The interdependence of Taiwanese and Japanese stock prices

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Abstract

This paper empirically analyzes the relationship among the prices of Taiwanese stocks, Japanese stocks, and crude oil from January 1980 to July 2008. It provides some interesting results: (1) crude oil prices made an impact on Japanese stock prices, while the latter exerted a strong influence on Taiwanese stock prices during the period of Japan's economic growth; (2) however, no causality was observed among the variables during the Japanese economy's "lost decade"; and (3) causality from Japanese stock prices and crude oil prices to Taiwanese stock prices was observed during the period of Japan's economic recovery.

Keywords: Taiwanese stock prices, Japanese stock prices, LA-VAR

1. Introduction

In recent years, the globalization of capital markets and advancement in information technology have increased international economic interdependence in areas such as stock prices and economic cycles. Bessler and Yang (2003) employed error correction modeling to analyze the interdependence of stock prices in nine of the world's major stock markets, located in Canada, France, Germany, Italy, Switzerland, Japan, Hong Kong, the UK, and the US. They concluded that US stock prices have made a sustained and powerful impact on stock prices in other countries over the long term. Yang *et al.* (2006) examined the interdependence between four emerging Eastern European stock markets and those in the US and Germany. Their results indicated that long-term price relationships and dynamic price transmission in these markets strengthened after the Russian financial crisis, but that Germany had no noticeable influence on emerging stock markets in the wake of the crisis. Chen, Firth, and Rui (2002) studied the interdependence of stock prices in Central and South American countries, namely, Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela. Using error correction modeling, they determined that the Asian and Russian financial crises did not make a dramatic impact on the interdependence of Central and South American stock prices; however, but they hold that long-term cointegrating relationships disappeared after the Russian crisis. Focusing on Taiwan, Chang and Nieh (2001) also used error correction modeling to analyze the interdependence of stock prices in Taiwan and three trading partners, Hong Kong, Japan, and the US. They identified one cointegrating vector for the four markets and determined that the Japanese stock market, rather than the more distant US stock market, exerted the strongest influence on the Taiwanese stock market. In most cases, the above studies obtained results indicating the existence of cointegrating relationships among stock markets in different countries over the long term.

An analysis of interdependence using stock indices in the G7 countries (Canada, France, Germany, Italy, Japan, the UK, and the US) by Hamori and Imamura (2000) showed that the US economy has a strong impact on the entire world. Meanwhile, in a separate study, Hamori (2000) employed industrial production indices for Germany, Japan, the UK, and the US to examine the interdependence of business cycles in these countries. Hamori's empirical results strongly indicated that the first oil shock (1973) engendered a major change in international economic cycle dependence. Both Hamori and Imamura (2000) and Hamori (2000) are salient studies in that they use nonstationary data and the lag augmented vector autoregression (LA-VAR) approach, developed by Toda and Yamamoto (1995), to prevent problems with unit root and cointegration tests.

The present paper is distinguished from previous studies by three factors. The first is the empirical analysis of the interdependence between stock prices in Japan and Taiwan. Although these two East Asian island nations have been closely linked throughout history, very little has been written on the interdependence of their economic development. The second key factor of this paper is its use of the LA-VAR approach developed by Toda and Yamamoto (1995), which facilitates the direct analysis of the interdependence of Japanese and Taiwanese stock prices, while avoiding problems with unit root and cointegration tests. Lastly, the third factor is that the paper uses the price of crude oil as a model variable. Because the Japanese and Taiwanese economies depend on processing trade, they may be significantly impacted by changes in the price of oil. Therefore, considering the possible impact of crude oil price changes, this paper examines the interdependence among three variables—Japanese stock prices, Taiwanese stock prices, and crude oil prices—after the first oil crisis.

2. Data

The data for this study comprise 343 monthly observations for three variables from January 1980 to July 2008. The three variables are values for the Taiwan Stock Exchange Capitalization Weighted Index, Nikkei 225, and the price of West Texas Intermediate crude oil. All the variables are expressed in logarithmic values.

