E C O N O M I C S   B U L L E T I N

Exactly what is the link between export and growth in Taiwan? new evidence from the Granger causality test

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Abstract

We assess the validity of the Export-led Growth (ELG) and the Growth-driven Export (GDE) hypotheses in Taiwan by testing for Granger causality using the vector error correction model (VECM) and the bounds testing methodology developed by Pesaran {\it et al.} (PSS, 2001). The empirical results substantiate that a long-run level equilibrium relationship exists among exports, output, terms of trade and labor productivity of the model and that Granger causal flow between real exports and real output is reciprocal. Thus, our results attest to the advantage of the export-led growth strategy for continuous growth in Taiwan.

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Abstract

We assess the validity of the Export-led Growth (ELG) and the Growth-driven Export (GDE) hypotheses in Taiwan by testing for Granger causality using the vector error correction model (VECM) and the bounds testing methodology developed by Pesaran *et al.* (PSS, 2001). The empirical results substantiate that a long-run level equilibrium relationship exists among exports, output, terms of trade and labor productivity of the model and that Granger causal flow between real exports and real output is reciprocal. Thus, our results attest to the advantage of the export-led growth strategy for continuous growth in Taiwan.

Keywords: Economic growth, Exports, Bounds test, Granger causality
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1 Introduction

The causal link between exports and economic growth has long been at front and center of considerable discussion and debate among the public sector, economists and other business professionals alike. On the theoretical front, four outcomes are possible. As for the first outcome, export growth is typically considered to be one of the main determinants of an economy's growth in production and employment. This is the so-called *export-led growth* (ELG) hypothesis. Empirically, ELG is characterized by unidirectional causality from exports to GDP. As for the second outcome, the *growth-driven export* (GDE) hypothesis postulates that a rise in GDP generally leads to a corresponding increase in exports (Bhagwati, 1988).[1] Empirically, unidirectional causality from output to exports for GDE. The third and fourth possible outcomes cannot be overlooked: bidirectional causal (feedback) and neutral relationships between exports and economic growth.[2]

A myriad of studies have examined (see, *inter alia* Kunst and Marin, 1989; Marin, 1992; Yamada, 1998; Wernerheim, 2000; Ramos, 2001; and Reppas and Christopoulos, 2005) the exports-GDP linkages. But, unfortunately, studies such as these have borne the brunt of a great deal of criticism for two reasons. First, many studies that examine the ELG hypothesis have just focused on two variables, i.e.,causality between exports and economic growth (Ahmed and Kwan, 1991; Ahmad and Harnhirun, 1995; Chow, 1987; Hsiao, 1987; Jung and Marshall, 1985; Thornton, 1996, 1997; Xu, 1996; and Hatemi-J, 2002). The causal models in these studies may very well have been misspecified, as noted by Awokus (2003), on account of the fact that (i) an important variable may be omitted and (ii) the traditional Granger causality F-test in a regression context may not be valid if the variables in the system are integrated, since the test statistic does not have a standard distribution (Toda and Phillips, 1993). Second, the findings from many previous studies have been mixed and, for the most part, do not reach a consensus as to the causal relationship between

[1]For theoretical and detailed explanations of ELG and GDE, readers are referred to Ramos (2001) and Reppas and Christopoulos (2005).

[2]This type of feedback has also been explained by Grossman and Helpman (1991) through their models of north-south trade.

exports and economic growth.[3]

In its investigation of the causal relationship, this research has two features that distinguish it from previous studies. First, we model the long-run relationship in accordance with the Pesaran *et al.* (PSS, 2001) bounds testing approach, and we extract the critical values from Narayan (2005) and Turner (2006) specific to small samples. The advantages of the bounds test for cointegration are that (i) it can be applied to models consisting of variables with order of integration less than or equal to one, and (ii) it can distinguish between dependent and independent variables. Second, we take into account relevant variables that have been omitted in previous studies and investigate Granger causal relationships using this multivariate model. The application of recent developments in time series modeling coupled with the inclusion of relevant variables makes it possible to identify which hypothesis is most applicable to Taiwan.

The organization of the paper is as follows. Section 2 provides an overview of the econometric methodology that we employ. Section 3 describes the data and discusses the empirical test results. Finally, Section 4 presents the conclusions that we draw from this research.

