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Tests of Causality and Exogeneity Between Exports and Economic Growth:

The Case of Asian NICs*

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This paper presents a detailed econometric investigation using Sims' unidirectional exogeneity test and Granger's causality test to detect the existence and the directions of causality between exports and GDP for the four rapidly developing Asian NICs: Hong Kong, South Korea, Singapore, and Taiwan. In general, our analysis shows that the two tests did not yield the same causal implications for each country. The Sims' test indicates a feedback relationship while the Granger's test indicates no causal relation between the exports and GDP, except for Hong Kong which both tests indicate a unidirectional causality from GDP to exports without feedback. Thus, our results from Sims' test strongly indicate that the rapid economic growth of the Asian NICs is not only achieved with the export promotion policy, but also derived from the domestic growth of industries and import-substitution.

I. Introduction

The opposing views of trade as an "engine" of growth or a

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"handmaiden" of growth are well-known. For example, Lewis asserts that trade serves as an "engine" of growth for developing countries, that is, the growth of developing countries have depended on their exports to the developed countries. Thus, slower growth in developed countries effects on the growth of developing countries. On the other hand, Kravis and Riedel suggest that trade is more likely a "handmaiden" of growth, rather than an "engine," thus the recent world recession should not have much effect on the growth of developing countries. In recent years, the phenomenal growth of Japan and the newly industrializing countries (NICs) with their exports promotion policies during 1960s and 1970s (OECD), and the pessimistic prospects for the NICs due to the world recession and the rise of protectionism in Western countries after the second oil shock (1979-1980), have revived interest in the study of the relationship between trade and economic development.

In many previous studies, the relationship between exports and economic growth has been quantitatively analyzed by Spearman's rank correlation and/or ordinary least-squares (OLS) regression analysis (e.g. Emery; Feder; Riedel). From the econometric point of view, all the above studies were based on the a priori assumption that exports is an exogenous variable in the growth equation and no causality tests were offered. However, it is well-known that a high degree of correlation does not necessarily imply causation, and a meaningful econometric model requires support from causality tests between variables. Recently, Jung and Marshall has applied Granger's test to examine the direction of causality between the growth rates of exports and GNP. for thirty-seven developing countries. Their statistical results show no strong support for the export promotion hypothesis.

The main purpose of this paper is to apply Sims' unidirectional exogeneity test (Sims) and Granger's causality test (Granger) to detect the existence and the direction of causality between exports and GDP[1] for the four Asian NICs: South Korea, Hong Kong, Singapore, and Taiwan. These four countries are widely recognized as the countries which have achieved rapid

[1] The GDP is used, instead of GNP, as the growth variable, because GDP is considered as a better measurement for internal economic activities.

growth with vigorous export promotion during the past two decades. They also have more or less similar economic conditions, production technology, social and cultural background compared with other developing countries outside the group (Hsiao and Hsiao). For these reasons, it is of great interests to study the exports-economic growth relationship for the Asian NICs using the recently developed econometric methods.

Although Sims' test and Granger's test have been applied in econometric studies of other fields (e.g. Schnitzel), they are seldom used and compared in the study of the relationship between trade and economic growth. In addition, we are able to use the exact Durbin-Watson test and nonparametric run-test to detect the existence of the first-order autoregressive errors, AR(1), in OLS regression residuals. We then apply the maximum likelihood Cochrane-Orcutt iterative procedure to estimate the equations to correct autocorrelated errors. Box-Pierce's Q-statistic is also employed to test for the acceptance of causal model specifications.

In section II, we specify the causal models between exports and GDP for Granger's test and Sim's test. In section III, we describe the data sources, variables, and double-log regression functions. In section IV, we explain the econometric procedures used in estimation. In section V, we present, analyze and compare the empirical results obtained from the two causality tests. Some concluding remarks are given in section VI.