Figure 1 shows the Japanese stock prices, Taiwanese stock prices, and a crude oil price index. To examine changes in the impact of Japanese economic cycles on Taiwan's economy, an analysis was performed by using samples representing three periods. Sample A spans the period from January 1980 to December 1991, the time of Japan's economic bubble. Sample B covers the period from January 1992 to December 2003, a period that includes the burst of the economic bubble and the ensuing economic stagnation referred to as "Japan's lost decade." Sample C spans the period of economic recovery, from January 2004 to July 2008. The resumption of Japanese economic growth during this time stemmed from the resolution of nonperforming loans and growing consumption of digital products.

3. LA-VAR

The LA-VAR model was developed by Toda and Yamamoto in 1995. It is described below. First, we express the n dimension vector $\{y_t\}$ as follows:

$$y_t = \gamma_0 + \gamma_1 TR_t + J_1 y_{t-1} + J_2 y_{t-2} + \ldots + J_k y_{t-k} + \varepsilon_t, \quad t = 1, 2, \ldots T \tag{1}$$

where TR is the trend, k is the number of lags, ε_t is the vector of error terms with mean zero and variance-covariance matrix Σ, and $\gamma_0, \gamma_1, J_1, J_2, \ldots J_k$ are the vectors (matrices) of the parameters.

Let the null hypothesis be

$$H_0 : f(\varphi) = 0, \tag{2}$$

where φ is a subset of $(\gamma_0, \gamma_1, J_1, J_2, \ldots J_k)$. To test this hypothesis, we consider estimating a VAR formulated in levels using the ordinary least squares (OLS) method as follows:

$$y_t = \hat{\gamma}_0 + \hat{\gamma}_1 t + \hat{J}_1 y_{t-1} + \hat{J}_2 y_{t-2} + \ldots + \hat{J}_p y_{t-p} + \hat{\varepsilon}_t, \tag{3}$$

where p is equal to the true lag length (k) plus the possible maximum integration order considered in the process ($d_{\max}$), and $\hat{\gamma}_0, \hat{\gamma}_1, \hat{J}_1, \hat{J}_2, \ldots \hat{J}_p$ are vectors (matrices) of the parameter estimates. Note that $d_{\max}$ must not exceed the true lag length (k). Since the true coefficient value of $\hat{J}_{k+1}, \hat{J}_{k+2}, \ldots \hat{J}_p$ is zero in the true model, it should be noted that the restriction φ does not include them. We can rewrite equation (3) as follows:

$$y_t = \hat{\Gamma}\tau_t + \hat{\Phi}x_t + \hat{\Psi}z_t + \hat{\varepsilon}_t, \tag{4}$$

where

$$\hat{\Gamma} = (\gamma_0, \gamma_1),\quad \tau_t = (1, t)',\quad \hat{\Phi} = (\hat{J}_1,\ \hat{J}_2, \ldots \hat{J}_k),$$
$$x_t = (y'_{t-1}, \ldots y'_{t-k})',\quad \hat{\Psi} = (\hat{J}_{k+1}, \ldots \hat{J}_p),\quad z_t = (y'_{t-k-1}, \ldots y'_{t-p})'.$$

We can also express it in the vector form as follows:

$$Y' = \hat{\Gamma}T' + \hat{\Phi}X' + \hat{\Psi}Z' + \hat{E}, \tag{5}$$

where

$$Y = (y_1, \ldots y_T)',\quad T = (\tau_1, \ldots \tau_T)',\quad X = (x_1, \ldots x_T)',\quad Z = (z_1, \ldots z_T)'.$$

The Wald statistic W can be calculated as follows:

$$W = f(\hat{\phi})'\left[\left(\frac{\partial f(\phi)}{\partial \phi'}\right)\left(\hat{\Sigma}_\varepsilon (X'QX)^{-1}\right)\left(\frac{\partial f(\phi)}{\partial \phi'}\right)'\right]^{-1} f(\hat{\phi}), \tag{6}$$

where

$$\hat{\Sigma}_\varepsilon = \frac{1}{T}\hat{E}'\hat{E},\quad Q = Q_\tau - Q_\tau Z(Z'Q_\tau Z)^{-1}Z'Q_\tau,$$
$$Q_\tau = I_T - T(T'T)^{-1}T,$$

and I_T is an identity matrix.

