# The US Tech Pulse, stock prices, and exchange rate dynamics: Evidence from Asian developing countries*

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**Abstract**

This paper empirically investigates the economic relationship between the US and Asian economies during the post-crisis period in Indonesia, Korea, the Philippines, Singapore, and Thailand, employing a vector error correction model approach. Based on the empirical results, we conclude that the interdependence between the US and these Asian economies has intensified especially in information technology markets, and that their stock markets are integrated. On the other hand, the relationship between the domestic stock and foreign exchange markets is found to be different in each country.

*JEL Classification:* C32; F31; F36

*Key Words:* Tech Pulse; Stock market; Exchange rate dynamics; Asian developing countries

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## 1. Introduction

The US high-technology sector has witnessed increasing development and has been of vital importance to the US as well as the international economy. Particularly, the new economy of information technology (IT), including companies that make and use intensively computer hardware, software, the other IT-related goods, and telecommunications equipment, has been a central force in the US business cycle of booms and busts (IMF, 2001). Therefore, an accurate and timely understanding of the US IT industry activities is necessary for economists, policy makers, and business practitioners. Above all, the US Tech-Pulse index, which is constructed by the Federal Reserve Bank (FRB) of New York, is a coincident index of these very activities, assisting in the US economy forecasting efforts (Hobijn et al., 2003). In addition, the US has invested in the IT industry in the East and Southeast Asian developing countries and has imported most of their IT products since the 1990s (Hsiao et al., 2003). As a result, the economic interdependence between the US and the Asian developing countries has intensified more than ever.

The US IT sector activities appear to have been affecting the exchange rate behavior while simultaneously influencing the Asian economies through trade, investment, and stock markets considerably. Conversely, a fluctuation in the exchange rate may affect the balance of trade position in the country in which it occurs, consequently influencing its domestic stock price. The exchange rate dynamics has also played an important role in the economies of the Asian developing countries since most of their central banks adopted the floating or the more flexible exchange rate regime after the currency crisis. Therefore, studying not only the interdependence between the US and Asian developing countries but also their exchange rate dynamics has recently gained importance among international monetary economists. For example, Phylaktis and Ravazzolo (2005), who used monthly data over the period 1980–1998, found that a positive relationship between the stock and foreign exchange markets in the Asian developing countries. However, there are few empirical studies concerning the post-crisis period.

The aim of this paper is to empirically investigate the economic relationship between the US and Asian developing countries during the post-crisis period. Thus, we estimate a vector error correction model (VECM) in the case of five Asian developing countries, namely, Indonesia, Korea, the Philippines, Singapore, and Thailand. More specifically, we explore whether the domestic stock price has long-run relationships with the US IT industry activities, the US stock price, and the exchange rate dynamics, employing a cointegration methodology. We also explore the effects of the domestic stock price to economic shocks, especially IT-related shocks, in the VECM, based on the estimated impulse response functions. The empirical results suggest that the economic relationship between the US and the Asian developing countries has intensified, particularly in the IT industries, and that all the stock markets are integrated with the US market. However, we also find that the relationship between the domestic stock price and the real exchange rate behavior is negative in some countries.

This paper is organized as follows. Section 2 describes real economic and financial linkages

between the US and Asian developing economies. Section 3 explains methodological issues and data. Section 4 presents the empirical results derived from the cointegration methodology and the impulse response function analysis. Section 5 provides some concluding remarks.

## 2. Background

Over the past two decades, economic linkages between developed and developing countries have intensified, which has generated faster transmission of macroeconomic fluctuations across countries (Akın and Kose, 2008).[1] Specifically, the recent rapid growth of semiconductor and IT equipment production has strengthened the real economic linkage through foreign direct investment (FDI) and trade as well as the financial linkage through stock markets across countries specializing in IT production. Such strong economic interdependence has increasingly enabled the US to derive the macroeconomic benefits and to accelerate the FDI in emerging market economies in the East and Southeast Asia, even in situations of the booms and busts in the US and Asian financial markets since the 1990s (IMF, 2001).[2]

