ON THE NEXUS BETWEEN OPENNESS AND GROWTH IN GREECE

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Abstract

This paper attempts to examine the causal relationship between openness and economic growth in Greece. For this investigation we apply the integration and cointegration properties of the data using Granger, Sims, Geweke and Hsiao models. The results of this paper suggested that there is a bilateral causality between economic growth and exports plus imports.

keywords: openness, economic growth, causality

JEL O10, C22
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I. INTRODUCTION

Today there is no economy, which can be characterized as totally closed. All economies are open to some extent, with the degree of openness varying substantially from one country to another. How openness is defined appears to be determined by the objective at hand. In this respect at least three definitions are found in the literature, one identifying openness with imports, another with exports and a third one with imports plus exports, all expressed as GDP ratios. There are no invariable patterns of openness, nor is there an unshakable rationale regarding its measurement. Harrison (1996) refers to seven measures of trade openness and defines the ratio of external trade as the simplest estimation measure which is based on actual trade flows such as exports plus imports as a share of GDP or the growth rates of imports and exports. The World Bank openness can be defined as the ratio of external trade (exports plus imports) to GDP (World Bank 1991).

Equally acceptable definitions could go beyond the trade of goods to include the flows of international services. However, for our purposes, services are excluded firstly because in the early stages of development they are usually insignificant and second there were no statistical records of their significance as those of goods for the examined period in our model.

Whether openness as a direct manifestation of international trade flows contributes to economic development has not been unambiguously determined empirically. On the one extreme side of the spectrum neoclassical economists, faithful in free markets as a necessary condition for equalization of returns and optimal resource allocation, stand out as firm advocates of free trade, whereas on the other extreme the leftist Latin American school of dependency economists views openness
as an obstacle to economic development that inexorably leads to the immizeration of the periphery. Between the extremes of free trade and isolation lies the real world in which countries operate with different degrees of ability to participate in international trade and to employ the balance of payments as a tool of raising government revenue and promoting their economic development (Afxentiou and Serletis 1992).

The relationship between openness and economic growth, including the direction of causality between the two variables, has long been the subject of extensive debate and research. Empirical studies of this relationship provide mixed results. Methodologically there are two common approaches. One is the production function based on regression model approach (Michaely 1977, Krueger 1978, Tyler 1981, Kavoussi 1984, Feder 1985, Balassa 1985, Moschos 1989, Salvatore and Hatch 1991, Yaghmaian 1994, Dritsaki et al 2004). These models can identify the relationship between exports and economic growth in alternative growth equations, which include various factors of production, and in some cases the process of development and structural change. However, most papers do not examine the matter of causality between these variables.


Greece, which is a developing country, is known to be constrained by its limited foreign exchange earnings and may be regarded as a less open economy compared with other industrial countries. However, there are exceptions to this rule that have to
do with the size of a country, the historical experience of its trading relations and its economic orientation. The size of openness in Greece has not only been freely determined by market forces but also by government policies.

The evolution of Greek International economic relations during the post-war period was influenced not only by the progress of intrinsic economic incident but also by the development in the economies of its major rivals in the international markets. The period 1960-2000 is characterized by the development of national trade, the increase of GDP and capital productivity increase and marks the post-war rapid development of the Greek economy. By all means the question that arises is whether the national conjuncture and the international economic relations of Greece during the examined period have influenced or even better have determined the development of capital accumulation in Greece.

The aim of this paper is to investigate the relationship between openness and economic growth in Greece and thereby reduce the fiscal deficit that exists. Perkins and Syrquin (1989) argue that size is the greatest hindrance to developing countries trying to follow an export-led growth strategy. The larger the size, the more difficult is to follow this strategy. Greece as a small developing country in the world has the advantage to follow this strategy according to Perkins and Syrquin (1989). An investigation of the Greek experience in trade and economic growth would thus provide a useful reference point for other developing countries, especially those of small size. Section II of this paper provides a theoretical discussion of openness – growth causality. Section III employs the methodology of this paper where models of Granger (1969), Sims (1972), Geweke et al. (1983), and Hsiao (1979) are employed to investigate the causal relationship between openness and economic growth. Section IV presents the results of unit root test and cointegration analysis between the
examined variables. Section V analyses the Granger causality test. Finally, section VI provides the conclusions of this paper.

