	Correctly Classified	Sensitivity Rate	Specificity Rate
1	89.9%	77.5%	94.5%
2	88.8%	80.6%	92.5%
3	95.9%	87.5%	99.1%

4	91.2%	80.0%	95.3%
5	95.2%	85.7%	97.9%
6	93.1%	88.9%	95.0%
7	92.0%	82.5%	95.4%
8	90.5%	77.5%	95.3%
9	97.2%	92.5%	99.0%
10	96.5%	94.4%	97.4%
11	91.8%	82.1%	95.3%
12	95.1%	85.2%	97.9%
13	92.4%	84.6%	95.2%
14	93.9%	87.2%	96.3%
15	95.2%	92.3%	96.3%

Source: authors.

In addition, the Hosmer–Lemeshow test for the goodness of fit[3] in binary models – table 5 – shows non rejection of the null hypothesis.

Model #	*# obs.*	*# groups*	*Hosmer-Lemeshow*	*Prob > chi²*
1	149	10	3.3	0.91
2	116	10	1.8	0.99
3	145	9	0.2	1.00
4	145	9	0.2	1.00
5	125	10	0.5	1.00
6	116	10	3.8	0.87
7	149	10	6.9	0.55
8	147	10	6.9	0.54
9	143	9	0.4	1.00
10	113	8	1.2	0.98
11	146	10	0.6	1.00
12	122	10	2.2	0.97
13	144	10	0.5	1.00
14	148	10	0.5	1.00
15	146	10	3.5	0.90

Source: authors.

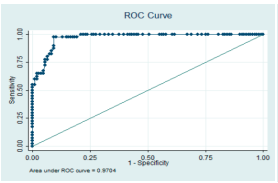
[3] The Hosmer–Lemeshow test assesses whether or not the observed event rates match expected event rates in subgroups of the model population. The Hosmer–Lemeshow test specifically identifies subgroups as the deciles of fitted risk values. Models for which expected and observed event rates in subgroups are similar are called well calibrated.

Receiver Operating Characteristic (ROC) Analysis

Taking into account the sensitivity and specificity ratios, corresponding ROC curves were constructed to show the trade-off between the false negative and false positive rates for every possible cut off of each model. Again, the estimated models perform very well.

Figure 1. ROCs figures

Model 1



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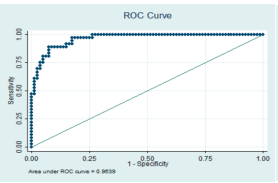

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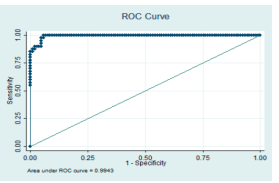

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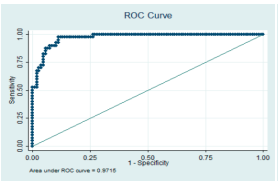
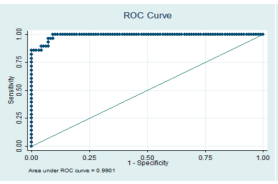
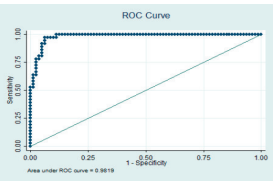


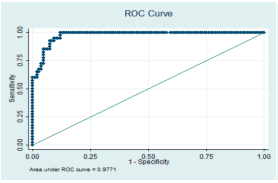
Model 5



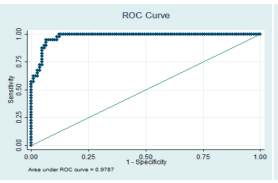
Model 6



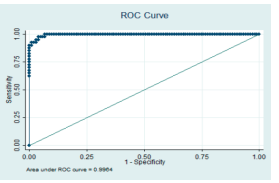
Model 7



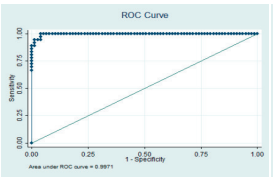
Model 8



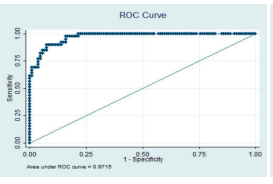
Model 9



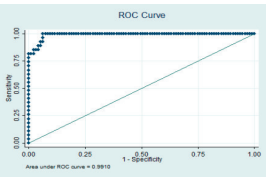
Model 10



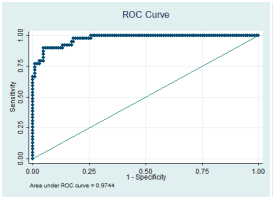
Model 11



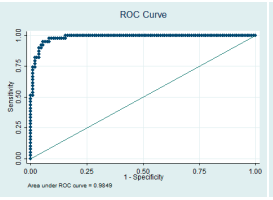
Model 12



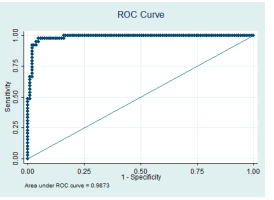
Model 13



Model 14



Model 15



The reading of the individual effects of parameters on the odds of being a developed country are not directly observed under binary probit estimations because it is necessary to assume values for the rest of the explanatory variables. In order to obtain a better understanding of the results it is necessary to calculate the first difference, which represents the change in the probability of the event of our interest (developed/undeveloped) as a result of a specific change in one independent variable, keeping constant the rest of the variables. This is $\hat{}gx = P(y = 1|x = 1) - P(y = 1|x = 0)$.