We can test the causal relationship using this test statistic W. In this approach, it is not necessary to know the order of integration or the existence of cointegration; thus, a pretest bias can be prevented.

4. Empirical Results

A unit root test was used to determine whether or not the data used for this study were stationary time series data. The identification of a unit root for each variable would suggest that the data are nonstationary. We used the ADF (Augmented Dickey-Fuller) test to determine whether or not each variable had a unit root. More specifically, for the variable y_t, we estimated the model expressed in Equation (2),

$$\Delta y_t = \mu + \delta t + \beta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + u_t \qquad (7)$$

which includes an ADF constant and time trend. Further, we tested the null hypothesis $\beta = 0$ that a unit root exists with the t-statistic proposed by Dickey and Fuller (1981). Rejection of the null hypothesis would mean that each variable lacks a unit root and represents a stationary time series. To select an appropriate model, we used the Akaike Information Criterion (AIC) to determine the lag order. Test results are presented in Table I. The null hypothesis was not rejected at the 1% level for all variables at each variable level. However, beyond the first-order difference, the null hypothesis was rejected for all variables, which were therefore determined to be stationary. Thus, it was clear that all variables are $\mathrm{I}(1)$ process, which is common to each sample period.

Next, we used the Johansen test proposed by Johansen (1988) to test for long-term cointegration among the three variables. Both types of Johansen test—the trace test and maximum eigenvalue test—were performed. The test results are presented in Table II. For samples A and C, the null hypothesis $r = 0$ was rejected at the 5% level in both the trace test and the maximum eigenvalue test; this clearly indicates that at least one cointegrating relationship exists among the variables. For sample B, the null hypothesis $r = 0$ was rejected at the 5% level in the trace test but not in the maximum eigenvalue test. However, on the basis of the fact that trace tests are considered more robust than maximum eigenvalue tests, we concluded that long-term equilibrium relationships were detected among Taiwanese stock prices, Japanese stock prices, and crude oil prices for all three sample periods.

Lastly, we used the Lag-Augmented VAR (LA-VAR) approach to test for interdependence among Taiwanese stock prices, Japanese stock prices, and crude oil prices; proposed by Toda and Yamamoto (1995), this approach makes it possible to determine the direction of causality, while avoiding problems with unit root and cointegration tests. As shown in Table III, we used AIC to determine the lag order for selecting an appropriate model, and settled on a lag of 2 for each sample. In addition, the unit root test results indicated that with a first-order difference, the variables do not have a unit root and are stationary. Therefore, we performed our analysis with $d_{\max}$ as 1; in other words, we performed level VAR estimates up to a lag of 3. The LA-VAR test results for interdependence among the variables are summarized in Table IV. Here, the influence of explanatory variables, along the vertical axis, is shown on the non-explanatory variables, along the horizontal axis. This paper analyzes the impact of Japanese economic cycles on the Taiwanese economy during three periods of growth, decline, and recovery.

Sample A covers a period of Japan's economic growth. For this sample, it was observed that Taiwanese stock prices were influenced by unilateral causality from Japanese stock prices but not by crude oil prices. In contrast, Japanese stock prices were influenced by unilateral causality from crude oil prices but not by Taiwanese stock prices. As for interdependence with crude oil prices, no causality was observed from either Taiwanese or Japanese stock prices. Sample B spans the lost decade following the burst of Japan's economic bubble. For this sample, no causality was observed among the three variables. Sample C includes data for the Japanese economy's recent period of recovery. Here, test results show unilateral causality from Japanese stock prices and crude oil prices to Taiwanese stock prices. No causality, however, was observed toward Japanese stock prices or crude oil prices.

Summarizing the above, crude oil prices were observed to have a unilateral impact on Japanese stock prices and Japanese stock prices were observed to have a strong impact on Taiwanese stock prices during the period of Japanese economic growth. No causality was observed among the variables, however, during the Japanese economy's lost decade. Furthermore, unilateral causality from Japanese stock prices and crude oil prices to Taiwanese stock prices was observed during the period of Japan's economic recovery. Thus, Japanese stock prices and crude oil prices were considered to exert a strong influence on Taiwan's economy.

