CHAPTER 5

SIMULATION RESULTS

According to the log linear-approximation model in the previous chapter, this chapter presents the parameters of the model and the simulation results. Parameters used in the calibration of the model are selected from the related literature and historical data statistics from the Bank of Thailand (BOT), and National Economic and Social Development Board (NESDB). The model is calibrated with quarterly data.

After the parameter setting, the model is solved by using the algorithms presented in the previous chapter. The simulation results are experimented and then the predicted standard deviations and correlation coefficients of selection variables generated from the model will be compared to those from the historical data of Thailand.

The simulation results are presented through impulse response functions, in the third section. Since this paper focuses on the effects of an oil price shock to the macroeconomic variables, the experiment in this paper will be taken only this shock measured for one-time, exogenous 10 percent increase to an oil price.

5.1 Model Parameterization

This section describes the parameterization of the model. There are many parameters in the model and the major work of this paper is to analyze the response of macroeconomic variables to an oil price increase and to find the numerical response of the monetary policy. Our attempt, therefore, is not to estimate the model. The parameters of the model, for simplicity, are collected and selected from the related literature, and the relevant empirical results from previous studies on Thailand's economy. The model is calibrated to fit characteristics of Thailand's data.

Many of the parameters are set according to Svensson (1998, 2000) and Ahuja, Puenchanchaikul, and Piyakarnchana (2004). Some of parameters for the foreign country are estimated according to US data. The model is calibrated at a quarterly frequency between 1993Q1-2007Q4.

The discount factor is set so that the annual real interest rate equals 4 percent in steady state, i.e. $\delta = .99$. The risk aversion parameter ρ in RBC is typically used from 0.5 to 2 and those used in New-Keynesian models is from 1 to 6. In this paper we use 6.3994 according to the estimation provided by Ahuja, Puenchanchaikul, Piyakarnchana (2004). The quarterly depreciation rate is set equal to 0.025, which implies 10 percent steady state depreciation rate per annum.

The elasticity of substitution between varieties of goods, ϑ, is chosen to be 10 consistent with Ahuja, Puenchanchaikul, Piyakarnchana (2004), which implies a steady state markup of 11 percent. On the other hand, the elasticity of substitution between home and foreign goods, ξ, is set to equal 0.6, which is the average value of the estimation from Asia. This value is reported by Reinhart (1995), and Cook and Devereux (2006) use this value in their calibrated model for the Thai economy. The elasticity of substitution between home and foreign goods for the foreign country, ξ^*, is set to 2; this value is set following Svensson (1998, 2000). This means that the price elasticity of demand for home produced goods of the foreign country is quite elastic. The parameter of the marginal disutility of labor is set to equal 3.0 following Gali and Monacelli (2005). This value implies the elasticity of labor supply is set to equal 0.33.

According to the parameters in the production function, many of the studies in the real business cycle model use the Cobb Douglas production function with a typically value of capital share at 0.7 and labor share at 0.3. The production function in this study comprise of three inputs: labor, capital, and energy. Basically, the substitution between oil-labor is relatively less than oil-capital. Therefore, the oil share in the production function of this study would be classified from the share of capital.

The share of the labor in the Thai production is selected from Mallikamas, Thaicharoen, and Rodpensangkahe (2003) who report the capital share in the national income account, based on Cobb Douglas production function with capital and labor input, for the period during the 1980-2002 at approximately 0.35. This capital share, therefore, implies the labor share at 1-0.35. We, therefore, take labor share at 0.65.

According to the assumption of constant return to scale properties of the model's production function, the share of the capital and energy are implied to be equal to 0.35. Due to the statistics of energy consumption as a share of GDP between periods 1993-2007 (yearly), it takes account to 0.14. The capital share in our model, therefore, is taken at 0.21.

The frequency of price adjustment, α, is set according to Ahuja, Puenchanchaikul, Piyakarnchana (2004). They estimate this value during the post-crisis years, from January 2002-May 2004, prices in the consumer basket change about 6.38 times per year or 1.5958 times per quarter implied that $\alpha = 0.2028$.

