EXPORTS AND ECONOMIC GROWTH:
AN EMPIRICAL INVESTIGATION OF E.U, U.S.A AND JAPAN USING CAUSALITY TESTS

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Abstract

This paper investigates the relationship between exports and economic growth in the three of the largest exporting countries in the world, such as European Union, United States of America and Japan. For this purpose we have used Granger causality analysis based on error correction model. The results of this paper suggested that exports have a causal effect on the development process for the countries of European Union, USA, while there is no causal relationship between the examined variables for Japan.

keywords: exports, economic growth, cointegration, Granger causality

JEL. O10, C22
1. Introduction

There is a wide body of literature analyzing the theoretical links between exports and economic growth. According to this literature, the relationship between exports and economic growth is determined by different factors. Clearly, since exports are a component of GDP, exports growth contributes directly to GDP growth. Exports relax binding foreign exchange constraints and allow increases in imported capital goods and intermediate goods (McKinnon 1964, Chenery and Strout 1966). Also exports allow poor countries with narrow domestic markets to benefit from economies of scale (Helpman and Krugman 1985). In addition, exports lead to improved efficiency in resource allocation and, in particular, improved capital utilization owing to competition in world markets (Balassa 1978, Bhagwati and Srinivasan 1979, Krueger 1980).

The ratio of exports to gross domestic product also provides us information about the importance of exports in the national economy. Since the ratio of exports to gross domestic product is an index of openness, a larger ratio of exports to gross domestic product indicates a more open economy. Larger economies – as measured by area, population, and size of the domestic market- can produce and absorb a larger share of their output domestically, they tend to have lower ratios (Pereira and Xu 2000).

On the other hand low ratios of exports to gross domestic product can reflect restrictive trade policies. Nevertheless, the low-ratio countries, which are classified as potentially oriented by the World Bank, are fitted to this category appropriately. Four different views can be distinguished for the relationship between exports and economic growth. The first is the neoclassical export-led growth hypothesis. This
theory suggests that the direction of causation is running from exports to economic growth for the following reasons:

- Export expansion will increase productivity by offering greater economies of scale (Helpman and Krugman 1985).

- Export expansion brings about higher-quality products because of the exporter’s exposure to international consumption patterns (Krueger 1985).

- Exports will lead a firm to overinvest in a new technology as a strategy for a precommitment to a larger scale of output, increasing the rate of capital formation and technological change (Rodrik 1988, Ghirmay, Grabowski and Sharma 2001).

- An export-oriented approach in a labor-surplus economy permits the rapid expansion of employment and real wages (Krueger 1985, Abdulai and Jaquet 2002).


The second view is that causality runs from economic growth to exports. Higher productivity leads to a lower unit cost, which facilitates exports growth (Kaldor 1967). Economic growth affect exports growth if the domestic production increases faster than the domestic demand (Sharma and Dhakal 1994), Ahmad and Harnhirun 1996, Shan and Tian 1998).

The third view, which is a combination of the first and the second views, suggests that there can be a bilateral causal relationship between exports and economic growth (Ghartey 1993, Wernerheim 2000, Ramos 2001, Hatemi-J. 2002).
Final, the fourth view is that there is no causal relation between exports and economic growth, namely exports and economic growth are both the result of the development process and technological change (Yaghmaian 1994).

For the causal analysis between exports and economic growth, recent empirical studies have adopted the causality approach suggested by (Granger 1969 and Sims 1972). The results from causality tests are however mixed. Some studies find a positive relationship between exports and economic growth (Sharma 1991, Xu 1996, Liu, Burridge and Sinclair 2002), while other results from causality tests are largely negative (Bahmani-Oskooee et al 1991 and Dodaro 1993), even for those economies such as Hong Kong, Korea, Taiwan, whose growth experience is widely believed to result from their successful export-promoting policies.

In this paper, the methodology proposed by (Granger 1969 and Sims 1972) for the causality tests on the relationship between exports and economic growth is applied. This methodology is based on the estimation of bivariate relationships between the two variables. These tests are designed to capture exclusively the short-run dynamics between the two variables. However, there might exist a long-run relationship between these variables. For this reason the cointegration analysis is used to test the long-run equilibrium relationship between exports and economic growth for the examined countries. (Dritsakis and Adamopoulos 2004)

The aim of this paper is to investigate the relationship between exports and economic growth for these three economies, which are mainly the major exporters in the world market. The remainder of the paper proceeds as follows: Section 2 describes the theoretical framework of this paper. Section 3 presents the results of unit root tests, while the cointegration analysis between the used variables is implied.
in Section 4. The causality analysis based on error correction model is deployed in Section 5. Finally, section 6 provides the conclusions of this paper.

