

The Impact of a Loss of Confidence in Emerging Market Economies to the World Economy: A Simulation with the G-Cubed Model^{*}

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Abstract

Risks in emerging market economies have considerably gone up as capital inflows have soared since the global financial crises in 2008. Once the advanced economies recover, especially in the US where its monetary stimulus ends, market expectations change. It may then potentially lead to sudden capital outflows from emerging economies which could lead to loss of confidence in the emerging market economies. To study the impacts of such event, this paper simulates with the G-Cubed Model. The results show that once financial shocks hit emerging market economies, it can produce critical real effects in the economic downturn which will last for a long period. The simulation also shows the strong interdependence between financial and real economies. In the emerging economies, expected future incomes and wealth fall, while the developed economies gain through the reallocation of investment. Another important channel of the shocks is through trade channel as most emerging market economies rely on imports for their production inputs.

Abstraksi

Risiko di pasar keuangan negara – negara berkembang meningkat sejak derasnya arus modal masuk pasca krisis keuangan global 2008. Ketika perekonomian negara maju mulai pulih, terutama di AS apabila stimulus moneter dihentikan, ekspektasi pelaku pasar akan berubah. Hal ini kemudian berpotensi memicu pembalikan arus modal dari negara – negara berkembang yang dapat menyebabkan hilangnya tingkat kepercayaan di pasar negara – negara berkembang. Untuk mempelajari dampak dari kejadian tersebut, tulisan ini menyimulasikan menggunakan model *G-Cubed*. Hasilnya menunjukkan bahwa ketika terjadi guncangan di pasar negara – negara berkembang, sektor riil akan melemah dan dampaknya bertahan dalam waktu yang cukup lama. Selain itu, pendapatan di masa yang akan datang dan kekayaan juga turun di negara – negara berkembang, sebaliknya negara – negara maju menikmati realokasi investasi. Salah satu saluran transmisi dampak guncangan tersebut ke sektor riil, yaitu melalui saluran perdagangan.

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1. INTRODUCTION

The world economy has not been fully recovered since the global financial crisis in 2008. IMF (2016) predicts a modest 3.2 per cent growth of the world output in 2016 which is in line with last year, despite signaling recoveries in several economies such as the United States (US) and some emerging market economies. Quantitative easing policy undertaken by the US ended in 2014, plummeting commodity prices, Chinese currency devaluation, UK's exit from the Euro (Brexit), and negative interest rates in Japan have been major shocks for the global economy (IMF, 2016). The first hike of the Fed Funds Rate in December 2015 has also tightened the financial and monetary conditions, particularly in the emerging economies (IMF, 2016).

IMF (2016) also reports that the risks in emerging market economies have considerably gone up since 2013. The escalated risks are originated from risen participation of foreign investors in bond markets of the emerging economies. It brings about additional pressures on capital outflow and growing market volatility. There is evidence that capital flows intensively into Asia since 2009 and it consequently produces large pressures on asset bubbles and inflation (Taguchi, 2011). It also implies that emerging market economies now become more vulnerable to external global conditions.

As the advanced economies recover, especially in the US where its monetary stimulus ends, market expectations change. It may then potentially lead to sudden capital outflows from emerging economies as their capital markets are vulnerable. If the emerging economies do not have strong financial infrastructures, they may suffer loss of confidence which in turn may trigger a financial crisis (Calvo & Mishkin, 2003). They reveal that emerging market economies feature weak financial, fiscal and monetary institutions and vulnerable to sudden capital stops, currency crisis and high inflation. They find that between 1992 and 2001, 63 per cent of events of sudden capital stops in emerging market economies were associated with currency devaluations.

Many studies have been conducted investigating factors that trigger falling currencies then lead to a financial crisis and it has been a prolonged debate. In East Asia crisis 1997 – 1998, Radelet and Sachs point out that the shock hitting the economy is simply a swing of investor confidence (W. J. McKibbin, 1998). McKibbin (1998) believes that the trigger comes from rising interest rates in US and its falling equity markets which then make economies with pegged exchange rate collapse. From another point of view, identified several primary factors that cause the crises are unstable international financial and capital markets, weakness of domestic macroeconomic policy in terms of loose fiscal policy together with an unbending nominal exchange rate and poor governance (Dungey & Jacobs, 2010; Hill, 1999; Krueger et al., 2003). Similarly, Grenville (2000) identifies that the major factor causing the crisis is volatile and huge international capital flows combined with fragile financial sectors in the domestic economy. Moreover, Hill (1999) notes that the East Asia crisis was triggered by the crisis in Thailand which experienced combined poor financial regulation, huge capital account deficit, rapid exports slowdown and climbing capital outflows. Meanwhile, the global financial crisis in 2008 was initiated by overflowing housing bubble in US followed by sub-prime mortgage market collapse resulting in surging risk premium in the world (W. J. McKibbin & Stoeckel, 2011).

This paper argues that a loss of confidence in emerging economies will adversely affect the emerging market economies through investment reallocation and adjustment mechanism of trade balance. Developed economies gain from the emerging economies' expenses by the reason of expectation changes of the agents in the economies. In the long run all economies converge to the baseline due to the existence of adjustment costs but still hard for developing economies to reach the initial steady state levels.

This paper aims to investigate the consequences of such event to both emerging market economies and developed economies. The framework used to analyze is the G-cubed model as will be described in the following section. The rest of this paper is structured as follows. Section 2 describes the model and the shocks performed. Section 3 discusses the implications of the shocks for both developing and developed economies including real effects on national account and financial, monetary and fiscal responses. Finally, section 4 draws conclusions.

2. THE MODEL

The G-cubed model which is a combination of econometric general equilibrium modelling, modern macroeconomics and international trade theory is an inter-temporal general equilibrium model (McKibbin & Wilcoxon, 2013). It also incorporates numerous countries and sectors and has been used to study a number of policies, such as tax reform, environmental regulation, fiscal and monetary policy and international trade. This model encompasses the best features of the modern macroeconomics, econometric general equilibrium modeling and international trade theory (W. J. McKibbin & Wilcoxon, 1999).

The G-cubed model used in this paper is version 108V which has aggregation of seventeen regions and six sectors as shown in Table 1.

Table 1 **List of regions and sectors**

Regions:	Sectors:
United States (USA)	Energy
Japan (JPN)	Mining
United Kingdom (GBR)	Agriculture
Germany (DEU)	Non-durable manufacturing
Rest of Euro Zone (EUZ)	Durable manufacturing
Canada (CAN)	Services
Australia (AUS)	
Korea (KOR)	
ROECD (OEC)	
China (CHI)	
India (IND)	
Indonesia (INO)	
Other Asia (OAS)	
Latin America (LAM)	
Other developing countries (LDC)	
Eastern Europe and former Soviet Union (EEB)	
Oil-exporting and the Middle East (OPC)	

Notes: codes in parentheses.

Each economy or region in the model comprises a number of economic agents, i.e. households, government, financial sector, and the production sectors as listed in the Table 1. Structure of the G-Cubed Model in detail can be seen in appendix.

To examine the effects of a loss of confidence in emerging economies, we impose a shock scenario exhibited in Table 2. The table shows that the real exchange rate of US currency goes up by 2 per cent permanently in China, India, Indonesia and other developing countries in Asia, Latin America and rest of the world. This shock scenario is motivated by the fact that between January and June 2014, currency of developing countries like China, India, Indonesia, and Brazil had depreciated by about 2 per cent against the US dollar.

Table 2 **Shock scenario**

	CHI	IND	INO	OAS	LAM	ROW
Real exchange rate USD per unit of local currency	2	2	2	2	2	2

Notes: permanent shock from 2014 and on; in per cent

3. EMPIRICAL RESULTS

The results presented in figures 1 to 9 are expressed in percentage of deviation showing a comparison to the baseline of the model (W. J. McKibbin & Stoeckel, 2011). A zero indicates that a variable does not vary from the baseline.