The import share in the CPI inflation, ω, is set according to Buddhari, Anotai, Chensavasdijai (2003). They report the weight of imported group in the overall CPI basket in the base year (1998) at 20.4 percent. They derive the import content of each CPI product from the NESDB's Input-Output Table of Thailand.

The persistence coefficient of domestic natural output, $\gamma_y^n = 0.86$, is set to follow AR(1) process. This value is estimated using the potential output from Chathom (2001). Chathom (2001) estimated the potential output of Thailand during 1993Q1-2000Q4 using a different method; Non-accelerating Inflation Rate of Unemployment (NAIRU), Stochastic Frontier Production Function, Hodrick and Prescott Multivariate filter and Structural Vector Autoregressive Regression (SVAR). Lee (2005) extrapolates this series to end at 2004:Q1. Therefore, the observations account for 44 observations, and with the assumption that there is no mean reverting for the series of potential output. Therefore it, can be used to estimate γ_y^n, and in this paper, γ_y^n is estimated by using NAIRU series.

Considering the monetary policy rule of the domestic country, the weight on output and inflation are put differently, i.e. weight on inflation is equal to 1.5 and weight on output is equal to 0.5. The inflation weight is chosen according to the "Taylor Principle", that interest rates should respond more than one to one to the inflation rate. This is the standard weight in the Taylor rule (1993).

The simple partial adjustment weight on aggregate supply α_π is set to equal 0.3. The partial adjustment weight for aggregate output β_y is also set to 0.5[1]. However there is no evidence for both parameters being found in Thailand. Therefore, both parameters are checked in the sensitivity analysis of results to alternative values of 0.6 and 0.8, respectively.

According to the AR (1) process of oil prices, persistent coefficient, γ_{p^w} , is set to 0.8 which is consistent with the time series evidence on the West Texas intermediate crude oil price series. This result represents a simplification of the stochastic process followed by oil prices over the postwar period. This is estimated by Leduc and Sill (2004).

According to foreign interest rate, the parameters are set to match the US economy, since the US economy is large enough to represent the world economy. In addition, the Thai economy has a high level of trade account with the US. The AR(1) process of foreign interest rate is estimated according to equation (4.24) by using the average quarterly Fed Fund rate between 1993Q1-2007Q4. The persistence coefficient of foreign interest rate, γ_i^* , is 0.97.

The other foreign conditions are also based on the data of the U.S. and are assumed to follow AR (1) process. The persistence coefficient of the US core CPI inflation, γ_π^*, and output gap, γ_y^*, are equal to 0.89 and 0.86, respectively. Those values are estimated by Whelan (2004). The persistence coefficient of the risk exchange rate premium, γ_Ω , is set to equal 0.8, following Svensson (1998, 2000). In addition, the income elasticity of foreign real consumption, $\overline{\beta}_y^*$, is estimated by simple ordinary least square from the real private consumption and real GDP of the US data between 1993Q1:2007Q4[2]. This value is equal to 0.86.

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[1] Svensson (1998, 2000) use the probability of firms who can not reset their price α = 0.5 and picks $\alpha_\pi = 0.6$ and $\beta_y = 0.8$. In this model the probability of fixed price is set equal to 0.20.

[2] The data can be downloaded from the website of Federal Reserve Bank of Dallas.

Besides the parameterizations, the steady state value of variables will be set according to historical data statistics. The model is calibrated so that the non-stochastic steady state fits the observed long term mean and ratios. The data are taken from the Bank of Thailand and the National Economic and Social Development Board (NESDB). The share of consumption in GDP is set to equal 0.66, the share of an export in GDP is 0.62, and the share of imports in GDP is 0.58. The share of investment in GDP is 0.26.