II. Causal Models between Exports and GDP

The basic idea of Granger's causality (Granger) between any two variables X and Y is that X (the right-hand-side independent variable) causes Y (the left-hand-side dependent variable) in a regression equation, if the part of current Y that cannot be explained by the past values of Y is explained by the past values of X. Thus, in the context of the exports-GDP relationship, the Granger's causality test involves estimation of the following two distributed lag regression equations:

$$(1)\ Y(t) = \alpha + \sum_{i=1}^{m} a(i)Y(t-i) + \sum_{i=1}^{m} b(i)E(t-i) + u(t)$$

$$(2)\ E(t) = \beta + \sum_{i=1}^{m} c(i)Y(t-i) + \sum_{i=1}^{m} d(i)E(t-i) + v(t)$$

where $Y(t)$ is the GDP variable at time t ($t = 1, 2, \ldots, n$), $E(t)$ is the exports variable at time t, i denotes the lagged period, m is the predetermined length of lag variables, α and β are constant terms, $a(i)$'s, $b(i)$'s, $c(i)$'s, and $d(i)$'s are coefficients, and $u(t)$ (or $v(t)$) is an uncorrelated series of disturbances. According to Granger's definition of causality, E causes Y if the past values of E in equation (1), namely, $E(t-1)$, $E(t-2), \ldots, E(t-m)$ taken as a group of additional explanatory variables, have joint significant influence on $Y(t)$, but the past values of Y in equation (2), namely, $Y(t-1)$, $Y(t-2), \ldots, Y(t-m)$ taken as a group of additional explanatory variables, have no joint significant influence on $E(t)$. On the other hand, Y causes E if the past values of Y in equation (2) have joint significant influence on $E(t)$, but the past values of E in equation (1) have no joint significant influence on $Y(t)$. If the past values of E in equation (1) have joint significant influence on $Y(t)$, and at the same time, the past values of Y in equation (2) also have joint significant influence on $E(t)$, then there is a bidirectional feedback relationship between Y and E.

On the other hand, Sims proposed an exogeneity test for the existence of unidirectional causality (Sims). According to Sims, if the causality runs one way from current and past values of some list of exogenous variables to a given endogenous variable, then in a regression of the endogenous variable on future, current, and past values of the exogenous variables, the future values of the exogenous variables should have zero coefficients. Thus, the application of Sims' test to the case of exports and GDP involves estimation of the following two distributed lag regression equations:

$$(3)\ Y(t) = a + \sum_{i=-k}^{m} b(i)E(t-i) + e(t)$$

$$(4)\ E(t) = c + \sum_{i=-k}^{m} d(i)Y(t-i) + w(t)$$

where $Y(t)$, $E(t)$, i, and m denote the same variables as in equations (1) and (2), $-k$ denotes the lead length of future values of a variable, a and c are constant terms, $b(i)$'s and $d(i)$'s are coefficients, and $e(t)$ (or $w(t)$) is an uncorrelated series on disturbances. Thus, E is exogenous to (or causes) Y if the future values of E in equation (3), namely, $E(t+1)$, $E(t+2)$,..., $E(t+k)$ taken as a group of additional explanatory variables, have no joint significant influence on $Y(t)$. That is, the estimates of $b(i)$'s for $i = -1,\ldots,-k$ in equation (3) are jointly insignificantly different from zero. Y is exogenous to (or causes) E if the future values of Y in equation (4), namely, $Y(t+1)$, $Y(t+2)$,...,$Y(t+k)$ taken as a group of additional explanatory variables, have no joint significant influence on $E(t)$. That is, the estimates of $d(i)$'s for $i = -1,\ldots,-k$ in equation (4) are jointly insignificantly different from zero. If the estimates of $b(i)$'s and $d(i)$'s for $i = -1,\ldots,-k$, are both insignificant, then there is a feedback relationship between Y and E. If the estimates of $b(i)$'s and $d(i)$'s, for $i = -1,\ldots,-k$, are both significant, then there is no causality relation between Y and E.

III. Data, Variables, and Double-Log Functions

The statistical data available for the Asian NICs differ slightly in sample size. Annual data from 1960 to 1982 for South Korea and Taiwan, from 1961 to 1982 for Hong Kong, and from 1966 (Singapore became an independent nation in 1965) to 1982 for Singapore were collected. GDP (in millions of US dollars) and GDP price deflators (1975 is the base year) were collected from *National Accounts Statistics* yearbooks published by the United Nations, except Taiwan's GDP were collected from *Statistical Yearbook of the Republic of China,* and GDP price deflators were calculated using the data from *Taiwan Statistical Data Book,* all published by the government in Taiwan.[2] Export data (in millions of US dollars) were collected from *Direction of Trade Statistics* yearbooks published by the International Monetary Fund, except Taiwan's data for 1977 to 1982 were collected from the *Statistical*

2 Since 1978, Taiwan has not been a member of the United Nations(UN), and the UN and International Monetary Fund(IMF) have not published statistical data for Taiwan. The *Statistical Yearbook of the Republic of China* and *Taiwan Statistical Data Book* are the official statistical data sources for Taiwan published by the government. The format of statistical tables, definition of terms, and survey methods used in the yearbooks are essentially the same as those used by other countries in the UN and IMF statiatical yearbooks.

