INTERNATIONAL TRADE AND ECONOMIC GROWTH IN LATIN AMERICA: A GRANGER CAUSALITY ANALYSIS WITH PANEL DATA

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ABSTRACT

The causal relationship between international trade and economic growth has been the object of great controversy in applied literature. In the attempt to explain this relation, many studies have been undertaken and the literature on this subject is vast. However, a relative scarcity of studies applied to the Latin American countries is verified. In this context, the aim of this paper is to investigate the relation between commercial openness and growth for a panel dataset of 18 Latin American countries in the period of 1952-2003. For this purpose, we apply the Granger non-causality test, using a panel-data approach based on SUR systems. The non-causality test is carried out beyond the standard bivariate model and three alternative specifications are employed. The results indicate that: in seven countries there is one-way causality from trade to growth; in three countries the causality goes from growth to trade; in two countries there is two-way causality between this variables; and in six countries there is no evidence of causality in either direction.

JEL classification: F43, F49, O54.

Key-words: International Trade; Economic Growth; Granger Causality; Panel Data.

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1. INTRODUCTION

There is an extensive applied literature concerning the relation between international trade and economic growth. In this literature, the causal relationship between these two variables has been the object of great controversy. While some authors support the hypothesis that the external commerce stimulates growth, others, by contrast, argue that it is the economic growth that boosts trade. There are also those who do not recognize a clear causal relation between such variables.

Despite of the existence of a large number of applied studies concerning this issue, a relative scarcity of empirical work analyzing the context of the Latin American countries is verified. These countries, after a long period of import-substitution industrialization, initiated a process of commercial opening in the decade of 1980.

The main motivation that led to this commercial opening was the belief that it would cause a faster growth of the economies. However, almost two decades have passed and the results, in terms of growth, do not seem to have fulfilled the initial expectations. In sight of this, many doubts concerning the path of the commercial policy in the region have emerged. Should the Latin American countries deepen the ongoing process of commercial opening to accelerate economic growth or should they focus on economic growth first, which in turn will generate more trade? If the direction of causality runs from trade to growth, then the Latin American countries should reduce the trade barriers which restrict imports and reduce the externality effects of exporting. On the other hand, if the causal relation occurs in the opposite direction, then these countries do not need to concentrate their scarce resources with trade liberalization measures to the detriment of programs for physical capital investment and human resource development.

In order to provide empirical evidence to support this debate, the objective of this paper is to investigate the causal relationship between commercial openness and economic growth for a panel dataset of 18 Latin American countries in the period of 1952-2003. For this purpose, we apply the Granger non-causality test, using a panel-data approach based on SUR systems. The non-causality test is carried out beyond the standard bivariate model and three alternative specifications are employed: a bivariate model with a linear time trend; a trivariate model with and without a linear time trend. The details of these models are presented in the methodological section.

To achieve the objective proposed, the paper was organized as follows. Section 2 makes a brief theoretical review of the links between trade and growth and presents some main empirical studies on the subject. Section 3 presents the methodological approach employed. Section 4 presents the results and their discussion. Finally, section 5 contains the main conclusions of the paper.

2. THEORETICAL AND EMPIRICAL BACKGROUND

2.1. THEORETICAL PERSPECTIVES ON THE LINKS BETWEEN TRADE AND GROWTH

One of the main arguments in favor of free trade is based on the principle of comparative advantages, which claims that countries can achieve better results by specializing themselves in the productive activities in which they are relatively more efficient. The central idea is that the higher specialization and the expansion of the markets, through free trade, would increase efficiency and provide economy of scale gains.

Thus, given that the Latin American countries possess an abundant endowment of low qualification labor force, the specialization of the economy in the production of primary products for export combined with the import of manufactured products from the developed countries became a widespread strategy in the region. The basic idea was that the technical progress generated in the developed countries would reach the Latin American countries, through the reduction of the prices of industrialized goods. Moreover, the lower incorporation of technology in the production of primary products and the increasing demand from the developed countries would contribute to the rise of the prices of these products. As a result of these aspects, the terms of trade would improve in favor of the Latin American countries, and these would not need to industrialize themselves in order to achieve economic development (Souza, 1997, p. 199).

However, it is crucial to realize that the concept of comparative advantages is a static one. This way, in the long run, there may also be a tendency for the terms of trade to deteriorate against the developing countries specialized in the production of primary products (Ray, 1998, pp. 650-51). This constitutes the main argument of the structuralist criticism of the theory of comparative advantages. Structuralist economists such as Gunnar Myrdal, Raúl Prebisch and Hans Singer were prominent critics of the view that the export of primary products could promote economic development.

Prebisch (1949) criticized the theory of comparative advantages and proposed a new analytical approach. This approach became the catechism of the economists of the Economic Commission for Latin America (ECLA) and inspired the import-substitution industrialization strategy (ISI) adopted in many of the Latin American countries. This author, examining the evolution of the prices of agricultural and industrial products in the period of 1880-1945, found a clear tendency to the deterioration of the terms of trade against the underdeveloped countries: the agricultural prices/industrial prices ratio, equal to 1 in 1880, had fallen to 0,687 in 1945[4].

The explanation offered by Prebisch (1949) for this phenomenon was based on the theory of economic cycle. In the ascending phase of the economic cycle, a rise in the international demand for primary products occurs, as a result of the increase in the income and the prices in the developed countries. Stimulated by the favorable prices, the peripheral countries increase the supply. However, the rigidity of the supply of primary products hinders the underdeveloped countries from making all the potential profits related to the rise of the prices and the demand.

