The Causes of Recent Inflation in Vietnam: Evidence from a VAR with Sign Restrictions

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First version: Jan, 2011. This version: May, 2011.

(Preliminary. Comments are welcome.)

Abstract

This paper studies the causes of high and chronic inflation in Vietnam in recent years using the structural VAR method identified by sign restrictions. The sign restrictions are drawn from a New Keynesian small open economy DSGE model built and calibrated to the data of Vietnam. Variance decomposition results show that supply shocks and demand shocks seem to explain a large part of inflation over the whole sample period, while the contribution of monetary shocks is smaller but not negligible. Historical decomposition results show that demand shocks and, to a lesser extent, monetary shocks seem to be the main determinants of inflation in the period 2004Q1-08Q3, while supply shocks appear to be more important in the period 2008Q1-10Q4.

Keywords: VAR, sign restriction, New Keynesian DSGE model, inflation, Vietnamese economy.

JEL codes: E32, F33, F41.

1. Introduction

High and somewhat persistent inflation has been one of the most challenging macroeconomic issues in Vietnam over the last few years with the rate being 8.3%, 23.1%, 5.9%, and 11.8% in the years 2007, 2008, 2009, and 2010, respectively, which is much higher than that in other neighboring East Asian countries in the same period. This has directly affected the lives of the people, especially the poor, and has raised a difficult task for the government who is struggling to maintain macroeconomic stability. A natural question arises as to what has caused this inflation. The likely determinants of the inflation that have been argued so far vary according to people and organizations that argued them. Government officers often blame factors such as the soaring prices of oil and other commodities in the world market, the prevalent of SARS, animal diseases and so on for the high inflation, while some economists argue that the inappropriate conduct of monetary and exchange rate policy of the monetary authority should have been the main causes. Some other people assert that expansionary fiscal policy in the form of huge investment in large state-owned firms should have played an

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important role. Most of the arguments, however, were made in the mass media in an informal way. To facilitate the discussion and provide some policy implications, this paper attempts to formally analyze the causes of inflation in Vietnam in recent years in both qualitative and quantitative aspects. To this end, I classify the determinants of inflation into supply, demand, and monetary shocks, and use a novel structural vector auto-regression (VAR) method to identify them from data on (real) GDP, the CPI and the real effective exchange rate (REER) of Vietnam. A popular method to identify shocks of the types noted above is the structural VAR approach developed by Blanchard and Quah (1989) in which shocks are identified by long run restrictions. In the literature, Clarida and Gali (1994) apply this approach in a three-variable VAR to identify supply, demand, and monetary shocks from GDP, CPI, and REER data. They impose restrictions, which are that in the long run monetary shocks have no effects on GDP and the REER, and demand shocks have no effect on GDP, based on a stochastic open macro model with stick prices developed by Obstfeld (1985) in the sprit of traditional Keynesian macroeconomics.[2] Two problems of this approach can be pointed out. First, impulse responses obtained are often not consistent with the theory used. For example, the theoretical model suggests that a favorable supply shock should reduce the price level, but we observe the opposite in the impulse response functions (IRFs) of the VAR in many cases. This problem can happen because the method does not impose any restriction on the IRFs. The second problem is that the restriction that demand shocks have no effect on output in the long run may be unreasonable and is not consistent with the now more popular DSGE models (of either New Keynesian or RBC type).[3] Consider the case of a fiscal policy shock, an important demand shock. In a general equilibrium framework in which the budget constraint of the government is specified explicitly, a permanent increase in government spending can have a long run effect on GDP because it would necessarily require an increase in taxes, which in turn reduces permanent income of households, and households seeking to sooth out their consumption will react by increasing their labor supply, and thus output increases. This feature can be observed in a standard DSGE model. Moreover, if government spending is used to build public physical capital (as in Baxter and King, 1993), or human capital, or to promote technological progress as often observed in reality,[4] it can affect the supply side of the economy. This is another channel through which a fiscal policy shock might have long run effects on GDP.

To overcome these problems, I utilize the structural VAR method using sign restrictions developed by Uhlig (2005). I build a New Keynesian DSGE model of a small open economy, calibrate and

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[2] Bayoumi and Eichengreen (1993) use a bivariate VAR to identify supply and demand shocks from GDP and the CPI data. They derive the long run restriction that demand shocks have no effects on GDP in the long run based on the AD-AS model. Many subsequent studies use either two- or three-variable VAR with similar restrictions.

[3] Note that for a three-variable VAR, the Blanchard-Quah VAR method requires exactly three long run restrictions to identify structural shocks, and it cannot be implemented without one of the restrictions.

[4] For example, the government spends its budget to build roads and dams, to subsidy job training, or to promote R&D and the adoption of new technologies.

simulate it to the Vietnamese data to obtain the IRFs of GDP, the CPI, and the REER to structural shocks, and then use them to impose sign restrictions on the IRFs in the VAR to identify the three structural shocks. Thus the method I use here produces the IRFs that are consistent with the theoretical model that I base on, and it avoids imposing the unreasonable long run restriction noted above. Having identified the structural shocks, I conduct the variance decomposition and the historical decomposition to analyze the role of each shock in causing inflation in Vietnam.

The rest of the paper is organized as follows. Section 2 presents an overview of inflation in Vietnam in recent years. Section 3 describes the theoretical model from which the IRFs are derived and used to impose sign restrictions. Section 4 explains the structural VAR method using sign restrictions. Section 5 explains the data and section 6 analyzes the results. The final section concludes.

2. An overview of inflation of Vietnam in recent years

Figure 1 shows the annual rates of inflation and growth in Vietnam in the period 1996-2000. It can be seen that during the Asian currency crisis and several years that followed both inflation and growth slowed down. After the year 2000 growth recovered quickly and stayed high until the year 2007, while inflation turned negative in the two years 2000 and 2001 (the deflationary period) and remained under 5% until 2003. After the year 2004 inflation got above 5%, accelerated further and hit the peak of 23.1% in 2008. In the year 2009, with the macroeconomic policy tightened to fight inflation and the effects of the world economic crisis, both inflation and growth started to slow down again. The year 2010 saw a resurgence of inflation which reached 11.8%, the second highest in the last fifteen years in Vietnam.

Figure 2 provide a comparison of inflation between Vietnam and its neighboring countries in the period 2005-10. We observe that the inflation rate of Vietnam was always considerably higher than those of most other Asian countries. This is especially true for the period 2007-09. Simple calculations show that the average inflation rate of the neighboring Asian countries for the period 2005-10 is 4.1% while that of Vietnam is as high as 10.5%.

We conclude this section by stating that a quick look at the data tells us that inflation in Vietnam has been high and persistent over the last few years. In subsequent sections we proceed to answer the question raised at the beginning: what have been the determinants behind this inflation phenomenon.