Table 5.1 summarizes the parameters value used to find the numerical simulation of the model. They are categorized as the following:

Table 5.1

Parameters of the Model

Parameter	Notations	Value
Preference Parameters		
Discount Rate	δ	0.99
Depreciation Rate of Capital	δ_K	0.025
Inverse of Intertemporal Elasticity of Substitution	ρ	6.37
Marginal Disutility of Labor	ρ_L	3.00
Elasticity of Substitution Between Varieties of Goods	ϑ	10.0
International Parameters		
Share of Imported Goods in CPI (Domestic Country)	$\omega = (1-\kappa)$	0.20
Share of Domestically Produced Goods in Foreign Country	ω^*	0.15
Share of Domestic Aggregate Demand	κ	0.80
Elasticity of Substitution between Home and Foreign Goods	ξ	0.60
Elasticity of Substitution between Home and Foreign Goods	ξ^*	2.00
Income Elasticity of Foreign Consumption	$\overline{\beta}_y^*$	0.86
Monetary Policy weight		
Weight of Inflation in Domestic Interest Rate Rule	f_π	1.50
Weight of Output Gap in Domestic Interest Rate Rule	f_y	0.50
Production Parameter		
Probability of Fixed Price	α	0.20
Output Elasticity of Labor Input	ϖ_1	0.65
Output Elasticity of Capital Input	ϖ_2	0.21
Output Elasticity of Energy Input	ϖ_3	0.14
Adjustment Weight		
Domestic Aggregate Demand Adjusting Weight	β_y	0.5
Domestic Aggregate Supply (Inflation) Adjusting Weigh	α_π	0.3

5.2 Comparing the Model to the Data

The system of the equations presented in the fourth chapter and parameterizations from the previous section allows us to solve the rational expectation model. As the algorithms for solving provided in the previous chapter, the solution of the model characterizes a system of vector autoregressive which can be employed to evaluate the dynamic response of endogenous variables to an oil price shock.

Before going to the simulation results, this section will provide a comparison of the predicted standard deviations values of variables generated from the model to those from the data of Thailand for evaluating the model. Table 5.2 summarizes the standard deviations of the selection endogenous variables: total consumption, gross domestic product, headline consumer price index inflation, interest rate, imported goods, exchange rate, and energy consumption.

All historical data have been logged and HP filtered (the HP smoothing parameter was set at 1,600 for quarterly series). The series of historical data are considered between 1993Q1-2007Q4.

The standard deviations of consumption and output are equal at 0.06. The standard deviation of inflation and interest rates are highly volatile since the period covers the 1997 crisis. During the crisis, inflation and interest rates fluctuated significantly leading to the mean and the standard deviations of those series. The standard deviations of the reaming variables: imported goods, energy consumption and real exchange rate have been less volatile than those two variables.

The predicted standard deviations of the corresponding variables are provided in the last row, labeled “Model”, of Table 5.2. The predicted standard deviations are generated using the base model. The standard deviations generated from the base model are quite related to the historical statistics for consumption, inflation and interest rate. For the other variables, there seems to be a low degree of correspondence between the data and model. The model has over-predicted the volatility of the domestic output, energy consumption, and the real exchange rate, and has under-predicted for the imported goods.

The historical correlations of the variables are provided in Table 5.3 which shows that consumption and gross domestic product are strongly correlated with a correlation coefficient of 0.97. In contrast, consumption and inflation are a weaker correlation with coefficient -0.08. The sign is minus since consumption and inflation are related in the opposite direction. The interest rate and inflation are quite correlated according to the inflation targeting policy of the Bank of Thailand.

Considering the correlation coefficients generated from the base model, as shown by the value in the parenthesis in Table 5.3, the correlation coefficients of selection variables generated from the model have the same direction corresponding to the data. However, the predicted correlation coefficients of almost variables are over-predicted. By contrast the correlation between imported goods and the other variables, and the correlation between consumption and output are under-predicted.

Due to the results from the comparison, it can conclude that the model is not suitable for Thailand’s economy. Because the model need many parameters and those parameters are rarely found in Thailand, the parameters used in the model are picked from the relevant literature that do not have an exact structure as the model in this study. Another reason to address this problem is that the sticky price adjustment assumption can not be applied in this model.

Table 5.2

Standard Deviation

Thailand Data	C	Y^H	Π^H	i	E	Q	C^F
1993Q1-2007Q4	0.06	0.06	0.39	0.31	0.05	0.08	0.09
Model	0.07	0.48	0.41	0.37	0.50	0.20	0.02

Note : The consumption, C, is the data of the total consumption , the interest rate, i, is represented by the RP14 days, the inflation rate is the headline CPI inflation, the domestic demand is represented by the GDP. The foreign good index , C^F , is represented by the import of goods, the energy is the data from the average quarterly unit of petroleum products consumption, the exchange rate is the average of exchange rate of Baht/USD.