3.1 Effects on national account, developing vs developed economies

A loss of confidence in emerging economies indicated by a significant depreciation of their currencies leads to immediately massive capital outflows in short run since financial capital is perfectly mobile and it results in reduction of capital values. The adjustment process in the model derives from a fall in Tobin's Q for investment (see Figure 4). As return to capital falls, private investment falls. These capital outflows also trigger spiking both short run and long run interest rates and assets' price deflations. The increase of the interest rates is a result of a long run surge in marginal product of capital and monetary authority responses in raising nominal interest rates. Those higher interest rates imply a higher cost of borrowing. The falls in wealth combined with the interest rates increases and dramatic cutbacks of expected incomes in the future result in significant drops in domestic consumption of the developing economies (see Figure 1 and 2).

According to the model, among the developing economies, other Asian countries such as Hong Kong, Malaysia and Thailand and Latin American countries suffer the most as their investments fall up to nearly 30 per cent and their outputs drop touching 3 per cent in short term. Indonesia is another Asian country which also suffers prominently. Unlike those countries, China is not hurt as high as them with 10 per cent drop in investment and 2.6 per cent decline in output at most. These results show that Indonesia, the Latin American and other Asian countries are highly reliant on imported inputs for production of exported manufacturing goods. As their exchange rates are severely depreciated, the imported inputs become very costly. On the other hand, China is not as highly dependent as them on imports for production inputs.

The contractions in the domestic consumption lead to contracting economy in the developing economies in short run. As real GDP collapses less than investment and consumption, it then contracts less than imports. That is why real GDP recovers more quickly than the consumption in the long run. It is also because the physical capitals are still in place which consequently trigger rapid recovery when the confidence is back. Improving trade balance also contributes to the recovery process. Exported products of developing economies become cheaper due to their currency depreciation, so that the demand for products from the developing economies goes up. The recovery of China's economy in the long run accelerates faster than the other developing economies because they can sustain the production as its reliance on imports for production inputs is not as high as the others.

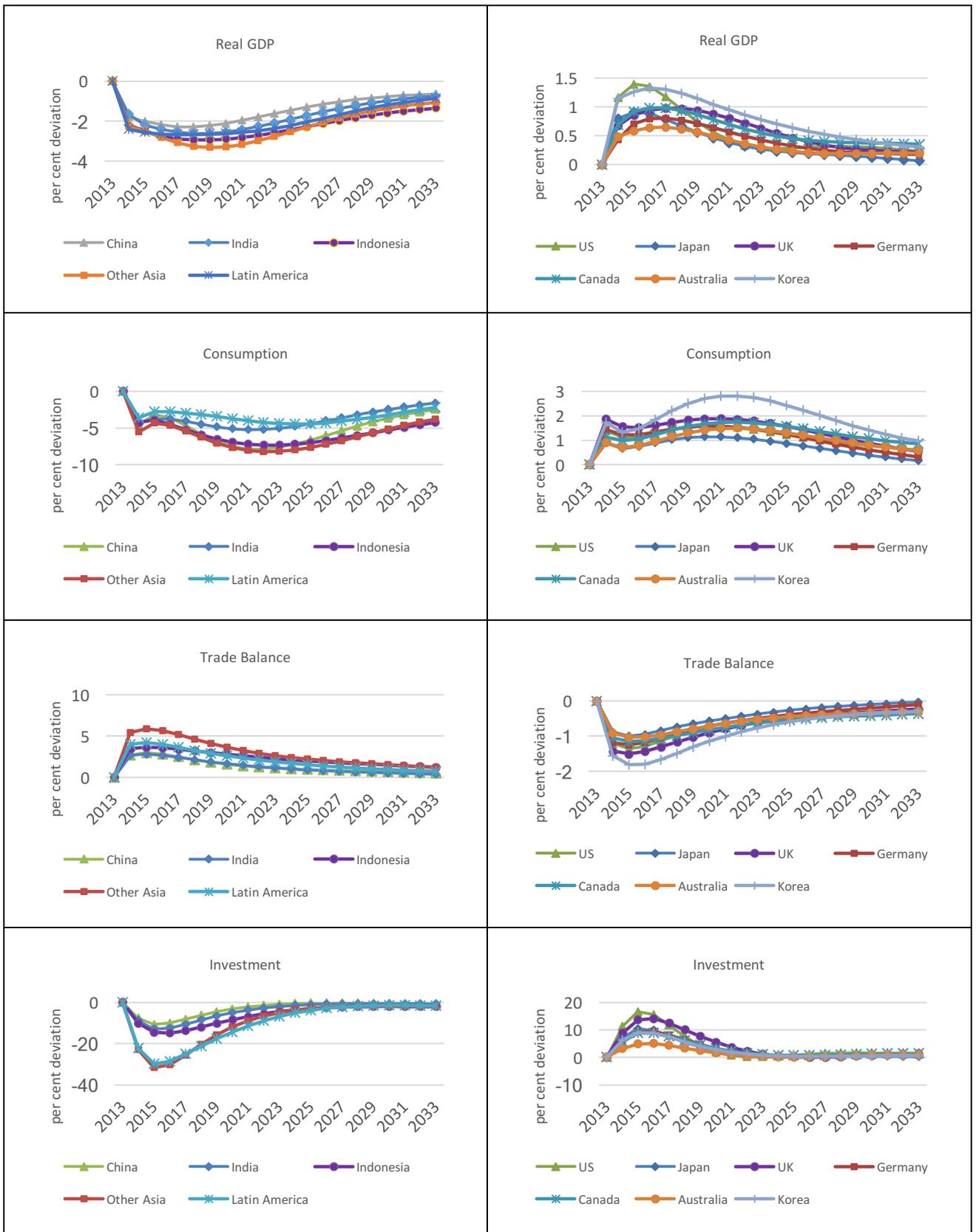
The sharp upsurge in exports of developing economies is in line with the surplus in trade account. This surplus comes from both exports increase and imports decrease (see Figure 3). The simulation results show that the adjustment originates from a large portion of exports surge and a small fraction of imports decline. Combined with the vast increase in Tobin's Q for investment, altogether contribute to the recovery process of the economy in the long run. However, the real GDP of developing economies such as China, India and others still does not go back to the baseline until 2033, just about two decades later.

What happens in developed economies is in contrast with what happens in developing economies as there are transmissions across regions. There is a process of investment reallocation in the global economy. In the short run, developed economies gain huge capital inflows coming from developing economies as there is a substantial increase in Tobin's Q for investment (see Figure 4). It then leads to falling short run and long run interest rates which generate lower cost of borrowing. The decrease in interest rates stems from dropping marginal product of capital and monetary authority responses in reducing nominal interest rates. Those lower interest rates stimulate non-exports oriented domestic industries in turn. There is also an improvement on the real exchange rate resulted from the capital inflows. The combination of wealth rises, falling interest rates and upswing of expected future income initiate the economy to expand in the short run and consumption boosts up henceforth. Further discussions on monetary and financial responses will be explored in section 3.2.

The domestic demand plunge in developing economies is reflected in exports deterioration of developed economies. The deteriorating trade balance comes from a large fraction of exports falls and a small portion of imports increase (see Figure 3). Exports fall due to improved real exchange rate which makes exported products more costly. Imports increase in these developed economies accommodates the exports surge in developing economies. Korea suffers the most in the trade deterioration process. It signifies noticeable trade interdependence between Korea and the developing countries especially in Asia. This strong trade interdependence gives Korea the highest GDP and consumption growth for both medium and long run compared to the other developed economies.