2. The theoretical framework

In order to examine the relationship between exports and economic growth, the present paper uses two models from the existing literature (Feder 1982, Ram 1985, 1987). One is a production function-type framework in which the level of exports, the level of government expenditures and the terms of trade enter as ‘inputs’ in the production process (Khalifa-Al Yousif 1997, Dritsakis and Vazakidis 2003). The open nature of the three countries explains the inclusion of both terms of trade, the level of exports, the labour, the capital and the level of government expenditures as possible explanatory variables in the production function. This specification can be derived from the following general aggregate production function

\[ Y = f(L, K, X, G, T) \]  \hspace{1cm} (1)

where:

- \( Y \) = Real aggregate output
- \( L \) = Labour
- \( K \) = Capital
- \( X \) = Exports
- \( G \) = Government spending
- \( T \) = Terms of trade
By taking the total differentials of function (1), we have:

$$dY = Y_L dL + Y_K dK + Y_X dX + Y_G dG + Y_T dT$$  \hspace{1cm} (2)

where $Y_i$ is the partial derivative of $Y$ with respect to the $i$th functional argument.

Dividing function (2) through by $Y$ and manipulating the expression, we get the following growth function (3):

$$\dot{Y} = e_L \dot{L} + e_K \dot{K} + e_X \dot{X} + e_G \dot{G} + e_T \dot{T}$$  \hspace{1cm} (3)

where a dot over a variable indicates its rate of growth and $e_L$, $e_K$, $e_X$, $e_G$, $e_T$ are the elasticities of output in relation to labor, capital, exports, government expenditures and the terms of trade respectively.

However, since the rate of growth of capital is not available for the three examined countries, it can be replaced by $\Delta K/Y$, which approximates the investment – income ratio. With this modification function (3) can be written as follows:

$$\dot{Y} = e_L \dot{L} + \frac{\partial Y}{\partial K} \frac{dK}{K} + e_X \dot{X} + e_G \dot{G} + e_T \dot{T}$$  \hspace{1cm} (4)

and replacing $dK$ by $I$ we have:

$$\dot{Y} = e_L \dot{L} + a \frac{I}{Y} + e_X \dot{X} + e_G \dot{G} + e_T \dot{T}$$  \hspace{1cm} (5)
where $\alpha$ is the marginal product of capital. Adding a constant term and a stochastic component to function (5), yields our economic growth model:

$$\dot{Y} = a_0 + a_1 \dot{L} + a_2 \frac{I}{Y} + a_3 \dot{X} + a_4 \dot{G} + a_5 \dot{T} + u$$

(6)

The second model, which is used in this paper is proposed by (Feder 1982). According to this model, the economy consists of an export sector and a non-export sector. The output process in the export sector is produced with labour ($L$) and capital ($K$), while output in the non-export sector is produced with labour ($L$), capital ($K$) and an “externality effect force” stemming from the export sector. This externality effect represents the positive effects of exports on other sectors such as the introduction of improved production techniques, highly skilled management and the continuous flow of imported inputs (Feder 1982). Also the production functions for the two sectors are different, and relative marginal products of inputs differ across the two sectors. Feder’s model of economic growth can be stated as follows:

$$\dot{Y} = a_o + b_L \dot{L} + a_K \left( \frac{I}{Y} \right) + \left( \frac{\delta}{1 + \delta} + MP_X \right) \dot{X} \left( \frac{X}{Y} \right) + e$$

(7)

where $\delta$ denotes the intersectoral relative coefficient productivity differential and $MP_X$ is the marginal externality effect of the export sector on other sectors. The sum total of these two effects is captured by the coefficient of $\dot{X} \left( \frac{X}{Y} \right)$ in function (7).
Functions (6) and (7) will constitute the basis for the estimates reported for each of the three examined countries. However when the coefficients of government expenditures or the terms of trade or both in function (7) are found to be either statistical insignificant then they are omitted.