3. A theoretical model

3.1 The model

In this section we build a New Keynesian DSGE model of a small open economy, which will be used to study how an open economy like that of Vietnam would respond to various types of shocks. The model is borrowed from my previous work (Vu, 2011), and is a variant of the one developed in Shioji, Vu, and Takeuchi (2009) with the main difference being that the production structure of the economy is revised to be more suitable for the Vietnamese economy. There are four types of firms in this economy, and hereafter we shall call them (and the sector to which they belong) *N*, *I*, *M*, and *X* firms. *N* firms produce a homogenous final good by combining domestic and imported intermediate goods. *I* firms are domestic intermediate goods producers, and *M* firms are importers of foreign intermediate goods. *X* firms are exporters which produce goods and sell exclusively to the foreign market. In the short run, firms in sectors *I*, *M*, and *X* might face sticky prices. Price stickiness is introduced in the form of the Rotemberg-type quadratic price adjustment cost, and is meant to give a role for monetary policy in affecting the real side of the economy. Moreover, price stickiness in sectors *M* and *X* is meant to capture the possibly incomplete and slow pass through of the nominal exchange rate to import and export prices, which will be important to the dynamics of macro variables in response to shocks. On the invoicing currency used in international trade, considering the case of an emerging country like Vietnam, it is reasonable to assume that exported and imported prices are invoiced in the foreign currency. This corresponds to the case of local currency pricing (LCP) on the export side and producer currency pricing (PCP) on the import side.

Households

Households in the economy live infinitely and are distributed in the range [0,1]. They work, consume goods, pay taxes to the government, and save in the form of holding money and bonds using their wage income and dividends received from domestic firms which they own. They derive utility from consuming goods and holding money, and disutility from working. The expected life-time utility of a representative household is

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u_t (C_t, L_t, M_t / P_t), \tag{1}$$

where E_t denotes expectation at time *t*, β is the subjective discount factor, and C_t, L_t, and M_t / P_t are consumption, work hours, and real money holdings, respectively. The period utility is specified as

$$u_t(C_t, L_t, M_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \omega_l \frac{L_t^{1+\phi}}{1+\phi} + \omega_m \frac{(M_t / P_t)^{1-\chi}}{1+\chi}, \tag{2}$$

where σ is the inverse of the intertemporal elasticity of substitution, ϕ is the inverse of Frisch labor supply elasticity, and ω_l and ω_m are the weights placed on disutility from labor and utility from money holdings, respectively. The budget constraint of the household is

$$M_t + B_t + S_t B_t^* = (1+i_{t-1}) B_{t-1} + (1+i_{t-1}^*) S_{t-1} B_{t-1}^* + M_{t-1} + W_t L_t + \Pi_t - P_t C_t - T_t. \tag{3}$$

Here M, B, S, P, W, Π, T, and i stand for money holdings, bond holdings, the nominal exchange rate (the home currency price of one unit of foreign currency), the price level, the nominal wage rate, profits from firms, the lump-sum tax paid to the government, and the nominal interest rate, respectively. Here we assume that there are two kinds of nominal bonds, one denominated in the home currency and traded only domestically (B), and one denominated in the foreign currency and

traded internationally (B^*), with the corresponding interest rates i and i^*, respectively.
The household seeks to maximize the expected life-time utility function in (1) subject to the budget constraint (3) and the period utility specified in (2). Solving this maximization problem yields the following results.

$$\beta E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} (1+i_t) = 1 \tag{4}$$

$$1+i_t = E_t (1+i_t^*) \frac{S_{t+1}}{S_t} \tag{5}$$

$$W_t / P_t = \omega_l L_t^{\phi} C_t^{\sigma} \tag{6}$$

$$\frac{M_t}{P_t} = \left(\omega_m \frac{1+i_t}{i_t} C_t^{\sigma} \right)^{1/\chi} \tag{7}$$

Here, (4) is the Euler equation, (5) is the uncovered interest rate parity condition, (6) is the labor supply function, and (7) is the money demand function.

Final good firms *(N* firms)

We assume that sector *N* is perfectly competitive. *N* firms are distributed in the interval [0,1]. They use *I* goods and *H* goods (described below) as intermediates to produce a homogenous good which is consumed by domestic households and the government. The production function of a firm *n* in sector *N* is assumed to take the following CES functional form

$$Y(n) = \left[\alpha^{1/\theta} \int_0^1 Y(n,i)^{(\theta-1)/\theta} di + (1-\alpha)^{1/\theta} \int_0^1 Y(n,m)^{(\theta-1)/\theta} dm \right]^{\theta/(\theta-1)}, \tag{8}$$

where $Y(n,i)$ and $Y(n,m)$ are the quantities of an *I* good and an *M* good used as inputs for the production of firm *n*, θ is the elasticity of substitution between these inputs, and α is a weight parameter. Prices of *N* goods are assumed to be flexible. Firm *n* seeks to maximize its profit taking the prices of its output and inputs as given

$$\max_{\{Y_t(n,i), Y_t(n,m)\}} \Pi_t(n) \equiv P_t Y_t(n) - \int_0^1 P_t(i) Y_t(n,i) di - \int_0^1 P_t(m) Y_t(n,m) dm \text{, s.t. (8).}$$

Solving this maximization problem yields the demand of firm *n* for each of the intermediate goods *i* and *m* as follows

$$Y_t(n,i) = \alpha \left[\frac{P_t(i)}{P_t} \right]^{-\theta} Y_t(n) \text{,} \tag{9}$$

$$Y_t(n,m) = (1-\alpha) \left[\frac{P_t(m)}{P_t} \right]^{-\theta} Y_t(n) \text{.} \tag{10}$$

Domestic intermediate goods firms (*I* firms)

We model sector *I* as monopolistically competitive with *I* firms are distributed in [0,1], and each of them uses labor as the only input to produce a differentiated nontradable good which is then used as intermediate for the production of *N* goods. A firm *i* in sector *I* uses labor as the only input for its production, and its production function is linear in labor

$$Y_t(i) = A_{I,t} L_t(i), \tag{11}$$

where $A_{I,t}$ is the labor productivity (or TFP) of sector *I*, which is the same for all *I* firms and is given exogenously.

The demand for the good of firm *i* is the aggregation of demands from all *N* firms as in (9):

$$Y_t(i) = \int_0^1 Y_t(n,i)dn = \alpha \left[\frac{P_t(i)}{P_t}\right]^{-\theta} \int_0^1 Y_t(n)dn = \alpha \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_{N,t}. \tag{12}$$

Firm *i* faces the following Rotemberg-type quadratic per-unit adjustment cost measured in the units of the final good when it changes its price

$$acp_t(i) = \frac{\psi_I}{2} \cdot \frac{\left[P_t(i) - P_{t-1}(i)\right]^2}{P_t \cdot P_{t-1}(i)}, \tag{13}$$

where ψ_I is the parameter governing the size of the price adjustment cost and thus the degree of price stickiness in sector *I*. The larger is ψ_I, the more sticky are prices in sector *I*. The profit of firm *i* in period *t* is

$$\Pi_t(i) = P_t(i)Y_t(i) - W_t L_t(i) - P_t acp_t(i) Y_t(i). \tag{14}$$

The profit maximization problem of firm *i* is

$$\max_{\{P_t(i)\}} V_t(i) \equiv E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\prod_{s=t}^{\tau} \left(1+i_s\right)^{-1}\right] \Pi_\tau(i), \text{ s.t. (11)~(14).}$$

Solving this maximization problem gives the following optimal price setting of the firm

$$P_t(i) = \frac{\theta}{\theta-1}\frac{W_t}{A_{I,t}} + \frac{\theta}{\theta-1}\frac{\psi_I}{2}\frac{\left[P_t(i)-P_{t-1}(i)\right]^2}{P_{t-1}(i)} - \frac{\psi_I P_t(i)}{\theta-1}\left[\left(\frac{P_t(i)}{P_{t-1}(i)}-1\right) - \frac{1}{2}E_t\left(\frac{1}{1+i_t}\frac{P_{t+1}(i)^2 - P_t(i)^2}{P_t(i)^2}\frac{Y_{t+1}(i)}{Y_t(i)}\right)\right]. \tag{15}$$

Note that in the absence of the price adjustment cost (i.e. ψ_I =0), (15) reduces to the conventional pricing equation of a monopoly: firm *i* will set its price as a markup over its marginal cost $W_t / A_{I,t}$.

