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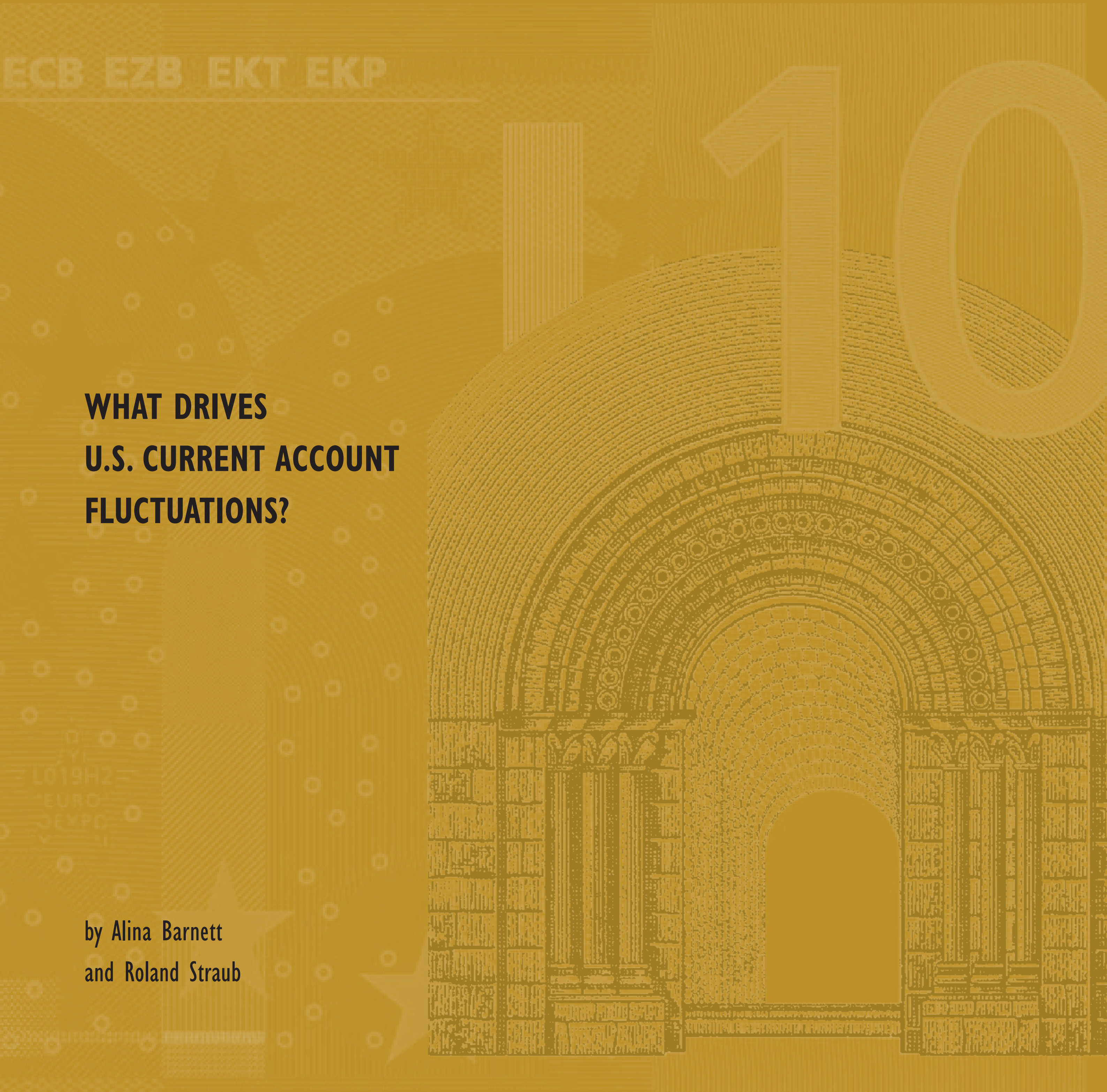

WHAT DRIVES U.S. CURRENT ACCOUNT FLUCTUATIONS?

by Alina Barnett
and Roland Straub

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In 2008 all ECB publications feature a motif taken from the €10 banknote.

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Abstract

We use a structural VAR with sign restrictions to jointly identify the impact of monetary policy, private absorption, technology and oil price shocks on current account fluctuations in the U.S.. We derive the sign restrictions from theoretical impulse response functions of a DSGE model with oil, ensuring that these are consistent with a broad range of parameter values. We find that a contractionary oil price shock has a negative effect on the current account which lasts for approximately 3 years. We also find that monetary policy shocks and private absorption shocks are the main drivers of historical current account deteriorations in the U.S. Furthermore, monetary policy shocks can explain approximately 60 percent at a one year forecast horizon, although this reduces to around 40 per cent at a 7 year horizon, whilst the oil price explains just under 10 percent of the forecast error variance of the U.S. current account.

Keywords: Current Account, Global Imbalances, Sign Restrictions

JEL Classification: E0, F32, F4

Non-Technical Summary

External imbalances are a central theme in international economics and a powerful driver of change in economic history. Under the gold standard, trade balance adjustments were typically very slow and costly for countries with current account deficits, leading to a search for alternatives. During the interwar period, widening imbalances ended in a dismantling of international free trade and monetary arrangements, adding to the geopolitical tensions in the run-up to World War II. The 1970s were marked by a significant rise in the oil price and thus by a terms of trade shock which led to a net transfer of resources from oil importing countries to oil producers. In the decade that followed, the continuation of widening current account positions triggered intensive international coordination with concrete policy commitments under the G7 Plaza (1985) and Louvre (1987) agreements that focused on exchange rates. In the 1990s, external imbalances in emerging economies became a key source of concern particularly since financial crises hit most large emerging economies.

In the 21st Century, the world again faces large, even unprecedented, external imbalances. Aggregate current account positions as a share of global output are twice as large as they were in the mid-1980s when current account imbalances were at their highest ever. One of the main contributors to these developments has been the United States. In particular, from a nearly balanced position at the beginning of the 1990s, by 2006 the US current account deficit had increased to above 6 percent of US GDP. This has spurred an intense debate in academic and policy circles about the drivers of the US current account deficit by focusing in particular on the role of a handful of potential culprits, namely a surge in US private absorption, a rise in US government spending, loose monetary policy, the substantial increase in oil prices, as well as strong total factor productivity growth.

In this paper, we use a structural VAR with sign restrictions to jointly identify the impact of monetary policy, private absorption, productivity and oil price shocks on current account fluctuations in the US. We derive the sign restrictions from theoretical impulse response functions of a DSGE model with oil, ensuring that these are consistent with a broad range of structural parameter values.

The results indicate that contractionary oil price shocks have a negative effect on the current account which lasts for approximately 3 years. However, the surge in oil prices cannot entirely explain the deterioration of the US current account deficit, in the recent years. Considering forecast error decompositions, the results imply that monetary policy shocks explain cc. 60 percent of the forecast error variance of the US current account at a one year forecast horizon, although this reduces to around 40 per cent at a 7 year horizon, whilst the oil price shock explains just under 10 percent. In order to assess the relative importance of all disturbances on the current account and how this has evolved over time, we also conduct a historical decomposition based on our VAR specification for the US current account. The results also confirm the importance of expansionary monetary policy, as well as of private absorption shocks for US current account fluctuations.

1 Introduction

External imbalances are a central theme in international economics and a powerful driver of change in economic history. Under the gold standard, trade balance adjustments were typically very slow and costly for countries with current account deficits, leading to a search for alternatives. During the interwar period, widening imbalances ended in a dismantling of international free trade and monetary arrangements, adding to the geopolitical tensions in the run-up to World War II. The 1970s were marked by a significant rise in the oil price and thus by a terms of trade shock which led to a net transfer of resources from oil importing countries to oil producers. In the decade that followed, the continuation of widening current account positions triggered intensive international coordination with concrete policy commitments under the G7 Plaza (1985) and Louvre (1987) agreements that focused on exchange rates. In the 1990s, external imbalances in emerging economies became a key source of concern particularly since financial crises hit most large emerging economies.

In the 21st Century, the world again faces large, even unprecedented, external imbalances. Aggregate current account positions as a share of global output are twice as large as they were in the mid-1980s when current account imbalances were at their highest ever. One of the main contributors to these developments has been the US In particular, from a nearly balanced position at the beginning of the 1990s, by 2006 the US current account deficit had increased to above 6 percent of US GDP. This has spurred an intense debate in academic and policy circles about the drivers of the US current account deficit, with policy focus in particular on the role of a handful of potential culprits, namely a surge in US private absorption, a rise in US government spending, loose monetary policy, the substantial increase in oil prices, as well as strong total factor productivity growth[1].