II. THEORETICAL CONSIDERATIONS

The relationship between exports and economic growth has been widely discussed in the literature. Four different views can be discernable. The first is the neoclassical export-led growth hypothesis to the extent that exports’ expansion will increase productivity providing larger economies of scale Helpman and Krugman (1985). The second view is that causality runs from economic growth (productivity) to exports. Higher productivity leads to lower unit costs, which facilitate exports Kaldor (1967). Economic growth cause export growth if innovation and technical progress result in well-developed markets, which improve export performance in the trade sector Ghartey (1993). The third view is a combination of the first and second one. There can be a feedback causal relationship between exports and economic growth Helpman and Krugman (1985). The fourth view is that no causal relationship exists between exports and economic growth. These are both the result of the process of development and structural change Yaghmaian (1994).

There are at least three arguments that can be used for the provision of theoretical rationale over the hypothesis that exports and economic growth are interrelated. Firstly, according to Keynesian suggestion, exports’ increase leads to economic growth expansion through the external trade multiplier. Secondly, exports bring foreign exchange that can be used for import of capital products promoting economic growth. Finally, competition leads to growth of economies of scale and to technology’s acceleration in the production, two of the most important sources of economic growth.
The application of the causality model between exports and economic growth has important effects on the development of strategies for the least developed countries. If exports’ growth cause economic growth, then the exports-led economic growth strategy is appropriate for the examined country. If the causal relationship operates to the opposite direction, then the achievement of the certain rate of growth can be a prerequisite for a country to increase its exports Chow (1987), Moschos (1989). Feedback causality between exports and economic growth implies that the one consolidates the other Liu X. et al (1997).

The hypothesis of the causal relationship between exports and economic growth does not imply that exports are the only determinant of economic growth and *vice versa*. Although there are numerous studies about the relationship between exports and economic growth, few of them have been conducted in relation to the causal relationship between economic growth and exports plus imports. One important reason behind this lack of relevant studies may arise from macroeconomic theory where imports represent the cyclical flow of income and will result more in domestic unemployment than economic growth. However, it should be noted that imports represent an important determinant of economic growth if they are used as a mean of ensuring the supply of raw products and obtaining new technology through imports of capital goods. Differently, imports are used as a function of income Afxentiou and Serletis (1992). There is a bilateral causality between imports and economic growth. Since theoretical considerations indicate that causality between openness and economic growth can be in either direction, the nature of causality is essentially an empirical question. In the case of Greece, the introduction of economic reform and open-door policy has made it a very open economy. Furthermore, Greek’s trade policy has moved towards protected exports’ promotion. While encouraging an
outward oriented strategy, Greece uses imports as a way of importing key raw materials and embodied technology to promote import substitution, economic growth and new exports. Thus a bi-directional causation between openness in the broader sense and economic growth is anticipated. The test results are reported in section V.

III. METHODOLOGY

For the causality test we use the following three bivariate equations suggested by Granger (1969), Sims (1972), and Geweke, Meese, and Dent (1983).

\[ X_t = c_1 + \sum_{i=1}^{n} \alpha_i X_{t-i} + \sum_{j=1}^{q} \beta_j Y_{t-j} + u_{1t} \]  
\[ X_t = c_2 + \sum_{i=0}^{m} \gamma_i Y_{t-i} + \sum_{j=1}^{n} \nu_j Y_{t+j} + u_{2t} \]  
\[ X_t = c_3 + \sum_{i=1}^{s} \pi_i X_{t-i} + \sum_{j=1}^{z} \theta_j Y_{t-j} + \sum_{k=0}^{w} \xi_j Y_{t+j} + u_{3t} \]

To implement the Granger causality test of model 1 we estimate this equation with OLS for each time series or the equation of autoregressive model and we calculate the F-statistic by this estimation. The null hypothesis is:

Ho: Y does not Granger cause X, \{\beta_j = 0 \gamma_i \ i = 1, 2\ldots\}, if \( F_c < \text{critical value of } F \)