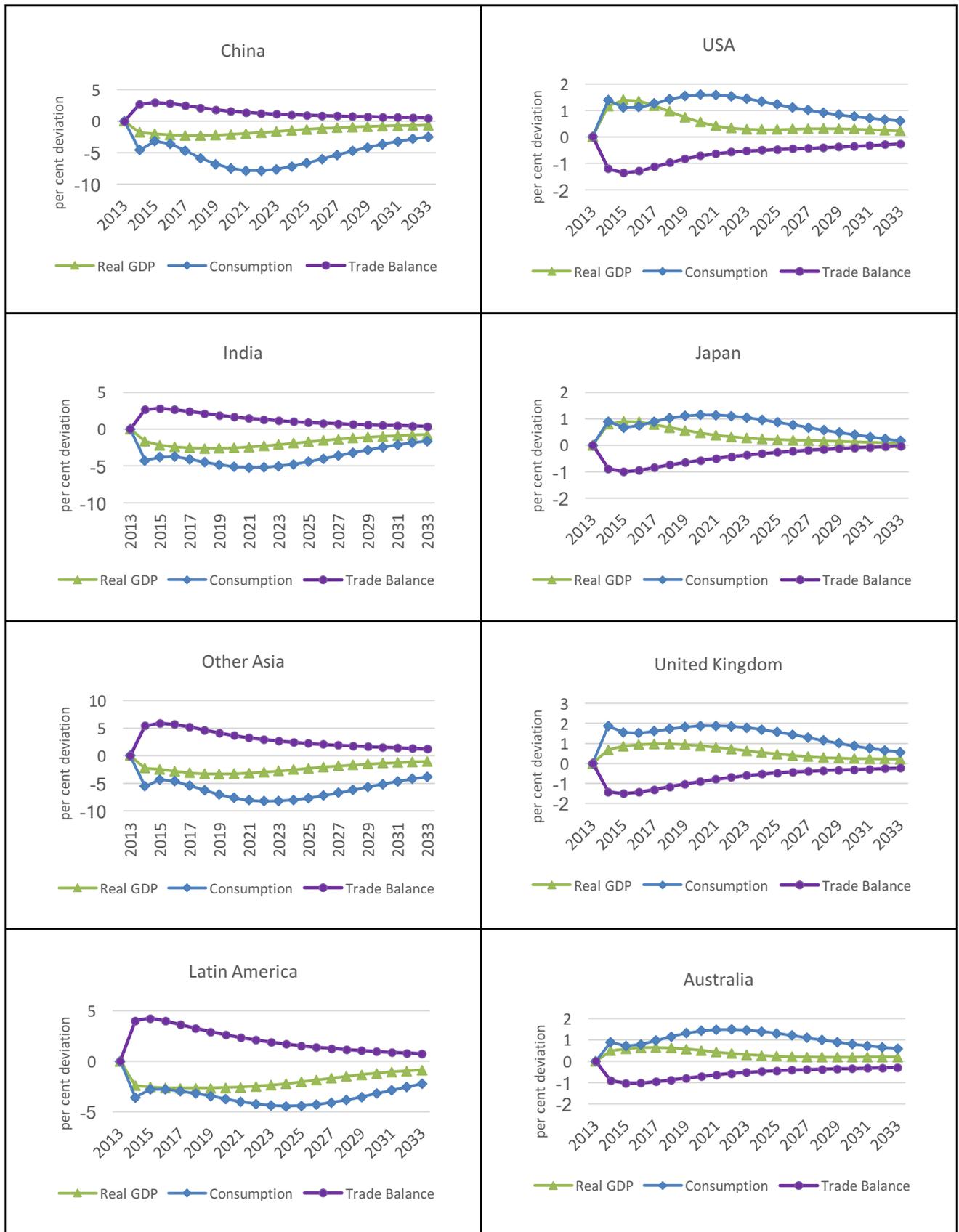
Overall, we can see from Figure 1 that even though the trade balance deteriorates in developed economies, their GDPs still grow in short run. This is because the amount of capital inflows originating from the developing economies is so huge reflecting fairly better prospects to invest. It mirrors that the expectations of investors change. As a result, it outweighs the negative effects of trade balance on GDP. Among the developed economies, US gain the most capital inflows as well as GDP growth in short run. In the long run, the real GDP of developed economies such as US, Japan and Germany return to the baseline. This is because investment goes back to the baseline as a consequence of existing adjustment costs reflected in falling Tobin's Q for investment and due to rapid recovery in developing economies when the confidence is back as the physical capitals are still in place.

FIGURE 1 Effects on national account, developing vs developed economies



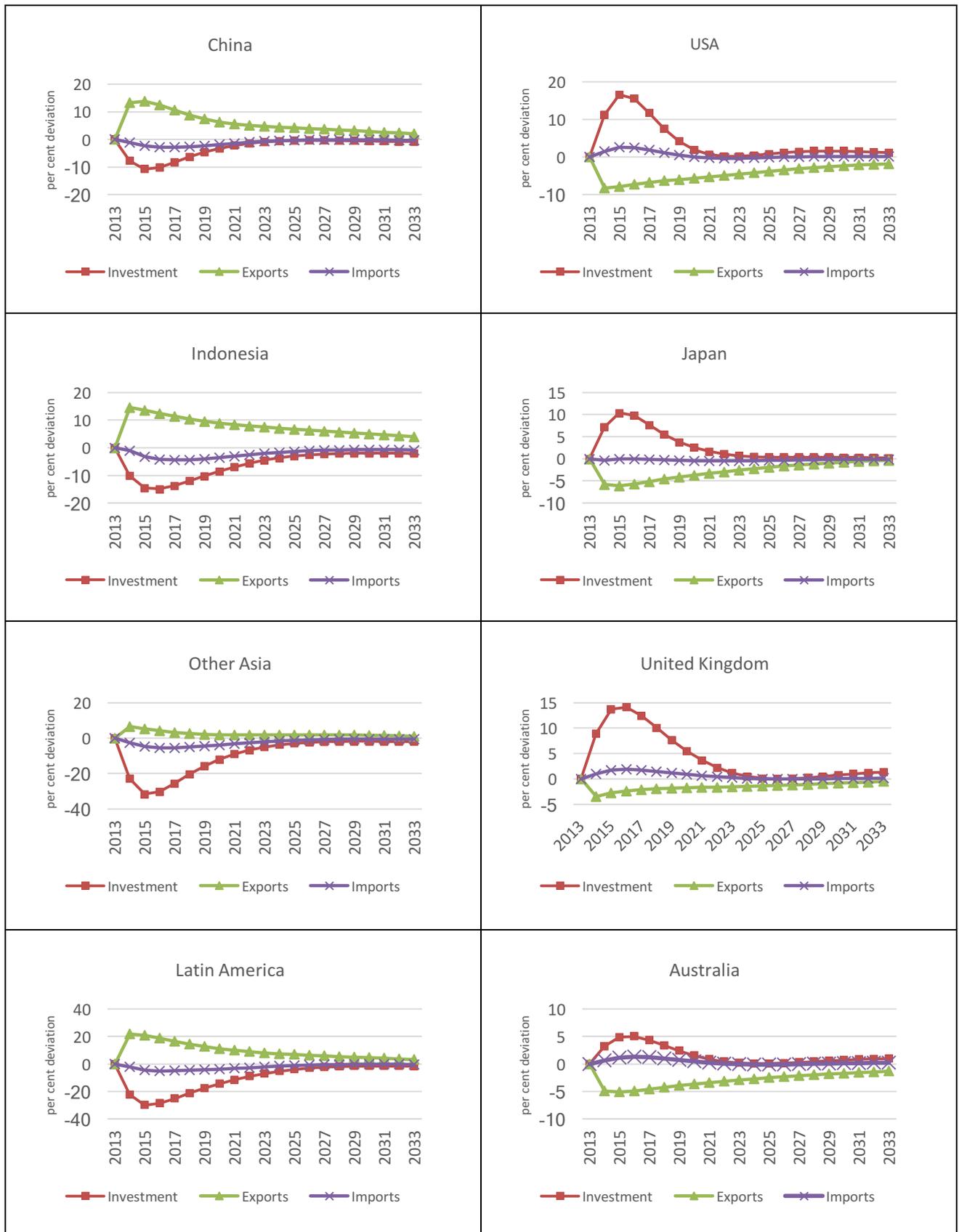
Source: Simulation with G-Cubed 108V model.