: The data is taken from EPPO, NESDB and BOT quarterly data. All of the observations have been logged and detrended using HP filter with smoothing parameter at1600.

Table 5.3

Correlation between Variables

	C	Y^H	Π^H	i	E	Q	C^F
C	1.00 (1.00)	0.97 (0.50)	-0.08 (-0.55)	-0.48 (-0.59)	0.91 (0.49)	0.39 (0.11)	0.94 (0.72)
Y^H			-0.12 (-1.00)	-0.44 (-0.99)	0.90 (0.95)	0.35 (0.87)	0.91 (0.19)
Π^H				0.61 (1.00)	-0.12 (-0.96)	-0.29 (-0.84)	-0.01 (-0.12)
i					-0.44 (-0.96)	-0.50 (-0.82)	-0.48 (-0.07)
E						0.46 (0.83)	0.82 (0.14)
Q							0.19 (0.60)

Note : The values in the parenthesis are the correlation coefficients generated from the model

5.3 Simulation Results

In order to assess quantitative effects and duration for an oil price shock, we explore the characteristics of the calibrated model by generating the impulse responses of the selected macroeconomic variables on one time 10 percent exogenous increase to the oil price. The impulse response functions of selection various endogenous variables; output, inflation, short term interest rate, aggregate consumption, energy consumption, capital stock, foreign bond holding, and real exchange rate, to an innovation of oil price are shown in Figure 1 from Panel A-J. The impulse response functions are computed as percentages deviation from the steady state and time frequency is measured to quarterly.

Panel A shows the impulse response of the output. Quantitatively, in response to one-time 10 percent exogenous increase in oil prices, the output will experience a maximum fall to nearly 3.0 percent in the fourth quarter to fifth quarter, and then gradually increasing before converging back to a long run steady state. This result is consistent with the results presented by Rotemberg and Woodford (1996) and Finn (2000)[3], but it is different in the magnitude and duration. Our small open economy model predicts more magnitude effects but the shorter duration returning to a steady state than those.

The CPI inflation, in Panel B, rises for responding to an increase in oil price The CPI inflation has highest increased approximately 2.5 percent after three quarters. Oil prices pass through domestic inflation both directly and indirectly. Oil prices are reflected directly - and almost immediately - in domestic fuel prices. After a time lag, price of domestic output increase due to an increasing on the costs of oil input in production. Note that, the prices of domestic outputs may not increase to the same

[3] Both papers study the effect of oil prices in a closed economy using data from the U.S. Rotemberg and Woodford (1996) estimate that one- time 1 percent increase, in imperfect competition theory, in oil price reduces output by 0.25 percent with in 5 or 6 quarters later. They conclude that imperfect competition is important in generating the decline in output to an oil price increase. Consistently, Finn (2000), by the perfect competition with capital utilization model theory estimated that 1 percent increase in oil price contract the output 0.17 percent with in 5 or 7 quarters after shocks. Finn (2000) concluded that an increase in oil price shock works muck like an adverse technology shocks.

degree as oil prices increase. Consequently, the firms' price setting adjustment will account for increase in CPI inflation.

The upward nominal interest rate responds to the upward CPI inflation. Since the central bank responds to the inflation with higher weight (1.5) than the weight in output gap (0.5), the nominal interest rate, then, increases initially to protect the effects from inflation which is potentially increase following an increase in the prices of oil. As the monetary policy has the objective to stabilize the output gap as well, the interest rate will respond more to inflation at the beginning of the periods after shocks relative to the later periods. Since the monetary policy must trade-off between stabilizing output gap and inflation, policy will react partially to inflation. The level of increase in the interest rate for fighting inflation is decreased as time passed.

The capital stock impulse response function is shown by Panel D. The capital stock is decline causing from oil prices rise dampening demand for oil then, working through the production function, the depressing in future's capital marginal product is expected. Consequently, the investment and capital stock will be reduction. The stock of capital is decreased up to maximum level approximately at 0.75 percent with in 2-3 years.

