Causality Analysis of Exports, Output and Stock Returns: Taiwan and South Korea

Raymond H.F. Kwok*

By applying the concept pioneered by Granger, this paper tests the causal relationship between real output, exports and stock returns in Taiwan and South Korea. We find that there is no clear causal relationship between real sector and financial sector in these two closed markets. (*JEL* E44)

I. Introduction

One of the widely accepted relationships in development economic theory is the positive causal relationship between the rate of growth of exports and the rate of growth of output. That is, export growth is causally prior to output growth. Many studies in favor of export promotion have indicated this direct link between export and growth and supported for export promotion as an effective development strategy.[1]

According to the theory of finance, high growth in output raises average real rate of return on capital and thus encourages capital expenditure. High capital expenditure will eventually raise stock prices. There is also research supporting the view that the stock market is a leading barometer of economic activity. Upward movements in stock prices generally indicate economic upturns, and attracts additional invest-

*Lecturer, Division of Commerce, City Polytechnic of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong. This research is supported by a fund from the City Polytechnic of Hong Kong. Comments by C.K. Woo and an anonymous referee were particularly helpful in sharpening the focus of the paper. The author wishes to thank Henry Wong for his research assistance. The author alone is responsible for any mistakes in the paper.

[1]See, for example, Voivodas (1973), Michaely (1977), Balassa (1978), Feder (1983).

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ment. Cooper (1974) and Rozeff (1974) suggest that under the efficient market hypothesis, stock returns accurately reflect all available information about the anticipated direction of monetary policy, and hence anticipated future changes in real output. In short, we should have a causal relations between real output and stock returns.

In the last decade, Korea and Taiwan experienced high economic growth rate. We all agree that these two countries are export-oriented economies, i.e. growth rate in real exports stimulates economic growth. The stock prices in these two countries increased substantially. The Korean Composite Index increased by 750% from 1980 to 1989, whereas Taiwan Weighted Index increased 1,600% in the same period. It is interesting to investigate the relationship between real sector and financial sector in these two countries. Unfortunately, the financial markets in these countries are highly regulated and closed markets when compared to the other two Asian Newly Industrialized Economies.[2] Although Korea and Taiwan are in the process of financial liberalization, the link between real sector and financial sector is not that clear. Kwok and Li (1991) and Kwok (1992) show that the behavior between real output and stock returns in the closed markets is not the same as in the open and efficient markets. Many scholars have established empirically the causal relationship between real output and stock returns in an efficient market. This paper differs from the previous work by testing the causal relationship between real sector and financial sector of a closed market.

The remainder of the paper is composed of four sections. Section II briefly presents Granger-causality testing and a decision procedure for fitting vector autoregressive models. Section III describes the data and section IV discusses the empirical results. Conclusions are in section V.

II. The Model

The model employed in this study is Granger's causality test. A standard bivariate dynamic structural model on which the Granger test is based can be expressed by the following reduced form:

$$\begin{aligned} x_t &= L(\pi_{11})^m x_{t-1} + L(\pi_{12})^n y_{t-1} + \mu_{1t} \\ y_t &= L(\pi_{21})^m x_{t-1} + L(\pi_{22})^n y_{t-1} + \mu_{2t} \end{aligned} \tag{1}$$

[2]Asian Newly Industrialized Economies include Hong Kong, Singapore, South Korea and Taiwan.

x and y be two stationary stochastic time series, and L is the lag operator such that $L(\beta)^m y_{t-1} = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \dots \beta_m y_{t-m} \cdot \mu_{it}$ for $i = 1, 2$ are two serially independent random vectors with zero mean and finite covariance matrix.

Following Granger (1969), a variable x is said to cause another variable y with respect to a given information set that includes x and y, if current y can be predicted better by using past values of x than by not doing so, given all other past information in the information set is used. In short, let x' and y' be the sets of past information of x and y respectively. The mean square error of the minimum mean square error prediction of y_t given the information set A_t is denoted by $\sigma^2(y \mid A)$. The general definitions of causality and feedback are as follows:

***Definition* 1 (Causality)**

If $\sigma^2(y \mid y') > \sigma^2(y \mid y', x')$, (i.e. the prediction of y using x' is more accurate than without using x', in the mean square error sense), there is a unidirectional relationship running from x to y, or x is said to cause y, denoted by $x \rightarrow y$.