Exporters (*X* firms)

X firms are monopolistically competitive exporters and are distributed in [0,1]. Each of these firms produces a differentiated good and sells exclusively to foreigners. Their production function is assumed to be linear in labor input as follows

$$Y_t(x) = A_{X,t} L_t(x) \tag{16}$$

where $A_{X,t}$ is the exogenous TFP of sector *X* and is the same for all *X* firms. The demand faced by firm *x* is

$$Y_t(x) = P_t^*(x)^{-\theta_X} Y_{F,t}. \tag{17}$$

Here $P_t^*(x)$ is the price of firm *x* denominated in the foreign currency, θ_X is the price elasticity of demand for *X* goods, and $Y_{F,t}$ is the foreign aggregate demand which is given exogenously. Firm *x* denominates its price in the foreign currency and faces a price adjustment cost when it changes this price. The per-unit price adjustment cost faced by firm *x* and its profit are

$$acp_t(x) = \frac{\psi_X}{2} \cdot \frac{\left[P_t^*(x) - P_{t-1}^*(x)\right]^2}{(P_t / S_t) \cdot P_{t-1}^*(x)}, \tag{18}$$

$$\Pi_t(x) = S_t P_t^*(x) Y_t(x) - W_t L_t(x) Y_t(x) - P_t acp_t(x) Y_t(x). \tag{19}$$

Solving this maximization problem

$$\max_{\{P_t(x)\}} V_t(x) \equiv E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\prod_{s=t}^{\tau} (1+i_s)^{-1}\right] \Pi_\tau(x), \text{ s.t. (16)~(19),}$$

gives us the following optimal price setting of firm *x*

$$\begin{aligned} P_t^*(x) = {} & \frac{\theta_X}{\theta_X - 1} \frac{W_t / A_{X,t}}{S_t} + \frac{\theta_X}{\theta_X - 1} \frac{\psi_X}{2} \frac{\left[P_t^*(x) - P_{t-1}^*(x)\right]^2}{P_{t-1}^*(x)} \\ & - \frac{\psi_X P_t^*(x)}{\theta_X - 1} \left[\frac{P_t^*(x) - P_{t-1}^*(x)}{P_{t-1}^*(x)} - \frac{1}{2} E_t \left(\frac{1}{1+i_t} \frac{P_{t+1}^*(x)^2 - P_t^*(x)^2}{P_t^*(x)^2 S_t / S_{t+1}} \frac{Y_{t+1}(x)}{Y_t(x)} \right) \right]. \end{aligned} \tag{20}$$

Importers (*M* firms)

M firms are monopolistically competitive importers and are distributed in [0,1]. They buy foreign goods and sell them to *N* firms as intermediates. A firm m in sector M imports a differentiated foreign good with the price $P_{M,t}^*(m)$ denominated in the foreign currency. We assume that $P_{M,t}^*(m) = P_{M,t}^*$ for all *m* with $P_{M,t}^*$ being determined exogenously. The demand faced by the firm is the aggregation of demands from all *N* firms as in (10):

$$Y_t(m) = \int_0^1 Y_t(n,m) dn = \alpha \left[\frac{P_t(m)}{P_t}\right]^{-\theta} \int_0^1 Y_t(n) dn = (1-\alpha) \left[\frac{P_t(m)}{P_t}\right]^{-\theta} Y_{N,t}. \tag{21}$$

The per-unit price adjustment cost faced by firm *m* and its profit are

$$acp_t(m) = \frac{\psi_M}{2} \cdot \frac{\left[P_t(m) - P_{t-1}(m)\right]^2}{P_t \cdot P_{t-1}(m)}, \tag{22}$$

$$\Pi_t(m) = P_t(m) Y_t(m) - S_t P_{M,t}^*(m) Y_t(m) - P_t acp_t(m) Y_t(m). \tag{23}$$

Solving the maximization problem

$$\max_{\{P_t(m)\}} V_t(m) \equiv E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\prod_{s=t}^{\tau} (1+i_s)^{-1}\right] \Pi_\tau(m), \text{ s.t. (17)~(20),}$$

yields the following optimal price setting of of firm *m*

$$\begin{aligned} P_t(m) = {} & \frac{\theta}{\theta - 1} S_t P_{M,t}^* + \frac{\theta}{\theta - 1} \frac{\psi_M}{2} \frac{\left[P_t(m) - P_{t-1}(m)\right]^2}{P_{t-1}(m)} \\ & - \frac{\psi_M P_t(m)}{\theta - 1} \left[\left(\frac{P_t(m)}{P_{t-1}(m)} - 1 \right) - \frac{1}{2} E_t \left(\frac{1}{1+i_t} \frac{P_{t+1}(m)^2 - P_t(m)^2}{P_t(m)^2} \frac{Y_{t+1}(m)}{Y_t(m)} \right) \right]. \end{aligned} \tag{24}$$

The price adjustment cost parameter ψ_M affects the degree of pass-through of exchange rate changes to import prices (denominated in the home currency). If $\psi_M = 0$, the cost of adjusting price is zero, $P_t(m)$ moves one-to-one with changes in the exchange rate, and the pass-through rate is 100%. In a more realistic case ψ_M is positive, and if ψ_M is large, exchange rate pass-through will be slow and incomplete in the short run.

The government

The government collects taxes from households, consumes *N* goods and controls money supply. We assume that the government does not issue bonds, and thus its budget constraint is as follows

$$M_t - M_{t-1} + T_t = P_t G_t . \tag{25}$$

Note that with infinite horizon and dynamically optimizing agents specified in this model, the Ricardian equivalence holds, that is, it does not matter whether an increase in government spending is financed by raising tax or by issuing government bonds. Thus introducing government bonds will not change the basic results below.