There is also a growing empirical academic literature, which aims at identifying the drivers of the US current account deterioration. Bems, Dedola and Smets (2007), for example, attribute the fluctuations in the US external position, using a VAR with long-run restrictions, mainly to supply shocks driven by improvements in total factor productivity. They also found that policy shocks, both fiscal and monetary, were less important. Fratzscher, Juvenal and Sarno (2007), on the other hand, argue that a surge in asset prices, both in real estate and equity markets, has been the main determinant of US current account fluctuations. Further to these, several empirical papers have looked at the impact of oil-price shocks on domestic macroeconomic aggregates in the US (Hamilton, 1993 and Bernanke, Gertler and Watson, 2004) and in particular at how the effect of oil price changes affected business cycle fluctuations (Hooker, 2002, Hamilton, 2005, Lippi and Nobili, 2007, Blanchard and Gali, 2007 and Clements and Krolzig, 2002). However none of these papers considered under the same framework the impact of oil price shocks and other real and nominal domestic shocks on current account fluctuations.

In this paper, we use a structural VAR with sign restrictions to jointly identify the impact of monetary policy, private absorption, technology and oil price shocks on current account fluctuations in the US We derive the sign restrictions from theoretical impulse response functions of a DSGE model with oil, ensuring that these are consistent with a broad range of parameter values, as they hold for a wide range of structural parameters in our model. We find that a contractionary oil price shock has a negative effect on the

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[1] Bems, Dedola and Smets (2007) find that for the US 1 percent increase in multi-factor productivity leads to a deterioration of the net trade/DGP ratio of 0.5 percent. De Walque, Smets and Wouters (2005) report a similar result when estimating a DSGE model for the US-euro area.

current account which lasts for approximately 3 years. Our paper shows that monetary policy shocks and private absorption shocks are the main drivers of US current account fluctuations. Furthermore, the forecast error variance decomposition finds that monetary policy shocks explain cc. 60 percent of the forecast error variance of the US current account at a one year forecast horizon, although this reduces to around 40 per cent at a 7 year horizon, whilst the oil price shock explains just under 10 percent.

The paper is organized as follows. In section 2, we set up a dynamic stochastic general equilibrium (DSGE) model. In section 3, we derive the sign restrictions used later in the empirical exercise. Section 4 presents the estimation strategy, while section 5 discusses the impact of structural shocks on US macro variables and on the historical evolution of the US current account. Section 6 concludes.

2 The Model

In this section, we will present a small open economy DSGE model with oil. The model is similar to the small open economy New-Keynesian model described in Medina and Soto (2005) or Blanchard and Gali (2006). In particular, in contrast to the standard New-Keynesian set-up, we assume that the economy is an oil-importer[2], where oil-prices are exogenously determined and oil is an input into the final consumption good as well as in the production process of domestic intermediate goods.

2.1 Households

The representative household in our economy maximizes its lifetime utility by choosing purchases of the consumption good, C_t, and labour supply N_t given the following utility function:

$$E_t\left[\sum_{k=0}^{\infty}\beta^k e_{b,t}\left(\frac{1}{1-\sigma}C_{t+k}^{1-\sigma}-\frac{1}{1+\zeta}\left(N_{t+k}\right)^{1+\zeta}\right)\right], \tag{1}$$

where β is the discount factor, σ denotes the inverse of the intertemporal elasticity of substitution, ζ is the inverse of the elasticity of work effort with respect to the real wage and $e_{b,t}$ is a shock to preferences, sometimes also labelled as a risk premium shock, that affects the intertemporal substitution of households. This follows an AR(1) process of the form $\ln(e_{b,t}) = (1-\rho_b)\ln e_b + \rho_b \ln(e_{b,t-1}) + \varepsilon_{b,t}$. The maximization of the utility function is subject to a sequence of budget constraints of the form:

$$P_t C_t + E_t\left\{\Psi_{t,t+1}D_{t+1}\right\} = W_t N_t + D_t$$

where P_t is the domestic price level, D_{t+1} is the nominal pay-off in period t+1 of the portfolio held at the end of the period t, N_t denotes the labour services provided to firms at wage rate W_t. $\Psi_{t,t+1}$ is the stochastic discount factor for one-period ahead nominal payoffs relevant to the domestic household. We assume that households have access to a complete set of contingent claims traded internationally.

The corresponding first order conditions are denoted by:

$$\Lambda_t P_t = e_{b,t} C_t^{-\sigma} \tag{2}$$

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[2] The U.S., although an oil producer, is running an oil balance balance deficit towards the rest of the world.

$$\beta\, E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} \right] = E_t \Psi_{t,t+1}, \tag{3}$$

$$\frac{W_t}{P_t} = {C_t}^{\sigma} N_t^{\zeta} \tag{4}$$

Combining (2) and (3), taking conditional expectations of both sides and rearranging terms we obtain a conventional stochastic Euler equation :

$$\beta\, R_t E_t \left[\frac{e_{b,t+1}}{e_{b,t}} \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right] = 1 \tag{5}$$

where $R_t = \frac{1}{\mathrm{E}_t \Psi_{t,t+1}}$ is the gross return on a riskless one-period discount bond paying off one unit of domestic currency in $t+1$ with $\mathrm{E}_t \Psi_{t,t+1}$ being its price.

2.2 International Risk-Sharing

Under the assumption of complete securities markets, a first order condition analogous to (5) must also hold for the representative household in the rest of the world:

$$\beta\, E_t \left[\left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\sigma} \frac{P^*_t}{P^*_{t+1}} \frac{S_t}{S_{t+1}} \right] = E_t \Psi_{t,t+1} \tag{6}$$

Combining (5) with (6) and using the real exchange rate definition $1 = S_t \frac{P_t^*}{P_t}$ results in a simple international risk sharing condition, which links domestic consumption and consumption in the rest of the world.

2.3 Firms

There are three types of firms. A continuum of monopolistically competitive primary-goods firms indexed by $f \in [\,0,1\,]$, each of which produces a single tradable differentiated intermediate good, $Y_{f,t}$, and a set of two representative firms. One of these combines the purchases of domestically-produced intermediate goods with purchases of imported intermediate goods to form a core consumption good, while the other combines the core consumption good and oil imports to a form a final consumption good.

2.3.1 Primary-Goods

Each primary-good firm f produces its differentiated output using a CES technology,

$$Y_{f,t} = z_t \left[(1-\varpi)^{\frac{1}{\alpha}} L_{f,t}^{1-\frac{1}{\alpha}} + \varpi^{\frac{1}{\alpha}} \left(O^h_{f,t} \right)^{1-\frac{1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} \tag{7}$$

using hours worked, $L_{f,t}$ and $O^h_{f,t}$, the quantity of oil in the production process. The parameter α represents the elasticity of substitution between labour and oil while the variable z_t represents (total-factor) productivity which is assumed to be identical across firms and which evolves over time according to an exogenous serially correlated process $\ln(z_t) = (1-\rho_z)\ln z + \rho_z \ln(z_{t-1}) + \varepsilon_{z,t}$, where z determines the steady-state level of productivity. Furthermore $Y_{f,t}$ is used as an intermediate input using a CES technology for the production of final domestic good H_t.

$$H_t = \left(\int_0^1 (Y_{f,t})^{1-\frac{1}{\theta}} \, df \right)^{\frac{\theta}{\theta-1}},$$

Taking the price of oil $P_{O,t}$ and wages W_t as given, the firm's optimal demand for oil and labour must solve the problem of minimizing total input cost $W_t \, N_{f,t} + P_{O,t} \, O^h_{f,t}$ subject to the technology constraint (7), resulting in the following conditions for marginal costs[3]:

$$MC_t = z_t^{-1} \left[(1-\varpi) \, W_t^{1-\alpha} + \varpi P_{O,t}^{1-\alpha} \right]^{\frac{1}{1-\alpha}} \tag{8}$$

Note that oil prices (in foreign currency) are exogenous in the model and follow an AR(1) process $\ln(P^*_{O,t}) = (1-\rho_{po}) \ln P^*_O + \rho_{po} \ln(P^*_{O,t-1}) + \varepsilon_{po,t}$. As the law of one price holds in the model, we have $P^*_{O,t} S_t = P_{O,t}$.

Each firm f sells its differentiated output $Y_{f,t}$ in both domestic and foreign markets under monopolistic competition, and there is sluggish price adjustment due to staggered price contracts à la Calvo (1983). Accordingly, firm f receives permission to optimally reset prices in a given period t with probability $1-\xi$. Each firm f receiving permission to optimally reset its domestic price in period t maximizes the discounted sum of its expected nominal profits,

$$E_t \left[\sum_{k=0}^{\infty} \Lambda_{t,t+k} \left(\xi^k \, D_{f,t+k} \right) \right],$$

Here, $\Lambda_{t,t+k}$ is the firm's discount rate while $D_{f,t} = P_{H,f,t} \, Y_{f,t} - MC_t \, Y_{f,t}$ are period-t nominal profits yielded. Hence, we obtain the following first-order condition characterizing the firm's optimal pricing decision for its output sold:

$$E_t \left[\sum_{k=0}^{\infty} \xi^k \, \Lambda_{t,t+k} \left(\tilde{P}_{H,f,t} - \frac{\theta}{\theta-1} MC_{t+k} \right) \, Y_{f,t+k} \right] = 0.$$

This expression states that in those intermediate-good markets in which price contracts are re-optimised, where the newly set price is denoted by $\tilde{P}_{H,f,t}$,these are set so as to equate the firms' discounted sum of expected revenues to the discounted sum of expected marginal cost. In the absence of price staggering ($\xi = 0$), the factor $\theta/(\theta-1)$ represents the markup of the price charged in domestic markets over nominal marginal cost, reflecting the degree of monopoly power on the part of the intermediate-good firms.