5. Conclusion

This paper studied the impact of the Japanese economy on Taiwan in recent years by testing for the existence of causal relationships affecting stock prices in Japan and Taiwan. Furthermore, given the possibility that the economies of these countries could be significantly impacted by changes in oil prices, the price of crude oil was taken into account in the analysis. Tests for causality among the variables were performed, while using the LA-VAR approach to prevent problems with unit root and cointegration tests.

Although this paper used non-stationary time series data and an analytical approach (LA-VAR), which differed from that used by Chang and Nieh (2001), it obtained a similar empirical result: the Japanese economy has had a long-term impact on Taiwan's economy. Another salient feature of this paper was its use of a model that, in contrast to those of Maghyereh (2004） and Yang *et al.* (2006), explicitly considers changes in oil prices. The results revealed that a single cointegrating relationship existed among the prices of Japanese stocks, Taiwanese stocks, and oil over the long term.

As for the impact of oil prices, Japan and Taiwan reformed their industrial structures in response to the two oil crises in the 1970s, and entered a period of transition, emphasizing energy efficiency and alternative sources of energy. An examination of causal relationships showed that Japanese stock prices were influenced by oil prices in the 1980s, but not in and after 2002, when oil price hikes following the implementation of energy efficiency policies did not have any impact on Japanese stock prices. In Taiwan, where a widespread impact of energy efficiency policies was not observed then, it is believed that stock prices were influenced by oil price changes during the period of dramatic increases in the oil price, beginning in 2002.

With the appreciation of the yen in the latter half of the 1980s, domestic production costs in Japan became relatively high. To produce goods at a low cost, Japanese companies shifted their production facilities overseas. As a result, investments by Japanese companies stimulated development of the East Asian industrial infrastructure; indeed, Japan's outward investment led to the expansion of East Asian economies. The results of causality analysis for this period show causality from Japanese stock prices to Taiwanese stock prices. Entering the 1990s, Japan witnessed the burst of its economic bubble and entered its "lost decade." China, on the other hand, began to open its economy in 1992, boosting trade with countries worldwide, including Taiwan. This caused a decline in the Japan-Taiwan trade ratio; moreover, with the gradual disappearance of causal relationships between the two countries, it is believed that Japan's impact on Taiwan also diminished. Later, beginning in 2004, the Japanese economy entered a growth phase, powered by the growing consumption of digital products. Starting in the 1990s, the production-based relationship between Taiwan and Japan changed into an assembly-based one. Furthermore, Japan's growing consumption of digital products fueled the growth of production volume for Taiwan's digital product component industry. With the Taiwanese economy in a growth phase and the Japanese economy in recovery, causality was again observed from Japanese stock prices to Taiwanese stock prices. Thus, the empirical results of this paper clearly indicate an economic interdependence between Japan and Taiwan.

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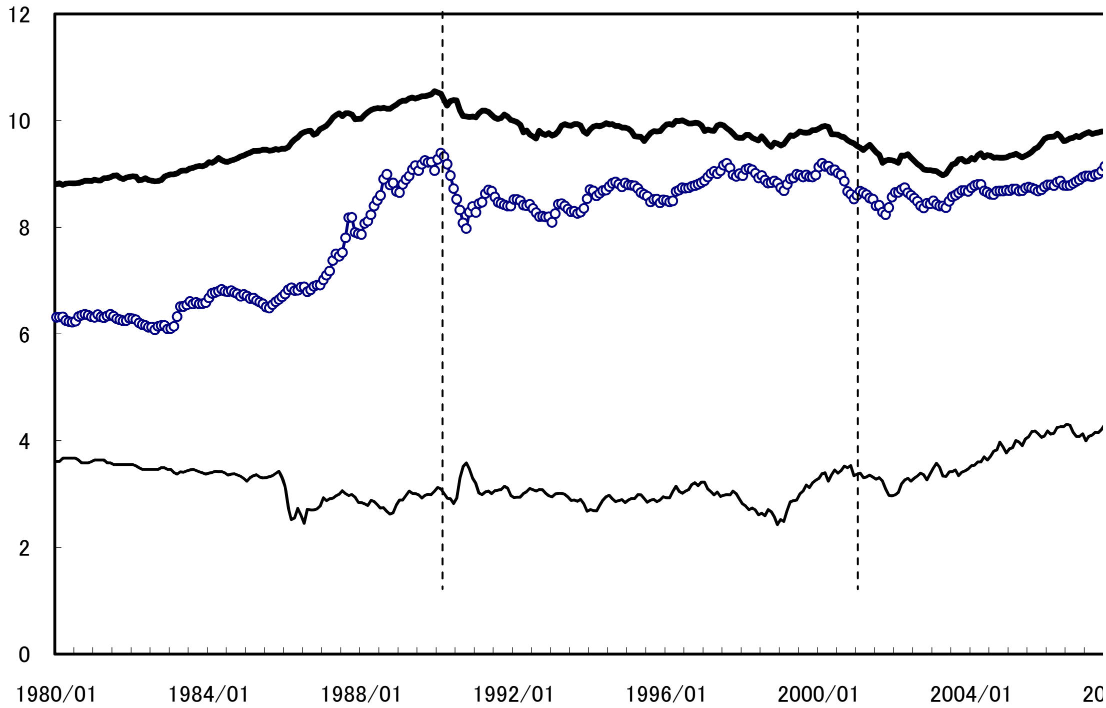