3. Unit root tests

Many macroeconomic time series contain unit roots dominated by stochastic trends as developed by (Nelson and Plosser 1982). Unit roots are important in examining the stationarity of a time series because a non-stationary regressor invalidates many standard empirical results. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. In this study unit root test is tested using Augmented Dickey-Fuller (ADF) (1979), and Kwiatkowski et al. (1992).

3.1 Augmented Dickey-Fuller (ADF) test

The augmented Dickey-Fuller (ADF) (1979) test is referred to the t-statistic of $\delta_2$ coefficient on the following regression:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t \quad (8)$$

The ADF regression tests for the existence of unit root of $X_t$ in all model variables at time $t$. The variable $\Delta X_{t-i}$ expresses the first differences with $k$ lags and final $u_t$ is the variable that adjusts the errors of autocorrelation. The coefficients $\delta_0, \delta_1, \delta_2,$ and
α_i are being estimated. The null and the alternative hypothesis for the existence of unit root in variable \( X_t \) is:

\[
H_0 : \delta_2 = 0 \quad H_a : \delta_2 < 0
\]

This paper follows the suggestion of (Engle and Yoo 1987) using the Akaike information criterion (AIC) (1974), to determine the optimal specification of Equation (8). The appropriate order of the model is determined by computing Equation (8) over a selected grid of values of the number of lags \( k \) and by finding the value of \( k \) at which the AIC attains its minimum. The distribution of the ADF statistic is non-standard and the critical values tabulated by (Mackinnon 1991) are used.

### 3.2 Kwiatkowski, Phillips, Schmidt, and Shin’s (KPSS) test

Since the null hypothesis in Augmented Dickey-Fuller test is that a time series contains a unit root, this hypothesis is accepted unless there is a strong evidence against it. However, this approach may have low power against stationary near unit root processes. In contrast Kwiatkowski et al (1992) present a test where the null hypothesis is that a series is stationary. The KPSS test complements the Augmented Dickey-Fuller test in that concerns regarding the power of either test can be addressed by comparing the significance of statistics from both tests. A stationary series has significant Augmented Dickey-Fuller statistics and insignificant KPSS\(^1\) statistics.

\(^1\) According to Kwiatkowski et al (1992), the test of KPSS assumes that a time series can be composed into three components, a deterministic time trend, a random walk and a stationary error:

\[
y_t = \delta t + r_t + \epsilon_t
\]

where \( r_t \) is a random walk \( r_t = r_{t-1} + u_t \). The \( u_t \) is iid \( (0, \sigma_u^2) \).
4. Cointegration test

Following the maximum likelihood procedure of (Johansen 1988 and Johansen and Juselious 1990), a p-dimensional \((p \times 1)\) vector autoregressive model with Gaussian errors can be expressed by its first-differenced error correction form as:

\[
\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-1} + u_t \quad (9)
\]

where:

\[
The \text{stationary hypothesis implies that } \sigma_u^2 = 0.
\]

Under the null, \(y_t\) is stationary around a constant \((\delta=0)\) or trend-stationary \((\delta \neq 0)\). In practice, one simply runs a regression of \(y_t\) over a constant (in the case of level-stationarity) or a constant plus a time trend (in the case of trend-stationarity). Using the residuals, \(e_t\), from this regression, one computes the LM statistic

\[
LM = T^{-2} \sum_{t=1}^{T} S_t^2 / S_\sigma^2
\]

where \(S_\sigma^2\) is the estimate of variance of \(e_t\)

\[
S_t = \sum_{i=1}^{T} e_{t-i}, \quad t = 1, 2, \ldots, T
\]

The distribution of LM is non-standard: the test is an upper tail test and limiting values are provided by (Kwiatkowski et al 1992), via Monte Carlo simulation. To allow weaker assumptions about the behaviour of \(e_t\), one can rely, following (Phillips 1987 and Phillips and Perron 1988 on the Newey and West 1987) estimate of the long-run variance of \(e_t\) which is defined as:

\[
S^2(I) = T^{-1} \sum_{i=1}^{T} e_i^2 + 2 T^{-1} \sum_{s=1}^{l} w(s,l) \sum_{k=s}^{T} e_k e_{i-k}
\]

where \(w(s,l) = 1 - s / (l+1)\). In this case the test becomes

\[
\nu = T^{-2} \sum_{t=1}^{T} S_t^2 / S^2(I)
\]

which is the one considered here. Obviously the value of the test will depend upon the choice of the ‘lag truncation parameter’, \(l\). Here we use the sample autocorrelation function of \(\Delta e_t\) to determine the maximum value of the lag length \(l\).
$Y_t$ is a $p \times 1$ vector containing the variables.