\( F_c \)-statistic is given by the following relationship:

\[ F_c = \frac{(RSS_R - RSS_c) / q}{RSS_u / (T - 2q - 1)} \sim F (q, T-2q-1) \]
where:

\[ \text{RSS}_U = \text{is the sum of squared residuals from unrestricted Equation 1} \]

\[ \text{RSS}_R = \text{is the sum of squared residuals when the restrictions } \beta_j = 0 \text{ for } j = 1, 2, \ldots \text{is conducted} \]

\[ T = \text{is the sample size} \]

\[ q = \text{is the lag length of } Y. \]

- If the calculated \( F_c \)-statistic is greater than the critical value for an \( F(q, T-2q-1) \) distribution (with degrees of freedom \( v_1 = q \) and \( v_2 = T - 2q - 1 \)), then the null hypothesis that \( Y \) does not cause \( X \) is rejected. If the calculated \( F \)-statistic is sufficiently large, then \( Y \) does cause \( X \) (\( Y \Rightarrow X \)).

- To test for \( X \Rightarrow Y \), the procedure is repeated in a reverse direction with a regression of \( Y \) on lagged \( Y \) and \( X \).

- If both tests reject the null hypothesis, then a feedback causal relationship exists between \( X \) and \( Y \) (\( X \Leftrightarrow Y \)).

An alternative approach in Granger’s model is the Sim’s (1972) model. Many empirical studies suggest that one of the problems with the Sims model is that the error term \( u_{2t} \) tends to be autocorrelated. Thus, a standard \( F \)-statistic of the null hypothesis that \( n_j \) is jointly equal to zero is likely to give an incorrect answer. The null hypothesis is:

\[ H_0: X \text{ does not Granger cause } Y, \text{ if and only if } \{ n_j = 0 \text{ for } j = 1, 2, \ldots \}, \text{ and } F_c < \text{ critical value of } F. \]

Another option is suggested by Geweke, Meese, and Dent (1983), in Equation 3 where the null hypothesis that \( X \) does not cause \( Y \) may be tested with an \( F \)-statistic of \( \xi_1 = \xi_2 = \ldots = \xi_\kappa = 0 \). The null hypothesis is:
Ho: X does not Granger cause Y, \( \{ \xi_1 = \xi_2 = \ldots = \xi_k = 0 \ \text{for} \ j = 1, 2 \ldots \} \), if \( F < \) critical value of F.

Hsiao's (1979) version of the Granger causality method follows a two-step procedure to determine the optimum number of lag length and the direction of causality of two or more variables using Akaike's (1969) final prediction error (FPE).

The first step follows a series of succeeding autoregressive regressions on the dependent variables. In the first regression, the dependent variable is lagged once. In the second one the dependent variable is lagged twice and so forth. If the maximum lag length of dependent variable is \( m \), the regression function has the following form:

\[
d(X_t) = \alpha_0 + \sum_{i=1}^{m} \beta_i d(X_{t-i}) + u_{1t}
\]

where the value of \( i \) is from 1 to \( m \). The choice of lag length is based on the sample size. Then the final prediction error (FPE\(^1\)) is computed. The optimal lag length, \( m^* \), is the lag length which produces the lowest FPE.

In the second step, since the optimum lag length \( m^* \) of dependent variables has been determined, the regressions are estimated with the lags on the independent variable added sequentially in the same manner. The new estimated regression is of the following form:

\[
d(X_t) = \alpha_0 + \sum_{i=1}^{m} \beta_i d(X_{t-i}) + \sum_{j=1}^{n} \gamma_j d(Y_{t-j}) + u_{1t}
\]

where the value of \( j \) ranges 1 to \( n \). Then we calculate the final prediction error (FPE\(^2\)). The optimum lag length \( n^* \) produces the lowest FPE for the variable Y.

\[
FPE(m) = \frac{(T+m+1)}{(T-m-1)}(RSS(m)/T) \text{ where } T \text{ is the number of observations, } m \text{ is the lag length and } RSS \text{ is the sum of squared errors respectively}
\]
Testing for causality with Hsiao method is compared with FPE \((m^*)\) and FPE \((m^*, n^*)\) as we get from the above regressions. The null hypothesis in this case is the following:

\(H_0: Y\) does not Granger cause \(X\), if and only if \(\text{FPE}(m^*)<\text{FPE}(m^*, n^*)\).

