JOURNAL OF ECONOMIC DEVELOPMENT
Volume 20, Number 1, June 1995

The Causal Relationship between Exports and Income

Jang C. Jin*
and
Eden S.H. Yu**

The causal relationship between exports and income has been investigated for Korea, Japan, Canada, and the United States. Since the causal relationship are in general sensitive to the chosen lag lengths, the FPE criterion was employed to select optimal lag lengths for each variable in each equation. With the chosen optimal lags, the Granger test was used to detect the causal links between exports and income. For the robustness of the results, Hsiao's FPE test was also employed. The results do not support the causal implication of the export-led growth hypothesis. For Korea and Japan, a feedback model fits the data better than the export-led growth hypothesis. For Canada and the United States, the internally generated economic growth perhaps due to technological progress appears to promote exports.

I. Introduction

The causal relationship between exports and income has been attributed to three different explanations. As indicated in Beckerman (1965), the growth of exports has a favorable impact on economic growth because resource allocation and production efficiency can be improved by export expansion. This export-led growth hypothesis suggests that exports are a key factor in explaining economic growth. In contrast to the export-led growth hypothesis, Vernon (1965) argues that causality may run from economic growth to exports. The internally generated growth hypothesis suggests that technical progress internally generates

* Assistant Professor, Dept. of Decision Science and Managerial Economics, The Chinese University of Hong Kong, Shatin, Hong Kong.
** Professor, Dept. of Economics, Louisiana State University, U.S.A.

economic growth which, in turn, leads to export expansion. Recently, Helpman and Krugman (1985) also suggest that besides the positive causal influence of economic growth on exports, the increase in exports will have feedback effects on economic growth. In this case, a bidirectional causality between economic growth and exports is suggested.

Several techniques have been used in the literature to investigate the causality between exports and income. Jung and Marshall (1985), for example, used the Granger test to examine the causal relationship between exports and economic growth for 37 less-developed countries (LDCs). They provided evidence that the causal directions varied among LDCs. Chow (1987) examined the causal directions further by using the Sims test and found a strong bidirectional causality between export growth and industrial development for eight newly industrialized countries (NICs). Darrat (1987), however, found that exports Granger-caused economic growth only for Korea but not for other Asian NICs. Hsiao (1987) and Ni et al. (1990) also provided evidence that the causal directions differ among countries in the sample. In addition, Marin (1989) found that the export-led growth hypothesis could not be rejected for Japan, Germany, and the United States.

It was, however, a common practice to choose an ad hoc lag length when specifying distributed-lag causal models. Feige and Pearce (1979), among others, indicate that causality tests are in general sensitive to the choice of lag length. The use of lags shorter than their true length may distort the causal impact of exports on economic growth, while the inclusion of irrelevant lags to the model may cause an absence of causality between them.[1] Septon (1989) further elaborates on the importance of using appropriate lag lengths in the specification of the causal model between exports and income. In contrast, few studies of this sort have allowed data themselves to select optimal lag lengths.

Following Thornton and Batten (1985), this paper employs Akaike's final prediction error (FPE) criterion to select optimal lags for each variable in each equation. The causal relationship between exports and income has focussed on the latecomers such as Korea and Japan where exports may have had significant influences on economic growth. The

[1] For example, when we used an ad hoc lag length of four quarters for export and income variables, no causality was found for Korea; for Japan, exports Granger-caused income; for Canada, income Granger-caused exports; and for the United States, a bidirectional causality was found. Because the results of causality might be sensitive to the lag length, we extended the lag length to eight quarters. Surprisingly, no causality was found for all countries.

investigation of the causal links between exports and income has been explored further with the U.S. and Canadian data.

The paper is organized as follows. Section II specifies the empirical model for Granger-causality and discusses the optimal lag lengths chosen by an FPE criterion. It then presents the results of the Granger test. The FPE test, which is a variant of the Granger test, is also employed for the robustness of the results. A brief summary and conclusion follow in section III.

II. Granger-causality between Exports and Income

A. Granger Test

Granger (1969) defines the causality such that X Granger-causes Y if Y can be predicted more accurately, in the sense of mean square error, with the use of past values of X than without using past values of X. Based upon the definition of Granger causality, a simple bivariate autoregressive (AR) model for exports and income is specified as:

$$(1) \qquad GNP_t = c + \Sigma_{i=1}^{p} \alpha_i \, GNP_{t-i} + \Sigma_{j=1}^{q} \beta_j \, EXP_{t-j} + u_t$$

$$(2) \qquad EXP_t = c + \Sigma_{i=1}^{r} \tau_i \, EXP_{t-i} + \Sigma_{j=1}^{s} \delta_j \, GNP_{t-j} + v_t$$

where GNP is the gross national product and EXP is the exports of goods and services;[2] u and v are serially uncorrelated white noise residuals; and p, q, r, and s are lag lengths for each variable in each equation.