Yearbook quoted above. Export price deflators for Hong Kong and South Korea were collected from *National Accounts Statistics* yearbooks. Since there were no export price deflator for Singapore and Taiwan, the Singapore's price deflators for manufacturing industries and the Taiwan's wholesale price indexes were used as the proxy for their exports price deflators. The GDP and export data are then calculated in real terms.

The functional form often used in the estimation of exports-GDP relationship is a double-natural logarithmic function of the level values of variables, that is, Y = ln(real GDP) and E = ln(real exports) in equations (1) to (4). The main advantage of using a double-log function is that the estimated regression coefficients are the constant elasticity coefficients with respect to the independent variables. Therefore, we choose to use double-log functions of real GDP and real exports in all equations (1) to (4). The computer program used is the *SHAZAM Econometrics Computer Program* for IBM-PC/AT microcomputers (White; White and Horsman).

IV. Estimation Methods

Theoretically, the length of distributed lags, m-periods, and leads, k-periods, in equations (1) to (4) should be long. In practice, however, each additional lag period will cause a loss of one sample point in the estimation process. To avoid the serious loss of data information, we assign $m = k = 3$ for all equation, except in Singapore's case where we assign $m = k = 2$ due to a smaller sample size.[3]

For Granger's test, we apply OLS to estimate the coefficients in equations (1) and (2) for each of the Asian NICs. Since equations (1) and (2) include the lagged dependent variables as independent variables, it is inappropriate to use the Durbin-Watson d-statistic to test for AR(1) errors. Hence, we have tried to compute Durbin's h-statistic (Judge, et al. 1985). However, the values of h-statistic cannot be computed in all cases, due to the necessity of taking the square-root of a negative value in the formula. In-

[3] Jung and Marshall have used two lagged periods in the Granger's causality test.

stead, two alternative tests are used. First, a nonparametric run-test is applied to test for general serial correlation (Gujarati). At the 5% significance level, the results from the run-test show that there is no autocorrelation in OLS residuals in all cases. Second, Box-Pierce's Q-statistic is also calculated for each of the residual series.[4] Column Q in Table 1 reports the calculated Q-values. They range between 1.396 and 11.602. All Q-values are below the critical χ^2 value, 15.987, at the 10% significance level. Thus, the Q-test indicates that we could accept the null hypothesis that the residual series is white-noise and the model specification is thus acceptable for all cases. Hence, the OLS estimates of equations (1) and (2) are used in the Granger's causality test.

On the other hand, for Sims' test, we first apply the OLS to estimate equations (3) and (4), and also calculate the probability-value of exact Durbin-Watson d-statistic to test for the existence of AR(1) errors in each regression (Judge, et al. 1985).[5] The calculated probability-values range between 0.00002 and 0.035 in most cases, except for 0.074 in Singapore's equation (3), 0.099 in Singapore's equation (4), and 0.133 in Hong Kong's equation(4). Thus, at the 10% significance level, the exact Durbin-Watson test indicates that we could not accept the null hypothesis of no positive AR(1) errors in all cases, except Hong Kong's equation (4).[6] This implies that the existence of AR(1) errors violates the OLS assumption of zero covariance among the disturbances, and the OLS formulas for the variances of the estimators no longer hold. Without correction, we would be unable to test hypothesis accurately. To correct this problem, we then use the maximum likelihood Cochrane-Orcutt iterative procedure to estimate equations with the first-order autoregressive scheme (Beach and MacKinnon; Judge, et al. 1982). We also calculate Box-Pierce's Q-statistic for each of the residual series estimated from maxi-

[4] See Box-Jenkins and Pindyck-Rubinfeld.

$Q + n\sum_{k=1}^{K} r^2$, where n = the length of residual series, K = the length of lags (we assigned $K = 10$ in this study), and $r_k = \Sigma u(t)u(t-k)/\Sigma u(t)^2$ is the kth estimated autocorrelation coefficient.