Panel E shows the impulse response of aggregate consumption. The aggregate consumption decreases due to the contractionary effects of output. As discussed above, the output will reduce in response to rising oil prices, this will affect consumption according to the income effects. The oil price shock will affect the production of output and, in turn, demand for labor. The decreasing in real wages is expected as a result. The change in wages and labor hours, therefore, contract the income of the household. In magnitude, the aggregate consumption initially decreases with maximum level nearly 1.0 percent and return to the steady state with in eight quarter eight after an oil price shock.

Panel F shows the impulse response functions of energy consumption. The energy consumption decreases as expected. Intuitively, energy consumption depends on the output produced. With the higher prices of oil, the cost of production increases, so firms reduce their production. In addition, the higher goods price set by firms who can reset their price will contract the demand for their output. A decrease in demand for output and an increase in prices has, in turn, lead to a direct effect on energy used in the production process. The energy consumption is decreased maximum at approximately 2.5 percent. The magnitude of the effects is not much since the energy input is low degree of substitutability between inputs.

Panel G presents the impulse response of the percentage deviation of the real exchange rate. The real exchange rate is depreciated according to deterioration of the trade balance following from the higher value of an import relative to an export..

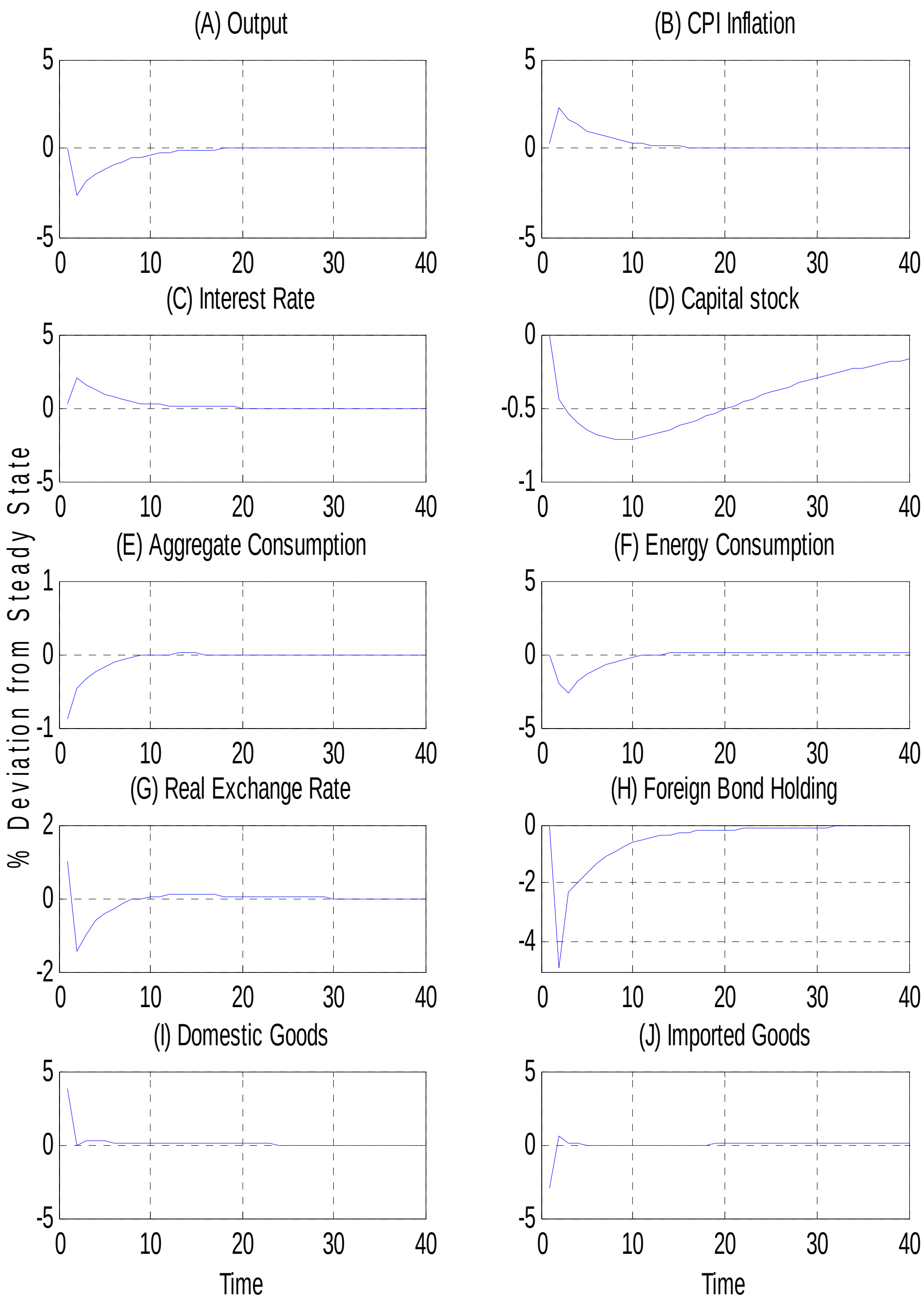
In response to an oil price shock, foreign bonds holding, Panel H, will decrease approximately 5 percent. The foreign asset holding decreases according to the depreciation in the real exchange rate. This makes the investment in foreign currency assets less interest relative to the domestic assets.