As noted earlier, Akaike's final prediction error (FPE) criterion is employed to select appropriate lag lengths for each variable in each equation. The FPE criterion is a purely statistical technique and allows the data themselves to select the optimal lag length. Using the causal model specified in equations (1) and (2), the FPE criterion selects an optimal lag length which gives the smallest FPE. The FPE is defined as

2 The series were taken from the *International Financial Statistics (IFS)* data tape produced by the International Monetary Fund. The seasonally adjusted quarterly series over the period 1960:1-1987:4 were used for the analysis. Due to the data constraint, gross domestic product (GDP) was used for Korea. Based upon the arguments of Nelson and Plosser (1982) that many macroeconomic time series contain first-order unit roots, the model employed first differences of the logs of export and income variables to achieve stationarity.

(3) $$FPE(p, q) = \frac{T+p+q+1}{T-p-q-1} * \frac{RSS(p, q)}{T}$$

where T = the number of observations used, and RSS (p, q) = residual sum of squares estimated with p lags of GNP and q lags of exports. The first term measures an estimation error and the second term measures a modeling error. As noted in Judge et al. (1982), an intuitive reason for using the FPE criterion is that longer lags increase the first term but decrease the RSS of the second term, and these two opposing forces are balanced optimally where their product reaches its minimum.

By using the FPE criterion, the procedure for selecting optimal lags can be illustrated with an example of the GNP equation. The first step is the determination of its own lag length for GNP in a univariate AR model. An export variable is ignored for a moment in this first step. Each time the equation is run by adding one more lag of GNP, the FPE is computed. This is done by varying the lag length from 1 to 16.[3] The equation which gives the smallest FPE is selected as an optimal lag length, p, for GNP. The second step is to determine an optimal la length of EXP in a bivariate AR model. By assuming the lag length of GNP to be the one determined in the first step, the bivariate AR model is again run 16 times by adding one more lag of EXP each time. The lag length of EXP that yields the smallest FPE is selected as an optimal lag length, q, for EXP in the bivariate AR model. At this point the optimal model for predicting GNP contains p lags of GNP and q lags of EXP.

Table 1 provides the optimal lag lengths determined by the FPE criterion. For Korea and Japan, the optimal lags are in most cases longer than those in other countries. In particular, the optimal lag length of EXP in an export equation for Korea was 16, which turned out to be the maximum lag length. Since we could not be sure this was the optimal lag length, the maximum lag length has been extended to 20. But the optimal lag length, 16, was unaltered. The optimal lag lengths for Canada and the United States are relatively short, and their patterns for the United States are, in particular, different from those in other countries. The U.S. export variable in the GNP equation had longer lags than the GNP variable itself; the U.S. GNP in the export equation had longer lags than the export variable itself.

Using the selected optimal lags, the causal models are estimated by

[3] The maximum lag length for each variable was set to 16 in accordance with the quarterly series used for this study and with the requirements concerning the degrees of freedom.

Table 1

OPTIMAL LAG LENGTHS DETERMINED BY FPE

Country	p	q	r	s
Korea	6	2	16	8
Japan	9	5	8	11
Canada	3	1	4	3
U.S.A.	5	7	1	4

Notes: p and q are lag lengths for GNP and exports, respectively, in equation (1). r and s are lag lengths for exports and GNP, respectively, in equation (2).

least squares. To determine the causal directions, the Granger test uses F statistics within a framework of unrestricted and restricted models. The F statistics are computed as:

$$(4) \qquad F = \frac{(RSS_r - RSS_u)/(df_r - df_u)}{RSS_u/df_u}$$

where RSS_r and RSS_u are the residual sum of squares of restricted and unrestricted models, respectively; and df_r and df_u are, respectively, the degrees of freedom in restricted and unrestricted models.

The causal directions are detected in the following manner. First, unidirectional causality runs from EXP to GNP if the F test rejects the null hypothesis that past values of EXP in equation (1) are insignificantly different from zero and if the F test cannot reject the null hypothesis that past values of GNP in equation (2) are insignificantly different from zero. That is, EXP causes GNP, but GNP does not cause EXP. Unidirectional casuality runs from GNP to EXP if the revese is true. Second, bidirectional causality runs between EXP and GNP if both F-statistics reject the null hypothesis in equations (1) and (2). Finally, no causality exists between EXP and GNP if null hypotheses in both equations cannot be rejected.