[5] See White and Horsman. The calculated probability — value of exact Durbin-Watson d-statistic is the probability of rejecting the null hypothesis that there is no positive AR(1) errors.

[6] Only in this Hong Kong case, the problem of first-order autoregressive errors may be considered not serious.

mum likelihood AR(1) regression. Column Q in Table 2 reports the calculated Q-values. Except for Taiwan's equation (3), the Q-values range between 3.392 and 12.771. They are below the critical χ^2 value, 14.684, at the 10% significance level. The Q-value for Taiwan's equation (3) is 18.769, which is below the critical value, 21.666, at the 1% significance level. Thus, the Q-test indicates that we could accept the null hypothesis that the residual series is white-noise and the model specification is acceptable in all cases. Hence, the results of maximum likelihood Cochrane-Orcutt estimation of equations (3) and (4) are used in the Sims' causality test.

V. Empirical Results of the Two Causality Tests

Table 1 presents the estimated coefficients, t-ratios, R^2 of equation (1) and (2), F-statistics,[7] and the causal directions indicated by Granger's test. In equation (1), the F-statistic is used here to test the null hypothesis that there is no joint significant influence from the past values of exports on current GDP, that is, to test H_0: $b(1) = b(2) = b(3) = 0$ against the alternative that H_0 is not true (see Kmenta). All F-values in equation (1), 0.661, 1.538, 0, and 1.64, are below their respective critical values, $F(3,12) = 2.61$, $F(3,13) = 2.56$, $F(2,10) = 2.92$, and $F(3,13) = 2.56$, at the 10% significance level. Thus, the F-test shows that we could accept the null hypothesis in all cases. This result implies that the past values of exports do not cause current GDP, and so the hypothesis of exports oriented growth policy in the Asian NICs is not supported by the empirical results from Granger's test.

On the other hand, in equation (2), the F-statistic is used here to test the null hypothesis that there is no joint significant influence from the past values of GDP on current exports, that is, to

7 See Kmenta. The values of F-statistic were calculated from the formula:

$$F = ((R_Q^2 - R_K^2)/(1 - R_Q^2))((n-Q)/(Q-K)),$$

where R_Q^2 is the value of R^2 for the regression equation with additional explanatory variables, while R_K^2 is the value of R^2 for the regression equation without the additional explanatory variables. n is the number of observations used in the estimation, Q is the number of coefficients in the regression equation with additional explanatory variables, and K is the number of coefficients in the regression equation without additional explanatory variables.

Table 1

OLS REGRESSION COEFFICIENTS FOR GRANGER'S TEST

Equation (1)	a(1)	a(2)	a(3)	b(1)	b(2)	b(3)	Const.	R^2	n	Q	F	Causal Direction
Hong Kong	0.969	0.341	-0.424	0.117	-0.354	0.332	0.268	0.9891	19	1.396	0.661	E does not
	(3.3)	(0.92)	(1.1)	(0.39)	(0.98)	(1.3)	(0.56)					cause Y
	0.914	0.338	-0.25				0.056	0.9873	19			
	(3.4)	(0.97)	(0.89)				(0.2)					
S. Korea	0.682	-0.086	0.119	-0.027	0.139	-0.024	2.195	0.9938	20	5.547	1.538	E does not
	(2.3)	(0.25)	(0.48)	(0.22)	(0.85)	(0.2)	(2.0)					cause Y
	0.946	0.031	0.005				0.264	0.9916	20			
	(4.1)	(0.1)	(0.02)				(1.2)					
Singapore	1.489	-0.519	—	0.013	-0.007	—	0.248	0.9980	15	5.434	0.000	E does not
	(6.0)	(2.1)	—	(0.62)	(0.34)	—	(0.59)					cause Y
	1.494	-0.511	—				0.184	0.9980	15			
	(6.5)	(2.3)	—				(1.2)					
Taiwan	0.448	0.012	0.219	0.23	-0.018	-0.056	1.849	0.9963	20	7.136	1.640	E does not
	(0.92)	(0.02)	(0.7)	(2.0)	(0.13)	(0.48)	(1.5)					cause Y
	1.318	-0.363	0.019				0.303	0.9949	20			
	(4.6)	(0.89)	(0.08)				(1.8)					