FIGURE 2 Effects on national account, developing vs developed economies



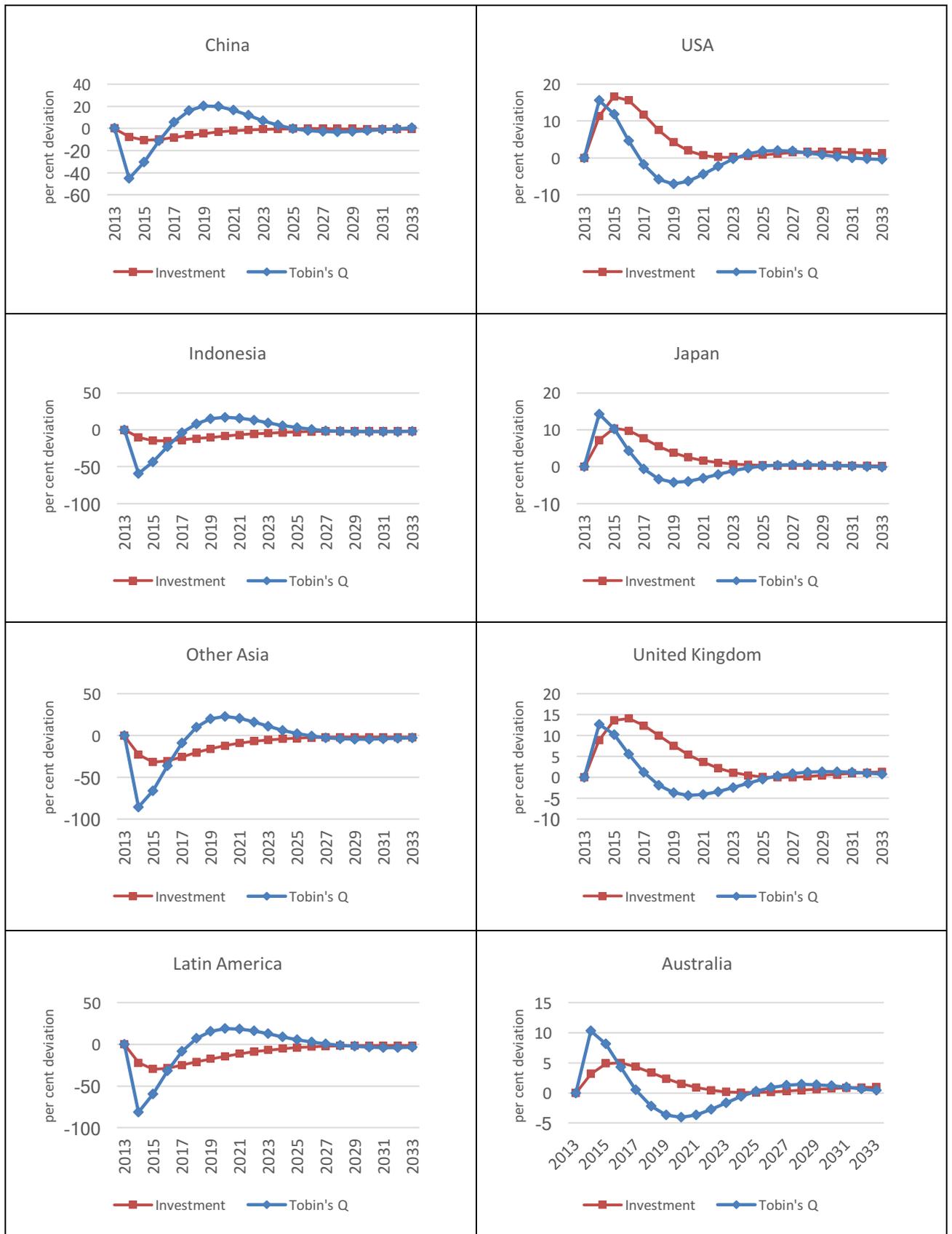
Source: Simulation with G-Cubed I08V model.

FIGURE 3 Investment, exports and imports, developing vs developed economies



Source: Simulation with G-Cubed 108V model.

FIGURE 4 Investment and Tobin's Q, developing vs developed economies



Source: Simulation with G-Cubed I08V model.

3.2 Financial, monetary and fiscal responses, developing vs developed economies

The stock market values in developing economies, for instance China and India, are dragged down by the loss of confidence in these economies (see Figure 5). This simulation result is consistent with findings in McKibbin and Stoeckel (2009) at which stock markets in all developing economies in the short run are adversely affected by loss of confidence during the global financial crisis in 2009. The falling stock market values cause rises in cost of capital. As a consequence, it contributes to downturn of investment in the short run beside the effect of stickiness of physical capital which brings about a substantial cutback in return to capital as the cost of financial capital significantly rises at the same time.

Overall, developing economies suffer around 5 per cent loss of stock market values in very short term before bouncing back in 2014. However, the composition between sectors is not the same between countries. The loss of stock market values for non-durable manufacturing goods in China is greatly less than in India and other Asian countries (see Figure 6). Latin American countries experience even worse with deviation of 20 per cent. It shows that China can maintain the production of non-durable manufacturing goods as they do not rely on imports for production inputs as much as other developing countries. That is why China's stock markets recover faster than stock markets in the other developing economies. Nevertheless, the stock market values in developing economies are still below the baseline in the long run.

Unlike the stock markets in developing economies, stock markets in developed economies grow positively in the short run as a result of reallocation of investment from developing into developed economies. The rising stock market values initiate a lower cost of capital which eventually has a positive impact on investment. In the long run, the stock market values return to baseline as the developing economies recover.

The upturn in the stock market values in the developed economies in short run are driven by stock market values of non-durable manufacturing goods, except in Japan which is driven by stock market values of services sector (see Figure 6). Non-durable manufacturing goods stock values in Japan even collapses until 2018.

The loss of confidence brings depreciation of real effective exchange rate in developing economies. Because price level is endogenously determined, the model makes a distinction between real and nominal exchange rate (W. J. McKibbin, 1998). As shown in Figure 7, the simulation results show that inflation shoots up in short run in the developing economies, except for China which goes down in the first year but follows the same pattern thereafter. Monetary policy in China targets the exchange rate (Cagliarini & McKibbin, 2009). It therefore produces less volatility in prices in the short run. In the long run, the monetary policy eventually goes back to initial starting price level due to the neutrality of monetary policy. In reality, there is some monetary adjustment as seen in China, India and other Asian countries. In this model, the monetary adjustment follows a functional form of Henderson-McKibbin-Taylor rule in the economies which assumes that monetary policy responses are endogenously determined (W. J. McKibbin & Stoeckel, 2009).

The monetary adjustment indicates that there is a larger variance between nominal and real exchange rates changes in this model simulation (see Figure 5). Greater shocks in inflation bring less change in the nominal exchange rates transformed into change in real exchange rate. As a result, a rise in exports gets lesser and exports finally return to the baseline in the long run.