Moreover, when the prices and the demand start falling, in the end of the ascending phase of the economic cycle, the countries are not able to reduce immediately the supply of the primary products, due to its rigidity, and this provokes even a greater fall of the prices of these products in the descending phase. On the other hand, the supply of manufactured goods is much more flexible, adjusting itself immediately to the demand and the prices. Besides, in the developed countries the wages are rigid downward due to the action of labor unions, which prevents larger reductions on the demand of manufactured products.

In this view, the deterioration of the terms of trade was the main obstacle to the development of the Latin American countries. Thus, the development model proposed by Prebisch and the ECLA was based on the import-substitution industrialization strategy (ISI). It was, therefore, an "inward oriented" development model.

The economic gains supported by the theory of comparative advantages are static. They generally take the form of a level effect on the product, but they do not affect its growth rate. More recent studies suggest some mechanisms through which commercial opening can

[4] Some critics of Prebisch's study argued that, when other periods were analyzed, there was no evidence of deterioration of the terms of trade against the developing countries specialized in the production of primary products.

generate dynamic gains and, therefore, affect the growth rate of the economy in the long run (Agénor, 2000, p. 473).

First, the commercial opening may lead to a better allocation of the resources among the productive sectors through the elimination of distortions, including rent-seeking activities. Second, the commercial opening tends to facilitate the acquisition of inputs, intermediary products and new technologies, which raises the total productivity of the economy. Third, if the marginal productivity of the domestic investment is greater than the international interest rate, the commercial opening will increase the supply of foreign capital and, thus, may raise the domestic welfare (Agénor, 2000, p. 474).

The recent literature has given great prominence to the mechanism of international diffusion of new technologies. Grossman & Helpman (1991) and Rivera-Batiz & Romer (1991) developed some models in which the technology is produced by profit-maximizing firms. In these models, the sector of research and development (R&D) is the source of growth. These authors show that, if the economic integration allows the countries to explore increasing returns to scale in the R&D sector, then the commercial opening will raise the long run economic growth rate simply through the expansion of the market. Moreover, the international trade may also increase the domestic productivity through the increase of the knowledge spillovers.

However, if the knowledge spillovers are imperfect, which is very plausible given that the developing countries usually are not able to assimilate all the knowledge available in the developed countries, then the commercial opening will lead to divergent growth paths. That is, if the country was already rich before the commercial opening, its growth rates after the liberalization will increase; on the other hand, if the country was poor, its growth rates will fall (Grossman & Helpman, 1991, ch. 8).

Romer (1994) explores the idea that the commercial opening increases the variety of goods available to the domestic agents and raises the productivity through the provision of cheaper or better quality intermediate products. In an economy subject to commercial restrictions, only a narrow range of specialized intermediate goods can be produced in a lucrative way and, therefore, the complete set of technological possibilities, which depends on a wider set of inputs, cannot be efficiently explored. Thus, in Romer’s model, the commercial opening promotes growth through the increase of productivity and the increase in the number of intermediate goods available in the economy.

In contrast with the examples in which international trade affects economic growth, we can also think of a reverse causal relation between these variables. First, let us consider the case of a static economy described by a standard 2×2 Heckscher-Ohlin model, where the only distortion is a tariff on the imported good. It is assumed that the international prices of goods are constant. An exogenous increase of the capital supply provokes an increase in the production of the capital-intensive sector and a fall in the production of the labor-intensive sector. If the country, compared to the rest of the world, is capital-abundant, then the increase of the capital supply promotes more trade as the economy becomes more specialized. On the other hand, if the country is labor-abundant, then the increase of the capital supply leads to a fall in the external commerce as the degree of specialization of the economy decreases (Wälde & Wood, 2004, pp. 278-79).

Moreover, assuming that a country grows faster due to subsidies to the R&D activities, it can be argued that there are also dynamic effects from growth to trade. The subsidies to the R&D activities cause a greater allocation of resources on the R&D sector, an increase in the relative price of the factors intensively used in R&D (e.g. human capital), and a relative specialization of the economy in the production of the good less intensive in human capital. This induces more commerce with the rest of the world through the acquisition of a larger amount of the non-specialized good. Besides, the subsidies to the R&D activities will increase the rate of innovation and the exports (Wälde & Wood, 2004, p. 280).

2.2. REVIEW OF THE APPLIED LITERATURE

According to Frankel & Romer (1996), one basic difficulty faced when estimating the impact of the external commerce on economic growth lies on the problem of the endogeneity of the independent variables related to commercial openness. That is, correlations between commercial openness and income do not allow the identification of the effect of trade.

Frankel & Romer (1996) take this problem into consideration and use a method of simultaneous equations and instrumental variables. The specification of their model is derived from the Solow growth model, with a Cobb-Douglas production function and exogenous technical progress and population growth rate. These authors assume that the geographic characteristic of the countries have important effects on trade and, besides this, are uncorrelated with other determinant aspects of their respective incomes. Thus, the authors construct measures of the geographic component of the countries' trade and use them as instrumental variables to estimate the effect of external commerce on economic growth. From the results obtained, Frankel & Romer (1996, pp. 31-33) conclude that trade has a positive, significant and robust effect on income.