Panel I and J, illustrate the response functions of domestically produced goods and imported goods, respectively. The demand for domestically produced goods will increase since the prices of domestic goods will be cheaper relative to the imported goods. In contrast, the demand for imported goods decreases due to the higher prices relative to domestic goods prices.

Figure 5.1

Impulse Response for One Time 10 Percent Increase in Oil Prices

(Base Case)



5.4 Sensitivity of the Model

In this section, we do the sensitivity analysis for three parameters, the first one is the persistence coefficient of the world oil price process, γ_{p^w}, the second is the partial adjustment weight on aggregate demand, β_y, and the last one is the partial adjustment weight on aggregate supply, α_π. When the sensitivity analyses are experimented, only the parameter corresponding to the sensitivity analysis is changed; the other parameters are kept constant as in the base model.

As suggested by Leduc and Sill (2004) that, there are some evidences that the stochastic process for oil prices changed in the 1980s and became more mean-reverting. We check the sensitivity of our results to alternative values of the AR (1) coefficient of oil price process. Figure 5.2 shows the impulse response functions of the selection variables corresponding to the base model with the persistence coefficient of oil price γ_{p^w} =0.5.

As shown in Figure 5.2, except for the capital stock, those variables have the dynamic response paths like in the base model. But they are different in the extent of the effects. Many variables are more severely affected in this case relative to the base model.

As discussed in the previous section, it cannot find the exact weight on past value of aggregate demand and aggregate supply. Therefore, in Figure 5.3 and 5.4 show the sensitivity analysis of the partial adjustment weight on past value of aggregate demand and aggregate supply, respectively. In Figure 5.3, the weight on aggregate supply is set to equal 0.6. The impulse response function of energy consumption will take longer duration before going back to the steady state value relative to the base model. But the extent of the decrease is less severe than the base model. Aggregate consumption and exchange rate have more severe effects relative to the base model. The foreign asset holding respond differently from the base model. It decreases in the initial period after shock, and then it jumps to increase before returning to a steady state. Since the real exchange rate in this case is initially increased (depreciation), then gradually decreases (appreciation), investment in foreign assets is more interest relative to early period of shocks.

Figure 5.4 presents the impulse response functions of endogenous variables when the weight of the aggregate demand, β_y, is taken at 0.80. In this case, the energy consumption takes more severe effect than the base case. The foreign asset holding has the same response as in the base model. In contrast, the capital stock and the exchange rate is remarkably different from the base model. The capital stock takes less magnitude but higher duration relative to the base model. The real exchange rate in this model is appreciation. It has more severe effects both in magnitude and duration than the base model.

In summary, lower persistence in oil price process, as broadly stated, takes more severe effects. The higher weight on the last period value of aggregate supply has a higher effect on real exchange rate and foreign asset holding. The higher weight on the last period value of aggregate demand has a higher effect on capital stock.