Market clearing conditions

Final goods market is in equilibrium when demand for them from households and the government equals the supply of them by *N* firms:

$$Y_{N,t} = C_t + G_t . \tag{26}$$

The labor market is competitive, and labor is freely mobile across sectors domestically, but not internationally. Labor market is in equilibrium when labor demand from *I* and *X* firms equals labor supply by households:

$$L_t = \int_0^1 L_t(i)di + \int_0^1 L_t(x)dx . \tag{27}$$

In the market for bonds, because *B* is traded only domestically, in equilibrium its amount is zero. We assume that the interest rate of bonds denominated in the foreign currency is related to a constant world interest rate i^W through the uncovered interest rate parity condition with a risk premium term

$$i_t^* = i^W + \psi[\exp(-S_t B_t^* / P_t Y_t) - 1] . \tag{28}$$

The risk premium is assumed to depend on the net foreign asset position (as ratio to nominal GDP) of the home country. If the home country borrows from abroad (so $-B_t^* > 0$ is the amount of external debt), it has to pay a higher interest rate to foreigners. The introduction of the risk premium is to obtain stationarity of the model as suggested by Schumitt-Grohe and Uribe (2003). In addition, real GDP, measured in final goods units and denoted by *Y*, is defined as

$$Y_t = Y_{N,t} + (P_{X,t} Y_{X,t} - S_t P_{M,t}^* Y_{M,t}) / P_t . \tag{29}$$

3.2 Solving the model, simulation and results

I use Dynare to solve and simulate the model. Given the 19 equations (3)~(11), (15)~(17), 20, and

(24)~(29) the exogenous variables M, G, A_X, A_I, and P_M^*, it is possible to solve for the steady state and the dynamics of the following 19 endogenous variables Y, C, T, B^*, i, i^*, P, S, W, L, Y_N, Y_I, Y_M, Y_X, L_I, L_X, P_I, P_M, and P_X^* in response to changes in the exogenous variables. Since the endogenous variables enter the reduced form VAR model (described in the next section) in first difference form, meaning that a structural shock in the VAR can have permanent effects on the *level* of the endogenous variables, I confine the simulation below to the case of *once-and-for-all* shocks in the theoretical model. In order to simulate the model, first we need to assign a specific value to each of the parameters.

Setting parameters

The model is calibrated to the data of Vietnam taken from the Asian Development Bank's Key Indicators for Developing Asian and Pacific Countries (ADB, 2010). The second column of Table 1 shows the structure of aggregate demand and external debt of Vietnam. Two noteworthy points are that Vietnam appears to be a highly open economy with trade being roughly one and a half GDP, and that the external debt-GDP ratio is as high as 0.37. The third column of Table 1 shows the values actually used in simulation after excluding investment, and adjusting so that in the steady state the home country is owing some debt to the foreign country, but it is also running a trade account surplus in order to pay exactly the debt service so that the debt-GDP ratio is kept constant. With these data, it is possible to pin down the basic structure of the model economy. Other parameters are set as shown in Table 2. Most of the values are quite standard in the literature, see for example Devereux, Lane, and Xu (2006). The subjective discount factor is 0.985 which implies an annum interest rate of 5.8% of the home country at the steady state. This, the debt-GDP ratio in Table 1, and the world interest rate imply a value of 0.011 for the debt elasticity of risk premium parameter. The coefficients on price adjustment costs are set to be 120, but we will consider several different values of ψ_M in the simulation below to see how the response of the economy to shocks is sensitive to the pass-through of the exchange rate changes to import prices.

Effects of various types of shocks

Figure 3 presents the effects of a permanent increase in the money stock. As expected, in the short run, we observe a rise in inflation, a depreciation of the home country currency in both nominal and real terms, and an increase in GDP and consumption. Imports increases because of the increase in GDP, which dominates the increase in exports (due to the depreciation) causing a fall in the trade account. The more sticky are import prices, the more GDP increases. In the long run, the monetary shock has no effects on GDP and the real exchange rate.

Figure 4 shows the effects of a permanent increase in government spending. We could see that in the short run the shock raises GDP and inflation, while reduces consumption because households have to pay more tax and thus have less permanent income. The effects on the nominal exchange and the RER are ambiguous, a result which is also pointed out in Shioji, Vu, and Takeuchi (2011). Using a New Keynesian open economy model with an overlapping generations (OLG) structure, these authors show that the response of the nominal exchange (and thus the real exchange rate) are sensitive to such factors as the myopia of agents, the degree of price stickiness and monetary policy rule. In the long run, GDP increases because households increase their labor supply in order to smooth out consumption which is reduced by the shock. This last result is inherited from the RBC model, and is in stark contrast with the traditional Keynesian view in which it is considered that demand shocks have no effects on output in the long run.

Figures 5 and 6 show the effects of an increase in the TFP of the export sector and the domestic intermediate goods sector. We could see that qualitatively the two TFP shocks have quite similar effects in both the short run and long run: GDP and consumption go up while inflation and labor go down. The difference between the effects of the two shocks lies in the responses of the nominal and real exchange rate: a rise in TFP of the export sector causes an appreciation of the home currency in both nominal and real terms, while a rise in TFP of the (nontradable) domestic intermediate goods sector causes a depreciation. Consider the case of the long run, this latter result is intuitive if we recall the well known Balassa-Samuelson effects.

The effects of a fall in the import price denominated in the foreign currency is presented in Figure 7. In response to the shock, inflation and the price level fall because imported intermediates are now cheaper. GDP and consumption increase, and the nominal and real exchange rate both depreciate.

Based on the above results and discussion, Table 3 summarizes the signs of the IRFs of GDP, the price level, and the real exchange rate, the three variables which enter the VAR model below. We classify the five shocks discussed above into three types, namely monetary, demand, and supply shocks. The shaded areas in this table mean that the signs there are used to impose on the IRFs in the VAR to identify structural shocks. Note that these sign restrictions are sufficient to distinguish between the three shocks. The long run restrictions on GDP and the real exchange rate help to distinguish a monetary shock with the other two types, while the sign restrictions on the price level help to distinguish between a demand shock and a supply one. The unshaded areas mean that the signs there are not imposed on the IRFs, but rather left open in the VAR.

4. Procedure to identify structural shocks in a VAR with sign restrictions

Based on Uhlig (2005), I follow the steps below to identify the three types of structural shocks.

<u>Step 1</u>: Estimate a three-variable reduced-form VAR as follows,

$$x_t = B_0 + B_1 x_{t-1} + B_2 x_{t-2} + ... + B_p x_{t-p} + u_t \qquad (1),$$

where $x_t = (\Delta \log GDP_t, \Delta \log CPI_t, \Delta \log REER_t)'$, t denotes quarter t, B_s ($s = 1,..., p$) are coefficient matrices of size 3×3, p is the lag length, and u_t is a 3×1 vector of residuals with the variance-covariance matrix denoted by Σ. The endogenous variables are in first-order log-differences to ensure stationarity. Assume that there are three types of structural shocks, namely supply, demand, and monetary ones, and A is the matrix that relates the residuals vector and the structural shocks vector (ε_t), that is, $u_t = A\varepsilon_t$.

Step 2: Use the sign restrictions in Table 3 to impose on the IRFs of the three endogenous variables to the three structural shocks. The short run is defined as $t = 0,..., n_{SR}$, while the long run (LR) is defined as $t > n_{LR}$, where t is the number of periods after the shock occurs.

Step 3: Based on the estimated matrices $\hat{\Sigma}$ and $\hat{B}$ obtained in step 1, randomly generate Σ from the inverse Wishart distribution $invW(\hat{\Sigma}^{-1}/T, T)$ with T being the sample size, and conditional on Σ, randomly generate B's column-wise vectorized form $vec(B)$ from the Normal distribution $N(vec(\hat{B}), \Sigma \otimes (X'X)^{-1})$ with X being the data matrix.

Step 4: For each draw (B, Σ) generated in step 3, randomly generate a large number (n_A) of matrix A using $A = A_0 Q$ where A_0 is the Cholesky decomposition of Σ, and Q is an orthonormal matrix obtained by Q-R decomposing a matrix randomly generated from $N(0,1)$.

Step 5: For each draw (B, Σ, Q), calculate the *accumulated* IRFs[5] of GDP, CPI, and REER to supply, demand, and monetary shocks, and check if the signs of these IRFs are consistent with those imposed (as in Table 3) or not. If they are, call the draw (B, Σ, Q) a valid draw and use it to compute the series of the three shocks from data and store them. Otherwise, discard the draw (B, Σ, Q).