All four tests require that the models are correctly specified and the error terms are normally distributed with zero mean and constant variance \(u_i \sim N(0, \sigma_i^2)\) where \(i = 1, 2, 3\). Violation of these hypotheses may cause misleading inferences. In addition, the causality tests also depend on whether the time series in the tests are cointegrated. Granger (1988) shows that if a pair of I(1) is cointegrated, it can always be transformed into a short-run error correction mechanism (ECM) of the form:

\[
\Delta X_t = f(lagged \Delta X_{t-1}, \Delta Y_{t-1}) + \gamma_1 \hat{u}_{t-1}
\]  

\[
\Delta Y_t = f(lagged \Delta Y_{t-1}, \Delta X_{t-1}) + \gamma_2 \hat{u}_{t-1}
\]  

where \(\hat{u}_t\) are the estimated residuals from the cointegration regression. Equations 5 and 6 indicate that for a pair of variables, which is in an equilibrium state, there must be some dynamic causality between them. If this is the case, there would be two possible sources of \(X_t\) with \(Y_{t-1}\) either through the error correction term or through the lagged \(\Delta Y_t\) terms.

The implication is that the specification tests in equations 1, 2 and 3 in which the error correction term (ECM) is not modeled, are inappropriate, so 5 and 6 equations should be used. If there is no cointegration relationship, then the causality

\[\text{FPE}(m^*, n) = \frac{[(T+m^*+1)/(T-m^*-1)](RSS(m^*, n)/T)}{T}\]  

where \(T\) is the number of observations, \(m^*\) is the optimal lag length for \(Y\) and RSS is the sum of squared errors respectively.
tests of equations 1, 2 and 3 are valid. Therefore, in deciding which form of causality should be used in the paper, the integration and cointegration properties of the openness and economic growth variables are examined in the first instance.

IV. UNIT ROOT TESTS AND COINTEGRATION ANALYSIS

The data that have been used in this analysis are quarterly covering the period 1960:1-2000:1 and came from the database of OECD (Business Sector Data Base). Openness can be defined as the sum of exports and imports as a share of GDP according to World Bank (1991) and Harrison’s (1996) study.

All data are expressed in logarithms in order to include the proliferative effect of time series and are symbolized with the letter L preceding each variable name.

If these variables share a common stochastic trend and their first differences are stationary, then they can be cointegrated. Economic theory scarcely provides some guidance relative to which variables appear to have a stochastic trend and when these trends are common among the examined variables as well. For the analysis of the multivariate time series that include stochastic trends, the augmented Dickey-Fuller (1979) unit root test is used for the estimation of individual time series, with intention to provide evidence of when the variables are integrated.

The test procedure presented in section 3 presupposes that time series that have been used for the causality test are stationary. The augmented Dickey-Fuller test is used for the stationarity test, which is based on the following regression:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t$$  \hspace{1cm} (7)
The ADF regression tests for the existence of unit root of $X_t$, namely in the logarithm of all model variables at time $t$. The variable $\Delta X_{it}$ expresses the first differences with $k$ lags and final $u_t$ is a white noise that adjusts the errors of autocorrelation. The coefficients $\delta_0$, $\delta_1$, $\delta_2$, and $\alpha_i$ are being estimated. The null and the alternative hypothesis for the existence of unit root in variable $X_t$ is

$$H_0 : \delta_2 = 0 \quad H_1 : \delta_2 < 0$$

If the OLS estimate of $\delta_2$ coefficient is negative and statistically significant (different from zero), based on the calculated $t$-statistic, then we can conclude that the time series that we have used is stationary or that the series don’t include a unit root. In inverse case the same procedure is repeated for the first differenced series and when it is necessary for their second differences until the time series become stationary. Since the $t$-distribution can’t be used as critical for the values of the coefficient $\delta_2$, critical values are given by Fuller (1976) and Mackinnon (1990). This study uses the critical values of Mackinnon. It also uses Akaike’s information criterion (AIC)$^3$ (1973) and Schwartz (SC)$^4$ (1978) for the determination of the appropriate lag length, and the Box-Pierce Q-statistic and Breusch-Godfrey (BG) LM$^5$ tests for the residuals serial correlation test.