***Definition* 2 (Feedback)**

If $\sigma^2(x \mid x') > \sigma^2(x \mid x', y')$ and $\sigma^2(y \mid y') > \sigma^2(y \mid y', x')$, there exists a bidirectional relationship between x and y, and feedback is said to occur, denoted by $x \leftrightarrow y$.

To examine the causal relationship between x and y in equation (1), the following hypotheses are tested: $L(\pi_{12})^n = 0$ and $L(\pi_{21})^m = 0$. If neither can be rejected, then x and y are independent series. If both are rejected, then there is feedback between x and y. If the former hypothesis is rejected but the latter is not, there is unidirectional causality running from y to x, whereas if the latter is rejected and the former is not, the reverse is true.

Tests of the above hypothesis are highly dependent on the unknown lag parameters. In this paper, the criterion for specifying the lag length is Akaike's (1969) minimum *final prediction error* (*FPE*). As suggested by Hsiao (1981), we formulate model 1 as follows:

$$x_t = a + \sum_{i=1}^{r} \alpha_i x_{i-1} + \sum_{i=1}^{m} \beta_i y_{i-1} + e_{1t} \tag{2}$$

$$y_t = b + \sum_{i=1}^{s} \tau_i x_{i-1} + \sum_{i=1}^{n} \delta_i y_{i-1} + e_{2t} \tag{3}$$

where a and b are constants and e_{1t} and e_{2t} are residual terms with zero mean. y is said to cause x when x_t can be predicted better by using x_{t-i}'s and y_{t-i}'s than by using x_{t-i}'s alone in equation (2). x is said to cause y when y_t can be predicted better by including x_{t-i}'s in equation (3). Feedback exists if both events occur.

Akaike's (1969) minimum final prediction error is:

$$E(y_t - \hat{y}_t)^2$$

where $\hat{y}_t$ is the predictor of y_t in equation (2). The equation which gives the minimum *FPE* is the one with the optimal number of lags. According to Hsiao's approach, we first regress x_t on its past values with different lag lengths, i.e.

$$x_t = a + \sum_{i=1}^{r} \alpha_i x_{t-i} + e_{1t} \tag{4}$$

and choose the r^* such that the *FPE* is minimum. Thus, optimal number of lags is estimated by:

$$\text{Min } FPE(x) = \frac{T + r^* + 1}{T - r^* - 1} \cdot \frac{RSS}{T}$$

where T is the total observations, *RSS* is the residual sum of square of the regression, r^* is the optimal number of lags.

For the given r^*, x_t is regressed again on its r^* lagged values with y_{t-1}:

$$x_t = a + \sum_{i=1}^{r^*} \alpha_i x_{t-i} + \sum_{i=1}^{m} \beta_i y_{t-i} + e_{1t} \tag{5}$$

The equation with lags (r^*, m^*) is chosen which gives the minimum *FPE* (x, y):

$$\text{Min } FPE(x,y) = \frac{T + r^* + m^* + 1}{T - r^* - m^* - 1} \cdot \frac{RSS}{T}$$

Compare the *FPEs* generated by the above procedures. If the min $FPE(x)$ > min $FPE(x, y)$, then y is said to cause x. If min FPE (x) < min $FPE(x, y)$, then x and y are two independent series.

Moreover, Kawai (1980) defines two forms of causality:

(1) Weak form: If min $FPE(x)$ > min $FPE(x, y)$, y is said to weakly cause x.
(2) Strong form: If all the coefficients for y_{t-i}'s are jointly and significantly different from zero, i.e. reject H_0: β_i's = 0 in equation (5), y is said to strongly cause x.

Strong causality can be tested using *F*-statistics. Obviously, a strong form causality guarantees a weak form causality but not the reverse.