2 Methodology

PSS (2001) have recently developed the bounds test procedure based on the AutoRegressive Distributed Lag (ARDL) model, and in the case of small samples, its performance is superior to that of other estimators (see Pesaran and Shin, 1995). More specifically, when written in the Error Correction model (ECM) form, the ARDL model is much less vulnerable to spurious regression (Pesaran and Smith, 1998). We estimate the following Unrestricted Error Correction model (UECM), taking each of the variables in turn as a dependent variable:

$$\begin{aligned} \Delta \ln GDP_t &= \alpha_0 + \pi_1 \ln GDP_{t-1} + \pi_2 \ln EX_{t-1} + \pi_3 \ln TOT_{t-1} + \pi_4 \ln PR_{t-1} \\ &+ \sum_{i=1}^{p_1} \gamma_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{p_2} \theta_i \Delta \ln EX_{t-i} + \sum_{i=0}^{p_3} \delta_i \Delta \ln TOT_{t-i} + \sum_{i=0}^{p_4} \omega_i \ln PR_{t-i} + \varepsilon_{1t} \quad (1) \end{aligned}$$

[3] Ahmad (2001) provides an assessment of major econometric studies that have estimated causality between exports and economic growth.

$$\begin{aligned}\Delta \ln EX_t &= \bar{\alpha}_0 + \bar{\pi}_1 \ln GDP_{t-1} + \bar{\pi}_2 \ln EX_{t-1} + \bar{\pi}_3 \ln TOT_{t-1} + \bar{\pi}_4 \ln PR_{t-1} \\ &+ \sum_{i=0}^{p_1} \bar{\gamma}_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{p_2} \bar{\theta}_i \Delta \ln EX_{t-i} + \sum_{i=0}^{p_3} \bar{\delta}_i \Delta \ln TOT_{t-i} + \sum_{i=0}^{p_4} \bar{\omega}_i \ln PR_{t-i} + \varepsilon_{2t} \quad (2)\end{aligned}$$

$$\begin{aligned}\Delta \ln TOT_t &= \tilde{\alpha}_0 + \tilde{\pi}_1 \ln GDP_{t-1} + \tilde{\pi}_2 \ln EX_{t-1} + \tilde{\pi}_3 \ln TOT_{t-1} + \tilde{\pi}_4 \ln PR_{t-1} \\ &+ \sum_{i=0}^{p_1} \tilde{\gamma}_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{p_2} \tilde{\theta}_i \Delta \ln EX_{t-i} + \sum_{i=1}^{p_3} \tilde{\delta}_i \Delta \ln TOT_{t-i} + \sum_{i=0}^{p_4} \tilde{\omega}_i \ln PR_{t-i} + \varepsilon_{3t} \quad (3)\end{aligned}$$

$$\begin{aligned}\Delta \ln PR_t &= \hat{\alpha}_0 + \hat{\pi}_1 \ln GDP_{t-1} + \hat{\pi}_2 \ln EX_{t-1} + \hat{\pi}_3 \ln TOT_{t-1} + \hat{\pi}_4 \ln PR_{t-1} \\ &+ \sum_{i=0}^{p_1} \hat{\gamma}_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{p_2} \hat{\theta}_i \Delta \ln EX_{t-i} + \sum_{i=0}^{p_3} \hat{\delta}_i \Delta \ln TOT_{t-i} + \sum_{i=1}^{p_4} \hat{\omega}_i \ln PR_{t-i} + \varepsilon_{4t} \quad (4)\end{aligned}$$

Here, $\ln GDP$ is the natural log of real domestic product; $\ln EX$ is the natural log of ratio of real exports; $\ln TOT$ is the natural log of the terms of trade (export unit value divided by import unit value); and $\ln PR$ is the natural log of labor productivity (output per employee). When a long-run relationship exists, the F-test indicates which variable should be normalized. The bounds test for examining evidence of a long-run relationship in Equation (1), denoted by $F(GDP|EX,\ TOT,\ PR)$, can be performed using the F-test by testing the joint significance of the coefficients on one-period lagged levels of the variables $H_0 : \pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$ against the alternative $H_1 0 : \pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0$. Similarly, the null hypothesis for testing the nonexistence of a long-run relationship in Equation (2) is denoted by $F(EX|GDP,\ TOT,\ PR)$. Narayan (2005) argues that because that existing critical values are based on large sample sizes, they cannot be used for small sample sizes; hence, he generates and reports a new set of CVs for sample sizes ranging from 30 to 80 observations. Because the sample size in the present study is relatively small, we extract appropriate CVs from Narayan (2005) and Turner (2006).[4]

The bounds test procedure is applicable regardless of whether or not the underlying regressors are integrated on the order of one or zero, or are mutually cointegrated. The ARDL regression, on the other hand, yields a test statistic which can be compared to two asymptotic critical values. When the test statistic is greater than a certain upper critical value, the null hypothesis of a no long-run relationship must be rejected whether or not the underlying orders of integration of the

[4] Turner (2006) recently generates critical values based on the response surfaces of an F-test for cointegration.

regressors are one or zero. Alternatively, when the test statistic is less than a certain lower critical value, the null hypothesis of a no long-run relationship between the regressors cannot be rejected. If the test statistic falls between these two bounds, the results are deemed unknown.