\[ \text{INSERT TABLE 1} \]
\[ \text{INSERT TABLE 2} \]

---

$^3$ Akaike’s information criterion (AIC) is calculated from: $\text{AIC} = (2k/T) + \log \left( \text{RSS}/T \right)$, where $k$ is the number of regressors, $T$ is the number of total observations and RSS is the sum of squared residuals.

$^4$ The Schwarz criterion (SC) is an alternative to the AIC with basically the same interpretation.

$^5$ The BG-statistic is the Lagrange multiplier test for $k$th order residual autocorrelation Godfrey (1978).
The results from Table 1 imply that the existence of unit root in the time series cannot be rejected in variables levels, at 1%, 5%, and 10% significance levels. Therefore, no time series appear to be stationary in variables levels. However, when the time series are transformed into their first differences, they become stationary and consequently the related variables can be characterized as integrated of order one, I(1). Moreover, for all variables in their first differences the B-G test shows that there is no correlation in the disturbance terms.

Further, the cointegration test through Engle-Granger (1987) method is examined between each pair of the variables – viz. (a) EXP & GDP, (b) IMP & GDP, and (c) (EXP+IMP) & GDP. Then cointegration relationships among the three variables in question, from GDP to IMP and EXP, from EXP to GDP and IMP, from IMP to GDP and EXP.

The results presented in Table 2 show that there is no evidence of cointegration relationships between openness and growth. This may be due to the omission in the cointegrated regression, such as factors of production, technological progress, which also determines the domestic economic growth, income levels, exchange rate and external trade policies that determine the openness of the economy. The lack of cointegration between economic growth and openness in Greece justifies the use of the traditional causality tests of the examined Equations 1, 2, 3

V. CAUSALITY

In testing for causality we estimate the Granger, Sims and Geweke models with different lag lengths for the dependent and causal variable. For each model Akaike and Schwarz criteria are estimated, while the residuals are examined for serial
correlation (the Box-Pierce Q-statistic and the Breusch-Godfrey LM test), for normality (Jarque-Bera statistic test (1980)), and heteroscedasticity (White’s test (1980)). The model with a white noise error term and minimum AIC and SC is selected for causality inference. In this paper a lag length of \( l = 20 \) is assigned to all causality equations. If the calculated Box-Pierce Q-statistic exceeds the 5% critical value, \( \chi^2(20) = 31.4 \), then the null hypothesis that the residuals are white noise is rejected. In some cases, it is difficult to achieve a model that passes all the diagnostic tests. In these cases, the one that satisfies most of the diagnostic criteria is chosen. The test results are presented in Table 3.

**INSERT TABLE 3**

Hsiao’s version Granger causality test is performed in a series of autoregressive regressions for dependent and independent variables of model (1). Then we calculate the final prediction errors for the two variables. The null hypothesis of non-causality is rejected if \( \text{FPE}(m^*) > \text{FPE}(m^*,n^*) \). Table 4 reports the Hsiao test results.

**INSERT TABLE 4**

The results from Table 3 and Table 4 are consistent with a feedback causal relationship between economic growth and openness (exports plus imports to GDP) for the models of Granger, Sims and Hsiao. It is interesting to note that the causality from openness to economic growth is achieved not only in the above models but also in Geweke’s model, while there is a reverse causality only in three models (apart from Geweke model). Also the causal relationship from openness to economic growth is achieved at 5% significance level, while the reverse causality at the 10% significance
level in both the Granger and the Sims models. This indicates that openness has a stronger impact on economic growth (in the broader sense) than the latter on the former.

The Geweke model, also known as the modified Sims model, suggests that there is a single causality from openness to economic growth and not vice versa. If we combine the results from the three models of Table 3 the final conclusion denotes clearly that there is causality between economic growth and openness running in either direction.