Rodríguez & Rodrik (2001) have a more skeptical view of the impact of commercial openness, in the sense of lower tariffs, on economic growth. These authors argue that although most applied studies have found a positive and significant relation between these two variables, these studies present several methodological problems. The main problems identified by them refer to the incorrect specification of the models and the use of inappropriate measures of openness. Thus, Rodríguez & Rodrik (2001) argue that those previous studies overestimate the effect of commercial openness. In these authors' view, there is little evidence that open trade policies are significantly associated with economic growth.

Giles & Williams (2000) made a comprehensive survey of more than one hundred and fifty applied papers, published between 1963 and 1999, concerning the export-led growth (ELG) hypothesis. These papers can be classified in three groups. The first group is based on correlation analysis, the second applies regression analysis with cross-section data, and the third group employs time series techniques. Most of the studies with time series are based on the concept of Granger causality. Giles & Williams (2000) demonstrate that the empirical results are very sensitive with respect to changes in the test methodologies and the samples. The overall conclusion of these authors is that there is still no consensus about the effect of exports on growth.

More recently, Akbar & Naqvi (2003) analyzed the case of Pakistan in the period of 1975-98. These authors use two distinct approaches to investigate the relation between exports and growth: the first one consists in the Granger non-causality test, while the second consists in the estimation of a production function using a VAR (Vector Auto-regression) model. In order to take into account other important macroeconomic variables that may have some influence in the relation between exports and growth, the authors also considered the imports, investment and energy in the analysis. The results showed that, in Pakistan, exports do not Granger-cause economic growth; the causal relation occurs in the opposite direction, from growth to exports.

Akbar & Naqvi (2003) also concluded that investment and energy are important variables in the export-income relationship, and that imports do not play an important role in this relation. The results obtained with the VAR model confirm those of the non-causality tests. Finally, one important finding of Akbar & Naqvi (2003) is that the omission of important macroeconomic variables from the analysis may either mask or overstate the causal relation between exports and growth.

The study of Kónya (2006) deserves some attention because it proposes a new panel-data approach for the Granger non-causality test, which is based on SUR (seemingly unrelated regressions) systems and Wald tests with country specific bootstrap critical values. This study investigates the possibility of Granger causality between the logarithms of real exports and real GDP in twenty-four OECD countries in the period of 1960-97. The results indicated: one-way causality from exports to GDP in Belgium, Denmark, Iceland, Ireland, Italy, New Zealand, Spain and Sweden; one-way causality from GDP to exports in Austria, France, Greece, Japan, Mexico, Norway and Portugal; two-way causality between exports and GDP in Canada, Finland and the Netherlands; while in the cases of Australia, Korea, Luxembourg, Switzerland, the UK and the USA there was no evidence of Granger causality in either direction.

Despite of the existence of a large number of applied studies concerning the relation between trade and growth, a relative scarcity of empirical work analyzing the context of the Latin American countries is verified. The work of Jung & Marshall (1985), Chow (1987), Xu (1996) and Matos (2003) are among the few studies concerning these countries.

Jung & Marshall (1985), using Granger non-causality tests and time series from 1950-81 for 37 developing countries, including 16 Latin American countries, obtained ambiguous results concerning the export-led growth (ELG) hypothesis. The results indicated one-way Granger causality running from exports to economic growth in Costa Rica and Ecuador; one-way causality from economic growth to exports in Bolivia, Chile and Peru; and no causality in either direction in Argentina, Brazil, Colombia, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Paraguay, Uruguay and Venezuela.

Chow (1987) tested the ELG hypothesis for eight newly industrialized countries (including Argentina, Brazil and Mexico) with annual data from 1960-87. The results revealed no causality in the case of Argentina, unidirectional causality from exports to growth in Mexico and bidirectional causality between these variables in the remaining countries, including Brazil.

Xu (1996) investigated the possibility of Granger causality between the logarithms of real GDP and exports in 32 developing countries, including 10 Latin American countries, in periods within 1951-1990. The results suggested unidirectional causality running from exports to growth in Colombia and Mexico; unidirectional causality from growth to exports in Nicaragua, Panama, Peru and Uruguay; bidirectional causality between exports and growth in Brazil, Ecuador and Honduras; and no causality between these variables in Paraguay.

Matos (2003), using the Granger non-causality test in a VAR context, studied the causal relations between financial development, exports and economic growth in Brazil from 1980-2002. The results indicated bidirectional effects between financial development and growth and also between growth and exports. However, the non-causality null hypothesis could not be rejected in the case of the relation between financial development and exports.

In summary, the review of the applied literature shows that the direction of causality between commercial openness and economic growth is by no means resolved. The existing empirical studies present results that are contradictory with each other. Moreover, most of the Granger causality analyses have been carried out with insufficient number of observation, as pointed out by Wälde & Wood (2004, pp. 284-85)[5]. Thus, further investigation of this issue, especially in the context of the Latin American countries, is necessary.

3. METHODOLOGICAL ISSUES

In this section, we discuss the technical issues of our empirical investigation. The dataset comprises annual measures, during the period of 1952-2003, on eighteen Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

Our analysis involves three variables: the annual growth rate of GDP per capita, the openness index (exports plus imports divided by GDP) and the investment share of the GDP. These variables were PPP (purchasing power parity) converted[6]. The data was obtained from the Penn World Table version 6.2 (Heston, Summers & Aten, 2006).

