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# ABSTRACT

## US Imbalances: The Role of Technology and Policy*

This paper investigates the role of three likely factors in driving the steady deterioration of the US external balance: US technology developments, changes in the US government fiscal position and the Fed's monetary policy. Estimating several Vector Autoregressions on US data over the period 1982:2 to 2005:4 we identify five structural shocks: a multi-factor productivity shock; an investment-specific technology shock; a monetary policy shock; and a fiscal revenue and spending shock. Together these shocks can account for the deterioration and subsequent reversal of the trade balance in the 1980s. Productivity improvements and fiscal and monetary policy easing also play an important role in the increase of the external deficit since 2000, but these structural shocks cannot explain why the trade balance deteriorated in the second half of the 1990s.

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## Non-technical summary

Since the early 1990s the US current account and net trade deficit have steadily deteriorated from close to balance to a deficit of more than 5 percent in 2004 and 2005. As a counterpart, various regions have developed large surpluses vis-à-vis the United States. The emergence of those global current account imbalances has generated a large literature investigating the sources of the imbalances, their sustainability and the likely adjustment mechanism including the role of the exchange rate in this adjustment and the implications of the adjustment process for global growth and financial markets. Clearly, both the sustainability and the features of the adjustment mechanism depend very much on the sources behind the emergence of the imbalances. A number of authors have focused on developments in the US economy, in particular the productivity boom starting in the second half of the 1990s, but also developments in fiscal and monetary policy in particular since the start of the new millennium. Others have emphasized excess savings in Asian countries pointing out that following the Asian crisis in 1997 savings rates in many Asian countries remained relatively high in spite of falling investment rates. Still others have highlighted the efforts of some Asian monetary authorities to resist an appreciation of their respective currencies and to accumulate large quantities of foreign reserves. Finally, more recently the recycling of the increased oil revenues by oil-producing countries has been pointed out as a major factor.

In this paper, we focus on the role of domestic US factors. The main reason for doing so is that the secular deterioration of the net trade balance has occurred relative to most of the major regions in the world. This suggests that some of the main sources are likely to lie in developments in the United States itself. The paper investigates the role of three likely factors: US productivity developments and the new-economy boom, changes in the fiscal position of the US government and the Fed's monetary policy. For that purpose we estimate Vector Autoregressions (VARs) on US data over the period from 1982 to 2005 and identify various structural shocks: multi-factor productivity shocks; investment-specific or embodied technology shocks, monetary policy shocks and fiscal revenue and expenditure shocks. We analyze the effects of those shocks on the current account and investigate how much of the developments in

the trade balance can be explained by those shocks. We find that each of the structural shocks have an economically and often statistically significant impact on the trade balance more or less in line with a priori reasoning: Positive technology shocks and expansionary fiscal and monetary policy developments lead to a deterioration of the trade balance. Together the shocks explain the deterioration of the trade balance in the early 1980s and its subsequent return to balance in the second half of the 1980s. They also explain the deterioration of the trade balance in the new millennium. Both positive technology developments and fiscal and monetary policy easing following the collapse of the dot-com bubble play an important role in the rapid deterioration since 2000. Somewhat surprisingly, the estimated technology shocks can not account for the increase in the trade deficit in the second half of the 1990s.

# 1. Introduction

Since the early 1990s the US current account and net trade deficit have steadily deteriorated from close to balance to a deficit of more than 5 percent in 2004 and 2005 (see Figure 1). As a counterpart, a number of countries/regions have developed large surpluses vis-à-vis the United States (Figure 2). The emergence of those global current account imbalances has generated a large literature investigating the sources of the imbalances, their sustainability and the likely adjustment mechanism including the role of the exchange rate in this adjustment and the implications of the adjustment process for global growth and financial markets.[1] Clearly, both the sustainability and the features of the adjustment mechanism depend very much on the sources behind the emergence of the imbalances. A number of authors have focused on developments in the US economy, in particular the productivity boom starting in the second half of the 1990s, but also developments in fiscal and monetary policy in particular since the start of the new millennium.[2] Others have emphasized excess savings in Asian countries pointing out that following the Asian crisis in 1997 savings rates in many Asian countries remained relatively high in spite of falling investment rates.[3] Still others have highlighted the efforts of some Asian monetary authorities to resist an appreciation of their respective currencies and to accumulate large quantities of foreign reserves.[4] Finally, more recently the recycling of the increased oil revenues by oil-producing countries has been pointed out as a major factor (e.g. WEO, 2006).[5]