VI. CONCLUSIONS

This paper examines the causal relationship between economic growth and openness in Greece for the period from 1960:1 to 2004:IV. The integration and cointegration properties of the data are analyzed and the models of Granger, Sims, Geweke and Hsiao are employed to identify the nature of the causal relationship. The results suggest that a feedback causal relationship exists between economic growth and openness – in line with the studies of Liu et al (1997) for China and Jin (2003) for North Korea, two countries which have recently presented a rapid growth. The findings are consistent with the development strategy pursued by consecutive Greek governments during the period under review. Exports were encouraged while imports policy was used to ensure the supply of key materials and embodied technology, so that import substitution and economic growth can be promoted to new exports. Thus, the interrelation between economic growth and openness seems to exist in all models for Greece over the examined period. However there is some potential for obtaining biased results because quarterly GDP series is estimated based on the quarterly data.
on total gross output value of industry. The direction of causality may also have changed over the sample period used in this study.

Empirical evidence from Greece can be important for other developing countries, especially those of small size and those in transition from a centrally planned to a market economy. Adherence to economic reform and opening to the outside world makes possible the realization of both the export-led growth strategy and the growth – export linkage even in a large developing country. Economic reforms improve efficiency and enhance economic growth, which in turn promotes exports and imports. On the other hand international trade based on resource endowments stimulates economic growth. Regardless of size, developing countries may benefit from the combination and coordination of economic reform, restructuring and integration into the world economy.

REFERENCES


### TABLE 1: TESTS OF UNIT ROOTS HYPOTHESES

<table>
<thead>
<tr>
<th>Variables</th>
<th>$\tau_\mu$</th>
<th>$\tau_\tau$</th>
<th>k</th>
<th>B-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEXP</td>
<td>-2.5113</td>
<td>-0.6084</td>
<td>2</td>
<td>1.9753 [0.167]</td>
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<tr>
<td>L(EXP+IMP)</td>
<td>-1.6634</td>
<td>-1.1506</td>
<td>2</td>
<td>1.7303 [0.188]</td>
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<tr>
<td>LIMP</td>
<td>-1.8555</td>
<td>-1.9668</td>
<td>3</td>
<td>1.3601 [0.244]</td>
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<tr>
<td>LGDP</td>
<td>-0.8037</td>
<td>-1.3928</td>
<td>4</td>
<td>4.6590 [0.032]</td>
</tr>
<tr>
<td>ΔLEXP</td>
<td>-3.6512</td>
<td>-4.2246</td>
<td>4</td>
<td>2.9390 [0.086]</td>
</tr>
<tr>
<td>ΔL(EXP+IMP)</td>
<td>-5.4831</td>
<td>-6.4487</td>
<td>4</td>
<td>3.7194 [0.054]</td>
</tr>
<tr>
<td>ΔLIMP</td>
<td>-3.8962</td>
<td>-4.1278</td>
<td>4</td>
<td>3.6413 [0.061]</td>
</tr>
<tr>
<td>ΔLGDP</td>
<td>-4.2530</td>
<td>-4.2679</td>
<td>4</td>
<td>0.3344 [0.563]</td>
</tr>
</tbody>
</table>

Notes:
- $\tau_\mu$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is not included in equation 7 and $\tau_\tau$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is included in equation 7.
- The critical values at 1%, 5% and 10% for $N=160$ are -3.44, -2.87 and -2.57 for $\tau_\mu$ and -4.01, -3.43 and -3.14 for $\tau_\tau$ respectively.
- Numbers inside the brackets indicate significant levels.