Figure 5.2

Impulse Response for One Time 10 Percent Increase in Oil Prices

A Case of Low Persistent Coefficient of Oil Prices Process

(γ_{p^w} =0.5)

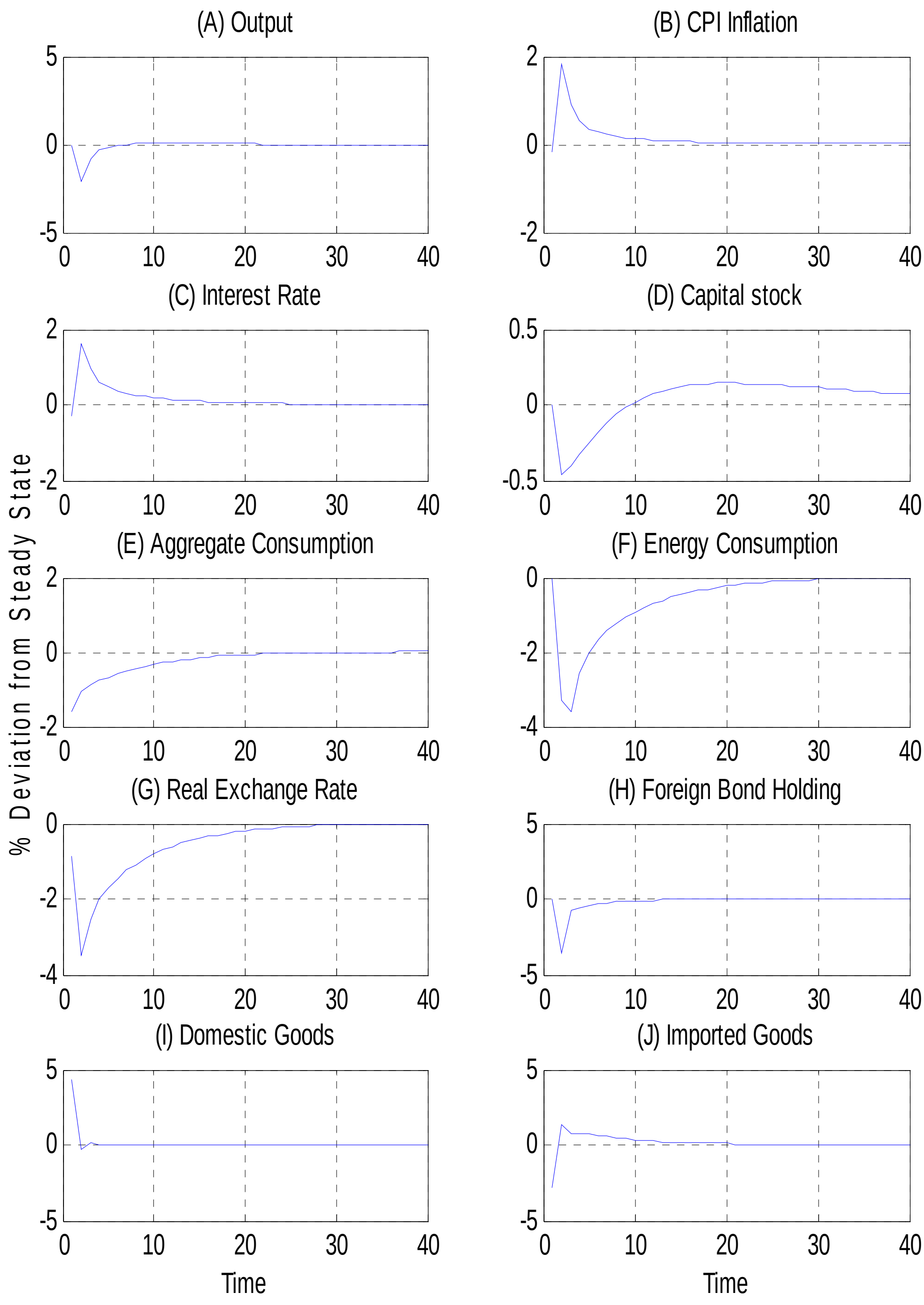


Figure 5.3

Impulse Response: A Case of High Weight on the Past Value

of Aggregate Supply ($\alpha_\pi = 0.6$)