In the framework of the dichotomous dependent variable (being developed or not), it might be interesting to address the difference —in terms of probability — of achieving a result of the dichotomous variable in a situation that provides a set of values for the explanatory variables with respect to another set of values in which one (or more) of these variables is (are) increased by a stipulated amount (not necessarily small). This quantity is known as the first difference change in the literature of binary models.

Given the above considerations, in the present study we examined the effects of particular changes in the odds of being a developed country linked to different values in the logistics variables. In particular we assumed a baseline scenario that accounts for the average of the logistics indexes in undeveloped countries, and a final scenario consistent with the average of logistics indexes viewed in developed countries, analyzing in each model the change in the probability of being a developed country caused by these two alternative scenarios. For the same purposes, the average values observed in underdeveloped countries[5] are assumed for the rest of the explanatory variables.
Table 6 shows the effects of the first differences that arise from the LPI changes considering the estimated models:

TABLE 6: ESTIMATED FIRST DIFFERENCES

Model #	First Difference Change	Variable Changed	Variable(s) not Changed
1	0.87	LPI	-
2	0.95	LPI	connectivity_index
3	0.07	LPI	gdppc_k_2000
4	0.89	LPI	natural_resources_rents
5	0.59	LPI	gini_index
6	0.33	LPI_reach	connectivity_index
6	0.64	LPI_infrastructure	connectivity_index
7	0.28	LPI_reach	-
7	0.43	LPI_infrastructure	-

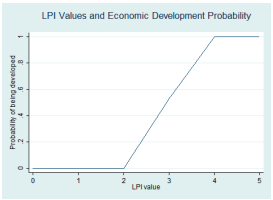
8	0.33	LPI_reach	FDI
8	0.37	LPI_infrastructure	FDI
9	0.02	LPI	gfkf, gdpp_k_2000
10	0.15	LPI_infrastructure	connectivity_index, gdppc_k_2000
11	0.79	LPI	Kaopen
12	0.43	LPI	gini_index, kaopen
13	0.82	LPI	natural_resources_rents, kaopen
14	0.16	LPI	rule_of_law
15	0.14	LPI	natural_resources_rents, rule_of_law

Source: authors.

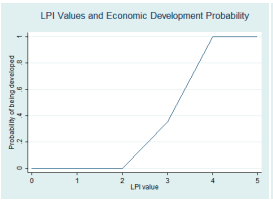
The first differences allow to quantify the impact on the probability of being a developed country according to changes in the values of logistics performance indices. In this paper the change corresponds to the change from the average logistics index value of underdeveloped countries to the developed country average. The results indicate that the increase in the probability of being developed that accompanies this passage in logistics indicators would be between 2% and 95% depending on the model taken as a basis for calculating.
Knowing the impact of the first differences is a very important indicator since it gives information of the potentiality of the logistics processes improvements over the probability of being developed. However, it is also interesting to observe the impact on the probability of being a developed country that is obtained by analyzing continuous changes in the logistics indices. To this end, below are the graphs for each model, where the abscissa axis represents the different magnitudes that the logistics indicator could take, while the ordinate axis gives the probability of a country being developed according to the corresponding logistics values, assuming constant all the other variables.

FIGURE 2. FIRST DIFFERENCES FIGURE

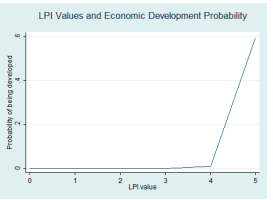
Model 1



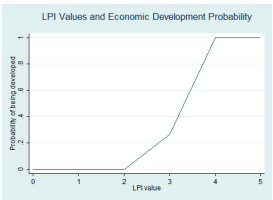
Model 2



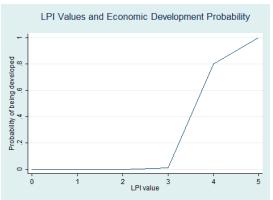
Model 3



Model 4



Model 5



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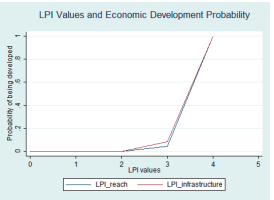