### TABLE 2: COINTEGRATION TESTS

<table>
<thead>
<tr>
<th>Cointegration equation</th>
<th>ADF</th>
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</thead>
<tbody>
<tr>
<td>LGDP on LEXP</td>
<td>-1.1629</td>
</tr>
<tr>
<td>LEXP on LGDP</td>
<td>-1.7109</td>
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<tr>
<td>LGDP on LIMP</td>
<td>-1.0958</td>
</tr>
<tr>
<td>LIMP on LGDP</td>
<td>-1.6981</td>
</tr>
<tr>
<td>LGDP on (LEXP+LIMP)</td>
<td>-1.6887</td>
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<td>(LEXP+LIMP) on LGDP</td>
<td>-1.3204</td>
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<tr>
<td>LGDP on LIMP &amp; LEXP</td>
<td>-1.9675</td>
</tr>
<tr>
<td>LEXP on LGDP &amp; LIMP</td>
<td>-1.7334</td>
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<tr>
<td>LIMP on LGDP &amp; LEXP</td>
<td>-1.4814</td>
</tr>
</tbody>
</table>

Critical Values: -3.44 (1%), -2.87 (5%), -2.57 (10%).
### TABLE 3: GRANGER CAUSALITY TESTS

<table>
<thead>
<tr>
<th>Model</th>
<th>F-statistic</th>
<th>Q-statistic</th>
<th>B-G</th>
<th>NOR</th>
<th>HET</th>
<th>Inference</th>
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<tr>
<td>Granger model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGDP on LEXP</td>
<td>5.317 (8,8)**</td>
<td>7.88</td>
<td>1.144</td>
<td>0.351</td>
<td>1.647</td>
<td>LEXP ⇒ LGDP</td>
</tr>
<tr>
<td>LEXP on LGDP</td>
<td>0.713 (8,8)</td>
<td>12.42</td>
<td>1.312</td>
<td>1.217</td>
<td>0.853</td>
<td>LGDP ≠ &gt;LEXP</td>
</tr>
<tr>
<td>LGDP on LIMP</td>
<td>1.428 (8,7)</td>
<td>9.08</td>
<td>0.492</td>
<td>0.944</td>
<td>5.184</td>
<td>LIMP ≠ &gt;LGDP</td>
</tr>
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<td>LIMP on LGDP</td>
<td>4.548 (8,7)**</td>
<td>7.35</td>
<td>0.717</td>
<td>7.148</td>
<td>1.223</td>
<td>LGDP ⇒ LIMP</td>
</tr>
<tr>
<td>LGDP on (LEXP+LIMP)</td>
<td>2.714 (8,8)**</td>
<td>10.43</td>
<td>1.131</td>
<td>2.018</td>
<td>1.914</td>
<td>(LEXP+LIMP) ⇒ LGDP</td>
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<tr>
<td>(LEXP+LIMP) on LGDP</td>
<td>2.027 (8,8)**</td>
<td>4.49</td>
<td>0.917</td>
<td>0.541</td>
<td>0.742</td>
<td>LGDP ⇒ (LEXP+LIMP)</td>
</tr>
<tr>
<td>Sims model</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>LEXP on LGDP</td>
<td>4.312 (8,6)**</td>
<td>9.12</td>
<td>1.419</td>
<td>2.914</td>
<td>1.371</td>
<td>LEXP ⇒ LGDP</td>
</tr>
<tr>
<td>LGDP on LEXP</td>
<td>0.419 (8,7)</td>
<td>14.72</td>
<td>4.127</td>
<td>0.587</td>
<td>1.814</td>
<td>LGDP ≠ &gt;LEXP</td>
</tr>
<tr>
<td>LIMP on LGDP</td>
<td>0.811 (8,8)</td>
<td>10.55</td>
<td>0.315</td>
<td>0.714</td>
<td>7.138</td>
<td>LIMP ≠ &gt;LGDP</td>
</tr>
<tr>
<td>LGDP on LIMP</td>
<td>2.917 (8,8)**</td>
<td>8.11</td>
<td>1.727</td>
<td>1.118</td>
<td>2.114</td>
<td>LGDP ⇒ LIMP</td>
</tr>
<tr>
<td>(LEXP+LIMP) on LGDP</td>
<td>2.944 (7,7)**</td>
<td>11.27</td>
<td>0.596</td>
<td>5.187</td>
<td>0.914</td>
<td>(LEXP+LIMP) ⇒ LGDP</td>
</tr>
<tr>
<td>LGDP on (LEXP+LIMP)</td>
<td>1.979 (7,7)**</td>
<td>8.14</td>
<td>1.817</td>
<td>1.914</td>
<td>0.214</td>
<td>LGDP ⇒ (LEXP+LIMP)</td>
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<td>Geweke model</td>
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<td></td>
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<tr>
<td>LEXP on LGDP</td>
<td>0.917 (6,6,6)</td>
<td>11.35</td>
<td>5.713</td>
<td>1.981</td>
<td>0.538</td>
<td>LEXP ≠ &gt;LGDP</td>
</tr>
<tr>
<td>LGDP on LEXP</td>
<td>0.615 (6,6,6)</td>
<td>14.27</td>
<td>0.914</td>
<td>0.448</td>
<td>0.913</td>
<td>LGDP ≠ &gt;LEXP</td>
</tr>
<tr>
<td>LIMP on LGDP</td>
<td>1.173 (8,6,6)</td>
<td>10.63</td>
<td>7.815</td>
<td>8.143</td>
<td>1.414</td>
<td>LIMP ≠ &gt;LGDP</td>
</tr>
<tr>
<td>LGDP on LIMP</td>
<td>1.954 (8,7,6)*</td>
<td>9.87</td>
<td>3.011</td>
<td>3.219</td>
<td>0.078</td>
<td>LGDP ⇒ LIMP</td>
</tr>
<tr>
<td>(LEXP+LIMP) on LGDP</td>
<td>3.545 (8,7,7)**</td>
<td>10.76</td>
<td>0.815</td>
<td>7.191</td>
<td>0.914</td>
<td>(LEXP+LIMP) ⇒ LGDP</td>
</tr>
<tr>
<td>LGDP on (LEXP+LIMP)</td>
<td>1.312 (8,7,7)</td>
<td>12.62</td>
<td>0.944</td>
<td>1.445</td>
<td>1.413</td>
<td>LGDP ≠ &gt; (LEXP+LIMP)</td>
</tr>
</tbody>
</table>