Since monetary authority responses affect rising interest rates to some extent, either short run or long run interest rates should be lower in the long run by the reason of neutrality of a monetary policy. However, as the shocks in the real exchange rates are permanent, the level of both short run and long run interest rates in developing economies stay higher than the baseline permanently. The effect of tighter monetary policy appears in nominal wages. Wages tomorrow depend on agent's expectation on today prices, so when monetary policy is tighter than expected, a price increase is

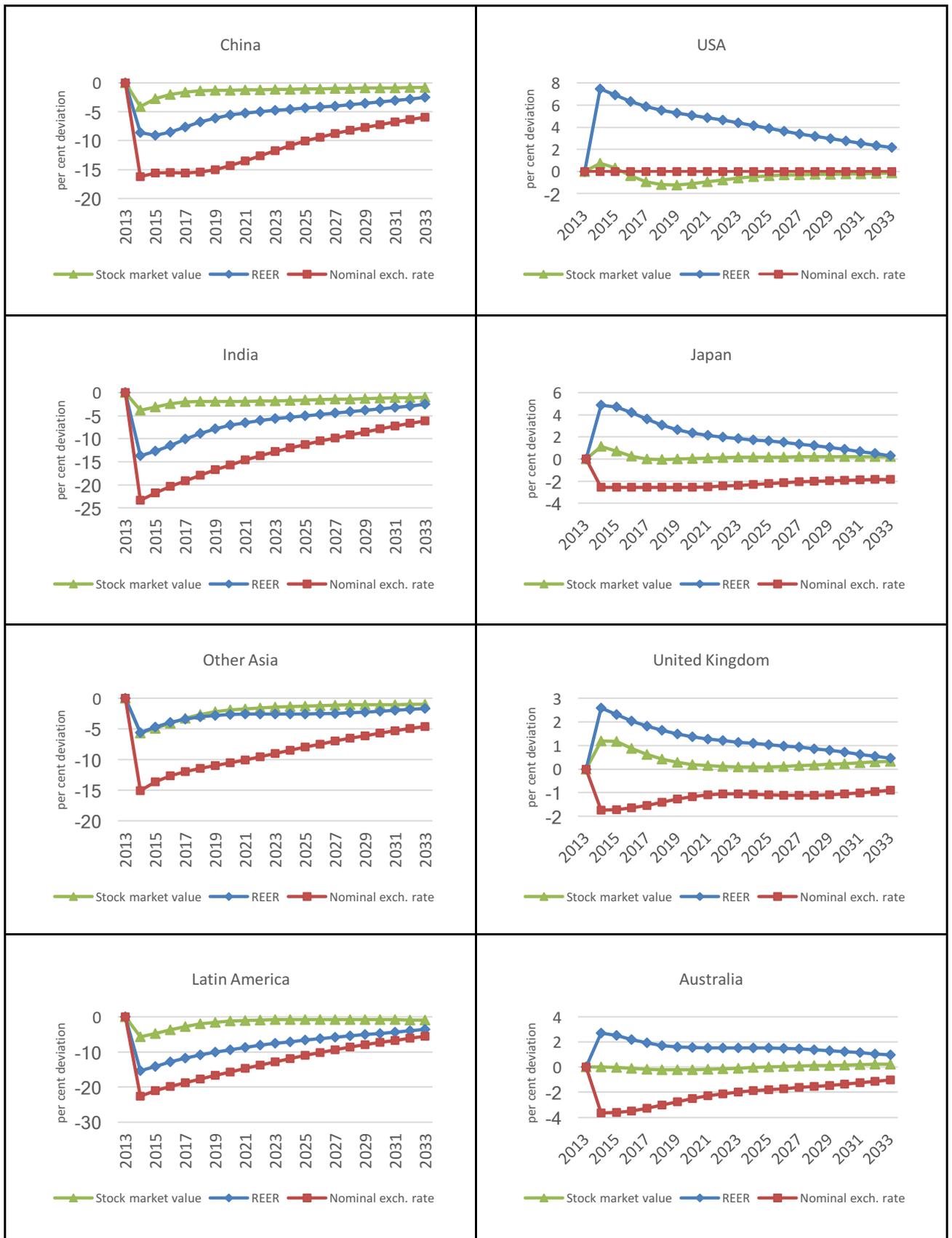
smaller than expected. It then causes a smaller real wage increase and more falling real output in the short run. On the other hand, higher interest rates are also likely to attract foreign capital which in turn appreciates exchange rates. It then crowds out exports and incomes are stimulated through the changes in relative prices. In consequence, exchange rates, exports, output, investment and consumption return towards baseline in the long run.

The developed economies go the other way of developing economies. Falling short run and long run interest rates are expected to rise returning to the baseline as monetary authority responses are neutral in the long run. However, as the shocks in the real exchange rates are permanent, the level of the interest rates stays lower than the baseline permanently. As monetary relaxation is anticipated by the agents, a greater real wage increase and more rising real output are subsequently generated in short run. On the other hand, lower interest rates also affect driven back capital, depreciated exchange rates, crowding out imports and dampening income. Thus, exchange rates, exports, output, investment and consumption are back to the baseline in the long run.

In addition, the effects of severely depreciated real exchange rates and higher interest rates in developing economies can also be seen on production and imports of non-durable manufacturing goods compared to the durables. Domestic production and imports of the non-durables fall sharper compared to the durable goods in the economy (see Figure 8). Additional costs initiate a reduction in the service flows from non-durables so that their demands decline significantly. Smaller effects in China's non-durables are due to less imports dependence for production inputs compared to the other developing economies. In contrary to developing economies, developed economies such as US and UK experience significant escalation in domestic production and imports for non-durables which are greater than for durables. The lower costs trigger a rise in the service flows from the non-durables and demand for these goods consequently upsurges.

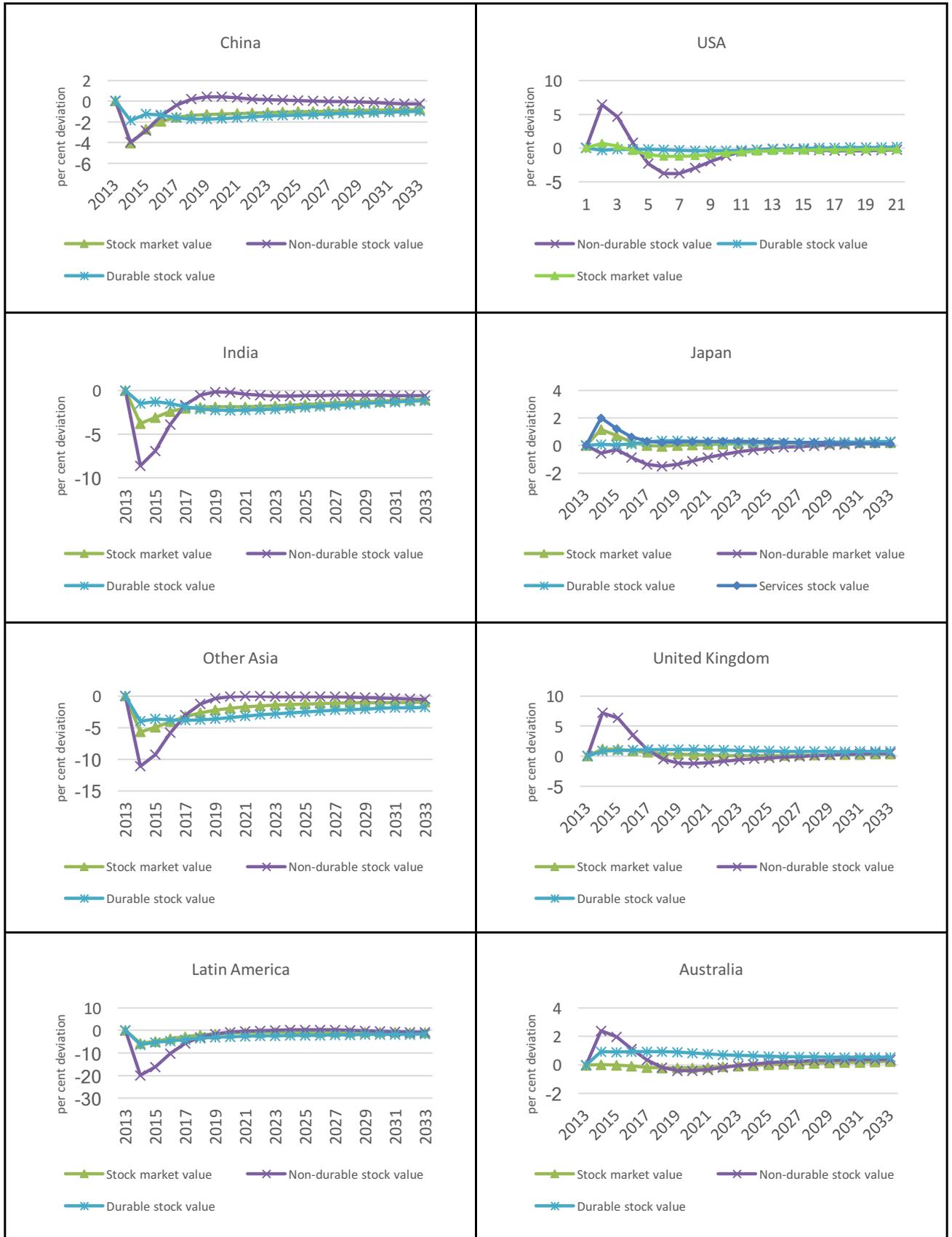
In the fiscal aspect, the government needs to provide incentives to deal with the turbulence in the economy so that as expected, the government spending escalates in developing economies (see Figure 9). To finance the spending, taxes including personal income tax, sales tax and corporate tax are increased, given government bonds are unchanged. The wedge between government spending and taxes levied as shown in Figure 9 reflects surge of government foreign debt that needs to be paid as a consequence of depreciated exchange rates. Latin American economies have to supply fiscal stimulus the most as they suffer the most compared to the other developing economies. The greater gap between the government spending and taxes, compared to the others, occurs because several Latin American countries still peg their currencies to some extent. Developed economies response differently at which the government spending falls followed by a decrease in taxes as a result of exchange rates appreciation.