Repeating steps 2 through 5 many times we obtain a certain number of valid draws, n_{valid}, and a set of the matrices B and Σ, and structural shocks, which are then used compute the variance decomposition and the historical decomposition of inflation.[6]

In the analysis below, I set $n_{SR} = 6$, $n_{LR} = 80$, $n_{valid} = 300$, and $n_A = 200$ for all countries.[7] Given these last two parameters, $n_{\Sigma B}$ becomes "endogenous". In addition, the lag length is chosen $p = 3$, following the Schwarz information criterion.

5. Data

Quarterly data of real GDP, the CPI, and the REER are used in the VAR model. The sample period is 1999Q1-2010Q4. Real GDP and CPI data are taken from the CEIC database. REER data is not available publicly so I calculated using data of the trade partners of Vietnam and the data of the exchange rates between the dong and the currencies of the trade partners.[8] These data are also obtained from the CEIC database. Data on the trade weights used to calculate the REER are available from ADB (2010).

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[5] Because variables of the reduced-form VAR are in first-differences and the sign restrictions are imposed on *levels*.

[6] For an explanation of how to compute variance decomposition and historical decomposition, see Canova (2007).

[7] The 'zero' restriction is imposed such that the absolute value of the IRFs subject to this restriction must be smaller than 0.0001 in the long run.

[8] These exchange rates are calculated as the cross rates between the dong and the currencies of the trade partners of Vietnam vis-a-vis the US dollar.

6. Results and analysis

Figure 8 shows the responses of GDP, the CPI, and the REER to supply, demand, and monetary shocks in the structural VAR. We could confirm with Table 3 that the IRFs on which the sign restrictions are imposed are correctly produced. It is interesting to look at the other IRFs on which we do not impose the sign restrictions. Two things can be observed. First, the REER increases in response to a supply shocks, suggesting that, in the case of Vietnam, the supply shocks should be either shocks to the TFP of the intermediate goods sector or shocks to import prices. Second, in the presence of a demand shocks the REER decreases, this fact lends support to models with an OLG structure in which the home currency appreciates, rather than depreciates, in both nominal and real terms in response to a government spending shock, as discussed in Shioji, Vu, and Takeuchi (2011).

Table 4 shows the variance decompositions of inflation. We can see that at short horizons, such as 1 or 2 quarter, most of the inflation forecast error variances is explained by demand shocks and especially supply shocks, while the contribution of monetary shocks is negligible. At long longer horizons monetary shocks become more important, but demand and supply shocks remain to dominate. It is also worth noting that that the contribution demand shocks is stable across different horizons. This result might support the view that demand shocks such as increases in public spending are the main cause of recent inflation in Vietnam.

Figure 9 provides the historical decompositions of inflation in Vietnam over the last ten years. It is observed that in the deflation period 2000-01 monetary shocks appear to have the largest contribution. In the period 2004-07 when inflation became higher, demand shocks and, to a lesser extent, monetary shocks seem to be the main determinants, while supply shocks seem to work in the favorable direction to reduce inflation. In the year 2008, when inflation hit the peak of 23.1%, all three types of shocks are important determinants with supply shocks contributing slightly more in the second and third quarters of the year. In the period 2008Q4-10Q3 demand shocks turn negative which might reflect the tightened fiscal policy of the government to fight inflation. Monetary shocks are also negative in the first three quarters of the year 2009, which is consistent with the fact that monetary policy was also tightened in this period. In contrast, supply shocks are always positive in the period 2008Q4-10Q3, making inflation to be persistent. In the year 2010 monetary shocks turn positive, pushing up inflation.

7. Concluding Remarks

In this paper we use a structural VAR identified by sign restrictions to analyze the causes of recent inflation in Vietnam. The sign restrictions are drawn from a New Keynesian DSGE model which is built to capture several important aspects of the Vietnamese economy and is calibrated to the data of Vietnam. We find that supply shocks and demand shocks seem to explain a large part of inflation over the whole sample period, while the contribution of monetary shocks is smaller but not negligible. In addition, demand shocks (typically government spending shocks) and to a lesser extent monetary shocks seem to be the main determinants of inflation in the period 2004Q1-08Q3, while supply shocks appear to be more important in the period 2008Q1-10Q4 in causing high and persistent inflation. The results suggest that the Vietnamese government should pay more attention to demand factors, especially government spending, if it wishes to keep inflation at a stable and reasonable level.

So far we have considered three types of structural shocks in the VAR. With more endogenous variable, it is possible to increase the number of shocks and get more precisely what they are. It is also interesting to conduct similar studies for other Asian countries, which are also facing the inflation problem, to compare with the results of Vietnam. I leave these tasks for future work.

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Table 1: Structure of aggregate demand and external debt of Vietnam (average of 2000-2009)

Indicators (as ratio to GDP)	Actual data	Values used in simulation (after adjusting to be consistent with the steady state of the model)
private consumption	0.65	0.75
government consumption	0.06	0.24
gross domestic capital formation	0.36	-
exports of goods and services	0.66	0.694
imports of goods and services	0.74	0.689
external debt	0.37	0.37

Notes: In adjusting the actual data, investment by state-owned firms, which is a part of gross domestic capital formation, is added to government consumption using data from the GSO. In addition, the shares of exports and imports are revised such that in the steady state the home country is running a trade surplus to pay exactly the debt service.

Table 2: Parameter values set for simulation

Description	**Parameter**	**Value**
subjective discount factor	β	0.985
world annum interest rate	i^W	5.8%
weight of labor disutility	ω_l	1
weight of money holding in utility	ω_m	1
inverse of Frisch labor supply elasticity	ϕ	1
inverse of intertemporal elasticity of substitution	σ	2
parameter on the share of *I* goods in *N* goods	α	0.5
elasticity of substitution within *I&M* goods	θ	5
elasticity of substitution within *X* goods	θ_X	11
interest rate elasticity of money demand parameter	χ	5
debt elasticity of risk premium parameter	ψ	0.011
coefficient on price adjustment cost for *I* firms	ψ_I	120
coefficient on price adjustment cost for *M* firms (benchmark case)	ψ_M	120
coefficient on price adjustment cost for *X* firms	ψ_X	120
steady state TFP of *I* firms	A_I	1
steady state TFP of *X* firms	A_X	1