{Insert Figure 1}

In this paper, we focus on the role of domestic US factors. The main reason for doing so is that, as illustrated in Table 1, the secular deterioration of the net trade balance has occurred relative to most of the major regions in the world. This suggests that some of the main sources are likely to lie in developments in the United States itself.

[1] For a recent more academic survey see Corsetti (2005). Policy surveys are Gros, Mayer and Ubide (2006), WEO (2005), BIS (2004).
[2] Examples are Engel and Rogers (2006), Backus et al (2006), Roubini and Setzer (2005).
[3] See, for example, Bernanke (2005), Caballero, Gourinchas and Fahri (2005), WEO (2005).
[4] See, for example, Dooley, Folkerts-Landau and Garber (2005).
[5] In addition, there is a quite lively literature on measurement issues ranging from papers that argue the US is not a deficit country (Hausmann and Sturzenegger 2005) to papers that argue that the problem may be even more serious than suggested by conventional measurement (Gros et al, 2006).

{Insert Table 1}

The paper investigates the role of three likely factors: US productivity developments and the new-economy boom, changes in the fiscal position of the US government and the Fed's monetary policy. For that purpose we estimate Vector Autoregressions (VARs) on US data and identify various structural shocks: a multi-factor productivity shock; an investment-specific or embodied technology shock, a monetary policy shock and a fiscal revenue and expenditure shock. In Section 2, we analyze the effects of those shocks separately following and extending an extensive academic literature that uses VARs to investigate the role of those shocks in US business cycles. In Section 2.1, we identify the technology shocks using long-run zero restrictions on labour productivity and the relative price of investment equipment respectively following Gali (1999) and Fischer (2006). Section 2.2 focuses on the role of fiscal policy and following Perotti (2005) uses contemporaneous zero restrictions to identify both government spending and revenue shocks. Finally, Section 2.3 analyses the role of monetary policy shocks as in Christiano, Eichenbaum and Evans (1999) and Kim (2001).

As argued in Altig et al (2005), a number of those shocks can account for a large fraction of business cycle fluctuations in the United States. It is therefore interesting to see how much of the developments in the trade balance can be explained by those shocks. An important caveat to this US-focused approach is that only asymmetric shocks are likely to affect current account and trade balances (Glick and Rogoff, 1995). Ignoring the international comovement and transmission of the US shocks as well as the incidence of foreign shocks may bias our results. However, the direction of this bias is not clear. To the extent that the identified shocks are common across countries, the estimated effects on the trade balance are likely to be underestimated. In contrast, if domestic and foreign shocks are negatively correlated, the estimated effects may be overestimated.[6]

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[6] In the case of productivity shocks, we have investigated the effect of identifying relative productivity shocks on the basis of relative labour productivity movements in the US versus the G7 countries. In this case, our estimates were not significantly affected.

Notwithstanding these caveats, we find that each of the structural shocks have an economically and often statistically significant impact on the trade balance more or less in line with a priori reasoning: Positive technology shocks and expansionary fiscal and monetary policy developments lead to a deterioration of the trade balance. Together the shocks explain the deterioration of the trade balance in the early 1980s and its subsequent return to balance in the second half of the 1980s. They also explain the deterioration of the trade balance in the new millennium. Both positive technology developments and fiscal and monetary policy easing following the collapse of the dot-com bubble play an important role in the rapid deterioration since 2000. Somewhat surprisingly, the estimated technology shocks can not account for the increase in the trade deficit in the second half of the 1990s.