FIGURE 5 Stock markets, REER and nominal exchange rate, developing vs developed economies



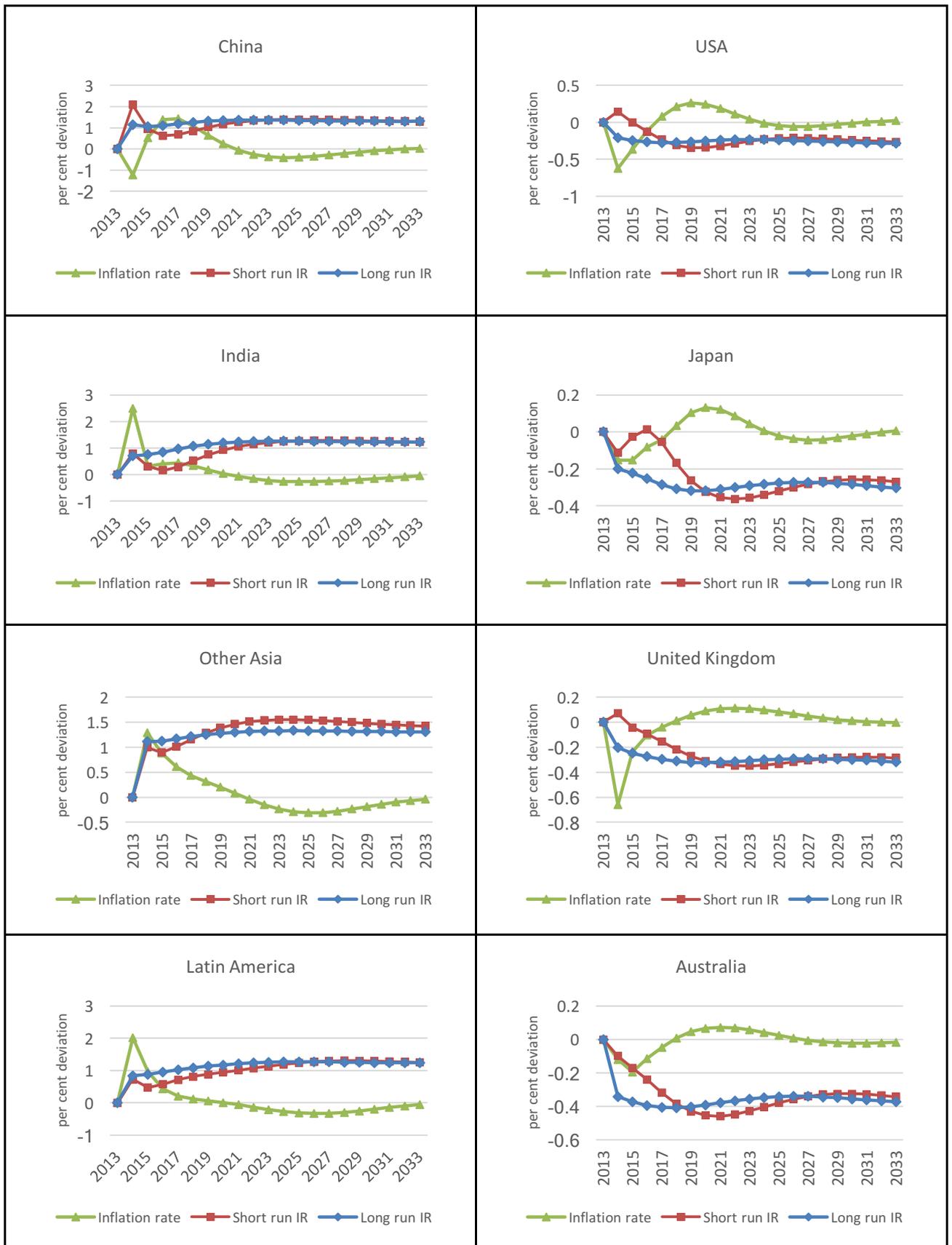
Source: Simulation with G-Cubed 108V model.

FIGURE 6 Stock market values, developing vs developed economies



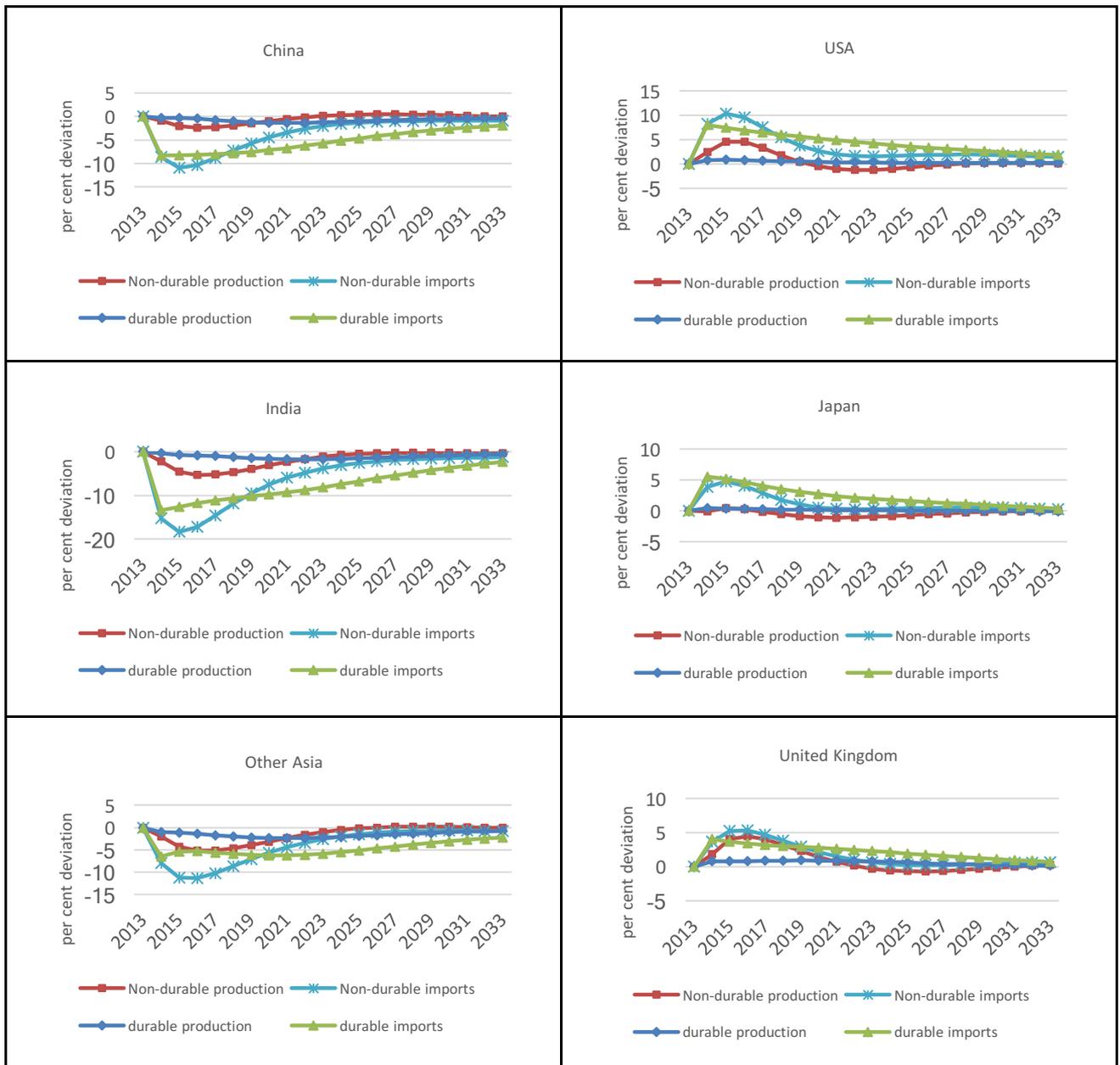
Source: Simulation with G-Cubed I08V model.