$\mu$ is the $p \times 1$ vector of constant terms.

$\Gamma_i = -I + A_1 + A_2 + \ldots + A_i$ (i = 1,2,...,p-1) is the $p \times p$ matrix of coefficients.

$\Pi = I - A_1 - A_2 - \ldots - A_p$ is the $p \times p$ matrix of coefficients.

$u_t$ is the $p \times 1$ vector of the disturbance terms coefficients.

The $\Pi$ matrix conveys information about the long-run relationship between $Y_t$ variables and the rank of $\Pi$ is the number of linearly independent and stationary linear combinations of variables studied. Thus, testing for cointegration involves testing for the rank of $\Pi$ matrix $r$ by examining whether the eigenvalues of $\Pi$ are significantly different from zero. (Johansen 1988 and Johansen and Juselious 1990) propose two test statistics for testing the number of cointegrating vectors (or the rank of $\Pi$) in the VAR model. These are the ($\lambda$-trace) test and the maximum eigenvalue ($\lambda$-max) test.

The likelihood ratio statistic for the $\lambda$-trace test is:

$$-2 \ln Q = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i)$$

(10)

where $\hat{\lambda}_{r+1}, \ldots, \hat{\lambda}_p$ are the estimated $p - r$ smallest eigenvalues. The null hypothesis to be tested is that there are at most $r$ cointegrating vectors. That is, the number of cointegrating vectors is less than or equal to $r$, where $r$ is 0,1, or 2..., and so forth. In each case, the null hypothesis is tested against the general alternative.

Alternatively, the $\lambda$-max statistic is:

$$-2 \ln Q = -T \ln(1 - \hat{\lambda}_{r+1})$$

(11)
In this test, the null hypothesis of \( r \) cointegrating vectors is tested against the alternative hypothesis of \( r+1 \) cointegrating vectors. Thus, the null hypothesis \( r = 0 \) is tested against the alternative that \( r = 1, r = 1 \) against the alternative \( r = 2 \), and so forth. It is well known the cointegration tests are very sensitive to the choice of lag length. The Schwarz Criterion (SC) (1978) and the likelihood ratio test are used to select the number of lags required in the cointegration test.

4.1 Long-run relationships

The presence of cointegrating vectors is tested for the long-run relationships among the set of variables considered here. The \( \lambda \)-trace and \( \lambda \)-max test statistics are reported in Table 2 along with the number of cointegrating vectors. Using the 5% and 10% critical values from (Johansen and Juselious 1990), it is observed that in some cases the \( \lambda \)-max and \( \lambda \)-trace test statistics give conflicting results (USA) (Johansen 1991) argues that such conflicting results arise from the low power of the test in cases when the cointegration relationship is quite close to nonstationary boundary. It is also argued that since the trace test takes account of all \((3-r)\) of the smallest eigenvalues, it tends to have more power than the \( \lambda \)-max test. Hence, in the conflicting cases (USA) the decision is made based on \( \lambda \)-trace statistic.

**INSERT TABLE 2**

The normalized cointegrating vectors of EU and USA are the following:

\[
Y_{EU} = 20239.9 + 1206X_{EU}
\]
\[
Y_{USA} = 2249 + 63781 X_{USA}
\]

(3.175) (2.562)

From these vectors it is noticed that in the long-run, exports have a positive relationship with economic growth.

In the next section, we examine whether a reliable short-run relationship exists between economic growth and the proposed explanatory variables.

4.2 Short-run relationships

Using annual data for all three countries, for the time period between 1960-2000, the equations 6 and 7 have been evaluated for each one of these countries by using the Ordinary Least Square method (O.L.S). The identification of the variables, which were used in the estimations, is the following:

\begin{align*}
Y &= \text{The rate of growth of national output is approximated by the average annual rate of growth of GDP.} \\
I/Y &= \text{The average annual rate of gross domestic investment as a percentage of GDP.} \\
L &= \text{The average annual national rate of growth of labour force.} \\
G &= \text{The average annual rate of growth of government expenditures.} \\
T &= \text{The average annual rate of growth of the terms of trade} \\
X &= \text{The average annual rate of growth of exports.} \\
\end{align*}

The nominal variables were deflated using the GDP deflator.
The data have been obtained by the European Economy, International Financial Statistics (IFS).