The distinct benefits of using the *FPE* approach are as follows:

(1) The optimal number of lags are determined by the data itself rather than using some arbitrary lag order specification.
(2) The *FPE* criterion does not contain the lag structure of each variable to be identical, i.e. $r^* = m^*$.
(3) As suggested by Hsiao (1981), this criterion is equivalent to applying an approximate *F*-statistics with varying significance levels. He states that the choice of whether a variable should be included in the equation is based on an explicit optimality criterion, i.e. minimizing the mean square prediction error. It frees us from the ambiguities inherent in the application of conventional procedures (*ad hoc* significance level of 5% or 1%).

Besides using the *FPE* to estimate the optimal numbers of lags, we also extend the investigation by using the rules of thumb, arbitrary lag specification. Two sets of arbitrary lags used in this study are 4-4 and 8-8. We will compare the *FPE* results with the arbitrary lag specification.

By using the Granger's causality analysis, we can examine the causal relationship between stock returns and industrial production, stock returns and real exports, and industrial production and real exports. In previous studies, various scholars have investigated a strong contemporaneous relation between the growth of industrial production and stock returns. We expect a strong causal relationship between stock returns and industrial production in these two markets. Moreover, since both Korea and Taiwan enjoyed a high export growth rate in last decade, we also want to examine whether there exists a strong causal relationship between stock prices and real exports. Finally, as Korea and Taiwan are export-led economies, we expect a strong link between real exports and real output. From the above discussion, we expect the null hypotheses of no causal relationship between stock returns and industrial production, stock returns and real exports, and industrial production and real exports to be rejected.

III. Data Description

The data used in this paper consist of quarterly figures over the period 1975 through 1990. The index of industrial production and export of these two countries are used to measure real economic activity which is obtained from the IMF Statistical Yearbook. The Korean Composite Stock Index and Taiwan Weighted Index are used to calculate real stock returns. The returns on stock are measured as the difference between continuous returns and the inflation rate calculated using the Korean and Taiwan Consumer Price Index.

The basic assumption of causality test is that the time series must be a stationary stochastic series or white noise. We first take the first differences of the logarithms of each variable in order to remove the time trends, using the Ljung-Box small sample Q-statistic and correlogram to confirm the series are stationary and white noise.

IV. Empirical Results

Table 1 and Table 2 present the result of *FPE*s for different measures of industrial production (IND), real export (EXP) and stock returns (SR) in Korea and Taiwan. Each variable is treated as a one-dimensional autoregressive process with the maximum lags equal to 24. The smallest *FPE*s for IND, EXP and SR in Korea are 5, 5, and 1 respectively, while in Taiwan they are 19, 18 and 8 respectively. Thus the optimal order of lags is quite small in Korea but relatively large in Taiwan.

Table 3 and Table 4 show the results of causality and feedback between industrial production and stock returns, real exports and stock returns, and industrial production and real exports in both Korea and Taiwan. Table 5 and Table 6 compare the *FPE* results with the arbitrary lag specifications.

In case of Korea, only industrial production and stock returns have a feedback relation while the others have no relation at all. Surprisingly, the lag length for stock returns causing industrial production is high (13 lags), indicating the effect of stock returns is long lasting. However, the lag length for industrial production causing stock returns is very short, only 1 lag, indicating that the effect of real sector to financial sector is short lived. This result is similar to Woong (1988) who reports that the financial sector in Korea appears to be greatly lagging behind the real sector. Moreover, the growth of the financial sector has not kept pace with the growth in other sectors of the economy. When we compare the results with the arbitrary lag specifications, there is no feedback relationship between industrial production and stock returns. This finding is similar to the result in Thornton and Batten (1985) who suggest that arbitrary lag-length specifications generate spurious results.