3 Data and Results

Annual time series data for the 1976–2004 period are used here, making for a total of 29 observations. The data for the four variables, i.e., real gross domestic product, real exports, terms of trade and labor productivity, are taken from the NIAA, MAN, PRICE data of AREMOS for the Taiwan area. First, the Augmented Dickey-Fuller (ADF) unit root test is applied to determine the order of integration of the four variables. The results are not reported here due to space constraints but are available from the author upon request. Based on the ADF tests in their level data, no additional evidence is found against the unit root hypothesis. When the ADF test is applied to the first difference of these series, the null hypothesis of a unit root must be rejected at the 5% level or better.

The first step in applying the bounds testing approach is to specify the optimal lag length of the UECM, i.e., Eqs. (1)–(4) and to check the long-run level equilibrium relationship. The Schwarz's Bayesian Information Criterion (SBC) is employed to choose the optimal lag length. The lag order determined from the SBC is $\hat{p}_{sbc} = 2$. The χ^2_{SC} statistic indicates that no serial correlation remains in the residual when the lag length is equal to 2.[5] Here we conduct the bounds tests to confirm the existence of a long-run equilibrium relationship, and the results are reported in Table 1. Worth noting is that due to the relatively small sample size in the present study (29 observations), the critical values are extracted from Narayan (2005) and are based on Turner's (2006) response surface

[5] As noted by PSS (2001, p312), "in testing the null hypothesis of the absence of the level long-run relationship in Eq. (1)–(4), it is important that the coefficients of the lagged change remain unrestricted; otherwise, these tests could be subject to a pre-testing problem. However, for the subsequent estimations of the level effects and short-run dynamics of the adjustments, the use of more parsimonious specifications seems advisable."

method specific to the sample size.[6] It is apparent that the computed F-statistic exceeds the upper critical value for $F(TOT|GDP,\ EX,\ PR)$ but is insignificant at the 10% level for the others. This indicates that the null hypothesis of a no level long-run relationship must be rejected and that the dependent variable should be $\ln TOT$.

In our effort to determine the causal relationship, a vector autoregressive model (VAR) where $\ln GDP$, $\ln EX$ and $\ln PR$ are the dependent variables and an error correction model where $\ln TOT$ is the dependent variable are estimated. This is because when there is cointegration, testing for Granger causality requires the inclusion of an error correction term in the stationary model in order to capture the short-run deviations of the series from their long-run equilibrium path. These are represented in equation form as follows:

$$\begin{aligned}\Delta \ln GDP_t &= \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \beta_i \Delta \ln EX_{t-i} \\ &+ \sum_{i=1}^{k} \gamma_i \Delta \ln TOT_{t-i} + \sum_{i=1}^{k} \delta_i \Delta \ln PR_{t-i} + \varepsilon_{1t} \end{aligned} \tag{5}$$

$$\begin{aligned}\Delta \ln EX_t &= \bar{\alpha}_0 + \sum_{i=1}^{k} \bar{\alpha}_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \bar{\beta}_i \Delta \ln EX_{t-i} \\ &+ \sum_{i=1}^{k} \bar{\gamma}_i \Delta \ln TOT_{t-i} + \sum_{i=1}^{k} \bar{\delta}_i \Delta \ln PR_{t-i} + \varepsilon_{2t} \end{aligned} \tag{6}$$

$$\begin{aligned}\Delta \ln TOT_t &= \tilde{\alpha}_0 + \sum_{i=1}^{k} \tilde{\alpha}_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \tilde{\beta}_i \Delta \ln EX_{t-i} \\ &+ \sum_{i=1}^{k} \tilde{\gamma}_i \Delta \ln TOT_{t-i} + \sum_{i=1}^{k} \tilde{\delta}_i \Delta \ln PR_{t-i} + \tilde{\theta} ECT_{t-1} + \varepsilon_{3t} \end{aligned} \tag{7}$$

$$\begin{aligned}\Delta \ln PR_t &= \hat{\alpha}_0 + \sum_{i=1}^{k} \hat{\alpha}_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \hat{\beta}_i \Delta \ln EX_{t-i} \\ &+ \sum_{i=1}^{k} \hat{\gamma}_i \Delta \ln TOT_{t-i} + \sum_{i=1}^{k} \hat{\delta}_i \Delta \ln PR_{t-i} + \varepsilon_{4t} \end{aligned} \tag{8}$$

All of the variables are as previously defined. ε_{1t}, ε_{2t}, ε_{3t} and ε_{4t} are error terms that are assumed to be white noise with zero mean, constant variance and no autocorrelation. In Equation (7), for

[6] Based on Turner's (2006) method, the 10% CVs for the lower and upper bounds are 3.428 and 4.552, respectively.

example, short-term causality implies that $\ln EX$ 'Granger-causes' $\ln TOT$ as long as $\tilde{\beta}_i \neq 0 \, \forall i$. But, the significance of the lagged error correction term, i.e., $\tilde{\theta} \neq 0$, denotes whether there is a long-run causal relationship. In equation (5), the ELG hypothesis argues that $\ln EX$ 'Granger-causes' $\ln GDP$ as long as $\beta_i \neq 0 \, \forall i$. Similarly, in equation (6), the GDE hypothesis argues that $\ln GDP$ 'Granger-causes' $\ln EX$ as long as $\bar{\alpha}_i \neq 0 \, \forall i$.