Cross-country OLS growth regressions, which are by far the most prevalent methodology utilized to provide evidence that more openness is important for domestic economic growth, cannot resolve the question of causality between these variables. Thus, the results obtained using this methodology may lead to ambiguous interpretations (Wälde & Wood, 2004, pp. 281-82).

[5] At least 50 data points are required for reliable results.
[6] The monetary unit of reference is the U.S. dollar in base year 1996.

Granger non-causality tests (1969) are well-suited to address this issue. The concept of Granger causality refers to the capacity of a variable to help in the prediction of the future behavior of another variable of interest. In other words, it consists in the existence of a time precedence that is statistically significant in the explanation of a given variable. The Granger non-causality test was originally developed for the analysis of time series. The extension of the Granger non-causality test to panel data is a recently developed methodological procedure[7].

The methodological approach employed in this paper was inspired by the work of Kónya (2006)[8]. The non-causality hypothesis is tested using the following SUR (seemingly unrelated regressions) systems:

$$
\begin{aligned}
y_{1,t} &= \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l} y_{1,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,1,l} x_{1,t-l} + \varepsilon_{1,1,t} \\
y_{2,t} &= \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} y_{2,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,2,l} x_{2,t-l} + \varepsilon_{1,2,t} \\
&\vdots \\
y_{N,t} &= \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} y_{N,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,N,l} x_{N,t-l} + \varepsilon_{1,N,t}
\end{aligned} \tag{1}
$$

and

$$
\begin{aligned}
x_{1,t} &= \alpha_{2,1} + \sum_{l=1}^{mly_2} \beta_{2,1,l} y_{1,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,1,l} x_{1,t-l} + \varepsilon_{2,1,t} \\
x_{2,t} &= \alpha_{2,2} + \sum_{l=1}^{mly_2} \beta_{2,2,l} y_{2,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,2,l} x_{2,t-l} + \varepsilon_{2,2,t} \\
&\vdots \\
x_{N,t} &= \alpha_{2,N} + \sum_{l=1}^{mly_2} \beta_{2,N,l} y_{N,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,N,l} x_{N,t-l} + \varepsilon_{2,N,t}
\end{aligned} \tag{2}
$$

[7] More detailed discussion about the extension of the Granger non-causality test to panel data can be found at Holtz-Eakin, Newey & Rosen (1985), Hurlin (2004) and Kónya (2006).

[8] There are, however, two main differences between our methodological procedure and those of Kónya (2006). First, while we use standard critical values in our tests, Kónya (2006) computes country specific bootstrap critical values. This allows the author to ignore the possible nonstationarity in the data. Second, the variables and the model specifications used in our tests are somewhat different from those employed by Kónya (2006).

where y represents the growth rate of GDP per capita, x represents the level of commercial openness, index i refers to the country ($i = 1, ..., N$), t refers to the time period ($t = 1, ..., T$) and l denotes the lag ($l = 1, ..., ml$).

The equations in system (1), and also in system (2), are independent of each other on the surface, since they have different predetermined variables. The only possible link among individual regressions is contemporaneous correlation within the system[9]. In this case, instead of estimating the system equations individually by least squares, the method of SUR should be applied. SUR, a model developed by Zellner (1962), is an extension of the linear regression model which allows correlated errors between equations.

This approach has two main advantages: (i) first, it does not require joint hypothesis for all panel members[10] and; (ii) second, since it allows for contemporaneous correlation across countries, this method makes it possible to exploit the extra information provided by the panel data setting.

The non-causality hypothesis is investigated through Wald tests of restrictions performed on the parameters of the model. For a given country, there is unidirectional Granger causality running from x to y if in (1) not all γ_{1i}'s are zero but in (2) all β_{2i}'s are zero. There is unidirectional Granger causality from y to x if in (1) all γ_{1i}'s are zero but in (2) not all β_{2i}'s are zero. There is bidirectional Granger causality between x and y if neither all γ_{1i}'s nor all β_{2i}'s are zero. Finally, there is no Granger causality between x and y if all γ_{1i}'s and β_{2i}´s are zero.

Although most empirical studies have focused on the bivariate relation between commercial openness and economic growth, the omission of important macroeconomic variables from the model may either mask or overstate the Granger causality between the variables of interest (Akbar & Naqvi, 2003, p. 2). Thus, the Granger non-causality test has been carried out beyond the standard two-variable method, with the inclusion of a third variable in our analysis: the investment share of the GDP.

In order to include this third variable in the analysis, we also considered the following extensions of (1) and (2):

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9 This assumption is plausible when we admit a certain degree of interdependence among the panel members. Thus, considering the strong economic links between the Latin American countries, contemporaneous correlation is very likely to happen in these systems.

10 This is a crucial advantage, especially when we are dealing with heterogeneous panels.

$$
\begin{aligned}
y_{1,t} &= \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l} y_{1,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,1,l} x_{1,t-l} + \sum_{l=1}^{mlz_1} \eta_{1,1,l} z_{1,t-l} + \varepsilon_{1,1,t} \\
y_{2,t} &= \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} y_{2,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,2,l} x_{2,t-l} + \sum_{l=1}^{mlz_1} \eta_{1,2,l} z_{2,t-l} + \varepsilon_{1,2,t} \\
&\vdots \\
y_{N,t} &= \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} y_{N,t-l} + \sum_{l=1}^{mlx_1} \gamma_{1,N,l} x_{N,t-l} + \sum_{l=1}^{mlz_1} \eta_{1,N,l} z_{N,t-l} + \varepsilon_{1,N,t}
\end{aligned}
\tag{3}
$$

