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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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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:

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

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,...,-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,...,-k in equation (4) are jointly insignificantly different from zero. If the estimates of b(i)'s and d(i)'s for i = -1,...,-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,..,-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.

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.

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)					

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 (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 auto-correlation 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.

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.

ods: SHAZAM," *Econometrica,* 46, 1, 1978, 239-240.

White, K.J., and N.G. Horsman, *SHAZAM: The Econometrics Computer Program User's Reference Manual,* University of British Columbia, Vancouver, 1985.