Table 3: Signs of IRFs to structural shocks drawn from the theoretical model

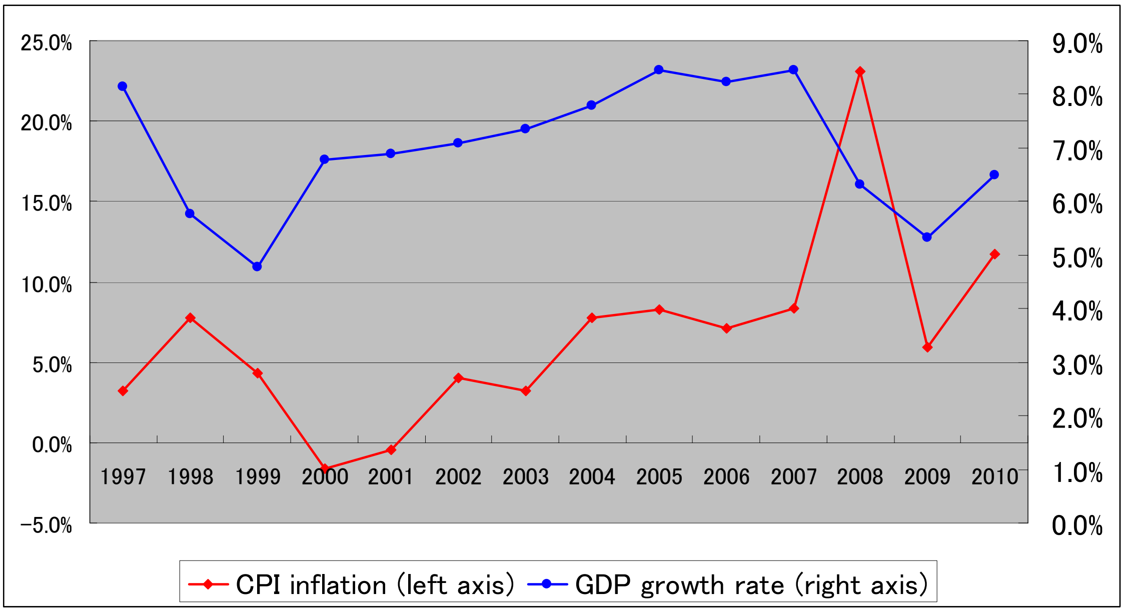
		GDP		Price level		Real exchange rate	
		SR	LR	SR	LR	SR	LR
Monetary shock (M)		+	0	+	+	+	0
Demand shock (Government spending shock)		+	+	+	+	?	?
Supply Shock	I-sector TFP shock	+	+	-	-	+	+
	X-sector TFP shock	+	+	-	-	-	-
	Foreign price shock	+	+	-	-	+	+
	Summary	+	+	-	-	?	?

Notes: The short run (SR) is defined as t=0,...,5, while the long run (LR) is defined as t > 80, where t is the number of periods after the shock occurs. A "?" means that the sign is ambiguous and thus is not used as restriction in the VAR. Shaded areas mean that the signs there are used to impose on the IRFs in the VAR model.

Table 4: Variance decompositions of inflation

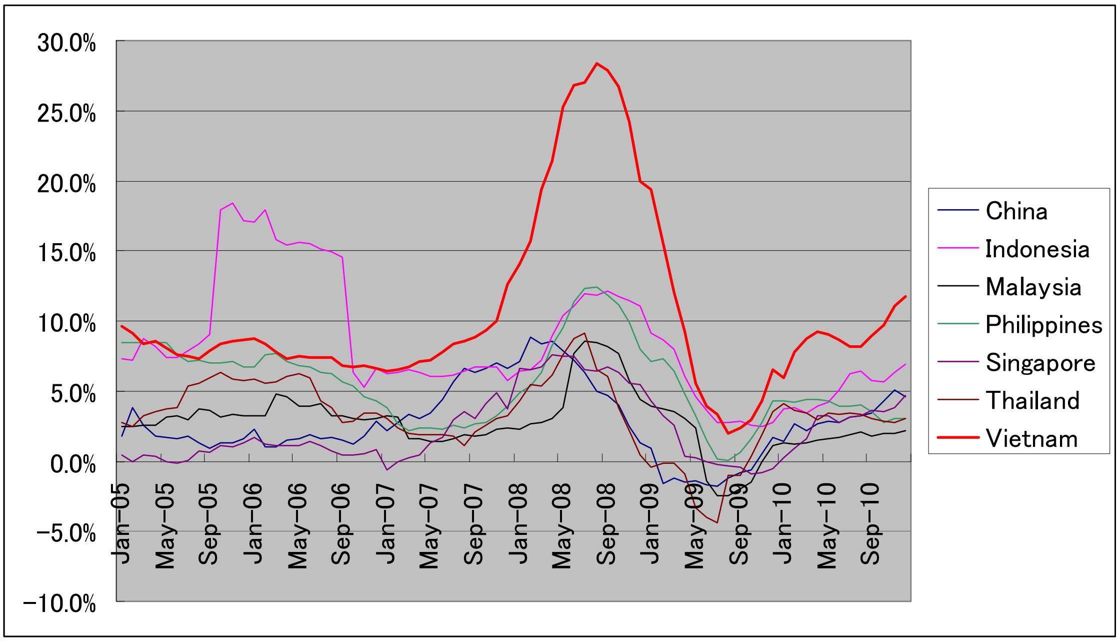
	Percent of inflation forecast error variances due to		
Quarter	Supply shock	Demand shock	Monetary shock
1	58.2	37.8	4.0
2	44.9	42.8	12.3
3	35.8	42.4	21.9
4	34.1	40.7	25.2
5	34.0	40.7	25.3
10	33.6	40.4	26.0
20	33.5	40.2	26.4

Figure 1: Annual rates of inflation and growth in Vietnam 1996-2010



Sources: ADB (2010).

Figure 2: Monthly inflation in Vietnam and its neighboring Asian countries 2005M1-2010M12



Sources: CEIC database.