and

$$
\begin{aligned}
x_{1,t} &= \alpha_{2,1} + \sum_{l=1}^{mly_2} \beta_{2,1,l} y_{1,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,1,l} x_{1,t-l} + \sum_{l=1}^{mlz_2} \eta_{2,1,l} z_{1,t-l} + \varepsilon_{2,1,t} \\
x_{2,t} &= \alpha_{2,2} + \sum_{l=1}^{mly_2} \beta_{2,2,l} y_{2,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,2,l} x_{2,t-l} + \sum_{l=1}^{mlz_2} \eta_{2,2,l} z_{2,t-l} + \varepsilon_{2,2,t} \\
&\vdots \\
x_{N,t} &= \alpha_{2,N} + \sum_{l=1}^{mly_2} \beta_{2,N,l} y_{N,t-l} + \sum_{l=1}^{mlx_2} \gamma_{2,N,l} x_{N,t-l} + \sum_{l=1}^{mlz_2} \eta_{2,N,l} z_{N,t-l} + \varepsilon_{2,N,t}
\end{aligned}
\tag{4}
$$

where z represents the investment share of the GDP.

It is important to mention that, in these trivariate systems, our focus will remain in the relation between commercial openness and economic growth. This means that the investment share of the GDP will be regarded as an auxiliary variable and it will not be directly involved in the Granger causality analysis.

Moreover, we use a linear time trend as a proxy variable for other important variables that may have been omitted from the specifications above. Thus, we consider four different specifications altogether: (i) the standard bivariate model; (ii) the bivariate model with a linear time trend; (iii) the trivariate model and; (iv) the trivariate model with a linear time trend.

The appropriate method to estimate systems (1), (2) and (3), (4) depends on the properties of the residuals. If the errors are not correlated between equations, then each equation should be regarded as a classical regression and estimated individually by least squares. However, if there is contemporaneous correlation within the systems, then the OLS estimators are not efficient, since they do not take into account this additional information. In this case, the SUR estimators are more efficient.

Considering that the SUR estimators are more efficient than the OLS estimators only when the errors are correlated between equations, it is important to test whether the variance-covariance matrix of the residuals is diagonal. For a given system *k* (where *k = 1, 2*), the null and alternative hypotheses are:

$$H_0 : \text{cov}(\varepsilon_{k,i,t}, \varepsilon_{k,j,t}) = 0$$

$$H_1 : \text{cov}(\varepsilon_{k,i,t}, \varepsilon_{k,j,t}) \neq 0 \qquad \text{for at least one pair of } i \neq j.$$

If the null hypothesis is true, there is no reason to apply the method of SUR. Breusch & Pagan (1980), assuming normality, suggested the following test statistic:

$$\lambda = T \sum_{i=2}^{N} \sum_{j=1}^{i-1} r_{ij}^2 \qquad (5)$$

where r_{ij} is the estimated correlation coefficient between $\varepsilon_{k,i,t}$ and $\varepsilon_{k,j,t}$ (for a given *k* and $i \neq j$) from individual OLS regressions. Under the null hypothesis, this test statistics has asymptotic chi-square (χ^2) distribution with $N(N-1)/2$ degrees of freedom (Greene, 2003, p. 350).

Before estimating the model, it is necessary to specify the lag length. This is a very important step, since the test results may depend substantially on the lag structure employed. The optimal number of lags can be selected by Schwarz Information Criterion (SIC), which is defined as:

$$SIC_k = \ln|W| + \frac{N^2 q}{T} \ln(T) \qquad (6)$$

where, for a given system *k*, *W* is the estimated residual covariance matrix, *N* is the number of equations, *q* is the number of coefficients per equation and *T* is the sample size. For the sake of simplicity, we assume that the number of lags ranges from 1 to 4 and that $mly = mlx = mlz$. Then, we estimate all specifications and choose the lag structure which minimizes the SIC.

4. RESULTS AND INTERPRETATION

The hypothesis of nonstationarity of the time series was investigated employing the augmented Dickey-Fuller (ADF) test[11]. The I(1) null hypothesis is rejected for the growth rate of GDP per capita at the 5% significance level for all countries. Thus, we assume that this series is stationary. On the other hand, the I(1) null hypothesis is not rejected for the commercial openness index at the 5% significance level for neither of the countries. The I(2) null hypothesis, however, is rejected at he 5% significance level. Therefore, we assume that this series is integrated of order one. With respect to the investment share of the GDP, the results of the ADF test indicate that this series is I(1) in eight of the eighteen countries analyzed, while it is stationary in the remaining cases.

In order to preserve the validity of the non-causality tests, the time series of the commercial openness index and the investment share of the GDP were first-differenced, eliminating the nonstationarity problem. The growth rate of GDP per capita, however, remained without any transformation.

Curiously, the Schwarz Information Criterion (SIC) indicated the selection of only one lag for all countries[12]. In general, the bivariate model without trend generated the lowest SIC value, while the trivariate model with a linear time trend generated the highest. Still, considering that the best specification may vary from country to country, we maintain all the four options.

In all specifications, the Breusch & Pagan (1980) test indicated the rejection of the null hypothesis of no contemporaneous correlation within the system even at the 1% significance level[13]. Thus, the application of SUR is justified.