In recent times, the US economic growth appears to be consistent with the behavior of the IT industry, such as technological developments in the power of semiconductor chips (Jorgenson, 2001). The rapid decline in semiconductor prices due to the advances in its science technology has led to an increase in its demand in the US. In addition, the investment of large US IT firms to domestic and foreign IT companies has also increased because of the overseas expansion of these IT firms. In particular, the US FDI to Asian developing economies increased considerably in the 1990s (Hsiao et al., 2003; Bonham et al., 2004). This explains why the linkage through FDI between the US and the Asian developing countries has been much stronger, especially in the IT industries.[3]

On the other hand, in the East and Southeast Asian developing countries, the production and exports of IT equipment have been highly specialized and have increasingly played an important role in the economic growth of these countries. Moreover, most of the IT products are exported to the US (Hsiao et al., 2003). In fact, the positive global IT demand shocks from 1999 to 2000 led to an increase in IT production, and this helped the Asian economies to rapidly recover from the Asian currency crisis of 1997 (IMF, 2001).

Table 1 presents the bulk of the exports of the IT products in the Asian developing countries. The recent export ratios in the country's total merchandise exports have considerably increased

[1] Some previous studies support the role of trade integration in explaining business cycle comovements (Baxter and Kouparitsas, 2005; Imbs, 2006; Kose and Yi, 2006). Jansen and Stockman (2004) emphasize the importance of FDI in addition to trade.

[2] Kumakura (2006) suggests that the electronics industry has played a relatively important role in driving business cycle comovements in Asia.

[3] Jorgenson and Vu (2005) investigate the impact of investment in the IT industry on the recent world economics, concluding that the contributions of its investment have remarkably increased only in advanced countries, such as the US, and in Asian developing countries.

in all the countries, as compared with the ratio of 1990. However, all the countries, with the exception of Korea, show a downtrend after around 2002, after reaching a peak at around 2001. Though their down ratios are diverse—ranging from 10% to 50%—the changes in the ratios are surely consistent with the evidence of the boom and sump in the US IT industry. This implies that the exports and economic growth of these countries have come to depend on the global, especially the US, IT demand conditions.[4]

At the same time, the performance of the IT-related firms has played a leading role in the current economic growth and tends to rely heavily on equity finance; thus, these firms become the main target of stock or portfolio investment across the developed and developing countries. Accordingly, changes in the US stock prices, driven mainly by the global IT business cycle, appear to have significant effects on the stock price behavior of the Asian developing countries. This implies that the financial linkage through stock markets has also intensified due to the more strengthened economic relationship between the US and the Asian developing countries. As is shown in Fig. 1, it appears that the stock market movements in these countries have increasingly integrated since the late 1990s.

## 3. Empirical methodology and data

### *2.1. VECM*

Now, consider the following simple VECM:

$$\Delta x_t = \mu + \sum_{i-1}^{p-1} \Gamma \Delta x_{t-i} + \Pi x_{t-p} + e_t \,, \tag{1}$$

where $x_t$ is an $n$-dimensional vector of the variables of $I(1)$, $\Delta$ represents the first difference operator, $\mu$ is an $n$-dimensional vector of constants, $\Gamma$ matrices denote coefficients, $e_t$ is an $n$-dimensional vector of error terms with zero means and covariance matrix $\Sigma_e$, and $\Pi x_{t-p}$ is the error correction term.[5] The rank of $\Pi$ is equal to the number of cointegrating vectors. If the rank of $\Pi$ is zero, the variables in $x$ will not be cointegrated, since there is no linear combination of all variables that are stationary. In contrast, if $\Pi$ is full of rank, $\Pi x_{t-p}$ is defined to be an error correction term.

In order to impose restrictions on cointegrating vector(s), we decompose $\Pi$ into $\alpha$ and $\beta$ matrices:

$$\Pi = \alpha\beta' \,. \tag{2}$$

Moreover, this can be rewritten as

[4] Mazier et al. (2008) argue that China is a significant importer from other Asian countries; moreover, it reexports to the US. This suggests that the export of other Asian countries to China also depends on the US business cycle movement after all.