## 2. The impact of technology and policy shocks on the US trade balance: VAR evidence

In this section we discuss each of the three possible factors (technology, fiscal policy and monetary policy) in turn. In each case, we examine the related VAR literature that has tried to identify those shocks and analyze their effects on the trade balance. In each of these sections, the empirical strategy is to first replicate a key VAR study in the literature and to then extend the analysis by extending the sample to 2005:4 and including the net trade/GDP ratio. For space reasons, in what follows, we only report the findings from the final VAR.[7]

In order to estimate the effects of the various shocks, we use a common data sample starting in the early 1980s (1982:2-2005:4 to be precise). There are various reasons for restricting the analysis to the last two decades or so. First, given our interest in understanding the US trade balance, it is important to focus on a period when the international markets in goods, services and financial assets were more or less liberalized. The 1980s was a period of general liberalization of international capital movements in many regions of the world making the external financing of domestic saving and investment imbalances easier. Second, Clarida, Gali and Gertler (2000) have argued that there has been a change in the conduct of monetary policy associated

[7] All quarterly VARs estimated in this paper contain four lags of the endogenous variables.

with the appointment of Paul Volker to the Federal Reserve. Gali, Lopez-Salido and Valles (2003) present evidence that the change in policy regime has also led to a change in the effects of neutral technology shocks on the US economy, while Boivin and Giannoni (2005) argue that it has also impacted the effects of monetary policy. Also Perotti (2005) and Fisher (2006) document pre-and-post-1982 sample differences in the effects of fiscal policy and technology shocks respectively. Third, a large literature starting with McConnell and Perez-Quiros (2000) has documented a substantial decline in the volatility of many macro-economic variables after 1984. The sources of this "great moderation" are still unclear.[8] Alternative hypothesis are changes in inventories, better stabilization policies and increased financial deepening and integration leading to a relaxation of credit constraints. Fourth, Fisher (2006) finds a structural break in the mean rate of decline in the baseline equipment deflator around 1982 (0.84% versus 1.49% after 1982). He relates this to the time when the personal computer began to be widely used in business. For all these reasons, we will focus on the period 1982:2 – 2005:4 in the rest of the analysis.

## *2.1. Technology*

The new economy boom of the 1990s and the increase in expected productivity growth in the United States is one of the most-often cited factors that are used to explain the deterioration of the current account since the 1990s. For example, Hunt and Rebucci (2005) argue that a persistent increase in productivity in the manufacturing/traded-goods sector associated with some learning can explain about one third of the deterioration of the US trade balance over the period 1996-2000. In this story foreign borrowing allows US households to consume part of their future wealth and firms to invest in order to make use of new profitable technologies. It is indeed a well-documented fact that over the past 15 years total factor productivity growth in the US has increased relative to the rest of the G7 countries and the world more generally. For example, recent estimates from the OECD show that US multi factor productivity grew by almost 2 percent per year over the 1998-2004 period and 1 percentage point higher than during 1991-1997. In contrast, the other G7 countries in general saw their productivity growth rates fall. At the same time, investment rates

[8] See, for example, Stock and Watson (2005) for a recent investigation.

boomed in the second half of the 1990s, suggesting that some of the new technologies may have been embedded in new capital goods.

In this section, we therefore aim at identifying two kinds of technology shocks (neutral - or multi-factor – and embodied technology shocks). There has been a lively debate about the role of productivity shocks in accounting for business cycle fluctuations in the United States. A number of authors (most prominently Galí (1999), Francis and Ramey (2005) and Galí and Rabanal (2004)) have argued that total factor productivity shocks can not account for a large fraction of US business cycles because they lead to a negative correlation between output and hours worked in the face of nominal rigidities, habit formation and adjustment costs in investment (See also Smets and Wouters, forthcoming). Others such as Altig et al (2005) and Dedola and Neri (2005) have argued that the empirical evidence on the effect of productivity on hours worked could be consistent with a positive impact. Fisher (2006) argues that investment-specific productivity shocks or embodied technology shocks can account for a much larger fraction of business cycle fluctuations than neutral technology shocks. Together they account for about 40 to 60 % of business cycle fluctuations, of which embodied technology shocks account for the most part. Altig et al (2005), using a different methodology, also argue that both productivity shocks can account for a large fraction of GDP fluctuations.