Table 2 presents the results of the Granger test that has used optimal lag lengths for each variable in each equation. For Korea, the causal direction is not consistent with the hypothesis that exports enhance economic growth in such a developing economy. A feedback model fits the data better than a unidirectional causality. The growth of exports promotes economic growth perhaps due to a better resource allocation. The economic growth then enhances their comparative advantage in in-

Table 2

GRANGER TEST

Country	Eq (1) GNP on past GNP & past EXP	Eq (2) EXP on past EXP & past GNP	Causal Inferences
Korea	3.20 (2, 86)*	2.07 (8,70)*	GDP ⇆ EXP
Japan	2.48 (5, 80)*	2.15 (11,75)*	GNP ⇆ EXP
Canada	2.05 (1, 90)	3.46 (3, 87)*	GNP → EXP
U.S.A.	1.82 (7, 82)	2.62 (4, 89)*	GNP → EXP

Notes: The F-statistics are computed with restricted and unrestricted models. Numbers in parentheses represent the degrees of freedom.
'*' indicates significant at the 5 percent level.

ternational markets, which in turn promotes the growth of exports. Under these circumstances, export promotion and economic growth are reinforcing each other in the process of economic development.

For developed countries, the causal directions are also at odds with the export-led growth hypothesis. For Japan, a bidirectional causality runs between exports and GNP. Japanese export promotion and economic growth appear, as in the case of Korea, reinforcing each other in the process of economic development. For Canada and the United States, the internally generated economic growth perhaps due to technical progress appears to promote exports. The causal relationships found in these two countries are consistent with the internally generated growth hypothesis.

B. FPE Test

The Hsiao's (1979, 1981) FPE test directly uses an FPE criterion, while the conventional hypothesis testing for Granger causality uses an F test. As indicated by Hsiao, using the FPE criterion is equivalent to using the F test, and their major differences are in the choice of a significance level. While the conventional choice is an ad hoc 5% or 1% significance level, the choice in the FPE test is based on an explicit optimality criterion that minimizes the mean square prediction error.

The Hsiao's FPE test follows the definition of Granger causality and compares the smallest FPEs obtained from univariate and bivariate AR models. In the GNP equation, for example, EXP causes GNP if the smallest FPE in the bivariate AR model is less than the smallest FPE in the univariate AR model. If the reverse is true, EXP does not cause GNP. The same procedure can be applied to detect the causality running from GNP to EXP in the EXP equation. Bidirectional causality, however, results from the feedback model that EXP causes GNP and, at the same time, GNP causes EXP. No causality exists if EXP does not cause GNP and GNP does not cause EXP.

Based upon the optimal lag length chosen by the FPE criterion, the specification of the model for each country is identified in the second column of Table 3. The FPEs are also presented in the third column. The first row in each country shows the smallest FPE of the univariate AR model. For example, when GDP is regressed on its own lagged values, the minimum FPE is 0.00193 with six lags of GDP in Korea. The second row shows the smallest FPE of the bivariate AR model. Assuming six lags of GDP fixed, the minimum FPE turns out to be 0.00187

Table 3

FPE TEST

Country	Model	FPE	Causal Inferences
Korea	GDP = GDP(6)	0.00193	GDP ⇄ EXP
	GDP = GDP(6) + EXP(2)	0.00187	
	EXP = EXP(16)	0.01143	
	EXP = EXP(16) + GDP(8)	0.01103	
Japan	GNP = GNP(9)	0.00027	GNP ⇄ EXP
	GNP = GNP(9) + EXP(5)	0.00026	
	EXP = EXP(8)	0.00228	
	EXP = EXP(8) + GNP(11)	0.00220	
Canada	GNP = GNP(3)	0.00012	GNP – EXP
	GNP = GNP(3) + EXP(1)	0.00012	
	EXP = EXP(4)	0.00256	
	EXP = EXP(4) + GNP(3)	0.00244	
U.S.A.	GNP = GNP(5)	0.00010	GNP – EXP
	GNP = GNP(5) + EXP(7)	0.00010	
	EXP = EXP(1)	0.00324	
	EXP = EXP(1) + GNP(4)	0.00315	

Notes: Numbers in parenthese represent the optimal lag lengths determined by an FPE criterion.

when exports have two optimal lags in this bivariate model. Since the minimum FPE (0.00187) of the bivariate AR process is smaller than the minimum FPE (0.00193) of the univariate AR model, exports Granger-causes GDP. In the export equation, the minimum FPE (0.01103) with inclusion of eight optimal lags of GDP is also smaller than the minimum FPE (0.01143) of the univariate AR model, and thus GDP causes exports. Therefore, the results of the FPE test indicate that for the case of Korea, a bidirectional causality runs between economic growth and exports.