[5] We assume that $\Gamma$ is a lower triangular matrix for short-run dynamics.

$$\Delta x_t = \mu + \sum_{i-1}^{p-1} \Gamma \Delta x_{t-i} + \alpha\beta' x_{t-p} + e_t \ , \tag{3}$$

where $\beta$ is the matrix of cointegrating vector(s) characterizing the restricted relationship based on the economic theory, and $\alpha$ is the matrix of the loading vector(s) characterizing the speed of the equilibrium adjustment on the variables.

*2.2. Data*

In this paper, we explore whether the domestic stock price has long-run relationships with the US IT industry activities, the US stock price, and the exchange rate dynamics, also exploring the effects of the domestic stock price to economic shocks, for selected five Asian developing countries: Indonesia, Korea, the Philippines, Singapore, and Thailand. Thus, to investigate the cointegrating vectors and to obtain the impulse response functions, we estimate a four-variable VECM that includes the US Tech-Pulse index as a proxy for the US high-technology sector activities.[6] Fig. 2 shows the activity of the US Tech Pulse, which is thought of as representing the influence of the recent world IT business cycle.

The variables that included in the VECM are the US Tech-Pulse index (*TP*), the US Nasdaq (or New York) stock price index ($P^{US}$), the stock price index of the Asian developing country ($P^{ADC}$), and the domestic bilateral spot real exchange rates ($E^{ADC}$), in this order. Here, $E^{ADC}$ is defined as

$$E_t^{ADC} = S_t^{ADC} + CPI_t^{US} - CPI_t^{ADC}, \tag{4}$$

where $S^{ADC}$ is the nominal exchange rate expressed as the domestic local currency per US dollar, $CPI^{US}$ is the consumer price index for the US, and $CPI^{ADC}$ is the consumer price index for the Asian developing country. Accordingly, an increase in $E^{ADC}$ denotes the depreciation of the real exchange rate of the Asian developing country. The data set is monthly for the period January 1999–September 2007 for the Philippines and January 1999–December 2007 for Indonesia, Korea, Singapore, and Thailand.[7] All the data are considered in natural logarithms.

## 4. Empirical results

[6] The US Tech-Pulse index is constructed by the FRB of New York, based on diverse information in three dimensions: supply, demand, and employment. More specifically, five data series are chosen to capture the three dimensions fluctuations. First, supply is comparable to industrial production in high-technology sectors and shipments of manufactures of computers and communication equipment. Second, demand is comparable to private fixed investment in IT and personal consumption expenditures on computers and software. And third, employment is comparable to the number of employees in high-technology sectors (Hobijn et al., 2003).

[7] All data with the exception of the US Tech-Pulse index are obtained from the IMF, International Financial Statistics. The US Tech-Pulse index is obtained from the FRB of New York's web site.

*3.1. Cointegration analysis*

We employ Johansen's (1995) procedure, analyzing the rank of Π and its decomposition in Eq. (1) to find the cointegrating relationships between variables. First, the optimal lag length of the unrestricted vector autoregression model is set at $k$ in each case (Table 2), by referring to the Akaike information criterion. Hence, the lag length for the first differenced series in the VECM is $k$–1. Next, we apply Johansen's (1988) cointegration test based on the trace statistics, in order to investigate the number of cointegrating vectors.[8] In Table 2, there appears to be at least one cointegrating vector in approximately every case, which implies that none of the variables are individually stationary.[9] However, the only exception is Singapore. We replace the US Nasdaq stock price index with the US New York stock price index to reject the null hypothesis that the rank of Π is zero. The cointegrating relationship can be normalized with respect to $P^{ADC}$, as follows:

$$P_t^{ADC} = b_0 + b_1 TP_t + b_2 P_t^{US} + b_3 E_t^{ADC} . \tag{5}$$

Table 3 reports the estimation results for the long-run equilibrium relationship (Eq. 5). First, we find that the activity of the US Tech Pulse is positively related to the domestic stock price of each Asian developing country. This implies that the boom in the US IT industry leads to an increase in the exports of the Asian developing countries, which positively affects the real economies and leads to an increase in the domestic stock prices. Second, the US stock price is also positively related to the domestic stock price of each of the Asian developing countries. This indicates that these markets are integrated.[10]