In this Section we estimate Fisher's (2006) VAR over the period 1982:2 – 2005:4 and add the net trade/GDP ratio in order to estimate the effects of total factor productivity and embodied technology shocks on net trade. As in Fisher (2006), the six-variable VAR reported in this section includes the log change in the relative price of equipment,[9] the log change in labour productivity in the non-farm business, the associated log per-capita hours worked, the log change in the GDP deflator and the federal funds rate.[10] In addition, we add the change in the net trade/GDP ratio[11]. The two technology shocks are identified using long-run restrictions. In particular, the embodied technology shock is the only shock that has a long-run impact on the

[9] We thank Riccardo Di Cecio and Reinout de Boeck for providing us with this series until 2004:4. We extended it further using the NIPA deflators.
[10] Fischer (2006) uses the same five-variable VAR for the sub-sample analysis, although in his specification a consumption deflator built by him replaces the GDP deflator in our analysis.
[11] Using a battery of conventional unit root tests, we could not reject nonstationarity of this variable over the sample period.

relative price of equipment. Moreover, the embodied and neutral (or multi-factor) productivity shocks are the only shocks that have a long-run impact on labour productivity. Finally, using a stylized growth model Fischer (2006) shows that the long-run impact of the embodied technology shock on labour productivity is related to the share of capital in production and uses this restriction as an over-identifying restriction.[12]

Precisely, denote the N variables in a VAR by $Y_t$:

$$Y_t = B(L)Y_{t-1} + u_t, Eu_t u'_t = \Sigma,$$
$$B(L) \equiv B_1 + B_2 L + \ldots + B_q L^{q-1},$$
$$Y_t = \begin{bmatrix} \Delta \log p_t \\ \Delta \log z_t \\ X_t \end{bmatrix}.$$

Here $p_t$ denotes the relative price of equipment, $z_t$ is labour productivity in the non-farm business sector, and $X_t$ is an additional vector of variables included in the VAR. In all of our applications we assume that the number of lags $q = 4$. Suppose that the fundamental economic shocks are related to the one-step ahead forecast error $u_t$ via the relationship:

$$u_t = Ce_t, Ee_t e'_t = I, CC' = \Sigma,$$

where the first two elements in $e_t$ are the embodied and neutral technology shocks, respectively. To be able to compute the dynamic effects of the two shocks on the elements of $Y_t$ we need the matrices $B_i$ and the first two columns of $C$. Remember that the two long-run restrictions imply that the long-run responses of the system $R$ obey:

$$R \equiv [I - B(1)]^{-1} C = \begin{bmatrix} r_{p1} & 0 & \underset{1x(N-2)}{0} \\ r_{z1} & r_{z2} & \underset{1x(N-2)}{0} \\ \underset{(N-2)x1}{R_{X,1}} & \underset{(N-2)x1}{R_{X,2}} & \underset{(N-2)x(N-2)}{R_{X,.}} \end{bmatrix}.$$

The 0's reflect the assumption that only the embodied technology shock has a non-zero long-run impact on the relative price of equipment $r_{p1}$ and only the embodied and neutral productivity shocks have non-zero long-run impacts $r_{z1}$ and $r_{z2}$ on labour productivity. Although we cannot directly estimate $R$, we can easily estimate $RR'$:

$$RR' \equiv [I - B(1)]^{-1} CC' [I - B(1)']^{-1},$$

[12] We find that in the extended sample, this restriction is rejected in the 6-variable VAR. Nevertheless, we still report the results obtained imposing it since they are very similar to those in the benchmark specification of Section 3, where the restriction is not imposed.