Furthermore, we assume that the foreign aggregate demand for home goods is given by the following expression

$$C^*_{F,t} = \nu^* \left(\frac{P^*_{H,t}}{P^*_{F,t}} \right)^{-\mu^*} C_{F,t}, \tag{9}$$

where μ^* is the elasticity of substitution between domestic and rest-of-the-world non-oil consumption goods in the rest of the world. Note also that $P^*_{H,t} = P_{H,t}/S_t$ as the law of one prices holds. Accordingly in equilibrium at the aggregate level, we have that $P_{H,t} Y_t = P_{H,t} H_t + P_{H,t} C^*_{F,t}$.

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[3] As equation (8) suggests the marginal cost is a function of α, the elasticity of substitution between oil and labour. However, when log-linearising the model α disappears from both the production function and the marginal cost, although it continues to play an important role for the dynamics, as it affects the demand for oil and labour of the primary-good firm. Further to this, it also affects the non-stochastic steady-state of the model.

2.3.2 Final- and Intermediate Goods

The representative firm producing the non-tradable core consumption good Z_t, which combines purchases of a bundle of domestically-produced intermediate goods, H_t, with purchases of a bundle of imported foreign intermediate goods, IM_t, using a CES technology of the following form:

$$Z_t = \left(\nu^{\frac{1}{\mu}} \left(H_t\right)^{1-\frac{1}{\mu}} + (1-\nu)^{\frac{1}{\mu}} \left(IM_t\right)^{1-\frac{1}{\mu}}\right)^{\frac{\mu}{\mu-1}}, \tag{10}$$

where μ is the elasticity of substitution between domestic goods and non-oil imports, and ν measures the quasi share of domestic goods in core consumption. Furthermore, we assume that the aggregate consumption good Q_t is produced by aggregating core consumption Z_t and O_t^c using a CES technology:

$$Q_t = \left(\delta^{\frac{1}{\eta}} \left(Z_t\right)^{1-\frac{1}{\eta}} + (1-\delta)^{\frac{1}{\eta}} \left(O_t^c\right)^{1-\frac{1}{\eta}}\right)^{\frac{\eta}{\eta-1}}, \tag{11}$$

where η is the elasticity of substitution between core consumption goods and oil imports, and δ measures the quasi share of non-oil related consumption goods in aggregate consumption. Note that in equilibrium $Q_t = C_t$. The corresponding price indices and individual demand functions for (10) and (11) can be derived accordingly.

2.3.3 Monetary Policy

The monetary authority is assumed to follow a Taylor-type interest-rate rule specified in terms of annual consumer-price inflation and quarterly output growth,

$$R_t = \phi_R R_{t-1} + (1-\phi_R) \left[\phi_\Pi \left(\frac{P_{C,t}}{P_{C,t-1}}\right) + \phi_{gY} \left(\frac{Y_t}{Y_{t-1}}\right)\right] + \varepsilon_{R,t},$$

where the term $\varepsilon_{R,t}$ represents a serially uncorrelated monetary policy shock.

2.4 Aggregate Resource Constraints

Imposing market-clearing conditions implies the following aggregate resource constraint:

$$P_{H,t} Y_t = P_{C,t} C_t + TB_t \tag{12}$$

Finally, the trade balance of the economy is defined as follows:

$$TB_t = P_{H,t} C^*_{F,t} - P_{IM,t} IM_t - P_t^O (O_t^C + O_t^H) \tag{13}$$

In order to derive the empirical sign restrictions, we first log-linearise the model around the non-stochastic steady state and then derive the theoretical impulse response functions (IRFs) as described in the next section.

3 Deriving the Sign Restrictions

In this section we discuss the set of sign restrictions that we derive from the theoretical impulse response functions of the presented model. To do this we apply the strategy discussed by Pappa (2004) and Peersman and Straub (2006) and Peersman and Straub (2008), which requires the identification of model features that are robust to the variations of the structural parameters up to a first-order approximation, which is a sufficient dimension for deriving the sign restrictions from the VAR. In order to capture this robustness we define in the first step a sensible range for the structural parameter values. Certain parameter values, however, we calibrate from the start. We assume that in the steady-state, net exports are around 2% of GDP. Furthermore, the share of domestic intermediate goods in GDP is around 0.8. Also, based on US data, we calibrate the share of oil in the consumption basket δ to be 0.04. The intensity in oil value added in the production function ϖ equals 0.02, while the elasticity of substitution between domestic intermediate goods is set to 9.

We allow for key structural parameters, which are important for the dynamics of the model to take a broad range of values in order to ensure that our results are robust across a wide range. For example, the preference parameter driving the labor supply utility ζ is allowed to vary in the interval $[0, 10]$, the risk averse coefficient $\sigma \in [1, 10]$ and the Calvo parameters determining the degree of nominal wage and price rigidities θ_p are allowed to vary in the interval $[0.01, 0.95]$. For the monetary policy rule, we delimit the range of parameters to cover the values generally discussed in the Taylor-rule literature. To ensure determinacy of the model, we restrict the inflation response to the range between $[1, 3]$ while the output response and the degree of interest rate smoothing are allowed to vary in the interval $[0, 1]$.

We set the range for the subjective discount rate β between [0.985, 0.995] implying an annual steady-state real interest rate between 2 and 6 percent. The interval determining the elasticity of substitution between labour an oil α is set between [0.2, 0.5]. We also allow the elasticity of substitution between domestic goods and non-oil imports $\delta \in$ [0.01, 0.05] and the substitution between core consumption goods and oil imports $\mu \in [1, 10]$. That is, we assume, in line with the empirical literature, that core consumption and oil imports are complements, while foreign and domestic consumption goods are substitutes. Finally, and in line with the empirical literature, we restrict the persistence of the shocks to the interval $[0.5, 0.99]$. The chosen intervals are also reported in Table 1.

In the next step, we assume that the structural parameters are uniformly distributed over the selected parameter range and draw a random value for each parameter from the presented intervals and calculate the corresponding impulse response functions of the model. This exercise is repeated for 500,000 simulations. The median, 84th and 16th percentiles of all the conditional responses are shown in Figure 1.

Table 1: Parameter values and ranges

Parameter	**Description**	Range
β	discount factor	$[0.985, 0.995]$
σ	risk aversion coefficient	$[1, 10]$
ζ	labour supply elasticity	$[0, 10]$
θ	degree of monopolistic competition in the goods market	9
ξ	degree of nominal rigidities in the goods market	$[0.5, 0.95]$
α	elasticity of substitution between labour an oil	$[0.1, 0.6]$
μ	substitution between domestic goods and non-oil imports	$[1, 10]$
η, η^*	substitution between core consumption goods and oil imports	$[0.01, 0.99]$
ϕ^y	coefficient on output growth in the monetary policy rule	$[0, 1]$
ϖ	quasi-share of oil in the production function	0.02
δ	quasi-share of oil in the consumption function	0.04
ν	quasi-share of foreign imports in the core consumption	0.2
ϕ^π	coefficient on inflation in the monetary policy rule	$[1, 3]$
ρ^r	degree of interest rate smoothing	$[0, 1]$
ρ	persistence of shocks	$[0.5, 0.99]$

We use the information from Figure 1 to derive theoretical IRFs which we detail in Table 2, and which we will later use to uniquely derive the sign restrictions for the VAR analysis. In what follows, we define an expansionary shock as a shock that induces a positive reaction on output.

In our model, and in line with the literature, technology shocks induce a negative correlation between output and prices. This is in contrast to demand-side shocks, such as government spending, preference or monetary policy shocks[4]. In order to differentiate between technology and oil-price shocks, we use the response of relative oil-prices, defined in the model as the ratio of oil prices over CPI. In particular, the IRFs indicate that the reaction of relative oil-prices is positive following an expansionary technology shock and negative following an expansionary oil price shock. The latter restriction implies that the transmission of an oil-price shock to US CPI is not immediate, so that the oil-price falls on impact more than the domestic price-level. We are able to differentiate between a real and a nominal demand shock through the effects these shocks have on the interest rate. An expansionary monetary policy shock implies a reduction of the interest rate, while a preference shock leads to its increase.

Table 2: Theoretical Impulse Response Functions

	output	inflation	interest rate	p^{oil}-p
Technology shock	↑	↓		↑
Oil-price shock	↑	↓		↓
Preference	↑	↑	↑	
Monetary policy	↑	↑	↓	

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[4] Note that the terminology of a demand shock is not entirely correct in a DSGE set up, as for example preference shocks also induce supply side adjustment (e.g. through wealth effect). That being said, we apply the terminology of "demand side shocks" to all shock that induce, at least for a wide range of parameters, a positive correlation between output and prices, while demand side shock are assumed to imply a negative correlation of the latter.