Finally, we find that the real exchange rate behavior is positively associated with the domestic stock price in the two cases of the Philippines and Singapore. This result suggests that an appreciation of the exchange rates of the Asian developing countries caused by an increase in the US imports or in the exports of these two Asian countries, leads to an increase in the domestic stock prices, according to the standard economic theories (e.g., Dornbusch and Fisher, 1980). Thus, it appears that the trade linkage between the US and these two Asian developing countries is more substantial. In contrast, in Indonesia, Korea, and Thailand, the real exchange rates are negatively related to the domestic stock prices. This result may be due to the appreciation effects[11] of the dollar over the currencies of these three countries. The US stock price necessarily rises with a rise in the domestic stock prices because all the stock markets are

[8] Deterministic constant is allowed in the cointegrating space.

[9] Moreover, given the results of some unit root tests (not reported), all variables appear to be $I(1)$. A copy of these results is available upon request.

[10] This result is consistent with those of previous studies. For example, Ng (2000) found significant spillovers from the US economy to the Asian developing countries. Phylaktis and Ravazzolo (2005) also found that the stock price of these Asian countries were integrated with the US stock price. However, these studies deal mainly with the pre-crisis period.

[11] A rise in the stock price leads to an appreciation of the exchange rate since the excess demand for money leads to a rise in the interest rates, according to the portfolio-balance models (e.g., Frankel, 1983).

integrated.

Moreover, following Phylaktis and Ravazzolo (2005), we confirm that an important variable, such as the influence of the recent world market is included in our system. In the context of previous studies that investigated the relationship between domestic stock price and exchange rate dynamics, Phylaktis and Ravazzolo (2005) indicate that the US stock price variable was omitted from the system. In this paper, we assume that the US Tech Pulse as a proxy for the US IT industry activities is also an important variable in relation to the recent period as well as the US stock price. Thus, to examine the importance of including the US Tech Pulse in the system, we investigate whether there are cointegrating relationships between the variables from which the US Tech Pulse is excluded. The results are shown in table 4. We cannot reject the null hypothesis that there are zero cointegrating vectors in each country. Thus, this appears to imply that this system could be incomplete as a result of the omission of an important variable, and that the US Tech Pulse should be included in our system.

### *3.2. Impulse responses analysis*

Fig. 3 illustrates the impulse responses of the domestic stock price of each Asian developing country to the positive shocks of the US Tech Pulse, the US stock price, and the real exchange rate. The horizontal axis measures the number of months following the shock. We find that an increase in the US Tech Pulse leads to an increase in the domestic stock prices of approximately all the Asian developing countries. This implies that the US IT and high-technology sector activities positively influence the exports of the Asian developing countries to the US, which consequently affects their stock prices. Nevertheless, the US Tech Pulse does not affect the Indonesian stock price to a great extent; this is consistent with the fact that the export of its IT products is relatively small.

We also find that a rise in the US stock price leads to a rise in all the domestic stock prices. This result reconfirms the previous result that the stock markets of the US and Asian developing countries are integrated.

Finally, we observed two contradictory responses in the domestic stock price to a real exchange rate shock. In the cases of the Philippines and Singapore, a rise in the real exchange rates lead to a decrease in the domestic stock prices. This could imply that the US contractionary monetary policy causes the dollar to appreciate and leads to a decrease in the US economy and stock price. Due to the integration of the stock markets of the Philippines and Singapore with the US, the stock prices of these countries also decrease. In contrast, in the cases of Korea, Thailand, and Indonesia, a rise in the real exchange rates lead to an increase in the domestic stock prices. This may imply that the domestic expansionary monetary policy causes the domestic currency to depreciate and leads to an increase in the domestic economy and stock price; moreover, the domestic currency depreciation stimulates the demand for exports, at least in the short run, due to the J-curve effect, which also leads to a rise in the domestic stock market.