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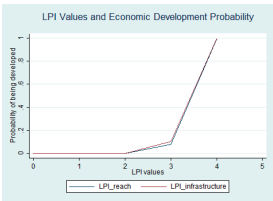
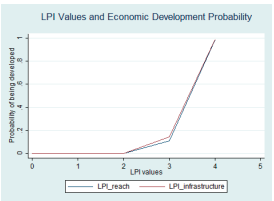
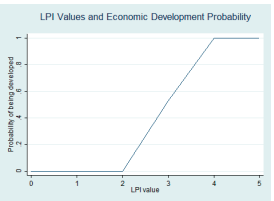


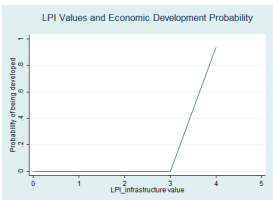
Model 8



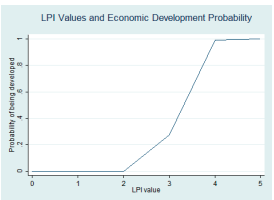
Model 9



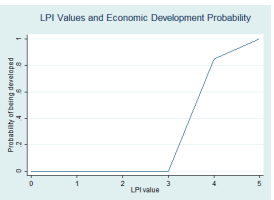
Model 10



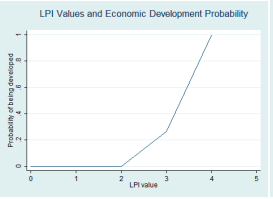
Model 11



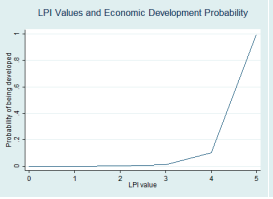
Model 12



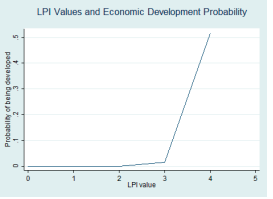
Model 13



Model 14



Model 15



3. Discussion

Much has been discussed about the technical characteristics of the construction of LPI. To question them is not the aim of this paper; however, the absence of similar measurements for all countries worldwide, which would allow us to include logistics performance in the development equation, made its usage a necessity. Nevertheless, the results of the paper show that logistics performance is closely related to the probability of a country being developed. In fact, according to the methodology used, the endogenous variable of the dichotomous model represents the probability of occurrence of the analyzed phenomenon, in this case "the probability of occurrence of the phenomenon 'being a developed country'". The results show that all the estimated parameters in each model are statistically significant and show the expected signs (the only exception being the coefficient of connectivity, which shows a relationship contrary to the prior expectancy). The overall significance ratios also exhibit good behaviour, while the pseudo R squared is in all cases above 60%.

Both the sensitivity and the specificity were analyzed in order to verify the quality of the estimations, for they are the appropriate factors to consider when a discrete binary variable is used:

- The sensitivity that indicates the capacity of the estimator to define as positive cases those which are actually positive; in this case, for the model to consider as a developed country a country that is actually developed.
- The specificity that indicates the capacity of the estimator to define as negative cases those which are actually negative; in this case, for the model to consider as not "developed" country a country that is actually not "developed".

As noted in the previous section, both analyses prove the high goodness-of-fit of the models, while the ROC curves also show such a goodness-of-fit.

The impact of different levels of LPI (keeping the rest of the variables' values constant in the non-developed countries' levels) is analyzed through the study of the first differences. The first differences allow a contrast between the differences in the probabilities of occurrence of the dependent variable (in this case, being a developed country) and two alternative situations in the Logistics Performance Index.

The results indicate that in most cases the probability of being a developed country increases when logistics performance is improved. Here it is important to highlight that reaching development is not only due to improvements in lpi indexes, but also of improvements in a wider set of economic, social and political variables. We have only intend to show the change in the probability of being developed that correspond to changes in logistic indexes, ceteris paribus the rest of considered variables.

It is also important to note that the scope of development is clearly a long-standing issue. On this paper we have use the available logistic data of the World Bank which is for a reduced period of time. Therefore further research

has to be done incorporating alternative measures of logistic performance indexes that could provide an expanded time frame.

Another important issue is related to the possible endogeneity between the variables of the model: a high degree of development may be linked to higher logistical resources and vice versa. The authors will address this important topic in a future publication using instrumental variables methods.

Finally, some of the following comments are highly significant: 1) this paper is the first research (known by the authors) to relate logistics performance, measured through the LPI, with economic development, especially in a probabilistic approach. For this reason, some methodological issues had to be faced and solved in the best possible way; 2) when this study was carried out (end of 2011), the data for the variables contained limitations of information availability (between 112 and 149 countries out of 192 possible countries). Although the figure is significant, other possibly interesting variables could not be included due to the lack of a minimum amount of information equivalent to that of the utilized variables. 3) Even though the results are satisfactory, some particularities will have to be considered in the future, such as the reasons for the maritime connectivity to present signs contrary to those expected. Such motives could guide the specification or construction of the variable (connectivity_index).

The paper has achieved the goals originally set, and it is expected that future research will be able to include more variables linked to logistics, maritime and port performance that function as determinants of economic development.

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