Figure 1 Movements of Each Variable, January 1980–July 2008

Note
LNJP: Japanese stock price index measured in logarithm; JNTW: Taiwanese stock price index measure in logarithm; LNWTI: WTI crude oil price index measured in logarithm.

Table I Unit Root Tests (Trend and Intercept)

		Sample[A]	Sample [B]	Sample [C]
		1980 : 01－1991 : 12	1992 ： 01－2003 ： 12	2004 : 01－2008 : 07
Taiwan	Level	-1.9949	-2.3747	-1.8302
	1st difference	-7.8413***	-8.2912***	-4.4478***
WTI	Level	-2.7522	-2.4346	-1.5017
	1st difference	-6.5864***	-10.1883***	-7.2567***
Japan	Level	-0.2530	-2.2641	-0.4400
	1st difference	-7.6102***	-9.6125***	-6.6816***

Note
*** indicates that the null hypothesis of a unit root is rejected at the 1% level.

Table II Cointegration Tests

	Trace test		
	Sample [A]	Sample [B]	Sample [C]
Null Hypothesis	1980：01－1991：12	1992：01－2003：12	2004：01－2008：07
$r = 0$	0.0052**	0.0357**	0.0023**
$r \leq 1$	0.1545	0.1210	0.2723

	Maximum eigenvalue test		
	Sample [A]	Sample [B]	Sample [C]
Null Hypothesis	1980：01－1991：12	1992：01－2003：12	2004：01－2008：07
$r = 0$	0.0113**	0.1219	0.0022**
$r \leq 1$	0.2696	0.3466	0.3741

Note
** indicates that the null hypothesis of *r* cointegrating vector is rejected at the 5% level.
Each number indicates the *p*-value.

Table III Lag Selection (AIC)

Number of Lags	Sample [A] 1980 : 01－1991 : 12	Sample [B] 1992 : 01－2003 : 12	Sample [C] 2004 : 01－2008 : 07
1	-7.7213	-8.1377	-9.6672
2	-8.0585***	-8.2477***	-9.6905***
3	-8.0218	-8.1732	-9.5825
4	-8.0191	-8.0536	-9.4323
5	-7.9740	-7.9630	-9.6714

Note
*** indicates the minimum value of AIC.

Table IV Causality Tests (LA-VAR)

Explanatory Variable	Explained Variable		
	Taiwan	WTI	Japan
Sample [A] 1980：01－1991：12			
Taiwan	—	0.1336	0.8097
WTI	0.1927	—	0.0169**
Japan	0.0057***	0.5406	—
Sample [B] 1992：01－2003：12			
Taiwan	—	0.5762	0.1862
WTI	0.2293	—	0.9417
Japan	0.6345	0.3432	—
Sample [C] 2004：01－2008：07			
Taiwan	—	0.3452	0.5344
WTI	0.0060***	—	0.2362
Japan	0.0214**	0.4826	—

Note
*** (**) indicates that the null hypothesis of no causality is rejected at the 1% (5%) level.
Each number shows the *p*-value of the Wald test.