The results of the estimations are presented in tables 3 and 4.

**INSERT TABLE 3**

**INSERT TABLE 4**

The results of tables 3 and 4 suggest that:

The adjusted coefficient of determination \( R^2 \), is sufficiently high for all three countries.

The regressors and the regression coefficients of exports range from 0.28 to 0.70 and have the expected sign, so they are statistically significant at least at the 5% level.

The total of regression F-statistics are also statistically significant at least at the 5% level.

The diagnostic tests of Durbin-Watson and Bruesch-Godfrey statistics suggest the absence of serial correlation.

The F-statistics of the Farely-Hininch test suggest the functions stability, which were used.

**5. A VAR model with an error correction mechanism**

The error-correction model is used to examine the causal relationships between exports and economic growth for the examined countries. Such analysis provides the
short-run dynamic adjustment towards the long-run equilibrium (Dritsakis 2004). The error correction model has the following form:

\[
\Delta Y_t = \text{lagged}(\Delta Y_t, \Delta X_t) + \lambda u_{t-1} + V_t \quad (12)
\]

where \( \Delta \) is reported to all variables first differences

\( u_{t-1} \) are the estimated residuals from the cointegrated regression (long-run relationship) and represents the deviation from the equilibrium in time period \( t \).

\(-1<\lambda<0\) is a short-run parameter which represents the response of dependent variable in each period starts from equilibrium point.

\( V_t \) is a 2X1 vector of white noise errors.

(Granger 1988) argued that there are two channels of causality, the channel 1 is through of lagged variables (\( \Delta X \)), when the coefficients of these variables are all statistically significant (\( F\)-statistic), and the channel 2 if the coefficient \( \lambda \) of variable \( u_{t-1} \) is statistically significant (\( t\)-statistic). If \( \lambda \) is statistically significant in equation (12), exports affect economic growth.

**INSERT TABLE 5**

The numbers in parentheses are the lag lengths determined by using the Akaike criterion. As referred earlier there are two channels of causality. These are called channel 1 and channel 2. If lagged values of a variable (except the lagged value of the dependent variable) are jointly significant then this is channel 1. On the other hand, if the lagged value of the error correction term is significant, then this is channel 2. The
results of Table 6 denote the causality between through these channels. There is a “strong causal relationship” if it is through both channel 1 and channel 2 and simply a “causal relationship” if it is through either channel 1 or channel 2.

**INSERT TABLE 6**

From the results of Table 6 we can infer that there is a Granger causality between exports and economic growth, for these two countries, European Union and USA, namely this is a “strong causal relationship” between exports and economic growth, but there is no causal relationship for these variables for Japan.

6. Conclusions

In this paper an effort was made in order to examine the relationship between exports and economic growth in the three major exporter countries of the world through the analysis of multivariate causality based on an error correction model. For empirical testing of the above variables we used the Johansen cointegration test and Granger causality test based on an error correction model.

The results of the cointegration analysis suggest the existence of cointegration relationship between the three variables for the countries of European Union and United States of America, while there is no causal relationship for Japan. This indicates the presence of a common trend or a long-run relationship between the variables of these examined countries, while there is no long-run relationship between for the variables of Japan.

The results of causality analysis suggest that there is a “strong bilateral causal relationship” between exports and economic growth for European Union (this result is
consistent with the study of (Thornton 1997) for some countries of EU), and for USA (this result is consistent with the study of (Konya 2000), while the results for Japan suggest that there is not either a long run relationship or any causality between exports and economic growth.
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### Table 1. Tests of unit roots hypothesis