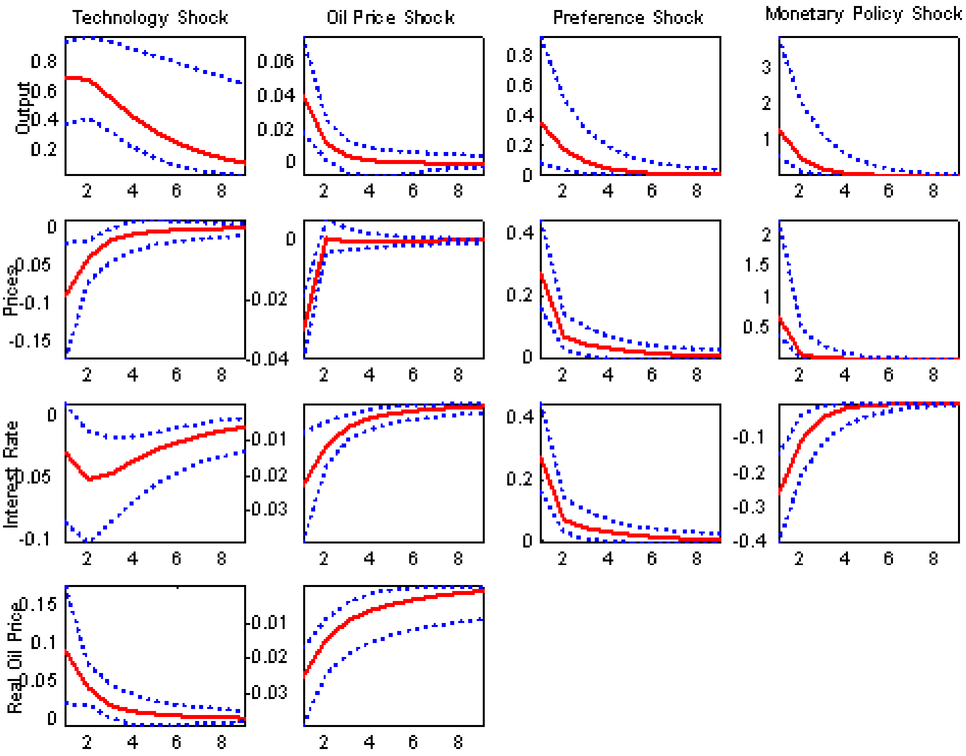

Figure 1: Theoretical Impulse Response Functions

The IRFs in Figure 1 allow us to identify shocks in the empirical exercise using a minimum set of sign restrictions. Most importantly, although we base our sign restriction identification strategy on the predictions of a theoretical model, we do not have to restrict the response of the current account and the real exchange rate, the main variables of interest. In this respect, we can let the data speak for itself. In the next section, we describe in detail the empirical model.

4 Empirical Model

Heated debate about the policies the US could and should take in order to help correct the continuous deterioration of the current account have animated both academic and policy circles. These debates have given rise to much disagreement over appropriate policy solutions mainly because there is no consensus about what led the deficit to become so large in the first place. It is plausible, however, that the drivers of the current account deterioration are more complex than those pertaining to just one group and are indeed a combination of market forces and government policies. In setting up our empirical model, we introduced a variety of variables that could help us capture the effects of policy developments as well as those of factors such as oil price shocks.

This section is split in two. The first part explains in further detail the restrictions and how we used them in the empirical model for shock identification, while the second describes the methodology.

4.1 Restrictions

We estimate a structural VAR using sign restrictions as in Canova and de Nicoló (2002). We base our sign restrictions on the theoretical IRFs derived from the DSGE model presented in the previous section. In what follows, we will discuss in more detail the restrictions that we impose in our identification strategy.

As described before, the restrictions on the oil price imply that a decline (rise) in the oil price expands (contracts) output and decreases (increases) the price of oil more than it lowers (raises) the general price level. Note that in what follows, we present a contractionary oil shock. Therefore, in order to make the distinction clear between this and a supply shock we present a negative supply shock by restricting the shock to affect the general price level more that it does the oil price. The restrictions identifying the monetary policy shock are standard and widely accepted in the sense that a expansionary shock causes a drop in the interest rate as well as an increase in output and prices.

Furthermore, we also identify the impact of a private absorption shock on the variables in the model. Note that an increase in private absorption, for example caused by a change in the time preference rate, is considered to be one of the most important drivers of the US current account in recent years. For the latter, we use the restriction that an expansionary private absorption shock leads, in contrast to a monetary policy shock, to a rise in the policy interest rates, as they generally lead to a rise in output and prices. The latter restriction is sufficient to disentangle a private absorption shock from a monetary policy shock. However, in order to ensure that the rise in demand is indeed triggered by a change in private consumption and investment, we need to impose a further restriction. In a DSGE world, the latter shock could be seen as a joint preference shock and a potential decline in investment adjustment costs, as discussed for example in Smets and Wouters (2000), leading in an open economy set-up to a rise in imports and prices, but having, due to capacity constraints, a limited impact on domestic output. In this respect, we follow Peersman and Straub (2007) and implement restrictions on consumption and investment relative to output. More specifically we assume that a private absorption shock will increase consumption and investment more than it will increase output and therefore enlarges the gap between the private absorption measure $(c+i)$ and output. Note that a private absorption shock has a different impact than an expansionary government spending shock, as the latter would be expected to lead to a fall in the private absorption to output ratio, independent of whether crowding out of private consumption and/or investment takes place or not (see Peersman and Straub, 2007 for details).

Table 3: Empirical Sign Restrictions

	output	inflation	interest rate	p^{oil}-p	(c+i)-y
Technology Shock	↑	↓		↓	
Oil-Price Shock	↑	↓		↑	
Private Absorption Shock	↑	↑	↑		↑
Monetary Policy Shock	↑	↑	↓		

4.2 VAR

Moving on to the methodology, the structural VAR model includes 7 variables, namely output, inflation, interest rate, oil price inflation, the ratio of the current account to GDP, the sum of consumption and investment (which following the literature, we labelled as private absorption) and the real effective exchange rate. Grouping these seven variables in y_t we can show the structural model as follows:

$$By_t = A(L)y_{t-1} + \epsilon_t$$

Thus the reduced form can be re-arranged as below:

$$y_t = B^{-1}A(L) + v_t$$

where $v_t = B^{-1}\epsilon_t$ is the residual of the reduced form model. The key step in applying the VAR methodology lies in identifying structural disturbances which have an economic meaning out of the information contained in the reduced form residuals. Therefore, to obtain estimates of ϵ_t given values of the estimated residuals v_t we follow Canova and de Nicoló (2002) who rather than impose zero restrictions on VAR coefficients (Sims, 1980) or on long-term impulse responses (Blanchard and Quah, 1989) use sign restrictions on the cross-correlation function of variables' responses to particular shocks. For convenience, we depart slightly from their methodology and impose restrictions on the impact coefficients and the IRFs rather than the cross-correlation function of the impulse responses. However this should lead to the same results[5].

Formally, after running the 7-variable VAR we get an estimate of the variance-covariance matrix $\sum_v = E(v_t v_t')$ which can be rewritten in terms of the underlying shocks as $\sum_v = E(B^{-1}\epsilon_t(B^{-1}\epsilon_t)') = B^{-1}E(\epsilon_t\epsilon_t')(B^{-1})' = AA'$ since $E(\epsilon_t\epsilon_t') = I$ by assumption. One way to decompose the var-cov matrix in the form applied here, is to break it down in eigenvalues (V) and eigenvectors (P) such that $\sum_v = PVP' = AA'$. Although the eigenvectors-eigenvalues decomposition does not have any economic meaning, by incorporating the theoretical restrictions we attach economic interpretations to the identified shocks. This decomposition has the advantage of generating orthonormal shocks which makes the value of P unique for each variance-covariance matrix decomposition without imposing any zero restrictions. The only restrictions made so far are that the shocks should be independent from one another and that their variance is the identity matrix. Although P is unique there exist orthonormal matrices J, such that $JJ' = I$ so a valid decomposition of $\sum_v$ is also $\sum_v = AJJ'A'$.

If the sign restrictions from Table 3 are met we retain the decomposition and move on to consider the orthonormal decompositions in order to provide alternative candidate structural shocks. We do this by using a rotational matrix J of the following form:

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[5] This is particularly obvious when restrictions are imposed only at time zero and output's response is required to be positive. The impact coefficients are in fact the values that the impulse response function takes at time 0 so imposing a restriction on the impact coefficients or on the first period of the impulse response function is the same. Also, if output is restricted to go up following a particular shock, imposing a negative cross correlation restriction between output and prices is the same as imposing a restriction for prices to go down following this shock.

$$J(\theta)_{ij} = \begin{bmatrix} 1 & 0 & ... & 0 & 0 \\ 0 & \cos(\theta) & ... & -\sin(\theta) & 0 \\ ... & ... & 1 & ... & ... \\ 0 & \sin(\theta) & ... & \cos(\theta) & 0 \\ 0 & 0 & ... & 0 & 1 \end{bmatrix}$$

where i and j represent the rows which are being rotated, while θ is the rotation angle. In a 7 variable model the number of orthonormal rotational matrices is large. We construct an algorithm covering all possible bivariate rotations, combinations of bivariate rotations by one angle as well as by two and three angles. For more details on this please see Appendix 1. We implement all of these in our model and are able to identify simultaneously four shocks, namely a supply, oil, monetary and private absorption shock.