Notes:
1. The figures in parentheses after the F-statistics are the number of lags and leads for the dependent variables and causal variables. F test: 1.70, 2.00, 2.62, 1.75, 2.07, 2.76 and 1.80, 2.16, 2.92.
2. Box-Pierce’s statistic is in the form of $Q = T \sum_{k=1}^{l} \hat{\rho}_k^2$ where $\hat{\rho}_k$ is the kth order autocorrelation function of the residuals. The Q-statistic is approximately distributed as the chi-square distribution with one degree of freedom.
3. The BG-statistic is the Lagrange multiplier test for kth order residual autocorrelation (Godfrey 1978).
4. The Jarque and Bera (1980) normality test is calculated from: $X^2(2) = \frac{1}{6} [(T-k)/6][\text{SK}^2+1/4\text{EK}^2]$, where SK and EK are skewness and kurtosis respectively. On the null of normality, the statistic is approximately distributed as $X^2$ with two degrees of freedom.
5. White’s heteroskedasticity test is based on an auxiliary regression of the squared residuals on all squares of the original regressors. The null hypothesis is that the errors are homoskedastic, i.e. they are unrelated to the regressors. * ** and *** indicate the 10%, 5% and 1% significance levels respectively. The **bold** figures indicate that the statistical criteria are not satisfied at the 10% level.

### TABLE 4: HSIAO CAUSALITY TESTS

<table>
<thead>
<tr>
<th>Causal variables</th>
<th>LGDP</th>
<th>LEXP</th>
<th>LIMP</th>
<th>(LEXP+LIMP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGDP</td>
<td>0.0057 (11)**</td>
<td>0.0061 (12)**</td>
<td>0.0439 (10)**</td>
<td>0.0342 (8)**</td>
</tr>
<tr>
<td>LEXP</td>
<td>0.0041 (10,9)**</td>
<td>---</td>
<td>0.0236 (9,8)**</td>
<td>0.0227 (10,8)**</td>
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<tr>
<td>LIMP</td>
<td>---</td>
<td>0.0059 (11,8)**</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>(LEXP+LIMP)</td>
<td>---</td>
<td>0.0047 (10,8)**</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Notes: In parentheses are the number of lags length.
1. FPE(m*).
2. FPE(m*,n*)