FIGURE 7 Inflation and interest rates, developing vs developed economies



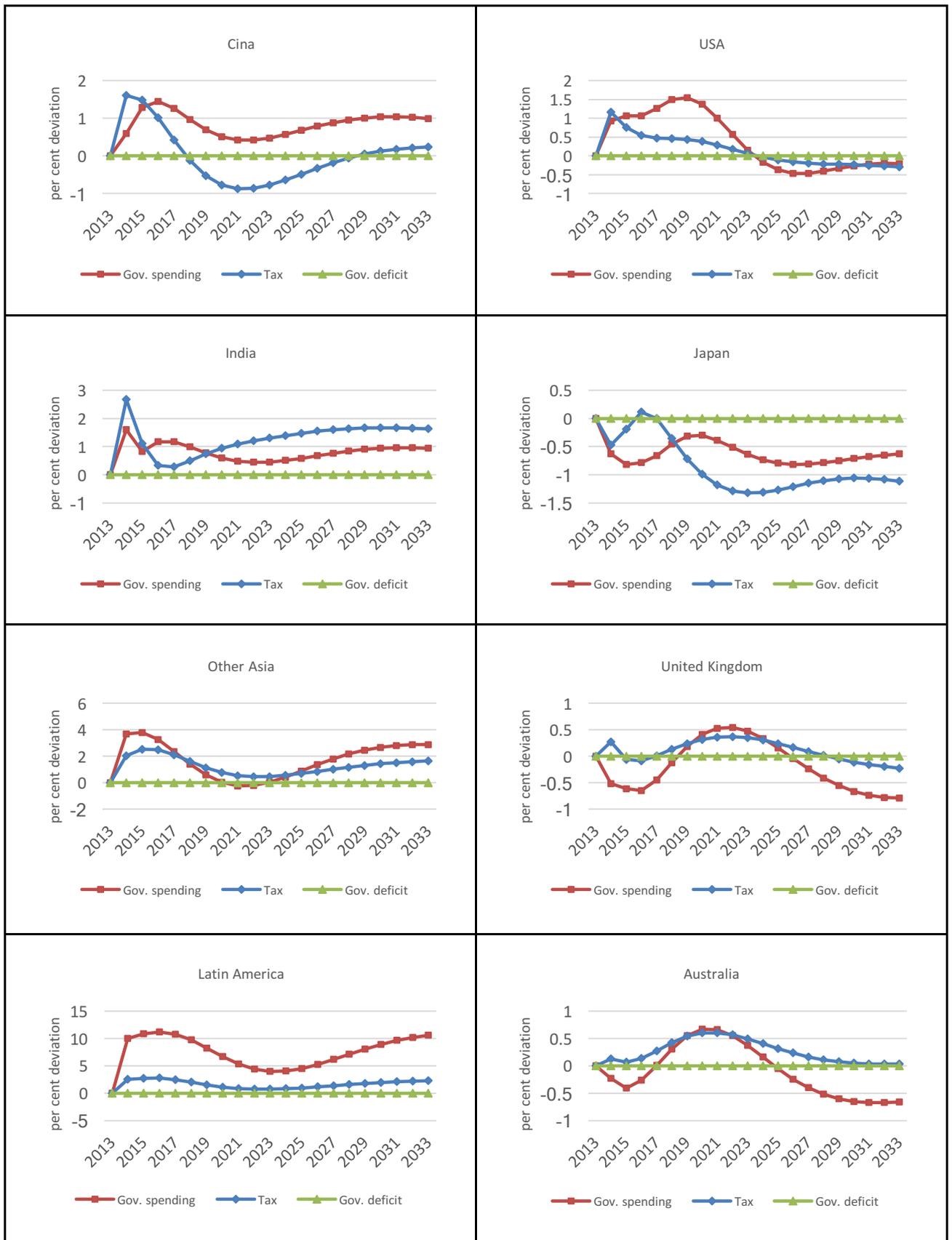
Source: Simulation with G-Cubed 108V model.

FIGURE 8 Production and imports of durables and non-durable goods, developing vs developed economies



Source: Simulation with G-Cubed 108V model.

FIGURE 9 Fiscal responses, developing vs developed economies



Source: Simulation with G-Cubed I08V model.

4. CONCLUSIONS

This paper has explored the effects of a loss of confidence in the emerging market economies as reflected in depreciation of domestic currencies relative to the US dollars. Emerging market economies suffer enormous capital outflows which in return, real interest rates stay higher for a long period. In the end, expected future incomes and wealth fall and economies come into recession. The economy is still hard to get back to the initial steady states as before the shocks hit the economy, even after a very long period when investment levels has been back to the baseline. In contrary, developed economies gain huge capital inflows from the emerging economies' expenses through the reallocation of investment, even though in the long run the economy converges to the initial steady states because of the presence of adjustment costs. When the confidence of developing economies is back, economic recovery performs more rapidly as the physical capitals are still in place.

One essential important lesson for policy makers is that once financial shocks hit emerging market economies, it can produce critical real effects in the economic downturn which will last for a long period. The characteristics of emerging economies itself make such event to happen. This simulation shows the strong interdependence between financial and real economies. To hinder such disruptions onto the economy in the future, emerging market economies need to deepen the financial system in the domestic economies. It includes currency regimes, financial integration in the domestic and adequate foreign reserves. Although emerging Asian economies has adopted floating currency regimes, some others including emerging Latin American economies still peg their currencies. Adequate foreign reserves can play a key role when such event of reversals and sudden stops of capital takes place. It can contribute in strengthening the autonomy of monetary system in the domestic economy. Therefore, an understanding of financial and real economic interdependence is fundamentally important for policy makers.

Another lesson is that countries which are highly dependent on imports for production inputs of exported manufacturing goods suffer more severely than less import-dependent countries, an important lesson from China. As most emerging market economies rely on imports for production inputs such as capital goods, they become more vulnerable when there is a sudden external shock in the global economy through the adjustment mechanism in trade balance. Less dependence on imports can reduce the fluctuations in the economy.

In financial markets, a loss of confidence drags down the stock market values in emerging market economies. The stock market values for non-durable manufacturing goods suffer the most in all emerging economies. However, China's stocks market is not hurt as much as the other emerging economies and it recovers more quickly than the other economies. Unlike emerging market economies, stock markets in developed economies rise in the short run as a result of investment reallocation. In the long run, they return to the baseline as the developing economies recover.

In the monetary responses point of view, deteriorating real effective exchange rates in emerging economies bring shooting up inflation, except in China which experiences an inflation drop in the first year. This is due to the exchange rate targeting performed by China and it shows that China's foreign reserve level is better than the other emerging economies. Higher level of real interest rates in emerging economies tend to attract foreign capital which then improves the exchange rates, crowds out exports and stimulates incomes in the long run. Conversely, in developed economies lower level of interest rates affect driven back capital, depreciated exchange rates, crowding out imports and dampening income in the long run.