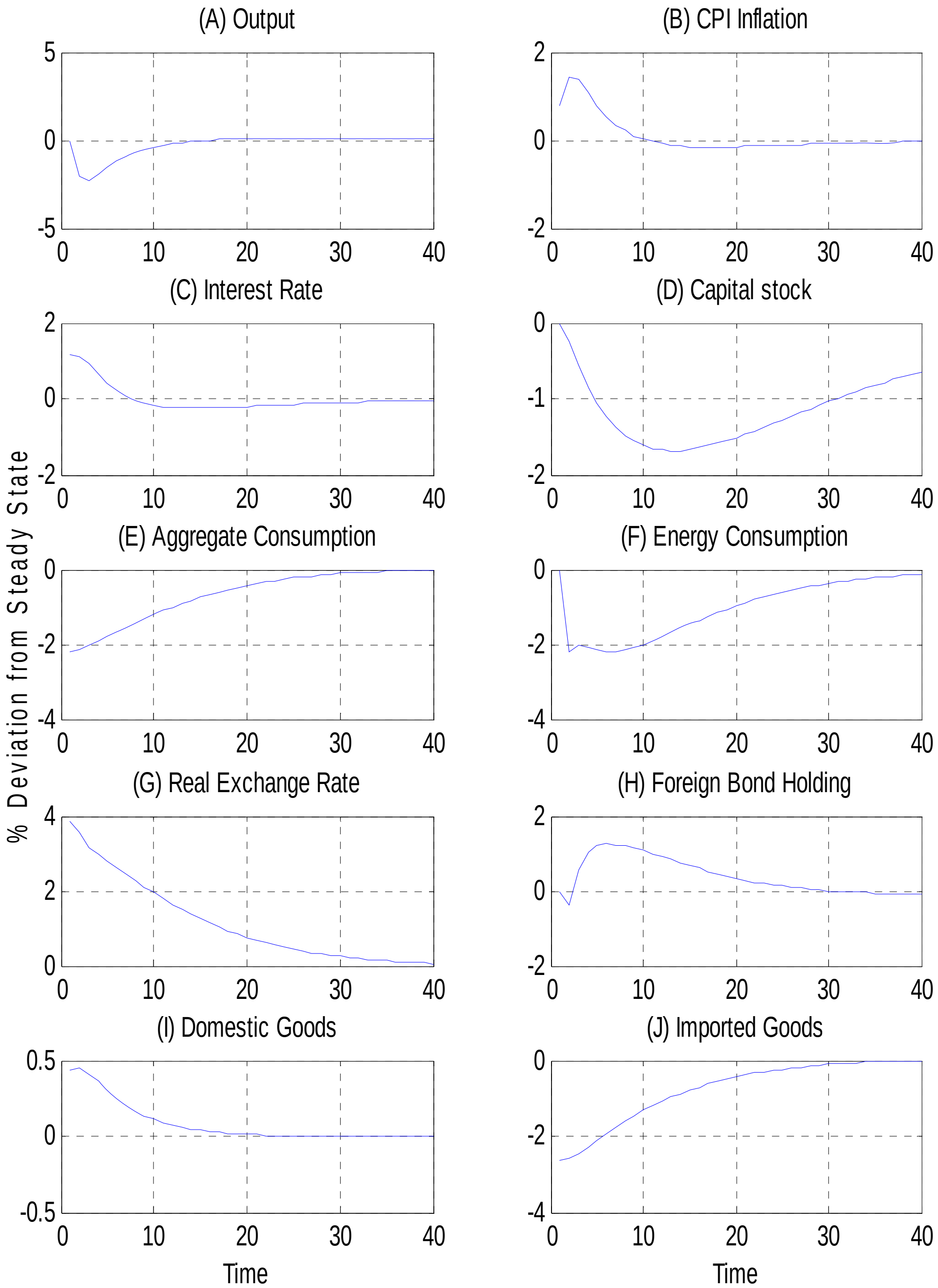


Figure 5.4

Impulse Response: A Case of the High Weight on the Past Value of Aggregate Demand ($\beta_y = 0.8$)