Our algorithm follows Canova and de Nicoló (2002) with two exceptions. First we consider three rotational angles and second rather than using an angle grid we perform a random draw for each angle. This works in three steps. First we make 4000 random draws for each rotation angle θ_1, θ_2 and θ_3 from the interval $[0, \pi]$. For each combination of angles we use the sign of the impact coefficients at time 0 to identify orthonormal shocks. Among these we pick the ones that are consistent with the restrictions presented in Table 1 and discarding the rest. An important difference between our paper and the existing literature that identifies a large number of shocks using sign restrictions is that we impose that all restrictions are met simultaneously.

In estimating impulse responses we take into account both data and identification uncertainty. We do this by bootstrapping the estimated residuals of the reduced form VAR, recalculating the variance covariance matrix and re-running the VAR for each draw.

5 Empirical Results

There are three main types of results that we report in this paper. Firstly we look at the effects of a one time shock on our variables, namely the impulse responses. Secondly, we discuss the historical decomposition of the current account. While impulse response functions provide information about the average effect of a one time shock on our variables, the historical decomposition looks at the cumulative influence of all shocks on these variables. Hence, in order to assess the relative importance of all disturbances on the current account and how this has evolved over time, we move away from impulse responses and look into the historical decomposition. Thirdly, we look at the relative importance of each shock at different time horizons, namely at the forecast error variance decomposition. As previously discussed, the impulse response functions indicate the impact of an isolated shock of unit variance at one point in time on each variable, whilst the variance decomposition combines the information in the variances of the shocks with that from the impulse responses, in order to describe their relative contributions to the forecast error.

5.1 Impulse Response Functions

5.1.1 Impulse Responses to Supply and Oil Price Shocks

The second column in Figure 2 shows the response of each of our variables to an oil price shock. We assume that the oil price increase is exogenous to the US and could be caused

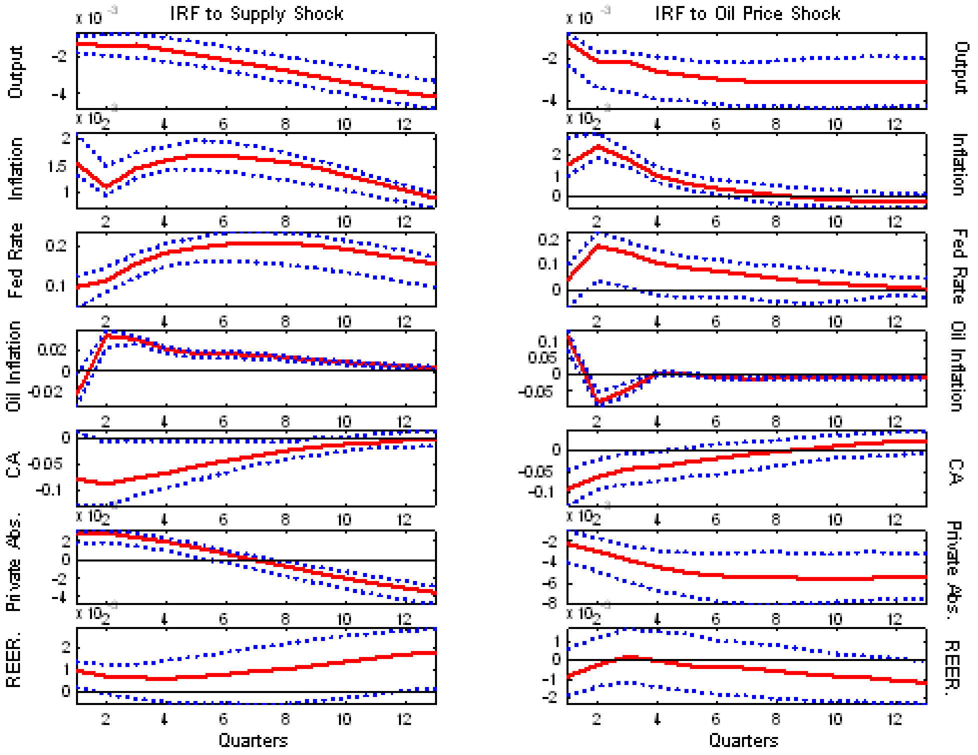

Figure 2: IRFs following Oil and Supply Shocks

by either an adverse oil supply shock in the oil exporting countries or an increase in foreign oil demand. In our case, a contractionary oil price shock increases the price of oil by more than it raises the general price level while having a negative effect on output. Its effect on the current account is negative for the first two years before it becomes positive for some time after. Results in the empirical literature are broadly supportive, but are sensitive to the methodology used. Kilian, Rebucci and Spatafora (2007) for instance, using a different procedure, find that following an increase in the oil specific demand or the foreign aggregate demand, the US current account goes into deficit initially but goes into a significant trade surplus after three years.

Results in the theoretical literature seem to be sensitive to whether the model assumes complete markets. For example, Bodenstein, Erceg and Guerriri (2007), using a two country DSGE model, find that under incomplete markets higher oil prices decrease the wealth of an oil importing country, inducing its non-oil terms of trade to improve and the oil trade balance to deteriorate. The timing and magnitude of the deterioration or improvement depend in their model on the assumption of incomplete markets.

The first column in Figure 2 displays the effects of a negative supply shock. Output decreases on impact and stays persistently below zero for a long period. As the price level increases, US goods become less competitive, which has an adverse effect on the current account and the REER which appreciates.

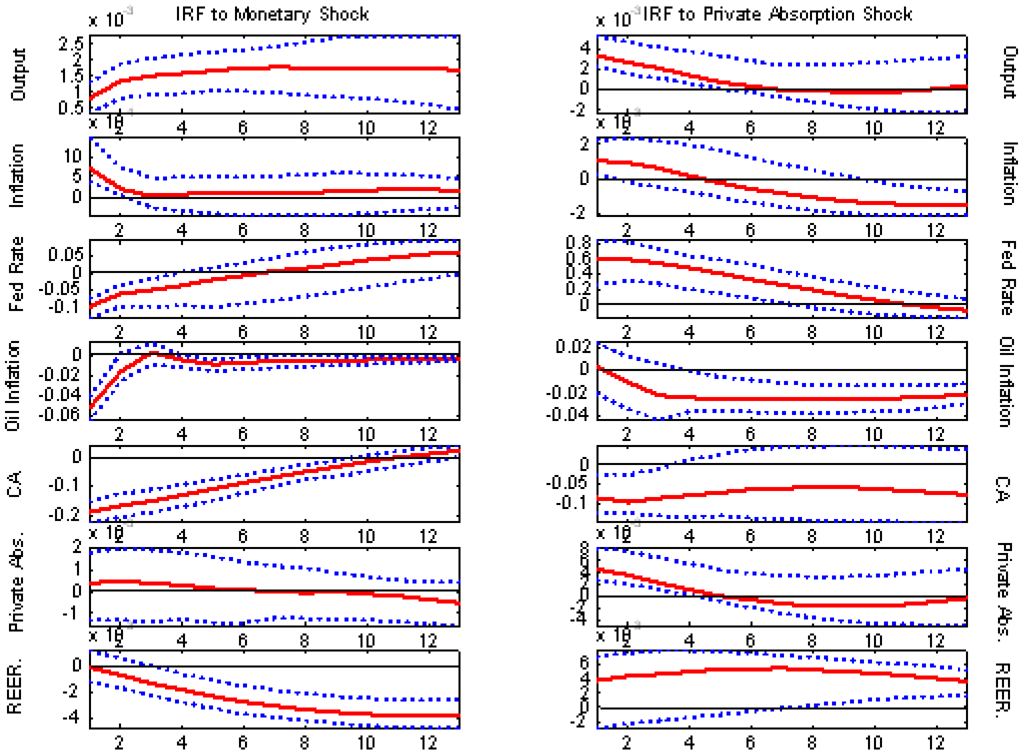

Figure 3: IRFs following Monetary Policy and Private Absorption Shocks

5.1.2 Monetary and Private Absorption Shocks

The first column in Figure 3 shows the impulse responses to a monetary policy shock. An expansionary monetary shock is one that decreases nominal interest rates while expanding both output and prices. We left the current account response to this shock unconstrained in order to let the data speak and found that the current account's response is negative and fairly persistent. This is in line with the "income absorption effect" theory which says that an increase in domestic income following an expansionary monetary policy shock increases domestic import demand, which leads to a deterioration of the current account. The subsequent convergence to equilibrium of the CA could be reinforced by the persistent depreciation of the REER which will make domestic goods more attractive than foreign ones. The current account may also deteriorate due to an increase in private investment following the interest rate reduction. Kim (2001) finds a similar impact on the current account but only in the short run. Our results are also in line with those of Bems, Dedola and Smets (2007) who also find a significant deterioration of the current account following an expansionary monetary policy shock.