<table>
<thead>
<tr>
<th>Country</th>
<th>Augmented Dickey-Fuller</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\tau_\mu$</td>
<td>$\tau_\tau$</td>
</tr>
<tr>
<td>E.U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>2.7410</td>
<td>-1.0877</td>
</tr>
<tr>
<td>X</td>
<td>-0.2249</td>
<td>-1.7303</td>
</tr>
<tr>
<td>$\Delta$Y</td>
<td>-2.6731*</td>
<td>-3.9389**</td>
</tr>
<tr>
<td>$\Delta$X</td>
<td>-4.6134**</td>
<td>-4.5706**</td>
</tr>
<tr>
<td>U.S.A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>1.9806</td>
<td>-0.5670</td>
</tr>
<tr>
<td>X</td>
<td>-1.1882</td>
<td>-1.9818</td>
</tr>
<tr>
<td>$\Delta$Y</td>
<td>-2.9870**</td>
<td>-3.2535*</td>
</tr>
<tr>
<td>$\Delta$X</td>
<td>-4.9405**</td>
<td>-4.8696**</td>
</tr>
<tr>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>1.8227</td>
<td>-1.2005</td>
</tr>
<tr>
<td>X</td>
<td>-2.0943</td>
<td>-2.0306</td>
</tr>
<tr>
<td>$\Delta$Y</td>
<td>-4.2147**</td>
<td>-4.7864**</td>
</tr>
<tr>
<td>$\Delta$X</td>
<td>-5.2522**</td>
<td>-5.2715**</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 2 and $\tau_\tau$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is included in equation 2. The calculated statistics are those reported in Dickey-Fuller (1981). The critical values at 5% and 10% are -2.94, -2.60 for $\tau_\mu$ and -3.53, -3.19 for $\tau_\tau$, respectively.

The lag-length structure of $a_t$ of the dependent variable $x_t$ is determined using the recursive procedure in the light of a Lagrange multiplier (LM) autocorrelation test (for orders up to four), which is asymptotically distributed as chi-squared distribution and the value t-statistic of the coefficient associated with the last lag in the estimated autoregression.

$\eta_\eta$ and $\eta_\tau$ are the KPSS statistics for testing the null hypothesis that the series are I(0) when the residuals are computed from a regression equation with only an intercept and intercept and time trend, respectively. The critical values at 5% and 10% are 0.463 and 0.347 for $\eta_\eta$ and 0.146 and 0.119 for $\eta_\tau$, respectively (Kwiatkowski et al, 1992, table 1).

Since the value of the test will depend upon the choice of the ‘lag truncation parameter’, $l$. Here we use the sample autocorrelation function of $\Delta x_t$ to determine the maximum value of the lag length $l$.

**, * indicate significance at the 5 and 10 percentage levels
Table 2. Cointegration tests based on the Johansen and Juselius approach
(Y, X, VAR lag = 2)

<table>
<thead>
<tr>
<th>Country</th>
<th>Statistic</th>
<th>k = 0</th>
<th>k ≤ 1</th>
<th>No. of Cointegrating Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.U</td>
<td>λ -max</td>
<td>17.1183</td>
<td>3.2288</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>λ -trace</td>
<td>20.3471</td>
<td>3.2288</td>
<td>1</td>
</tr>
<tr>
<td>U.S.A</td>
<td>λ -max</td>
<td>12.8964</td>
<td>7.1833</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>λ -trace</td>
<td>20.0797</td>
<td>7.1833</td>
<td>1</td>
</tr>
<tr>
<td>JAPAN</td>
<td>λ -max</td>
<td>10.6303</td>
<td>5.2924</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>λ -trace</td>
<td>15.9227</td>
<td>5.2924</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: The critical values for the λ – max test for k = 0, k ≤ 1, at 5% level of significance are respectively 15.87, 9.16. At 10% significance level they are 13.81, 7.53. For the λ – trace statistics the critical values for k = 0, k ≤ 1, at 5% level of significance are respectively 20.18, 9.16. At 10% significance level they are 17.88, 7.53.
Table 3. Regression results for equation 6 (t-statistics in parentheses)

\[
Y_{EU} = -12.9015 + 0.0654756\hat{L} + 0.0678697\frac{I}{Y} + 0.700252\hat{X} + 0.1166059\hat{I}
\]

\[\begin{align*}
(-4.9947)^* & \quad (12.6635)^* & \quad (0.76065) & \quad (2.1308)^* & \quad (5.6874)^*
\end{align*}\]

\[
R^2 = 0.97708 \quad F(4,36) = 427.2661 \quad D–W = 1.72991
\]