The results of the non-causality tests for the null hypothesis that commercial openness does not Granger-cause economic growth is presented in table 1. For thirteen out of the eighteen countries the tests are robust, in the sense that they lead to the same conclusion regardless of the specification. At the 10% or lower significance level, it is not possible to reject the null hypothesis in the cases of Argentina, Bolivia, Colombia, Dominican Republic, El Salvador, Peru and Venezuela. On the other hand, the null hypothesis is rejected in the cases of Chile, Costa Rica, Guatemala, Panama, Paraguay and Uruguay.

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[11] The complete test results are reported in Tables A1, A2 and A3 of the Appendix.
[12] See Tables A5 and A6 of the Appendix.
[13] See Table A4 of the Appendix.

Table 1

Granger non-causality test

– Null hypothesis: X does not Granger-cause Y –

Country	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
Argentina	1.392216	1.392643	1.860142	1.777451
Bolivia	0.362440	0.392629	2.085057	2.235706
Brazil	0.267229	3.015561 *	1.930276	6.305748 **
Chile	4.798325 **	3.274043 *	3.947566 **	2.715973 *
Colombia	0.027194	0.193371	0.009234	0.110202
Costa Rica	19.20748 ***	19.43491 ***	10.64589 ***	10.34950 ***
Dominican Rep.	0.340514	0.350332	0.269412	0.112211
Ecuador	0.785128	1.003763	7.759480 ***	9.245423 ***
El Salvador	1.356817	0.897731	0.023440	0.022679
Guatemala	19.29949 ***	19.70671 ***	4.244379 **	4.834059 **
Honduras	0.765674	0.589114	4.103622 **	3.720766 *
Mexico	0.203292	4.067989 **	0.031280	4.076449 **
Nicaragua	2.681257	3.174846 *	0.012786	0.043778
Panama	6.507642 **	6.899978 ***	6.634042 ***	7.091995 ***
Paraguay	6.067559 **	5.048165 **	2.948938 *	2.993369 *
Peru	1.994534	1.469972	0.094151	0.051622
Uruguay	8.959949 ***	8.582274 ***	9.313448 ***	9.513011 ***
Venezuela	1.940319	0.842251	1.163641	0.657349

Notes: Y denotes the growth rate of GDP per capita.
X denotes the commercial openness index (first differenced).
Reported statistics have asymptotic chi-square distribution.
***, ** and * indicate statistical significance at the 1, 5 and 10 percent levels, respectively.

Regarding the other five countries (Brazil, Ecuador, Honduras, Mexico and Nicaragua), the results are contradictory and it is not possible to decide which specification is the best without further analysis. Despite of the fact that the overall SIC indicated the selection of the bivariate model without the time trend, this specification is not necessarily the best for every country taken individually. Therefore, we have also computed the following single-equation version of SIC:

$$SIC_i = \ln\left(\hat{\sigma}_{i,i}^2\right) + q\frac{\ln(T)}{T} \tag{7}$$

where the index i refers to the country ($i = 1, ..., N$), $\hat{\sigma}_{i,i}^2$ is the variance of the residuals from the i^{th} equation, q is the number of coefficients per equation and T is the sample size.

This criterion indicated the selection of the standard bivariate model for Honduras and Nicaragua, the bivariate model with time trend for Brazil and Mexico and the trivariate model with time trend for Ecuador[14]. Therefore, the null hypothesis is not rejected in the cases of Honduras and Nicaragua, but it is rejected in the cases of Brazil, Ecuador and Mexico.

Table 2

Granger non-causality test

– Null hypothesis: X does not Granger-cause Y –

Country	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
Argentina	7.020422 ***	6.229428 **	1.534221	1.617008
Bolivia	1.489715	1.584739	1.269111	1.367305
Brazil	4.162843 **	0.559339	4.056330 **	0.704933
Chile	0.523351	0.924797	1.993492	2.872604 *
Colombia	0.427450	0.001462	0.914291	0.128773
Costa Rica	9.562884 ***	6.410612 **	8.315463 ***	5.667108 **
Dominican Rep.	6.227280 **	5.820903 **	7.884992 ***	7.664957 ***
Ecuador	1.705586	2.078794	1.800276	2.179420
El Salvador	5.781819 **	8.070557 ***	6.739416 ***	9.483207 ***
Guatemala	0.360373	1.586037	0.135678	1.105947
Honduras	0.656772	0.412880	1.768092	1.316152
México	2.749379 *	0.060756	0.179115	0.232676
Nicaragua	0.013115	0.000467	0.019405	0.005972
Panama	1.235246	1.617962	1.279789	1.620152
Paraguay	0.000653	0.009462	0.018838	0.008660
Peru	1.373069	1.005797	0.176388	0.017508
Uruguay	0.027858	0.081145	0.105212	0.206747
Venezuela	0.024676	0.117181	0.005646	0.190617

Notes: Y denotes the growth rate of GDP per capita.
X denotes the commercial openness index (first differenced).
Reported statistics have asymptotic chi-square distribution.
***, ** and * indicate statistical significance at the 1, 5 and 10 percent levels, respectively.

The results of the non-causality tests for the null hypothesis that economic growth does not Granger-cause commercial openness is presented in table 2. Now, the tests are robust for fourteen out of the eighteen countries. At the 10% or lower significance level, it is not possible to reject the null hypothesis in the cases of Bolivia, Colombia, Ecuador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela. However, at the 5%

[14] See Table A7 of the Appendix.

significance level, the null hypothesis is rejected in the cases of Costa Rica, Dominican Republic and El Salvador.