We present the Granger causality test results in Table 2 panel A. In terms of the causal relationships from real export to real output and from real output to real exports, the F-statistics are 3.39 and 4.01, and they are significant at the 5% level. What this means is that there is bidirectional causality between $\ln GDP$ and $\ln EX$, and it also confirms that the ELG and GDE hypotheses hold for Taiwan. Equally important, we observe that the lagged terms of $\ln TOT$ and $\ln PR$ are significant at the conventional level for $\ln GDP$. The lagged terms of $\ln TOT$ and $\ln PR$ are significant at the conventional level for $\ln EX$. That is, terms of trade and labor productivity Granger-cause real output and real exports. This reinforces the argument that there could very well be an omitted variable problem if only two variables, i.e., real output and real exports, are used in testing causality.[7]

Toda and Phillips (1993) show that in testing causality in cointegrated systems, the error correction form is preferable to the level VAR model. The ECM-VAR model, i.e., where the error correction term is added in Eqs. (5)–(8) is also estimated in this study, and the Granger causality test is applied again. The results are summarized in Table 2 panel B. Generally speaking, the findings are unchanged from those from the ECM-VAR model. Note that the estimate ECT_{t-1} for $\ln TOT$ is more significant at the conventional level than all of the others. These results are consistent with those from the bounds tests, as shown in Table 1.

[7] Chow (1987) and Ahmad and Harnhirun (1995) reached a similar conclusion for Taiwan based on the bivariate VAR model.

4 Conclusions

This paper revisits the ELG and GDE hypotheses in Taiwan. The methodology we use has only recently been developed by PSS (2001) and is based on the estimation of the UECM and the bounds test. There is no question that real exports, real output, terms of trade and labor productivity exhibit a level long-run relationship. Our findings also indicate that there is a bidirectional causal relationship between exports and output in Taiwan, which is fully in line with the third possible outcome explained in the Introduction. This does not, of course, rule out the validity of the other two possible outcomes, i.e., export-led growth and growth-driven export. What is certain is that the development of foreign trade is an integral part of the economic growth process in Taiwan. Our results confirm the advantage of the export-led growth strategy as means to continued growth for Taiwan.

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Table 1: Cointegration Test Results

Bounds test for cointegration			
	$T = 29$	Lower Bound, $I(0)$	Upper Bound, $I(1)$
$F(GDP \mid EX, TOT, PR)$	1.497	3.428	4.552
$F(EX \mid GDP, TOT, PR)$	0.728	3.428	4.552
$F(TOT \mid GDP, EX, PR)$	5.438†	3.428	4.552
$F(PR \mid GDP, EX, TOT)$	2.530	3.428	4.552

† denotes significance at the 10% level.

Table 2: Results from the Granger Causality Tests

Panel A	F-statistic [p-value]				
Dependent variable	$\Delta \ln GDP$	$\Delta \ln EX$	$\Delta \ln TOT$	$\Delta \ln PR$	ECT_{t-1}
$\Delta \ln GDP$	–	3.39 [0.05]*	4.27 [0.03]*	3.95 [0.04]*	–
$\Delta \ln EX$	4.01 [0.04]*	–	3.30 [0.06]†	5.11 [0.02]*	–
$\Delta \ln TOT$	5.82 [0.01]*	2.03 [0.16]	–	6.89 [0.01]*	26.62 [0.00]*
$\Delta \ln PR$	2.80 [0.08]†	2.15 [0.15]	3.78 [0.04]*	–	–

Panel B	F-statistic [p-value]				
Dependent variable	$\Delta \ln GDP$	$\Delta \ln EX$	$\Delta \ln TOT$	$\Delta \ln PR$	ECT_{t-1}
$\Delta \ln GDP$	–	3.16 [0.07]†	6.66 [0.01]*	2.78 [0.09]†	3.51 [0.08]†
$\Delta \ln EX$	3.77 [0.05]*	–	5.16 [0.02]*	3.87 [0.04]*	2.96 [0.10]†
$\Delta \ln TOT$	5.82 [0.01]*	2.03 [0.16]	–	6.89 [0.01]*	26.62 [0.00]*
$\Delta \ln PR$	2.32 [0.13]	1.84 [0.19]	5.40 [0.02]*	–	2.54 [0.13]

* and † denote significance at the 5% and 10% level, respectively.