B-G (\(X^2\)) = 2.1041 \quad Farely-Hinic (F-stat) = 0.7823

\[
Y_{US4} = -19.9984 + 0.1105852\hat{L} + 0.4516505\frac{I}{Y} + 0.282958\hat{X} + 0.0676553\hat{I}
\]

\[\begin{align*}
(-7.6587)^* & \quad (15.7271)^* & \quad (5.5844)^* & \quad (1.8905)^* & \quad (6.0294)^*
\end{align*}\]

\[
R^2 = 0.95304 \quad F(4,36) = 203.9514 \quad D–W = 1.86242
\]

B-G (\(X^2\)) = 3.3277 \quad Farely-Hinic (F-stat) = 1.8423

\[
Y_{JAP} = 7.3140 + 0.0383607\hat{L} + 0.1430410\frac{I}{Y} + 0.3765144\hat{X}
\]

\[\begin{align*}
(5.1736)^* & \quad (10.7292)^* & \quad (3.5825)^* & \quad (7.7092)^*
\end{align*}\]

\[
R^2 = 0.88150 \quad F(3,37) = 100.1873 \quad D–W = 1.70285
\]

B-G (\(X^2\)) = 1.9543 \quad Farely-Hinic (F-stat) = 2.1278

**The coefficient estimate is statistically significant at the 5% level.**

*The coefficient estimate is statistically significant at the 10% level.*
Table 4. Regression results for equation 7 (t-statistics in parentheses)

\[
Y_{EU} = -11.8682 + 0.1027514\hat{L} + 0.3450563\frac{I}{Y} + 0.27322\hat{X}\left(\frac{X}{Y}\right)
\]

\[
(-4.7826)^* (15.3830)^* (3.7638)^* (5.0599)^*
\]

\[
\bar{R}^2 = 0.97442 \quad F(3,37) = 508.9393 \quad D–W = 2.22452
\]

B-G (X²) = 0.9967 Farely-Hinic (F-stat) = 2.0667

\[
Y_{USA} = -5.3027 + 0.0656079\hat{L} + 0.2819298\frac{I}{Y} + 0.34145\hat{X}\left(\frac{X}{Y}\right)
\]

\[
(-2.4817)^* (11.3321)^* (2.5935)^* (2.3981)^*
\]

\[
\bar{R}^2 = 0.90556 \quad F(3,37) = 128.8503 \quad D–W = 1.84439
\]

B-G (X²) = 3.1005 Farely-Hinic (F-stat) = 1.4511

\[
Y_{JAP} = 7.4021 + 0.0190510\hat{L} + 0.2301824\frac{I}{Y} + 0.5014597\hat{X}\left(\frac{X}{Y}\right)
\]

\[
(2.2615)^* (1.5774) (2.9493)^* (1.98870)^*
\]

\[
\bar{R}^2 = 0.69912 \quad F(3,37) = 31.9806 \quad D–W = 1.81367
\]

B-G (X²) = 3.8752 Farely-Hinic (F-stat) = 0.7723

**The coefficient estimate is statistically significant at the 5% level.
*The coefficient estimate is statistically significant at the 10% level.
**Table 5.** Causality test results based on vector error – correction modeling

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>F – significance level</th>
<th>t – statistic</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ΔY</td>
<td>ΔX</td>
</tr>
<tr>
<td>E.U</td>
<td>0.000**(2)</td>
<td>0.048**(1)</td>
</tr>
<tr>
<td>ΔY</td>
<td>0.072*(1)</td>
<td>-1.8913*</td>
</tr>
<tr>
<td>ΔX</td>
<td>0.003**(2)</td>
<td>0.052*(1)</td>
</tr>
<tr>
<td>U.S.A</td>
<td>0.000**(1)</td>
<td>0.052*(1)</td>
</tr>
<tr>
<td>ΔY</td>
<td>0.003**(1)</td>
<td>-1.4187</td>
</tr>
<tr>
<td>ΔX</td>
<td>0.243(1)</td>
<td>0.311(2)</td>
</tr>
</tbody>
</table>

Notes: *, **, and *** indicate 10%, 5%, and 1% levels of significance. Number in parentheses are lag lengths.

**Table 6.** Summary of causal relations

<table>
<thead>
<tr>
<th>Country</th>
<th>Y → X</th>
<th>X → Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.U</td>
<td>1 2</td>
<td>1 2</td>
</tr>
<tr>
<td>U.S.A</td>
<td>1 2</td>
<td>1 2</td>
</tr>
<tr>
<td>JAPAN</td>
<td></td>
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</tbody>
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