As for the other four countries (Argentina, Brazil, Chile and Mexico), the test results are ambiguous. The single-equation SIC indicated the selection of the standard bivariate model for Argentina, Chile and Mexico, and the bivariate model with time trend for Brazil[15]. Thus, the null hypothesis cannot be rejected at the 10% significance level in the cases of Brazil and Chile, but it is rejected in the cases of Argentina and Mexico.

In summary, the tests suggest the existence of unidirectional Granger causality running from commercial openness to economic growth in Brazil, Chile, Ecuador, Guatemala, Panama, Paraguay and Uruguay. In the cases of Argentina, Dominican Republic and El Salvador, the tests indicate unidirectional Granger causality from economic growth to commercial openness. In the cases of Costa Rica and Mexico, there is bidirectional Granger causality between these variables. Finally, in Bolivia, Colombia, Honduras, Nicaragua, Peru and Venezuela there is no evidence of causality in either direction.

5. CONCLUDING REMARKS

In this paper we investigated the possibility of Granger causality between commercial openness and economic growth for a panel dataset of 18 Latin American countries in the period of 1952-2003. In this study, we employ a methodological approach that consists in the extension of the Granger non-causality test (1969) to panel data based on SUR systems. This approach has two main advantages: it does not require joint hypothesis for all panel members and; since it allows for contemporaneous correlation across countries, this method makes it possible to exploit the extra information provided by the panel data setting.

The results show that there is unidirectional Granger causality running from commercial openness to economic growth in seven countries (Brazil, Chile, Ecuador, Guatemala, Panama, Paraguay and Uruguay). On the other hand, in three countries (Argentina, Dominican Republic and El Salvador) there is unidirectional Granger causality running from economic growth to commercial openness. In two countries (Costa Rica and Mexico), there is bidirectional Granger causality between these variables and, finally, in six countries (Bolivia, Colombia, Honduras, Nicaragua, Peru and Venezuela) there is no evidence of causality in either direction. These results confirm what other studies have already

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[15] See Table A8 of the Appendix.

detected: there is no general rule concerning the existence and the direction of causality between commercial openness and economic growth. This relation varies from country to country and, possibly, from time to time.

In the present paper, however, the mechanisms through which commercial opening and economic growth may affect each other were not investigated. This extension of the analysis might help explain why we obtain such different results for countries with so similar economic formations. Another important extension is to analyze the effects of exports and imports individually. These further developments are already being carried out with the use of a more comprehensive dataset.

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APPENDIX

Table A1

Augmented Dickey-Fuller (ADF) unit root test

– Growth rate of GDP per capita –

Country	In level		In 1st difference		Order of integration
	t-Statistic	Prob.*	t-Statistic	Prob.*	
Argentina	-6.514417	0.0000	-	-	I(0)
Bolivia	-6.016611	0.0000	-	-	I(0)
Brazil	-5.775598	0.0001	-	-	I(0)
Chile	-6.461085	0.0000	-	-	I(0)
Colombia	-4.398116	0.0009	-	-	I(0)
Costa Rica	-6.304284	0.0000	-	-	I(0)
Dominican Rep.	-4.423088	0.0009	-	-	I(0)
Ecuador	-4.486063	0.0000	-	-	I(0)
El Salvador	-3.650897	0.0005	-	-	I(0)
Guatemala	-3.743091	0.0004	-	-	I(0)
Honduras	-7.541440	0.0000	-	-	I(0)
Mexico	-5.606947	0.0000	-	-	I(0)
Nicaragua	-3.220991	0.0018	-	-	I(0)
Panama	-6.587644	0.0000	-	-	I(0)
Paraguay	-3.997895	0.0002	-	-	I(0)
Peru	-4.666025	0.0000	-	-	I(0)
Uruguay	-5.017445	0.0000	-	-	I(0)
Venezuela	-5.787209	0.0000	-	-	I(0)

Note: *MacKinnon (1996) one-sided p-values.

Table A2

Augmented Dickey-Fuller (ADF) unit root test

– Commercial openness index –

Country	In level		In 1st difference		Order of integration
	t-Statistic	Prob.*	t-Statistic	Prob.*	
Argentina	1.885767	0.9847	-5.649175	0.0000	I(1)
Bolivia	-2.156087	0.2245	-10.61410	0.0000	I(1)
Brazil	-0.097839	0.9936	-7.177733	0.0000	I(1)
Chile	-1.534386	0.8044	-6.755559	0.0000	I(1)
Colombia	0.733154	0.8699	-7.544161	0.0000	I(1)
Costa Rica	-1.571045	0.7906	-4.941242	0.0000	I(1)
Dominican Rep.	-2.351475	0.1604	-6.641100	0.0000	I(1)
Ecuador	1.138274	0.9321	-6.826789	0.0000	I(1)
El Salvador	1.850486	0.9834	-6.204392	0.0000	I(1)
Guatemala	0.357771	0.7844	-5.762088	0.0000	I(1)
Honduras	-2.214493	0.2039	-5.335995	0.0000	I(1)
Mexico	-0.498829	0.9804	-4.796688	0.0016	I(1)
Nicaragua	0.581550	0.8387	-7.009966	0.0000	I(1)
Panama	-2.244637	0.1936	-7.050664	0.0000	I(1)
Paraguay	-2.855695	0.1855	-5.420514	0.0000	I(1)
Peru	0.157990	0.7278	-5.917486	0.0000	I(1)
Uruguay	-2.653134	0.2599	-2.143898	0.0321	I(1)
Venezuela	-0.658942	0.4267	-8.933550	0.0000	I(1)

Note: *MacKinnon (1996) one-sided p-values.