since the $B_i$'s and the variance-covariance matrix $\Sigma = CC'$ can be obtained by applying ordinary least squares to the VAR reduced form. Therefore, the first two columns of $C$ are obtained from the first two columns of the Choleski decomposition of $RR'$. If Fisher's over-identifying restriction on the long-run impact of the embodied technology shock on labour productivity is also imposed, implying a proportionality between $r_{p1}$ and $r_{z1}$, the two columns of $C$ will not be simply equal their counterparts in the Choleski decomposition, but the fully nonlinear system for $RR'$ above will need to be solved.

{Insert Figure 2}

Figure 2 reports the impulse responses of each of the six variables to both shocks.[13] A number of similarities and differences between both shocks are worth noting. Both increase labour productivity in the long run and lead to a fall in inflation although the timing and the dynamics of the effects is quite different. However, the embodied shock leads to a tightening of monetary policy, while the neutral shock leads to an easing. Moreover, in agreement with the theory, hours worked increase in response to the embodied shock, while they fall in response to the neutral shock. Most interestingly, both shocks lead to a deterioration of the trade balance. However, the impact of the neutral shock is a magnitude larger and more significant than that of the embodied shock.[14] A one percent increase in multi-factor productivity leads to an estimated deterioration of the net trade/GDP ratio by 0.5 percentage points, whereas a similar embodied technology shock has less than half this effect. At first sight, the smaller impact of the embodied technology shock on net trade may seem somewhat counterintuitive as it has a larger impact on absorption and therefore on imports. However, note that partly due to the differential interest rate response the terms-of-trade deterioration in the case of the neutral shock is likely to be much larger than in the case of the embodied technology shock. This price effect will tend to dominate the quantity effects on the nominal net trade to GDP ratio. This is indeed exactly what De Walque, Smets and Wouters (2005) find in their estimated US-euro area DSGE

[13] For clarity, in Figures 2 and 3 we have deleted the confidence bands in order to compare the impulse response of two shocks. The significance of the response of the net trade/GDP ratio is similar to that reported in Figures 5 and 6.

[14] As also shown in Figure 5, the impact of the embodied technology shock on the nominal net trade/GDP ratio is not significant at the 5% confidence level.

model. While the investment-specific technology shock has a larger negative effect on the real trade balance, the terms-of-trade response is much more favourable and tends to dominate in the case of such shocks. De Walque et al (2005) also show that this qualitative result is independent of whether a high or low elasticity of substitution is assumed. These findings are also partially confirmed in our VAR analysis. Substituting the real net trade/GDP ratio for the nominal one, we find that the impact of the embodied technology shock on the real net trade/GDP ratio is indeed much larger, reflecting the fact that the terms of trade improves following such a shock (not shown).

The ability of the technology shocks to explain the developments in the US external trade balance will be investigated in Section 3. Here it is, however, useful to compare the size of the effects with some of the estimates in the literature. Bussiere et al (2005) extend the study by Glick and Rogoff (1995) and find that a one percent asymmetric productivity increase (as measured by total factor productivity) leads to a current account deterioration of about 0.15 percentage points. Corsetti et al. (2006) look at the effects of productivity shocks in manufacturing identified with long-run restrictions, finding similar multipliers. Our estimates of the effect of a multi-factor productivity shock are clearly larger, although those of the investment specific shock are somewhat lower. This underlines the need for distinguishing between the various technology shocks when examining their impact on external balances. The role of productivity developments in accounting for the deterioration of the current account in the late 1990s is also discussed in Hunt and Rebucci (2005) using a calibrated two-country DSGE model. They conclude that the productivity shock needs to be augmented with a negative risk premium shock on US assets in order to be able to account for the full deterioration of the US trade deficit in the second half of the 1990s.