Figure 3: Effects of an increase in money supply in the theoretical model

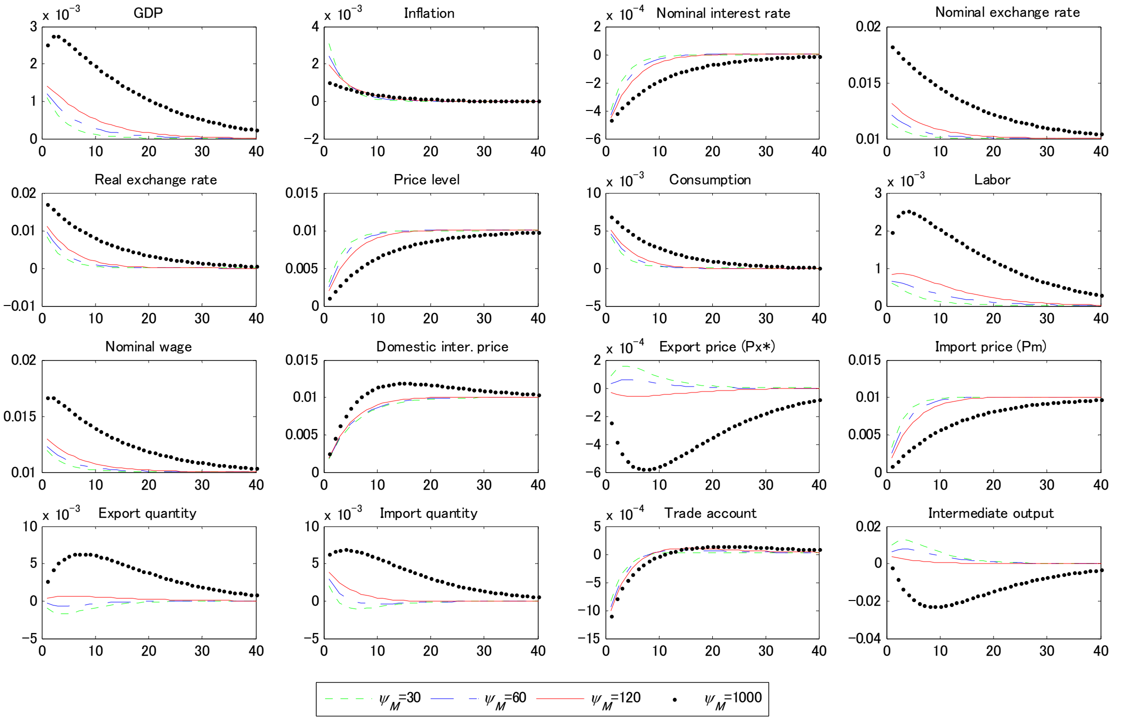


Figure 4: Effects of an increase in government spending in the theoretical model

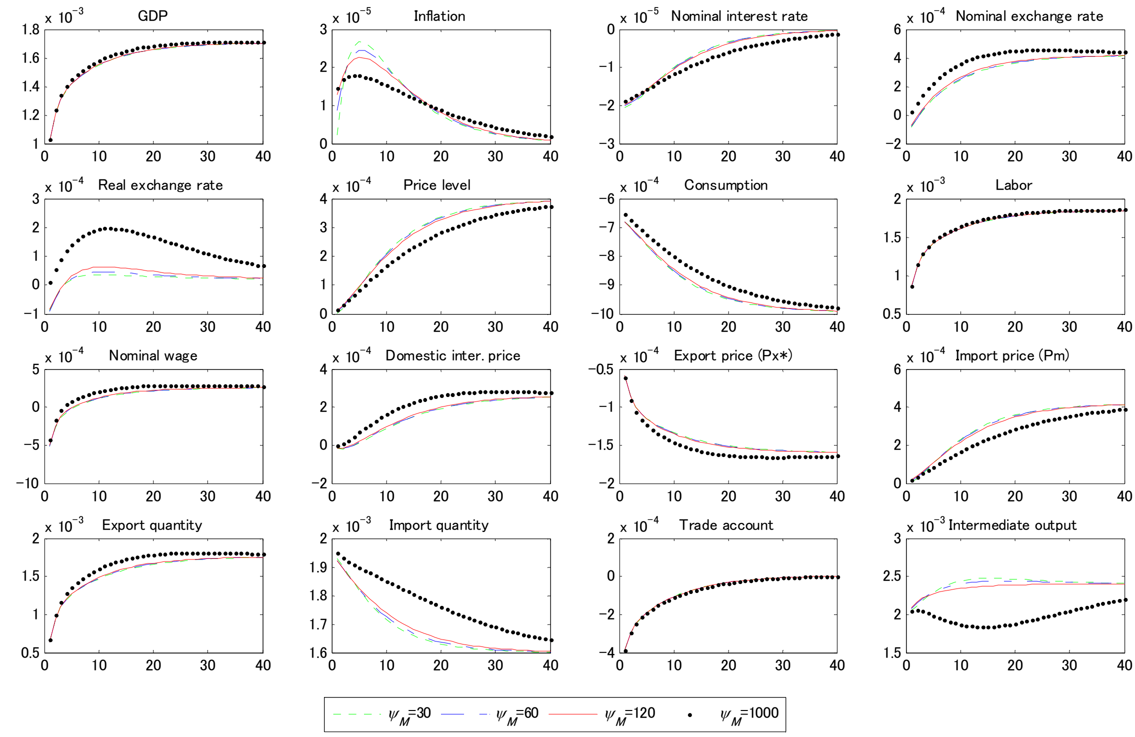


Figure 5: Effects of an increase in TFP of domestic intermediate sector in the theoretical model

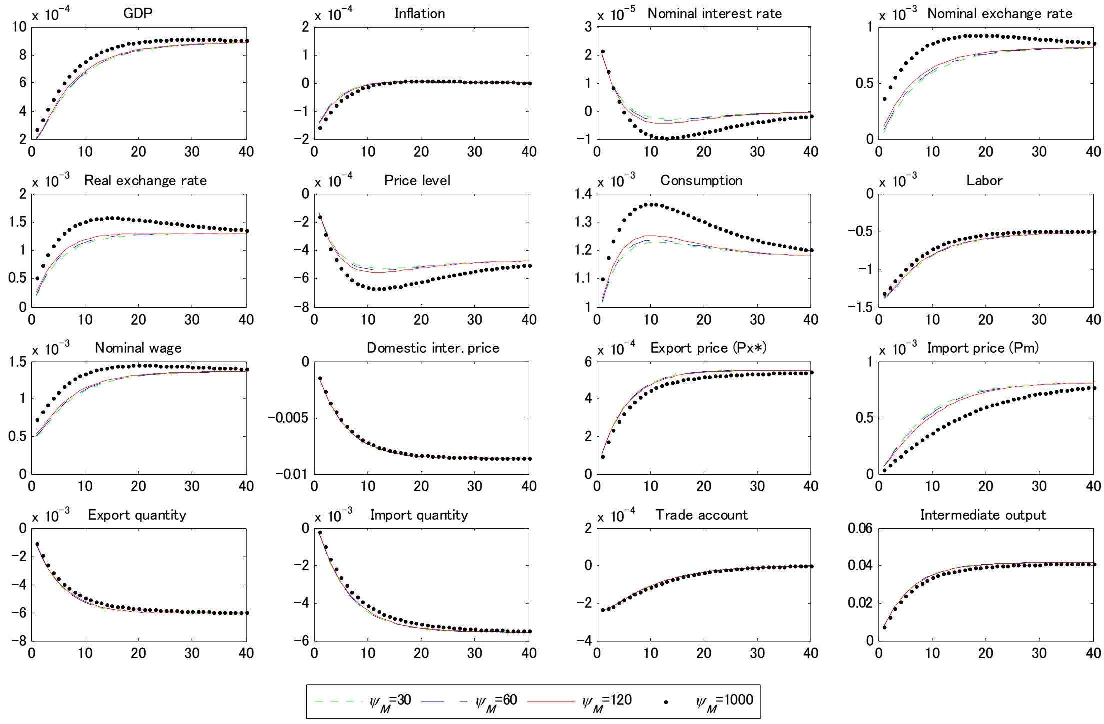


Figure 6: Effects of an increase in TFP of export sector in the theoretical model