Table A3

Augmented Dickey-Fuller (ADF) unit root test

– Investment share of GDP –

Country	In level		In 1st difference		Order of integration
	t-Statistic	Prob.*	t-Statistic	Prob.*	
Argentina	-2.187914	0.2131	-6.621802	0.0000	I(1)
Bolivia	-3.931924	0.0036	-	-	I(0)
Brazil	-1.129957	0.2318	-8.903902	0.0000	I(1)
Chile	-2.482242	0.1257	-8.874062	0.0000	I(1)
Colombia	-3.796961	0.0053	-	-	I(0)
Costa Rica	-3.547504	0.0455	-	-	I(0)
Dominican Rep.	-2.623836	0.2720	-6.423164	0.0000	I(1)
Ecuador	-4.672467	0.0023	-	-	I(0)
El Salvador	-3.316167	0.0192	-	-	I(0)
Guatemala	-3.030604	0.0387	-	-	I(0)
Honduras	-2.720815	0.2330	-6.281283	0.0000	I(1)
Mexico	-2.983349	0.0432	-	-	I(0)
Nicaragua	-3.641192	0.0361	-	-	I(0)
Panama	-2.041089	0.2689	-6.646784	0.0000	I(1)
Paraguay	-0.197307	0.6103	-6.110318	0.0000	I(1)
Peru	-1.950704	0.0496	-	-	I(0)
Uruguay	-3.813313	0.0052	-	-	I(0)
Venezuela	-3.154630	0.1052	-7.358419	0.0000	I(1)

Note: *MacKinnon (1996) one-sided p-values.

Table A4

Breusch & Pagan (BP) test

$$H_0 : \text{cov}(\varepsilon_{k,i,t}, \varepsilon_{k,j,t}) = 0$$

System	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
1	230.10 *	212.09 *	220.32 *	207.26 *
2	338.14 *	323.15 *	333.80 *	321.48 *

Note: * indicates rejection of the null hypothesis at the 1% significance level.
Reported statistics have asymptotic chi-square distribution.

Table A5

Overall Schwarz Information Criterion (SIC)

– System 1 –

Lags	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
1	117.62	142.34	142.19	166.89
2	168.73	193.48	218.99	243.90
3	221.00	245.94	297.32	322.34
4	274.84	300.34	377.76	403.56

Table A6

Overall Schwarz Information Criterion (SIC)

– System 2 –

Lags	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
1	109.36	134.01	134.26	158.81
2	160.10	185.35	210.32	235.48
3	212.55	238.04	289.33	314.95
4	266.96	292.92	370.54	396.38

Table A7

Single-equation Schwarz Information Criterion (SIC_i)

– System 1 –

Country	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
Argentina	3.558540	3.622478	3.637782	3.704184
Bolivia	2.764318	2.842183	2.859724	2.934018
Brazil	2.831466	2.753876	2.911046	2.835903
Chile	3.541894	3.602794	3.601348	3.665432
Colombia	1.200696	1.271823	1.272195	1.338904
Costa Rica	2.488878	2.519927	2.504516	2.548328
Dominican Rep.	3.454515	3.535498	3.538469	3.616521
Ecuador	3.054985	3.084696	3.052575	3.051387
El Salvador	1.876047	1.950374	1.903794	1.980308
Guatemala	1.445560	1.499206	1.484799	1.544894
Honduras	3.135775	3.211115	3.238911	3.314679
Mexico	2.695968	2.576101	2.780905	2.661359
Nicaragua	3.421927	3.439317	3.423616	3.426905
Panama	3.216123	3.286510	3.293755	3.362411
Paraguay	2.290795	2.309334	2.231610	2.266802
Peru	3.429419	3.492763	3.476166	3.545771
Uruguay	3.333526	3.414983	3.412632	3.492070
Venezuela	3.464352	3.464465	3.493025	3.521896

Table A8

Single-equation Schwarz Information Criterion (SIC_i)

– System 2 –

Country	Bivariate model	Bivariate model with time trend	Trivariate model	Trivariate model with time trend
Argentina	0.247259	0.278327	0.322755	0.348701
Bolivia	2.574434	2.649750	2.635996	2.711023
Brazil	1.336043	1.246473	1.424084	1.330709
Chile	1.392180	1.416637	1.480249	1.504560
Colombia	1.639381	1.624826	1.741513	1.717940
Costa Rica	2.524716	2.576677	2.596066	2.650869
Dominican Rep.	2.587835	2.662713	2.620273	2.698431
Ecuador	2.809609	2.878565	2.882570	2.952639
El Salvador	2.388315	2.373014	2.459523	2.442096
Guatemala	2.684382	2.759938	2.764980	2.839716
Honduras	4.021883	4.099155	4.069774	4.146627
Mexico	1.227097	1.238114	1.276984	1.288321
Nicaragua	4.000841	4.073310	4.073735	4.148307
Panama	5.644002	5.699504	5.722577	5.783221
Paraguay	4.123377	4.198416	4.212914	4.292728
Peru	1.740864	1.803335	1.793547	1.861827
Uruguay	1.049628	1.083633	1.123750	1.158660
Venezuela	2.276658	2.339490	2.354349	2.411801