Depreciated real exchange rates and higher interest rates in developing economies also have some effects on domestic production and imports of non-durable manufacturing goods compared to the durable at which the non-durables fall sharper compared to the durables. In contrary, developed economies undergo escalating domestic production and imports for non-durables larger than durables.

Finally, in order to attain a sustainable debt, development of financing system using domestic resources need to be taken into account by the policymakers. Incorporating fiscal policy shocks within the simulated model and examining how the real economic variables response is worth areas for future research.

5. ACKNOWLEDGEMENT

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APPENDIX

The G-cubed model used in this paper is version 108V which has aggregation of seventeen regions and six sectors. Each economy or region in the model comprises a number of economic agents, i.e. households, government, financial sector, and the production sectors with behaviors as follows.

1.1. Firms

Each of the sectors is assumed to be a price-taking firm with production technology of constant elasticity of substitution (CES) function. Output is a function of capital, labor, energy and materials.

$$Q_i = A_i^0 \left(\sum_{j=K,L,E,M} (\delta_{ij}^0)^{1/\sigma_i^0} X_{ij}^{(\sigma_i^0-1)/\sigma_i^0} \right)^{\sigma_i^0/(\sigma_i^0-1)} \quad (1)$$

Where Q_i is output of industry i , X_{ij} is industry i 's use of input j and A_i^0 , δ_{ij}^0 , σ_i^0 are parameters. A_i^0 is the technology level, while δ_{ij}^0 and σ_i^0 are elasticity of substitution and weights of different inputs, respectively. Subscript o reflects that the parameters apply to the output tier. The δ 's are constrained to sum to one. At the input tier, X_{iE} and X_{iM} , inputs of energy and materials, are themselves CES aggregates of goods and services. The goods and services purchased by firms are sums of domestic and imported commodities with imperfect substitutes. All agents are assumed to have identical preferences over domestic and foreign commodities.

1.2. Households

In the model, households have three activities including supplying labor, saving, and consuming goods and services. For each region, household behavior is modeled by a representative agent with an inter-temporal utility function (W. J. McKibbin & Wilcoxon, 1999), in the form:

$$U_t = \int_t^\infty [\ln C(s) + \ln G(s)] e^{-\theta(s-t)} ds \quad (2)$$

Where $C(s)$ is the household's aggregate consumption of goods and services at time s , $G(s)$ is government consumption at time s , and θ is the rate of time preference. The household maximizes Eq. (2) subject to the constraint that the present value of consumption equals to the sum of human wealth, H , and initial financial assets, F .

$$\int_t^\infty P^c(s) C(s) e^{-[R(s)-n](s-t)} = H_t + F_t \quad (3)$$

Human wealth is described as the expected present value of the future stream of after-tax labor income plus transfers:

$$H_t = \int_t^\infty (1 - \tau_1) [W(L^G + L^C + L^1 + \sum_{i=1}^6 L^i) + TR] e^{-[R(s)-n](s-t)} ds \quad (4)$$

Where τ_1 is labor income's tax rate, TR is the government transfers level, L^G is government employment, L^C is the quantity of labor used by final consumption, L^1 is labor used for producing investment goods, and L^i is employment in sector i . Financial wealth is the sum up of real money balances, MON/P , real government bonds owned by public, net holding of claims against foreign residents, and value of capital in each sector (W. J. McKibbin & Wilcoxon, 1999).

Household decisions rely on their forward looking expectations and a firm needs not to be necessarily optimum in short run, but it is instead optimum in long run. Consumption is built upon present consumption while aggregate consumption follows consumption weighted average on wealth which includes valuation of current assets and expected after tax income in the future (Mckibbin & Wilcoxon, 2013). In the model, money is introduced by assumption that household needs money for goods purchases.

1.3. *The labor market*

The labor market is assumed to be perfectly mobile among sectors within region, but immobile between regions. It means that wages are equal across sectors, but unequal between regions. Labor supply is totally inelastic in the long run implying that it is determined by the growth of population (Bryant & Mckibbin, 2001). While wages in the short run adjust slowly depending on contracts, in the long run the wages adjust to full employment. As nominal wage rigidity in short run is allowed to be varied across regions, unemployment period is allowed too depending on the institutions of labor market in each region. Dynamics in the labor market follow:

$$w_{t+1} = w_t \left(\frac{p_{t+1}^c}{p_t^c} \right)^{\alpha_5} \left(\frac{p_t^c}{p_{t-1}^c} \right)^{1-\alpha_5} \left(\frac{L_t}{L} \right)^{\alpha_6} \quad (5)$$

Showing that wages in the next period depend on current wages and consumer price level (lagged, current, and expected values) as well as current employment ratio to full employment. α_5 and α_6 are the assigned weights.

1.4. *Government*

Real government spending on goods and services in each region is assumed to be exogenous and allocated among inputs in fixed proportions. The expenditures cover goods and services purchases, interest payments on debt, tax credits and transfers to households. The revenue originates from corporate and personal income tax, sales tax, and from the issuance of government's bonds. So that, the relationship is expressed as:

$$\dot{B}_t = D_t = r_t B_t + G_t + TR_t - T_t \quad (6)$$

Where \dot{B}_t is the evolving debt stock, D_t is the budget deficit, G_t is the total government spending on goods and services, TR_t is the transfer payments to households, and T_t is the net total tax revenue.

1.5. *Financial markets and the balance of payments*

The regions in the model are linked by flows of goods and assets, so that trade imbalances are financed by asset flows between countries. A current account deficit in each region will be financed by capital account surplus, and vice versa (W. J. McKibbin, 1998). Asset markets are assumed to be perfectly integrated across regions with free capital mobility. It implies that expected returns on loans denominated in the currencies of regions have to be equalized period-to-period according to interest arbitrage relation:

$$i_k + \mu_k = i_j + \mu_j + \frac{\dot{E}_k^j}{E_k^j} \quad (7)$$

Where i_k and i_j are the interest rate in country j and k , μ_k and μ_j are exogenous risk premiums demanded by investors, and E_k^j is the exchange rate between the currencies of two countries.

Capital flows in the form of direct investment and portfolio investment are assumed to be perfectly substitutable *ex ante*. Since physical capital is sticky within regions and sectors, if there is a shock lowering profits in the sector, the physical capital stock will be unchanged, but its financial value will directly drop.

Financial assets including stocks and flows are explicitly treated at which investment leads to a capital accumulation, current account deficits create growing foreign demands against domestic productions and fiscal deficits end in an accumulation of government debt (Warwick McKibbin, Lee, & Cheong, 2004). Aggregate investment is an investment weighted average in proportion to Tobin's Q which is a valuation of market of the expected changes in the future in marginal product of capital relative to costs (Bryant & McKibbin, 2001; Cagliarini & McKibbin, 2009; Fry-McKibbin, Martin, & Tang, 2013; Warwick McKibbin et al., 2004; W McKibbin & Vines, 2000).

1.6. Parameterization, algorithm solution and baseline

To estimate the parameters in the G-cubed model, a consistent time series of input-output tables for the US is initially constructed (W. J. McKibbin & Wilcoxon, 1999). It covers the detailed benchmark US input output transaction tables produced by the Bureau of Economic Analysis (BEA) for years 1958, 1963, 1967, 1972, 1977, and 1982 whereby parameters within the model are estimated instead of calibrated (McKibbin & Wilcoxon, 2013; W. J. McKibbin & Wilcoxon, 1999).

For regions other than the United States, less time series input output data are available. In order to overcome this issue, restriction is imposed so that sets of elasticity of substitution within individual industries are equal across regions. The US elasticity estimates are then used everywhere.

Since the G-cubed model incorporates over 100 forward-looking co-state variables, it is challenging to solve. It is then solved using an algorithm and computer software developed by McKibbin (McKibbin, 1998). In this paper, the estimated parameters are updated until 2013, by this means, the year of 2013 is made to be the baseline.