## *2.2. Fiscal policy*

The twin deficit hypothesis that an increasing government deficit will result in a deterioration of the current account balance is hotly debated. Historically, movements in the general government surplus and the current account balance have hardly been identical twins. While the U.S. trade balance deteriorated throughout the 1990-2005 period, the general government budget position improved during the 90s and then fell sharply after 2000. At the same time, the sharp fall in government revenues and rise in government spending in 2001-2003 may have contributed to the accelerating fall of the current account balance in that period. Similarly, the deterioration and subsequent improvement of the current account in the 1980s may have been associated with the rise and subsequent fall in the US government deficit in that period. Several recent papers in the literature have re-examined the scope for twin deficits in the US data, but no clear conclusions have been reached. For example, Kim and Roubini (2004) find that government deficit and spending shocks have a positive effect on the trade balance, in contrast to the theoretical literature on the twin deficit hypothesis which would generally suggest a negative impact. Corsetti and Muller (2006) show that the response of the current account to government spending shocks may depend on the persistence of the shock as well as the degree of openness. In more open economies and with more persistent shocks, investment will be crowded out less, as the associated terms of trade improvement increases the rate of return on investment. As a result, the twin deficit hypothesis may be valid for small open economies, but less so for relatively closed economies such as the United States. Using a VAR analysis, Corsetti and Muller (2006) find some evidence in favor of their analysis. Bussiere et al (2005) perform a cross-country analysis of current account imbalances and government deficits. They find that a 1 percentage point reduction in the government deficit leads to less than a 0.1 percentage point deterioration of the current account. This is at the lower end of the multipliers in a number of studies surveyed by Bussiere et al (2005). For example, Erceg et al (2005), who use a calibrated modern DSGE model, find a multiplier of 0.2.

Most of the literature focuses on government deficit or spending shocks. Theoretically however, the effects of a deterioration in the government deficit on the current account may be different depending on the source of the deterioration, in particular whether it is due to increased government spending or reduced taxes.[15] The deterioration of the US government balance in 2001-2003 was mostly due to a fall in government revenues following a series of tax reductions. It is therefore of interest to look at both government spending and tax shocks.

[15] For a recent survey of some of the theoretical literature see Kim and Roubini (2004).

In order to assess the effects of fiscal policy, one needs to take into account the other shocks to the economy as well as the typical automatic stabilizers of fiscal policy. [16] In this section, we follow the work of Blanchard and Perotti (2002) and Perotti (2005) to estimate the effects of fiscal revenue and spending shocks on the trade balance.[17] [18] The results that we report are based on Perotti (2005), since this study includes more recent years and reports results for samples starting in the early 1980s. However, similar findings were obtained by extending Blanchard and Perotti (2002). Apart from a different sample period, the only difference with the VAR specification in Perotti (2005) is the addition of net trade. Thus, our VAR specification includes 6 variables: (i) the log of real per capita government spending on goods and services, including government purchases and government investment, (ii) the log of real per capita net primary revenues, defined as government revenues less government transfers,[19] (iii) the log of real per capita GDP, (iv) the log of GDP deflator, (v) ten year nominal interest rate, (vi) ratio of nominal net exports over nominal GDP. For fiscal variables and GDP, real values are obtained by deflating nominal values with the GDP deflator. Equations in the VAR also include four lags and a constant term. To make results directly comparable with the large-scale VAR results from the next section, all the variables, except the 10 year nominal interest rate, are expressed in log first differences.

Government spending and revenue shocks are identified using contemporaneous zero restrictions. In the VAR government spending ($G$) and net taxes ($T$) are ordered first and second, followed by real GDP, GDP deflator and the 10 year nominal interest rate. Net trade is added to the VAR by ordering it last; namely $Y_t$ is defined as:

[16] For an alternative story about the role of government debt policy in driving current account imbalances in the early years of the millenniun, see Kraay and Ventura (2005).
[17] A related study is Mountford and Uhlig (2005), who use sign restrictions rather than contemporaneous restrictions to identify fiscal policy shocks.
[18] Blanchard and Perotti (2002) also report separate responses of exports and imports to the fiscal shocks, although it is not the main focus of the paper.
[19] For exact definition of both fiscal series see Blanchard and Perotti (2002) or Mountford and Uhlig (2005). Spending and tax series from Perotti (2005) would be preferred here, but are not publicly available. These series should not be very different from the ones used in Blanchard and Perotti (2002) and Mountford and Uhlig (2005).

$$Y_t = \begin{bmatrix} \Delta \log G_t \\ \Delta \log T_t \\ X_t \end{bmatrix},$$

where $X_t$ includes the growth rates of real GDP and GDP deflator, the 10 year nominal interest rate net trade over GDP . Remembering that the fundamental economic shocks are related to the one-step ahead forecast error $u_t$ via the relationship:

$$u_t = Ce_t, Ee_t e'_t = I, CC' = \Sigma,$$

the two fiscal shocks of interest, ordered first and second in $e_t$, are identified directly restricting the (inverse of) matrix *C*, depicting how reduced form residuals map into structural shocks. In order to be able to recover the first two columns of *C*, we need N-1 + N-2 = 9 restrictions. We obtain them by positing reaction functions for the two fiscal variables, following Perotti (2005). First, we assume that expenditure does not contemporaneously react to revenues, and then is ordered first in the VAR.[20] Second, the contemporaneous responses of government spending and revenues to GDP and prices are set on a priori basis. For our sample of interest (1982:2-2005:4) we apply the elasticities that Perotti (2005) reports for the 1980Q1-2001Q4 period (see Table 4 in Perotti (2005), n[gy]=0; n[ty]=1.97; n[gp]=-0.5; n[tp]=1.4; n[gi]=0; n[ti]=0). Finally, the last two restrictions needed are obtained by assuming that similar elasticities concerning the trade balance are zero.

{Insert Figure 3}

Figure 3 shows the response of each of the variables to the government spending and net revenue shock. A few results are worth highlighting. First, a one-standard deviation positive government spending shock increases output in the short run by about 0.1 to 0.2%. This effect is marginally significant. In contrast, a reduction in taxes does not appear to have a significant impact on output, and if anything leads to a fall in output. While in particular the latter result is quite surprising, it is consistent with the results of Perotti (2005), who finds that the output effects of government spending are typically larger than those of a comparable change in revenues in five OECD countries (including the US). Perotti (2005) also finds that in general the

[20] This is the benchmark specification in Perotti (2005). As in this contribution, our results are broadly similar when we invert the ordering of spending and revenues.

output effects of a government spending shock have fallen significantly since the early 1980s. Second, both an increase in spending and a tax cut have a negative effect on the net trade/GDP ratio. In the case of a positive spending shock, we observe an immediate significant negative impact on the external balance. The associated multiplier is in the order of 0.30 to 0.40 and thus somewhat higher than the one found in Bussiere et al. (2005). For a tax shock the negative impact on net trade takes longer to materialise and is also less significant. In this case the multiplier ranges from 0.01 for immediate impact to 0.30 for impact after 12 quarters.[21]

In sum, overall we find a significant role of the deterioration of fiscal balances for the deterioration of the net trade balance. The quantitative relevance of fiscal policy shocks for the most recent deterioration of the current account will be examined in Section 3.

### *2.3. Monetary policy*

Finally, we investigate the role of monetary policy in the developments of the current account. One popular story is that loose monetary policy following the collapse of the dot-com asset price bubble, the resulting recession and fears of deflation has led to low short and long-term interest rates and rising house prices.[22] This in turn has stimulated domestic demand leading to a rise in imports and a deterioration of the terms of trade, both contributing to a rise in the nominal trade balance deficit. Indeed, as inflation has declined since the early 1980s, also nominal short and long-term interest rates have fallen considerably over the last two decades. More importantly, real short-term interest rates have been significantly negative in the period 2001-2004.