## 4. Conclusion

In this paper, we investigate the relationship between the US and Asian economies during the post-crisis period in Indonesia, Korea, the Philippines, Singapore, and Thailand, employing the VECM approach. The results indicated that the activity of the US Tech Pulse and the US stock price are positively related to the domestic stock prices of all these countries in Asia. It is also found that the shock caused by the US Tech Pulse has a positive impact on all the domestic stock prices, with the exception of Indonesia, and that the US stock price positively influences every domestic stock price.

Based on these empirical results, we conclude that the economic relationship between the US and Asian developing countries has intensified, particularly in the IT markets, and that all the stock markets are integrated with the US market. On the other hand, we find that the relationship between the domestic stock price and the real exchange rate behavior is different in each country.

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Table 1
The share of office machines and telecom equipment in the total merchandise exports (in percent)

| | 1990 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Indonesia | 0.5 | 6.1 | 11.7 | 10.5 | 10.8 | 9.1 | 9.1 | 7.9 | 6.0 |
| Korea | 22.1 | 29.7 | 29.9 | 29.4 | 32.2 | 34.9 | 32.5 | 29.1 | 25.7 |
| Philippines | 22.7 | 63.0 | 60.6 | 64.6 | 62.7 | 62.7 | 60.3 | 57.9 | 55.4 |
| Singapore | 36.5 | 52.8 | 53.7 | 50.7 | 50.2 | 48.0 | 48.0 | 44.3 | 43.4 |
| Thailand | 15.3 | 26.1 | 27.7 | 24.9 | 24.6 | 24.2 | 22.0 | 21.7 | 22.5 |

*Source:* WTO, International trade statistics

Table 2
Results of the Johansen's cointegration test

| | lag ($k$) | Trace statistics for cointegrating rank ($r$) | | | |
|---|---|---|---|---|---|
| | | $r = 0$ | $r \leq 1$ | $r \leq 2$ | $r \leq 3$ |
| A. the US tech pulse, the US Nasdaq stock price, domestic stock price, and the real exchange rate | | | | | |
| Indonesia | $k = 5$ | 55.697** | 26.493 | 13.706 | 1.569 |
| Korea | $k = 5$ | 49.584** | 22.466 | 8.168 | 0.501 |
| Philippines | $k = 4$ | 51.548** | 19.782 | 8.333 | 0.398 |
| Singapore | $k = 4$ | 44.410 | 23.892 | 9.465 | 0.011 |
| Thailand | $k = 5$ | 54.960** | 23.881 | 7.931 | 0.010 |
| B. the US tech pulse, the US New York stock price, domestic stock price, and the real exchange rate | | | | | |
| Singapore | $k = 4$ | 51.188** | 30.456** | 10.370 | 0.096 |

** denotes the rejection of the null hypothesis at the 5% level of significance.

Table 3

The long-run cointegrating vector: $P_t^{ADC} = b_0 + b_1 TP_t + b_2 P_t^{US} + b_3 E_t^{ADC}$

| | $b_0$ | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|---|
| Indonesia | -28.721 | 2.007 | 0.150 | 0.854 |
| Korea | -119.306 | 4.351 | 0.241 | 9.692 |
| Philippines | 0.923 | 1.724 | 0.648 | -5.436 |
| Singapore | -3.475 | 0.567 | 0.525 | -2.658 |
| Thailand | -40.198 | 1.767 | 0.731 | 5.331 |

Table 4

Results of the Johansen's cointegration test

| | lag ($k$) | Trace statistics for cointegrating rank ($r$) | | |
|---|---|---|---|---|
| | | $r = 0$ | $r \leq 1$ | $r \leq 2$ |
| A. the US Nasdaq stock price, domestic stock price, and the real exchange rate | | | | |
| Indonesia | $k = 5$ | 29.179 | 11.679 | 0.074 |
| Korea | $k = 2$ | 24.118 | 7.349 | 1.037 |
| Philippines | $k = 2$ | 26.512 | 11.999 | 0.338 |
| Thailand | $k = 2$ | 25.923 | 13.384 | 3.862** |
| B. the US New York stock price, domestic stock price and the real exchange rate | | | | |
| Singapore | $k = 2$ | 23.910 | 10.633 | 0.105 |