We also left the response of the REER unconstrained and found that this depreciates slowly and persistently after an expansionary monetary shock. The maximum impact of the shock does not occur contemporaneously but after 2 years. Although this result is inconsistent with the standard theoretical overshooting models[6], it is line with the classical

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[6] In these models (e.g. Dornbusch 1976) an expansionary monetary policy generates a large initial depreciation of the REER followed by a subsequent appreciation.

empirical work (e.g. Eichenbaum and Evans, 1995) as well as with the one using sign restrictions (e.g. Scholl and Uhlig, 2008).

The private absorption shock is an aggregate demand shock that increases output, prices and the interest rate as well as private investment and consumption. The effect on the current account is persistently negative and is in line with most of the empirical and theoretical literature on this topic.

5.2 Historical Decomposition of the Current Account

In order to assess the relative importance of all disturbances on the current account and how this has evolved over time, we need to move away from impulse responses and look into the historical decomposition of the current account. Therefore the next question that we pose is to what extent do the five shocks we identify explain the ups and downs of the US current account. In order to do this, we differentiate between the evolution of the current account explained by the variables of our model and that explained by the structural disturbances. In other words we calculate the baseline projection, which mirrors the level of the current account that would have been achieved if no shocks were present and the cumulative sum of all the aggregate demand, the supply and oil price shocks across time. Therefore the actual level of the current account is given by the sum of the baseline projections made at the beginning of the period and the combined effect of shocks that hit the current account thereafter. If economic agents were to make a forecast based on the information they had at the beginning of the period (base point), namely the structure of the empirical model and the value of the VAR parameters, they would be correct up to the shocks.

The choice of base point is very important because agents are assumed to know everything up to the time of the base point, including the shocks which previously hit the current account, therefore the deviation of the baseline from the actual series is given only by the shocks which occur after the projection is made. This is important particularly since there could be a persistent shock hitting the economy before the base point which would be included in the base forecast but not surface amongst the shocks which make the base forecast deviate from the actual series thereafter.

In order to perform the historical decomposition, we split this analysis in three parts as presented in Figure 4. The first covers the years between 1970 and 1980 and was characterized generally by a balanced evolution of the current account. This period saw the oil price increase in 1973 and 1974 and the Yom Kippur war in 1973. It also just covers the Iranian revolution in 1979 and the 1979-1980 increase in the oil price.

The second period starts in 1980 and goes all the way to 1997, covering a period of both current account deterioration and improvement. We chose to start this time window in 1980 for several reasons. The early 1980s was characterized by a world wide liberalization of goods, financial and services markets which made it easier for domestic firms to finance investment and saving abroad and by starting our window in 1980 we hoped to capture the effects of these changes on the current account. Moreover, Clarida, Gali, Gertler (2000) point out that Volcker's appointment as chairman of the Federal Reserve Board at the end of 1979 changed the way monetary policy was implemented. Other authors, believe that more generally the structure of the US economy has changed since the 1980s as either shocks hitting the economy have changed or their effect on the economy has changed[7]. We run

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[7] There is a large literature which analyses the potential chance in structure of the US economy, particularly the one dealing with the so called great moderation. See for example Benati and Surico (2007), Primiceri and Justiniano (2006) and Bilbiie and Straub (2007).

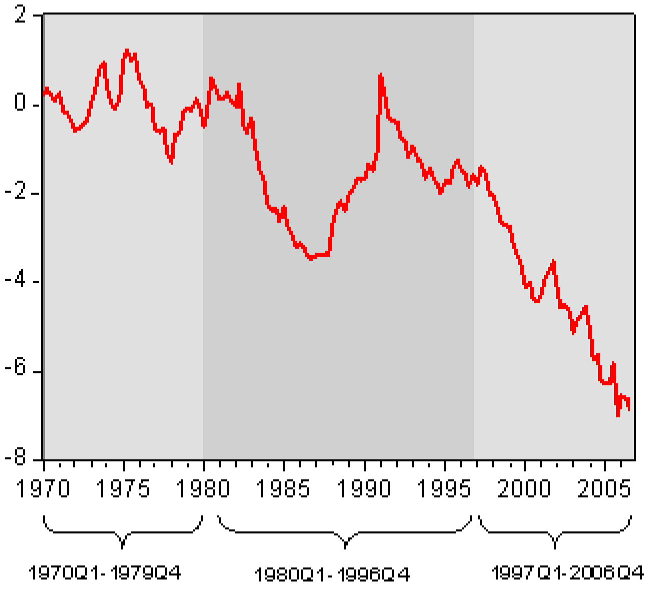

Figure 4: U.S. current account as share of GDP

this period until 1997 as it seems that during this period the current account still displayed some mean reversal properties.

The last period from 1998 to 2006 covers the longest and sharpest current account deterioration in US history. This includes the two oil price increases of 1999 and 2003[8] and the historically low interest rate environment of 2003 and 2004. In what follows and for the reasons explained above, we chose as base starts 1970, 1980 and 1997. The historical decomposition of the first period is presented in Figure 5.

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[8] For a detailed account of oil price increases and how they fit amongs macroeconomic events between 1960 and 2005 see Blanchard and Gali (2007).

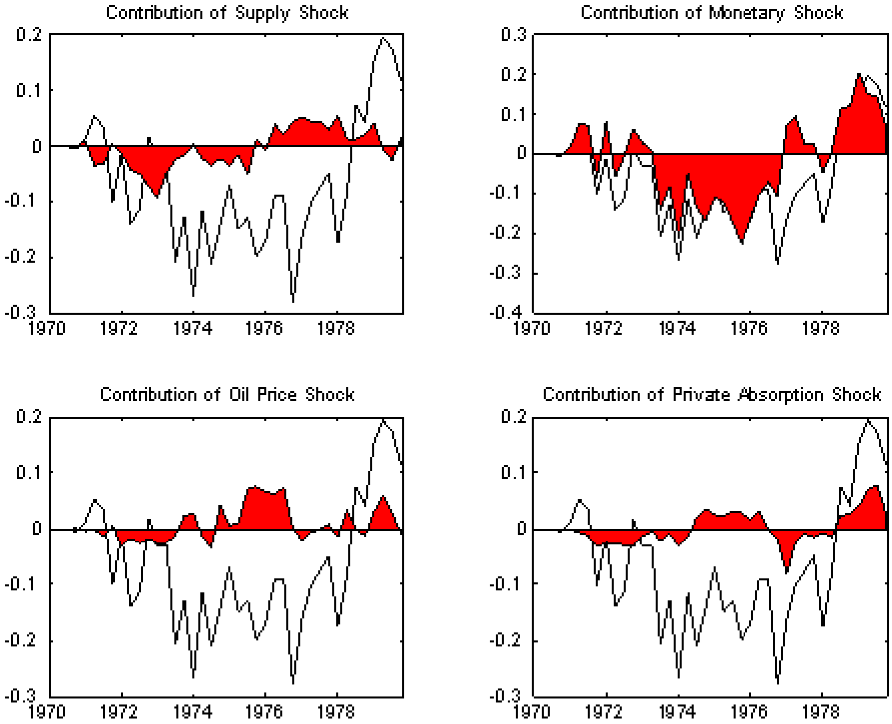

Figure 5 : Contribution of shocks to deviation from baseline- 1970-1979

The 10 year period between 1970 and 1980 was a period of relative calm for the current account. During this period monetary shocks proved relatively more important, particularly from mid 1973 to the end of 1976. We do not find that the oil price increase in 1973 had a significant negative influence on the current account, a fact which is perhaps not very surprising since other authors (e.g. Blanchard and Gali, 2007) came to the same conclusion with respect to the decline of output and increase of inflation during that period.

Figure 6 shows the historical decomposition from 1980 to the end of 1996. The most important thing to notice about this period is that the private absorption and monetary shocks have been more important for the negative evolution of the current account than all other shocks. More specifically it seems that the monetary shock is the most important factor in explaining the deterioration of the current account in the first half of the 1980s. The improvement that followed in the second half of the 1980s was driven in part by supply shocks. The subsequent deterioration at the beginning of the 1990s seems to have been driven in part by a combination of monetary, private absorption and oil price shocks.