The same test procedure applies for other countries. For Japan, a bidirectional causality is also found. For Canada and the United States, GNP appears to cause exports. The results of the Hsiao's FPE test are consistent with the findings of the Granger test.

III. Summary and Conclusion

The causal relationship between exports and income has been investigated for Korea, Japan, Canada, and the United States. Since the causal relationships are in general sensitive to the chosen lag lengths, the FPE criterion was employed to select optimal lag lengths for each variable in each equation. With the chosen optimal lags, the Granger test was used to detect the causal links between exports and income. For the robustness of the results, Hsiao's FPE test was also employed.

The results from the causality tests that have used optimal lags do not support the causal implication of the export-led growth hypothesis. For the latecomers such as Korea and Japan, a feedback model fits the data better than the export-led growth hypothesis. The growth of exports promotes economic growth due to a better resource allocation and an improved production efficiency. This export-led economic growth then enhances their comparative advantage in international markets, which in turn promotes the growth of exports. Under these circumstances, exports and economic growth are reinforcing each other in the process of economic development. For Canada and the United States, Granger-causality runs from GNP to exports. The internally generated economic growth perhaps due to technological progress appears to promote exports. The results for these two countries are consistent with the internally generated growth hypothesis.

Since the behavior regarding exports and economic growth differs among the countries in the sample, some form of independent policy making based upon each country's own socioeconomic characteristics is warranted. Finally, we stress that these results indicate the importance of using optimal lag lengths when specifying distributed-lag causal models.

References

Beckerman, W., "Demand, Exports and Growth," in W. Beckerman et al., *The British Economy in 1975,* The National Institute of Economic and Social Research, 1965, 44-72.

Chow, P.C.Y., "Causality between Export Growth and Industrial Development: Empirical Evidence from the NICs," *Journal of Development Economics,* 1987, 55-63.

______, "Causality between Export Growth and Industrial Development: Empirical Evidence from the NICs — Reply," *Journal of Development Economics,* October 1989, 416-417.

Darrat, A.F., "Are Exports an Engine of Growth? Another Look at the Evidence," *Applied Economics,* February 1987, 277-283.

Feige, E.L. and D.K. Pearce, "The Causal Relationship between Money and Income: Some Caveats for Time Series Analysis," *Review of Economics and Statistics,* 61, 1979, 521-533.

Granger, C.W.J., "Investigating Causal Relations by Econometric Models and Cross-spectral Methods," *Econometrica,* July 1969, 424-438.

Helpman, E. and P. Krugman, *Market Structure and Foreign Trade,* Cambridge: MIT Press, 1985.

Hsiao, C., "Causality Tests in Econometrics," *Journal of Economic Dynamics and Control,* 1979a, 321-346.

______, "Autoregressive Modeling of Canadian Money and Income Data," *Journal of American Statistical Association,* 1979b, 553-560.

______, "Autoregressive Modeling and Money Income Causality Detection," *Journal of Monetary Economics,* January 1981, 85-106.

Hsiao, M.C.W., "Tests of Causality and Exogeneity between Exports and Economic Growth: The Case of Asian NICs," *Journal of Economic Development,* December 1987, 143-159.

Judge, G.G., R.C. Hill, W. Griffiths, H. Lutkepohl, and T.C. Lee, *Introduction to the Theory and Practice of Econometrics,* John Wiley and Sons, New York, 1982, chs. 15, 25 and 26.

Jung, W.S. and P.J. Marshall, "Exports, Growth and Causality in Developing Countries," *Journal of*

Development Economics, 1985, 1-12.

Marin, D., "Is the Export-led Growth Hypothesis Valid for Industrialized Countries," EUI Working Paper No. 89/386, European University, Florence, 1989.

Nelson, C.R. and C.I. Plosser, "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications, *Journal of Monetary Economics,* September 1982, 139-162.

Ni, S.S., B. Biswas and G. Tribedy, "Causality between Exports and Economic Growth: An Empirical Study," *Journal of Economic Development,* June 1990, 47-61.

Sephton, P.S., "Causality between Export Growth and Industrial Development: Empirical Evidence from the NICs — A Comment," *Journal of Development Economics,* 31, October 1989, 413-415.

Thornton, D.L. and D.S. Batten, "Lag-length Selection and Tests of Granger Causality between Money and Income," *Journal of Money, Credit, and Banking,* May 1985, 164-178.

Vernon, R., "International Investment and International Trade in the Product Cycle," *Quarterly Journal of Economics,* 80, 1966, 290-307.