** denotes the rejection of the null hypothesis at the 5% level of significance.

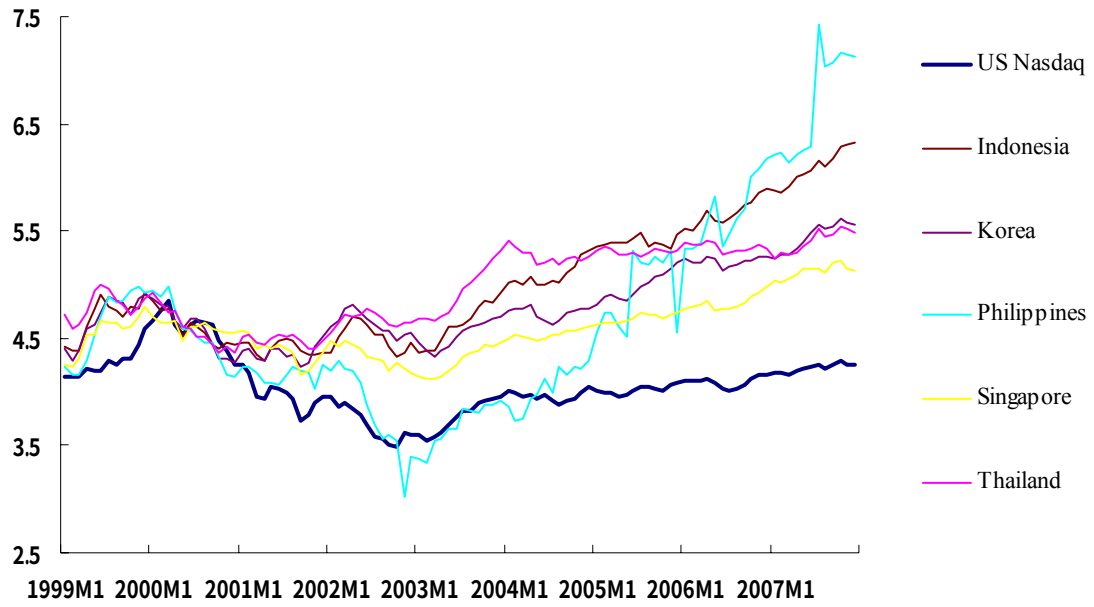


Fig. 1. The stock market movements in the US and Asian developing countries.
*Source:* IMF, International Financial Statistics.

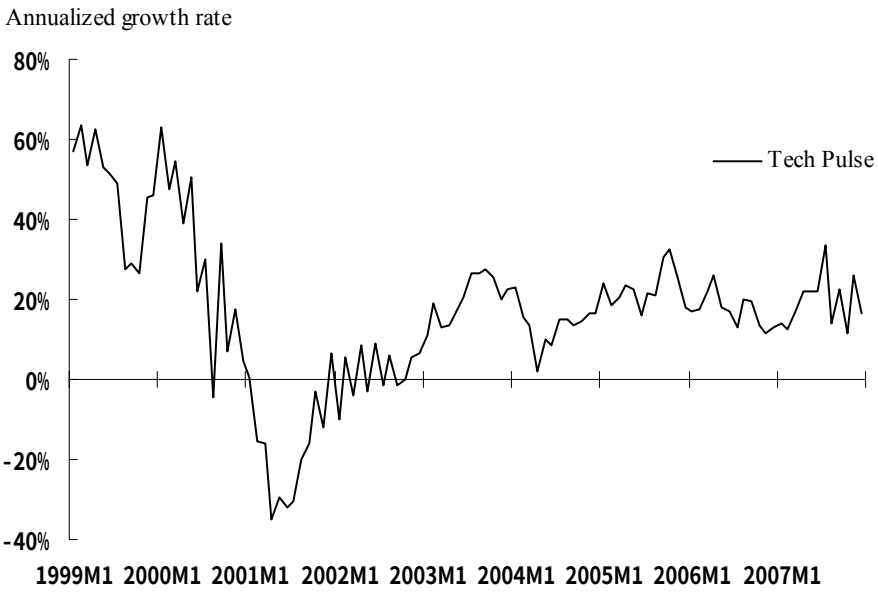


Fig. 2. Growth in the real Tech-Pulse Index.
*Source:* FRB of New York.