TABLE 1
THE *FPE* OF FITTING A ONE-DIMENSIONAL AUTOREGRESSIVE PROCESS FOR KOREAN INDUSTRIAL PRODUCTION, EXPORTS AND STOCK RETURNS

Lags	*FPE (X)*		
	IND	EXP	SR
1	0.001015	0.01446	0.009359*
2	0.001025	0.0143	0.009495
3	0.000936	0.008914	0.009565
4	0.001002	0.005739	0.009774
5	0.000925*	0.005676*	0.010189
6	0.000965	0.005960	0.010644
7	0.001002	0.006130	0.010976
8	0.001057	0.006400	0.011628
9	0.001069	0.0065	0.010734
10	0.001109	0.0068	0.011353
11	0.001144	0.0057	0.011861
12	0.001139	0.006066	0.012611
13	0.0012	0.00639	0.01348
14	0.001248	0.006626	0.01389
15	0.001304	0.006816	0.0142
16	0.001270	0.00695	0.0125
17	0.001366	0.00753	0.01259
18	0.001450	0.0081	0.01319
19	0.001580	0.0089	0.01407
20	0.001650	0.0096	0.01399
21	0.0018	0.01047	0.01378
22	0.002029	0.0111	0.01519
23	0.002290	0.01088	0.01677
24	0.002227	0.0094	0.01754

Note: * minimum *FPE (X)*

Although Korea experienced high export growth in the last decades, there is no causal relationship between real exports and stock returns. In the theory of economics and finance, high growth rate in real sector will encourage investors to invest more on capital in anticipation of higher future returns. This will push up the stock price. Since Korea is an export-led economy, high growth rate in real exports should boost stock returns. However, this is not the case. In Kwok (1992), the regression result between stock returns and real exports is also insignificant, this confirms that there is no direct relationship between export sector and stock market.

In case of Taiwan, we can only find a weak causal relationship

TABLE 2
THE *FPE* OF FITTING A ONE-DIMENSIONAL AUTOREGRESSIVE PROCESS FOR TAIWAN INDUSTRIAL PRODUCTION, EXPORTS AND STOCK RETURNS

Lags	*FPE* (*X*)		
	IND	EXP	SR
1	0.002303	0.009533	0.027070
2	0.002304	0.009156	0.027329
3	0.002265	0.008720	0.022422
4	0.001505	0.006473	0.021358
5	0.001462	0.006628	0.021748
6	0.001468	0.005733	0.022909
7	0.001485	0.006077	0.021873
8	0.001259	0.004477	0.020714*
9	0.001328	0.004193	0.021836
10	0.001381	0.004178	0.021839
11	0.001374	0.004235	0.022767
12	0.001317	0.004393	0.020716
13	0.001371	0.004277	0.022154
14	0.001212	0.004217	0.023784
15	0.001035	0.004325	0.024061
16	0.001084	0.004221	0.026035
17	0.001061	0.004565	0.028045
18	0.001016	0.003890*	0.026835
19	0.000969*	0.004282	0.024281
20	0.001053	0.004534	0.021403
21	0.001062	0.005074	0.022527
22	0.001205	0.004601	0.025322
23	0.001209	0.004878	0.027738
24	0.001404	0.004878	0.025622

Note: * minimum *FPE* (*X*)

between real sector and financial sector. Table 4 shows that *FPE* of industrial production and *FPE* of exports are higher than the one including stock returns. The *F*-statistics is insignificant. Moreover, there is no feedback relationship between real variables and stock returns. That is, only stock returns affect the industrial production and exports but not the reverse. Similar to Korea, the lag length for stock returns causing real variables is relatively high (6 lags for industrial production and 7 lags, for exports). Since the Taiwan stock market is also highly regulated by the government, high economic growth rate may not be a good indicator to stimulate stock prices. Instead, domestic speculation force and external factors such as fluctuation and

TABLE 3

GRANGER CAUSALITY *F*-STATISTICS FROM KOREAN *FPE*

X	*Y*	Lags *X*	Lags *Y*	Min *FPE* (*X*, *Y*)	*F*-test	*Y* → *X*
IND	SR	5	13	0.000912[a]	$F(13,31)=1.9904^*$	Yes
SR	IND	1	1	0.008557[a]	$F(1,59)=7.7019^\#$	Yes
EXP	SR	5	1	0.0058	$F(1,51)=0.0253$	No
SR	EXP	1	1	0.0096	$F(1,59)=0.4467$	No
IND	EXP	5	1	0.0009317	$F(1,51)=1.3855$	No
EXP	IND	5	1	0.005849	$F(1,51)=0.2589$	No