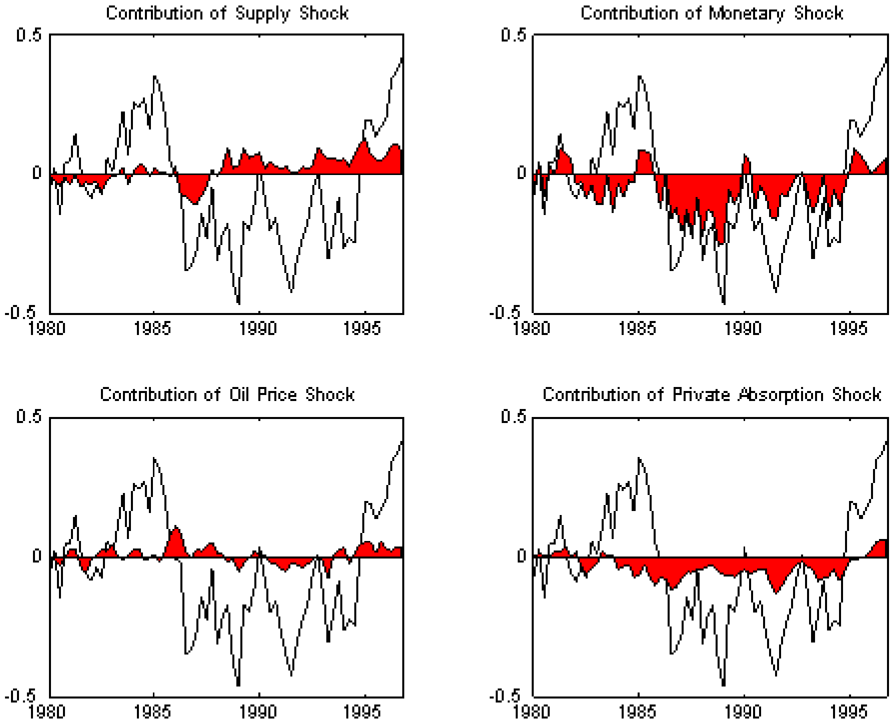

Figure 6 : Contribution of shocks to deviation from baseline- 1980-1996

The historical decomposition of the third and last period covering 1997 up to 2006 is presented in Figure 7. During this period monetary policy has been accommodative with relatively low interest rates while fiscal policy has been loosened particularly since 2001 with the aim of encouraging private savings. Oil prices have started going up particularly strongly since 2003, a fact that is believed by some to have had a role in the deterioration of the current account.

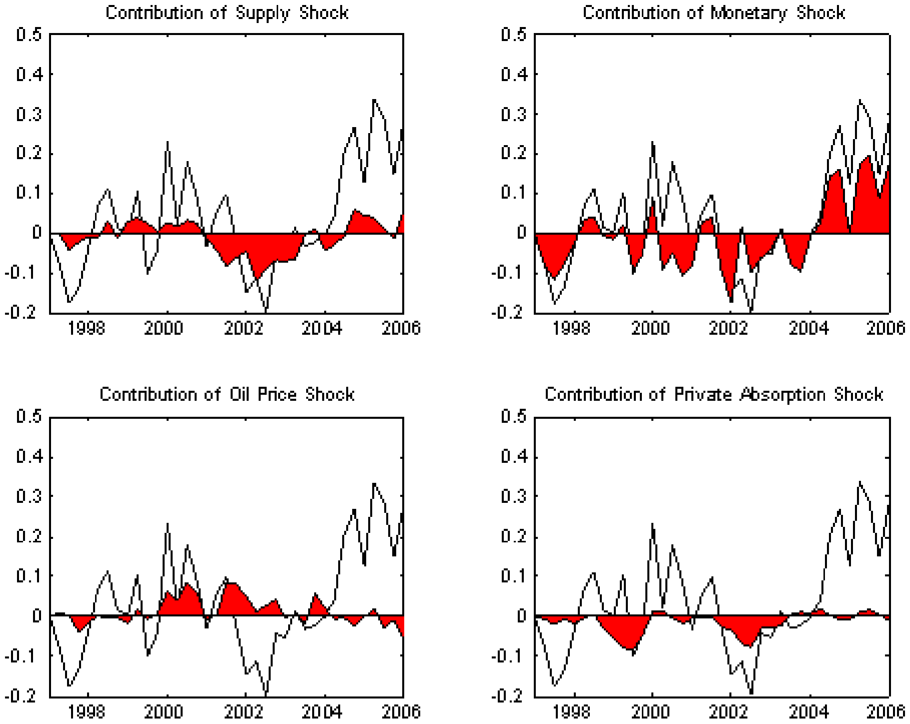

Figure 7 : Contribution of shocks to deviation from baseline- 1997-2006

The historical decomposition in Figure 7 picks up on the general loose monetary policy of the early years from 2000 and reflects it in a negative influence on the current account. This negative influence is reinforced in 2002 by the negative influence of the supply shock.

Given the importance of the link between the evolution of the current account and the REER, we also briefly looked at the historical decomposition of the REER using the same breakdown of the sample as for the current account. We performed this exercise mainly to give us a flavour for whether the current account and REER's movements are driven by common factors. We found that the monetary policy and the private absorption shocks are still the dominant forces behind the deviation of the REER from the base line projection. We present the graphs for the historical decomposition of the REER in the Appendix 3.

5.3 Forecast error variance decomposition

The variance decomposition provides information about how important one shock is relative to others in explaining the variance of the current account. In our case, it points out what percentage of the variance of the current account is explained by the supply shock, oil price shock, monetary policy shock and private absorption shock. Table 4 summarises these percentages for selected years and shows that at different forecast horizons the oil price shock explains a steady proportion of the total variance of the current account at around 9 percent. The private absorption shock explains as little as 11 percent of the variance of the current account at a 1 year forecast horizon, but steadily grows and settles at around 25 percent at a seven year forecast horizon. The monetary shock has the highest influence of cc. 62 percent at low forecast horizons although this gradually reduces to roughly 41 percent at a 7 year forecast horizon. In conclusion, at different forecast horizons the four shocks taken together explain over 80 percent of the variance of the current account, illustrating that whilst these may not be responsible for the entire deterioration of the current account they still explain a relatively high proportion of its variability.

Table 4: Forecast Error Variance Decomposition for the US CA

Years	Supply Shock	Oil Shock	Monetary Shock	Private Absorption Shock
1	15.3	9.1	62.5	10.6
3	12.8	6.7	53.1	16.4
5	9.8	6.8	43.9	24.8
7	7.6	9.7	41.3	25.8

6 Conclusion

We estimated a 7 variable structural VAR using data on US output, inflation, interest rate, oil inflation, current account, private absorption and the real effective exchange rate. We use sign restrictions derived from a DSGE model with oil to simultaneously identify four real and nominal shocks. The impulse response functions suggest that a contractionary oil price shock has a negative effect on the current account which lasts for approximately 3 years. This is broadly in line with the empirical literature. Kilian, Rebucci and Spatafora (2007) for instance, find that following an increase in the oil specific demand or the foreign aggregate demand, the US current account goes into deficit initially but goes into a significant trade surplus after three years.

We also presented results about the main drivers of current account fluctuations in the US For this, we split the data set into three parts. The common feature of the analysis is that expansionary monetary policy shocks as well as positive private absorption shocks were the main drivers of current account deterioration in all three periods. Note, however, that the effect of private absorption shocks are much more persistent. Bems, Dedola and Smets (2007) find that although fiscal and monetary policy shocks as well as supply shocks have been driving the US CA deterioration before the 1990s only the fiscal and monetary policy shocks plays some role, although small, during the decade that followed. The difference in the importance of supply shocks from our paper could be due to the fact that they do not account for oil price shocks separately. Also, the importance of the monetary shock could be larger in our paper due to the fact that we do not identify shocks such as fiscal shocks that are possible to have been picked up by the monetary shock and thus further work in disentangling these is required.

With regards to the forecast error variance decomposition, we showed that monetary policy shocks explain 62% at a one year forecast horizon although this reduces to 41% at a 7 year horizon whilst the oil price shock explains just under 10% at the same forecast horizons. Bems, Dedola and Smets (2007) find a smaller contribution of the monetary policy shock to the forecast error variance of the net trade/GDP ratio ranging between 8 and 12% at business cycle frequencies. Again, this difference could come from the different methodologies and variables in the VAR that we are using. However, overall we do find that monetary policy shocks have played an important role in the US CA deterioration over time, a conclusion which is also shared by their paper.

One interesting extension of the current paper could be to differentiate the impact of endogenous and exogenous oil price shocks on the US current account as in Kilian, Rebucci and Spatafora (2007). Endogenous oil price shocks could be defined thereby as oil price hikes that are the consequences of World GDP growth, while exogenous oil price shocks are defined to be created in the oil market itself. Also, we have neglected in our analysis some other prominent shocks that are contemplated as a driver of current account fluctuations. A good example of such shocks is an expansionary fiscal policy shock. In order to assess the importance of the omitted shocks, we would need to identify additional shocks in our VAR, which poses some challenges to the applied sign restrictions methodology[9]. We leave that, however, for future research.