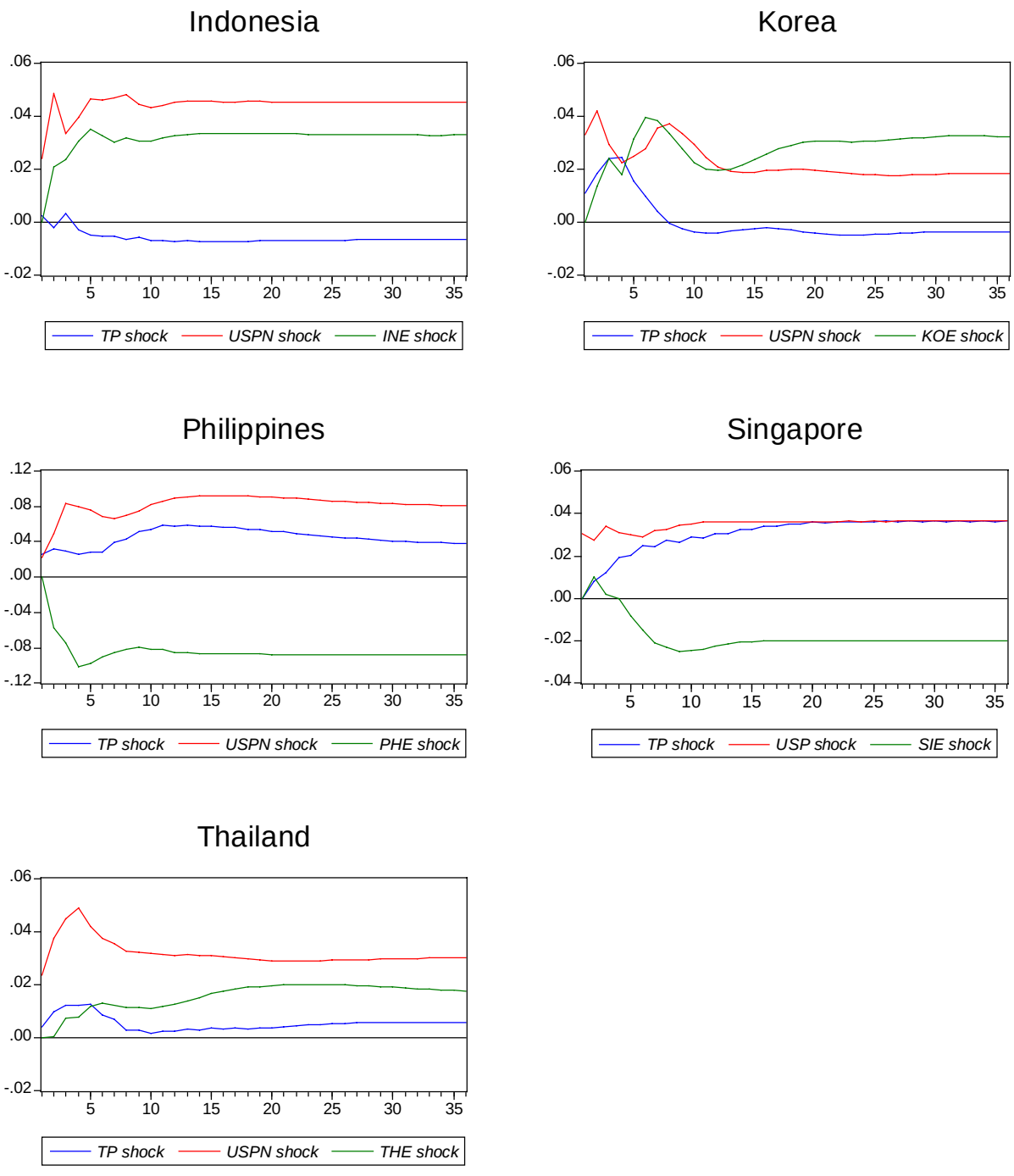


Fig. 3. Impulse response functions of the domestic stock price to shocks for up to 36 months.