Table 1 (continued)

Equation (2)	c(1)	c(2)	c(3)	d(1)	d(2)	d(3)	Const.	R^2	n	Q	F	Causal Direction
Hong Kong	0.19	-0.095	0.575	0.66	-0.616	0.382	-0.753	0.9955	19	11.602	5.156	Y causes E
	(0.9)	(0.36)	(2.1)	(3.1)	(2.4)	(2.2)	(2.2)					
				1.121	-0.551	0.415	0.275	0.9897	19			
				(4.8)	(1.6)	(1.8)	(1.2)					
S. Korea	-0.666	0.044	-0.075	0.882	-0.379	0.621	6.223	0.9971	20	4.401	2.241	Y does not cause E
	(1.2)	(0.07)	(0.16)	(3.8)	(1.2)	(2.7)	(3.0)					
				0.937	-0.4	0.381	0.954	0.9956	20			
				(4.1)	(1.3)	(1.8)	(4.0)					
Singapore	-1.300	2.724	—	0.314	-0.025	—	-5.761	0.9326	15	3.259	1.098	Y does not cause E
	(0.36)	(0.77)	—	(1.0)	(0.08)	—	(0.94)					
				0.562	0.280	—	1.603	0.9178	15			
				(2.2)	(1.2)	—	(2.6)					
Taiwan	-2.35	0.047	1.827	1.514	-0.043	-0.253	3.118	0.9913	20	5.308	1.992	Y does not casue E
	(1.7)	(0.03)	(2.0)	(4.4)	(0.11)	(0.74)	(0.87)					
				1.114	-0.359	0.191	0.609	0.9873	20			
				(4.7)	(1.0)	(0.83)	(2.6)					

Note: The absolute values of the estimated t-ratios are in parentheses. At the 5% (or 10%) significance level, the critical value for F(3,12) is 3.49 (or 2.61), F(3,13) is 3.41 (or 2.56), and F(2,10) is 4.10 (or 2.92). The Box-Pierce's Q-statistic was calcualted from the first 10 lags of the auto-correlation coefficients for each residual series. The critical value for the Q-test is $\chi^2(df=10)=15.987$ at the 10% significance level.

test H_0: c(1) = c(2) = c(3) = 0 against the alternative that H_0 is not true. In the case of Hong Kong, the F-value, 5.156, is greater than the critical value, F(3,12) = 3.49, at the 5% significance level. Thus, in Hong Kong's case, the F-test shows that we could not accept the null hypothesis, and the causality runs from GDP to current exports. For the other three Asian NICs, the F-values, 2.241, 1.098, and 1.992, are below their respective critical values, F(3,13) = 2.56, F(2,10) = 2.92, and F(3,13) = 2.56, at the 10% significance level. Thus, in the cases of South Korea, Singapore, and Taiwan, the F-test shows that we could accept the null hypothesis, that is to say, the past values of GDP do not cause current exports. It is rather surprising and disappointing to find that, using Granger's test, there is no evidence of causality from either direction between exports and GDP in the cases of South Korea, Singapore, and Taiwan.

Table 2 presents the estimated coefficients, t-ratios, R^2 of equations (3) and (4), F-statistics, and the causal direction indicated by Sims' test. In equation (3), the F-statistic is used here to test the null hypothesis that there is no joint significant influence from future values of exports on current GDP, that is, to test H_0: b(-3) = b(-2) = b(-1) = 0. In the case of Hong Kong, the F-value, 5.079, is greater than the critical value, F(3,8) = 4.07, at the 5% significance level. The F-test shows that we could not accept the null hypothesis. Thus, in Hong Kong's case, exports are not exogenous to the current GDP. In the other three Asian NICs, the F-values, 0.634, 1.732, and 0.706, are below their respective critical values, F(3,9) = 2.81, F(2,7) = 3.26, and F(3,9) = 2.81, at the 10% significance level. In these three cases, the F-test shows that we could accept the null hypothesis. Thus, exports are exogenous to (or causes) the current GDP. Note that, in Singapore's case, although the F-test is insignificant, the t-ratio of coefficient b(-2) is large, thus, the causality direction suggested by the F-test may be in doubt. The sum of the coefficients of current and past exports represents the long-run export elasticity, therefore, we have calculated and presented it in the column "Sum of b(i)" in Table 2. The long-run export elasticities are 0.315, 0.322, and 0.509 for South Korea, Singapore, and Taiwan, respectively.