Note: 1. a: min *FPE* (*X*) > min *FPE* (*X*, *Y*)
2. * : significant at 10% level
3. #: significant at 1% level

TABLE 4

GRANGER CAUSALITY *F*-STATISTICS FROM TAIWAN'S *FPE*

X	*Y*	Lags *X*	Lags *Y*	Min *FPE* (*X*, *Y*)	*F*-test	*Y* → *X*
IND	SR	19	6	0.000865[a]	$F(6, 18)=1.8983$	Yes
SR	IND	8	1	0.021493	$F(1, 45)=0.0263$	No
EXP	SR	18	7	0.003691[a]	$F(7, 19)=1.6282$	Yes
SR	EXP	8	1	0.021505	$F(1, 45)=0.0003$	No
IND	EXP	19	20	0.000039[a]	$F(20, 4)=5.8316^*$	Yes
EXP	IND	18	5	0.002154[a]	$F(5, 21)=3.3596^*$	Yes

Note: 1. a: min *FPE* (*X*) > min *FPE* (*X*, *Y*)
2. * : significant at 10% level

rumor in major stock markets or economic conditions in their major trading partners are the main elements to cause stock prices to change. Therefore, we are not surprised at these results.

Since Korea and Taiwan are export-led economies, we expect a close link between real exports and real output. That is, growth in real exports tends to cause the growth in real GNP. In addition, high growth rate in output also tends to increase export. This is what Jung and Marshall (1985) called "export promotion hypothesis" and "internally generated exports" hypothesis. Table 3 shows that we cannot find any direct relationship between these two variables in Korea, whereas we have a feedback relationship in Taiwan in Table 4. Unfortunately, the

TABLE 5
GRANGER CAUSALITY *F*-STATISTICS FOR VARIOUS LAG SPECIFICATIONS IN KOREA

X	*Y*	Lag Specifications		
		4-4	8-8	*FPE* (*X*, *Y*)
IND	SR	0.4046	2.0619	1.9904*
SR	IND	2.0199	1.1752	7.7019#
EXP	SR	0.0711	0.3150	0.0253
SR	EXP	0.9261	0.9114	0.4467
IND	EXP	1.0657	1.3054	1.3855
EXP	IND	0.2035	0.1972	0.2589

Note: 1. * : significant at 10% level
2. #: significant at 1% level

TABLE 6
GRANGER CAUSALITY *F*-STATISTICS FOR VARIOUS LAG SPECIFICATIONS IN TAIWAN

X	*Y*	Lag Specifications		
		4-4	8-8	*FPE* (*X*, *Y*)
IND	SR	1.6851	1.1111	1.8983
SR	IND	0.6713	0.7532	0.0263
EXP	SR	0.7812	1.3297	1.6282
SR	EXP	0.2380	0.5303	0.0003
IND	EXP	0.7460	0.9964	5.8316*
EXP	IND	3.3331*	2.4225*	3.3596*

Note: * : significant at 10% level

sum of export growth coefficients and the sum of output growth coefficients in Taiwan are negative in the output growth regression and the export growth regression. The results do not support the export promotion hypothesis and internally generated hypothesis. Instead, it can be explained by growth-reducing export hypothesis and export-reducing hypothesis respectively.[3] Jung and Marshall (1985) examine the causal relationship between these two variables using the causality analysis in 37 developing countries and find similar results.

[3]See Jung and Marshall (1985) for datails.

V. Conclusion

This paper uses Granger tests to investigate the causal relationship between real sector and financial sector in Korea and Taiwan. Since these two markets are closed markets, our results differ from those for efficient market. The most surprising result is that although Korea is commonly known as an export-led economy, we cannot find any link between real exports and real output. Moreover, the links between real output and stock returns, and real exports and stock returns are ambiguous. While we have a significant relationship between real output and stock returns, we do not have a significant relationship between real exports and stock returns because we do not have a clear link between real output and real exports. In other words, economic indicators may not have any significant influence on stock returns. This may be a characteristic of a closed market. As the market becomes more mature and efficient, the link between real sector and financial sector will become clearer.

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