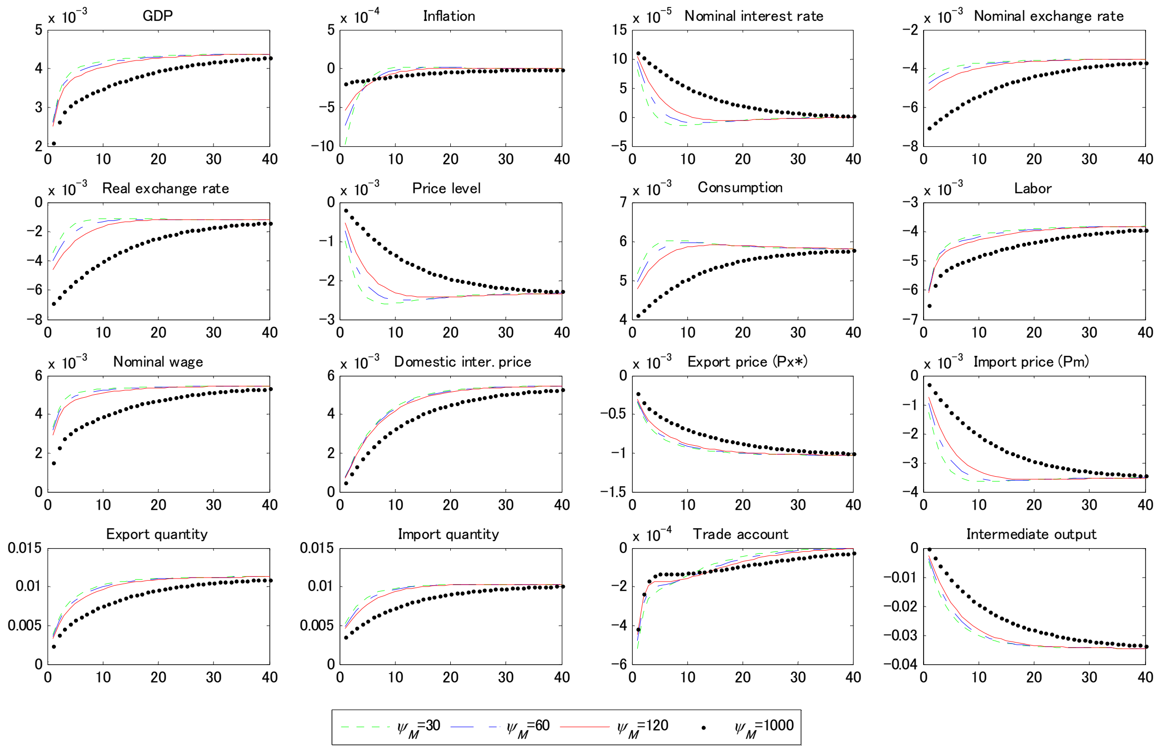


Figure 7: Effects of a *decrease* in import price in the theoretical model

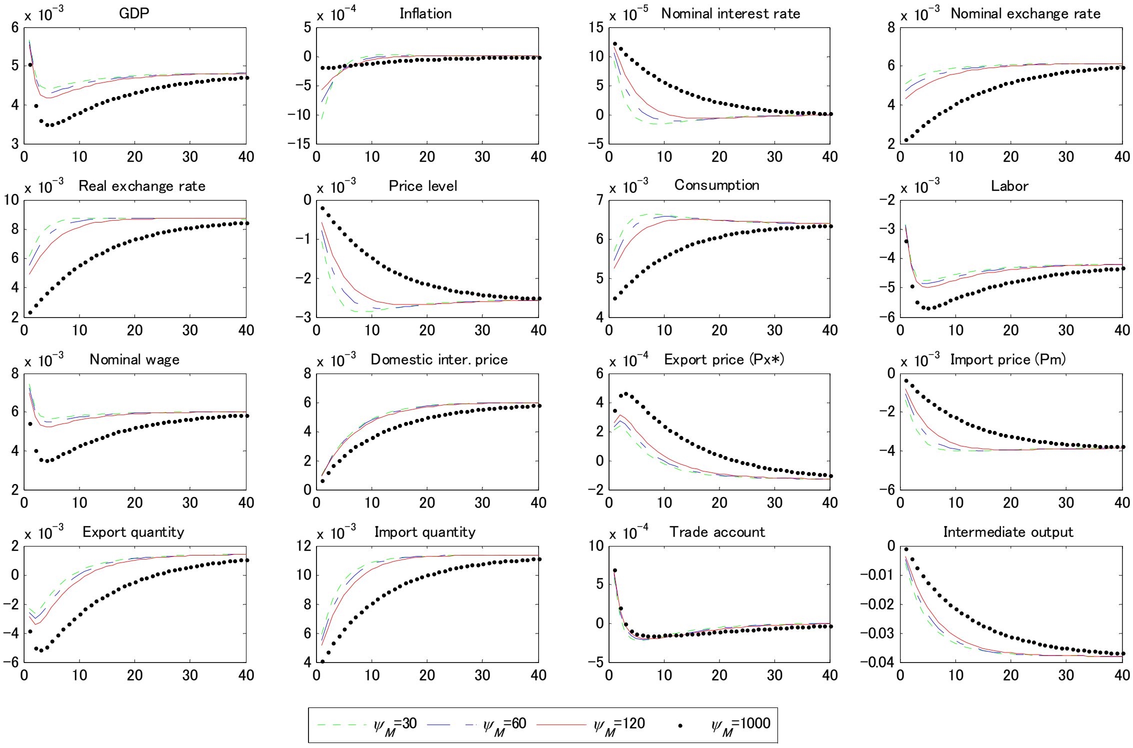
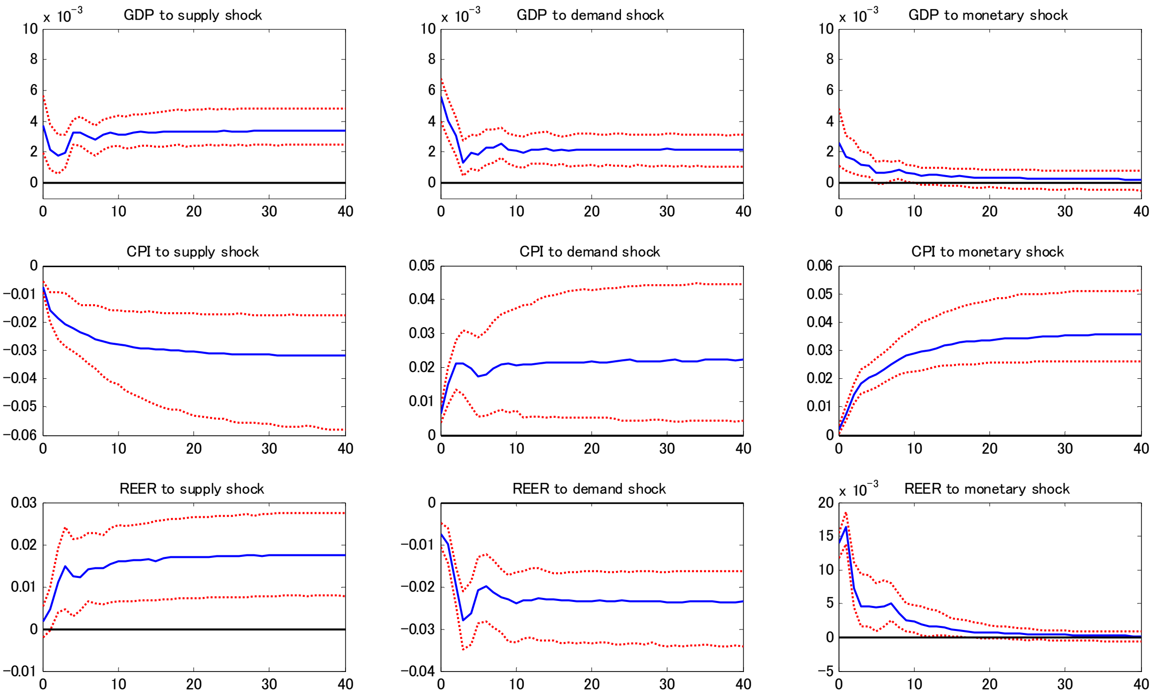


Figure 8: Responses of GDP, CPI, and REER to supply, demand, and monetary shock in the VAR model



Notes: Dashed lines are 16th and 84th quantiles, while solid lines are 50th quantiles.

Figure 9: Historical decompositions of structural shocks to inflation in Vietnam 2000-2010