On the other hand, in equation (4), the F-statistic is used here to test the null hypothesis that there is no joint significant influence from future values of GDP on current exports, that is, to

Table 2

AR(1) REGRESSION COEFFICIENTS FOR SIMS' TEST

Equation (3)	b(−3)	b(−2)	b(−1)	b(0)	b(1)	b(2)	b(3)	Const.	Sum of b(*i*)	R^2	n	Q	F	Causal Direction
Hong Kong	0.727	−0.248	0.622	−0.407	0.244	−0.29	0.241	0.986		0.9916	16	7.843	5.079	E is not
	(4.6)	(1.4)	(3.4)	(1.9)	(1.3)	(1.6)	(1.4)	(2.5)						exogenous
				0.251	0.318	0.006	0.287	1.61	—	0.9756	16			to Y
				(0.93)	(1.3)	(0.02)	(1.1)	(2.0)						
S. Korea	0	−0.159	−0.139	0.182	−0.038	0.299	0.109	8.065		0.9929	17	12.323	0.634	E is exo-
	(0.0)	(1.4)	(1.3)	(1.6)	(0.41)	(3.0)	(1.1)	(20)						genous to Y
				0.189	−0.078	0.203	0.001	7.37	0.315	0.9914	17			
				(2.0)	(0.89)	(2.3)	(0.02)	(31)	(1.75)					
Singapore	—	0.220	0.060	0.064	0.047	0.056	—	4.726		0.9905	13	4.405	1.732	E is exo-
	—	(3.9)	(1.8)	(1.9)	(1.4)	(1.8)	—	(18)						genous to Y
				0.095	0.126	0.101	—	5.950	0.322	0.9858	13			
				(3.1)	(4.7)	(3.4)	—	(27)	(6.44)					
Taiwan	0.072	−0.036	−0.02	0.268	0.109	0.087	0.035	5.253		0.9983	17	18.769	0.706	E is exo-
	(1.8)	(0.84)	(0.47)	(6.4)	(2.8)	(2.2)	(0.95)	(33)						genous to Y
				0.262	0.101	0.099	0.047	5.325	0.509	0.9979	17			
				(6.4)	(2.4)	(2.3)	(1.2)	(41)	(6.19)					

Table 2 (continued)

Equation (4)	d(-3)	d(-2)	d(-1)	d(0)	d(1)	d(2)	d(3)	Const.	Sum of b(i)	R^2	n	Q	F	Causal Direction
Hong Kong	0.109	-0.254	0.029	0.029	0.02	0.038	1.074	-2.055		0.9930	16	3.392	0.229	Y is exo-
	(0.66)	(1.2)	(0.13)	(1.0)	(0.07)	(0.16)	(5.1)	(6.3)						genous to E
				0.104	-0.043	0.046	1.126	-1.972	1.233	0.9924	16			
				(0.57)	(0.18)	(0.18)	(5.3)	(6.9)	(2.76)					
S. Korea	0.923	0.863	0.314	1.331	0.351	-0.632	-0.185	-21.54		0.9917	17	6.627	0.976	Y is exo-
	(1.3)	(1.3)	(0.48)	(1.8)	(0.53)	(1.0)	(0.25)	(11)						genous to E
				1.879	0.814	-0.287	0.364	-19.2	2.770	0.9890	17			
				(2.6)	(1.2)	(0.45)	(0.5)	(6.9)	(2.00)					
Singapore	—	-3.482	5.603	1.525	-5.788	4.450	—	-10.912		0.9300	13	4.002	0.110	Y is exo-
	—	(0.75)	(0.55)	(0.12)	(0.55)	(0.92)	—	(3.2)						genous to E
				5.015	-6.638	4.089	—	-12.526	2.466	0.9278	13			
				(1.2)	(0.92)	(1.0)	—	(4.3)	(0.27)					
Taiwan	-0.056	0.334	0.823	2.446	-0.865	-1.026	0.263	-10.22		0.9970	17	12.771	1.600	Y is exo-
	(0.16)	(0.78)	(2.1)	(6.6)	(2.2)	(2.2)	(0.78)	(13)						genous to E
				2.942	-0.728	-0.698	0.397	-9.914	1.913	0.9954	17			
				(7.1)	(1.6)	(1.4)	(1.1)	(12)	(2.19)					