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Appendix 1: Example of Rotational Matrices

Bivariate Rotation: rotate two variables while keeping the other two fixed. Below there is an example when only the first and the second row are being rotated.

$$\begin{pmatrix} \cos(\theta) & -\sin(\theta) & 0 & 0 & 0 & 0 & 0 \\ \sin(\theta) & \cos(\theta) & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Combination of Bivariate Rotations using one angle, θ: rotate two variables by θ while rotating the other two by the same angle while keeping the orthogonality condition still satisfied. The matrix below depicts an example when the first and the third row are rotated together while the second and the fourth are rotated together and by the same angle.

$$\begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 & 0 & 0 & 0 \\ 0 & \cos(\theta) & 0 & -\sin(\theta) & 0 & 0 & 0 \\ \sin(\theta) & 0 & \cos(\theta) & 0 & 0 & 0 & 0 \\ 0 & \sin(\theta) & 0 & \cos(\theta) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Combination of Bivariate Rotations using two angles, θ and θ_1: rotate two variables by θ while rotating the other two by θ_1 preserving the orthogonality condition. For any size VAR there will be an infinite number of rotations given by the fact that for each θ we can rotate the other two variables by any angle θ_1. To reduce the infinite problem to an accountable one, we choose θ and θ_1 from the interval $(0, \frac{\pi}{2})$ by fractionating it into 100 points for each angle. Below we reproduce the previous example but rotate the second and the fourth rows by a different angle than the angle by which the first and the third row are rotated.

$$\begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 & 0 & 0 & 0 \\ 0 & \cos(\theta_1) & 0 & -\sin(\theta_1) & 0 & 0 & 0 \\ \sin(\theta) & 0 & \cos(\theta) & 0 & 0 & 0 & 0 \\ 0 & \sin(\theta_1) & 0 & \cos(\theta_1) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

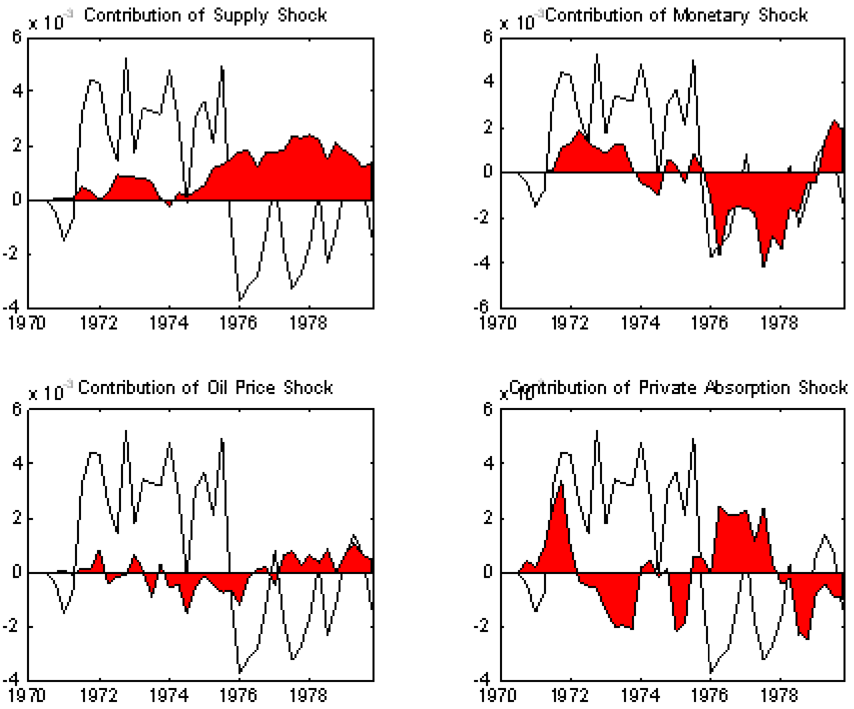
Combination of Bivariate Rotations using three angles, θ, θ_1 and θ_2: rotate two variables by θ while rotating two others by θ_1 and two others by θ_2 preserving the orthogonality condition. As above, for any size VAR there will be an infinite number of rotations of this type. To reduce the infinite problem to an accountable one, we choose θ, θ_1 and θ_2 from the interval $(0, \frac{\pi}{2})$ by fractionating it into 100 points for each angle. Below we reproduce the previous example but now rotate the remainder of the variables by a different angle than the angle to which the first, second, third and fourth row are rotated.

$$\begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 & 0 & 0 & 0 \\ 0 & \cos(\theta_1) & 0 & -\sin(\theta_1) & 0 & 0 & 0 \\ \sin(\theta) & 0 & \cos(\theta) & 0 & 0 & 0 & 0 \\ 0 & \sin(\theta_1) & 0 & \cos(\theta_1) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \cos(\theta_2) & -\sin(\theta_2) \\ 0 & 0 & 0 & 0 & 0 & \sin(\theta_2) & \cos(\theta_2) \end{pmatrix}$$

Appendix 2: Data

We use quarterly data starting in 1970 Q1 and finishing in 2006 Q4. GDP, consumption and investment are used in logs while the CPI index and oil prices are used in log differences. The interest rate and the REER are used in original form.

Appendix 3: Historical Decomposition of the US REER


Contribution of Supply Shock

Contribution of Monetary Shock

Contribution of Oil Price Shock

Contribution of Private Absorption Shock

Figure 1*A* : Contribution of shocks to deviation of REER from baseline- 1970-1979

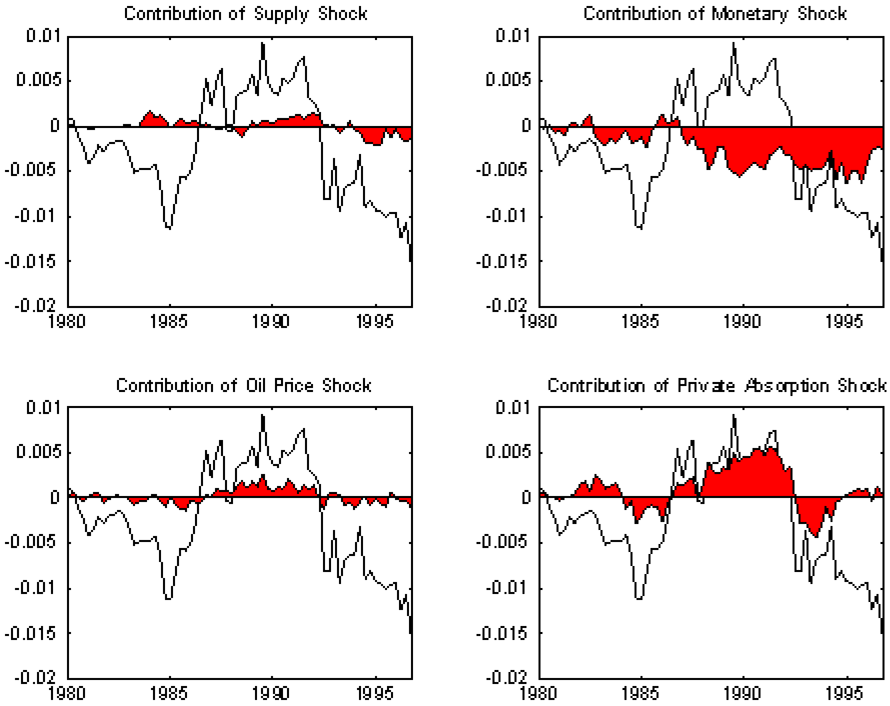


Figure 2*A* :Contribution of shocks to deviation of REER from baseline- 1980-1996

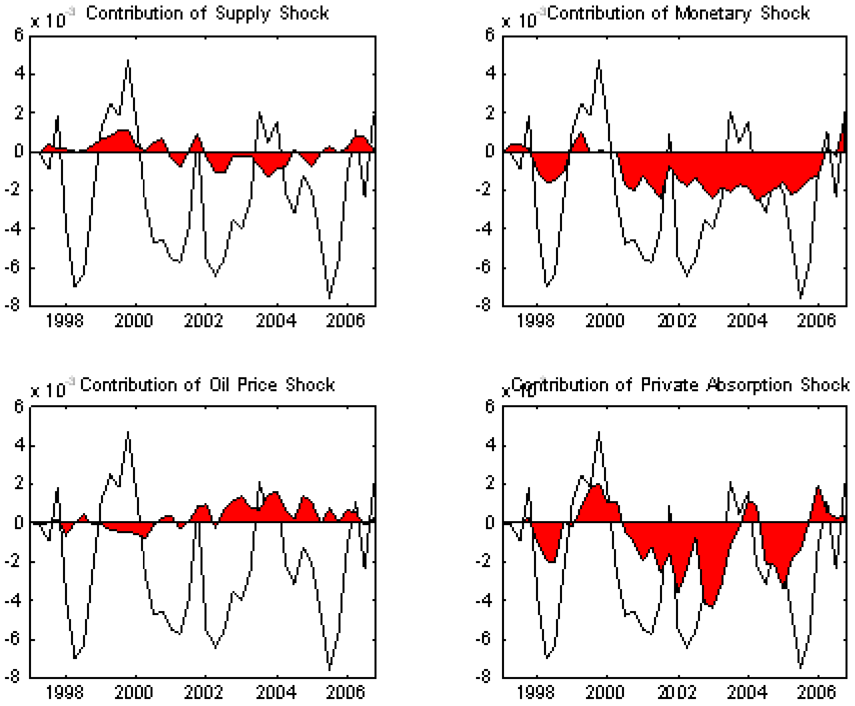


Figure 3 : Contribution of shocks to deviation of REER from baseline- 1996-2006

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