Note: The absolute values of the estimated t-ratios are in parentheses. At the 5% (or 10%) significance level, the critical value for F(3,8), is 4.07 (or 2.92), F(3,9) is 3.86 (or 2.81), and F(2,7) is 4.74 (or 3.26). The Box-Pierce's Q-statistic was calculated from the first 10 lags of the autocorrelation coefficients for each residual series. The critical values of the Q-test for the AR(1) model are χ^2 (df = 9) = 14.684 at the 10% significance level and 21.666 at the 1% significance level.

test H_0: $d(-3) = d(-2) = d(-1) = 0$ against the alternative that H_0 is not true. In all four cases, the F-values, 0.229, 0.976, 0.110, and 1.600, are below their respective critical values, $F(3,8) = 2.92$, $F(3,9) = 2.81$, $F(2,7) = 3.26$, and $F(3,9) = 2.81$, at the 10% significance level. Hence, F-test shows that we could accept the null hypothesis in all four cases. Thus, GDP is exogenous to (or causes) current exports. Note against that, in Singapore's case, although the F-test is insignificant, the t-ratios of the coefficients of current and past income variables are all very low, thus, the result of causality test may not be accurate. Since the sum of the coefficients of current and past income represents the long-run income elasticity, we have calculated and presented it in the column "Sum of $d(i)$" in Table 2. The long-run income elasticities are 1.233, 2.770, 2.466, and 1.913 for Hong Kong, South Korea, Singapore, and Taiwan, respectively.

When we compare the causal directions indicated from the two tests, we find that only in the case of Hong Kong, both causality tests yielded the same result of a unidirectional causality from GDP to exports without feedback. In the cases of South Korea and Taiwan, the two larger and faster growing countries among the Asian NICs, the two causality tests yielded different results. Sims' test indicates a feedback relationship between exports and GDP, while Granger's test indicates no causal relationship between exports and GDP. In the case of Singapore, the newest and smallest country among the Asian NICs, Sims' test indicates a feedback relationship between exports and GDP with some undesirable t-ratios for the estimated coefficients, while Granger's test indicates no causal relationship between exports and GDP.

VI. Concluding Remarks

Like many other empirical analyses, the results of a causality test between two variables, either with Granger's test or Sim's test, strongly depend on the data, the functional forms chosen, and the econometric techniques used in the analysis. Using the same set of data from the individual Asian NICs, the Granger's and Sims' causality tests have different causal implications. One common finding from the two tests shows a lack of support for the hypothesis of unidirectional causality from exports to GDP. On the other hand, if we may call the economic policy of stimulating GDP to induce export increase as the "domestic growth policy," then our test results for Hong Kong even suggest that rapid growth has been not so much a result of the export promotion policy as of the domestic growth policy. Thus, the intuitive experience suggested by the export-lead development theory cannot be supported in this empirical study. This finding is also consistent with that of Jung and Marshall whose conclusion is based on Granger's causality test, which, unlike ours, is applied to the relationship between GNP growth rates and export growth rates for most developing countries.

The results of our Sims' test enables us to go beyond and state that there exists a feedback relation between exports and growth for South Korea and Taiwan, the two larger and faster growing countries among the Asian NICs. Thus, our results strongly indicate that, at least for these two countries, the rapid economic growth is not only achieved with the export promotion policy, but also derived from the domestic growth of industries and import-substitution. We may conclude that the developing countries can learn from the experience of the major Asian NICs to achieve their economic growth by the policies of both export promotion and domestic growth. This is hardly a surprising recommendation. It, nevertheless, contains many valid points. It is still true that, in addition to the export promotion policy, a country should strive for domestic growth through efficient use of its limited resources to develop more efficient manufacturing industries, utilizing relatively low-cost labor, and creating a stable political and social environment to attract foreign capital and technology.

Naturally, it is theoretically preferable to investigate not only the causality relation between exports and GDP, other relations involving imports, industrial production, etc. may be investigated. However, rather than complicating the model, we feel that our presentation here may highlight the relation of the two most important policy variables — exports and GDP, which are especially suited for causality tests. We hope that, using our present results, a full scale model may be constructed in the future.

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