However, in order to asses whether monetary policy has been exceptionally loose, one needs to control for the normal policy response to changes in inflation and real economic activity. This is exactly what the large VAR literature on estimating the

[21] To obtain fiscal multiplier, the shock was expressed as a percentage point change in government spending/GDP (net revenue/GDP) by multiplying the shock with average spending/GDP (net revenue/GDP) ratio. For our sample period, average shares are 0.19 for spending/GDP and 0.14 for net revenues/GDP.

[22] See, for example, Gros, Mayer and Ubide (2006).

effects of monetary policy on the US economy has tried to do.[23] In this section, we follow the recent work by Kim (2001), who builds on this literature to analyse the effects of US monetary policy shocks on the trade balance and other international variables. More specifically, Kim (2001) estimates a small-scale VAR in real GDP, the GDP deflator, the federal funds rate and a commodity price index over the period 1974-1996. Following Christiano, Eichenbaum and Evans (1999), he identifies monetary policy shocks by assuming that they have no contemporaneous effects on output, inflation and commodity prices. Commodity prices are included to alleviate the so-called price puzzle, the common finding that prices rise for a while following an unexpected interest rate increase. A similar VAR is used by Boivin and Giannoni (2005) to investigate whether monetary policy has become more effective in the post-1982 period. Using this VAR, Kim (2001) and Boivin and Giannoni (2005) show that a rise in the federal funds rate leads to a hump-shaped fall in output and a much more gradual decline in prices. Kim (2001) then investigates the effects of a US monetary policy shock on the trade balance and foreign output. He finds that an expansionary monetary policy shock worsens the US real trade balance in about a year and leads to a terms-of-trade deterioration as the dollar exchange rate depreciates. Overall, this contributes to a significant deterioration of the nominal trade balance in the short to medium-run.

In analogy with the previous sections, we update the findings of Kim (2001) by estimating a similar VAR and using a similar identification strategy over the sample period 1982:2 till 2005:4. Apart from the different sample period, there are two main differences in the specification of the VAR. First, we leave out the commodity price index, as over this sample the inclusion of commodity prices did not improve the estimated effects of the policy shock very much (either in terms of sharpening the confidence bands or alleviating the price puzzle). Second, we introduce real GDP and the GDP deflator in log first differences (rather than in log levels) anticipating the specification of the large-scale VAR in the next Section. Neither of these changes has a material impact on the estimated impulse responses. Finally, as with the other VARs discussed in this Section, the net trade/GDP ratio (*NX*) is introduced in first differences and it is assumed that the monetary policy shock can have an immediate

[23] One of the classic references is Christiano, Eichenbaum and Evans (1999).

impact on net trade/GDP ratio, but that policy does not immediately respond to changes in the net trade ratio. Precisely, in this case $Y_t$ is defined as:

$$Y_t = \begin{bmatrix} X_t \\ i_t \\ \Delta NX_t \end{bmatrix},$$

where $X_t$ includes the growth rates of real GDP and GDP deflator, and $i_t$ is the federal fund rate. As before, in order to recover the monetary policy shock we need to appropriately restrict matrix $C$ in order to be able to recover its third column, describing the effect of a monetary policy shock on the VAR variables. Following Christiano, Eichenbaum and Evans (1999) and Kim (2001), without loss of generality we assume that $C$ has a recursive structure, so that the column of interest can be recovered from the third column of the Choleski factor of $\Sigma$. The monetary policy shock is then effectively identified as the residual from a regression of the policy instrument $i_t$ over contemporaneous and lagged values of $X_t$ and only lagged values of net trade and itself, controlling this way for the normal policy response to changes in inflation and real economic activity. This means that systematic monetary policy is assumed to react within the same quarter to observed values of GDP growth and inflation; for instance, increases in the nominal rate which only reflect increases in current and past inflation will not be attributed to exogenous changes in the monetary policy stance.

{Insert Figure 4}

Figure 4 shows the estimated impulse responses of the federal funds rate, the GDP deflator, real GDP and the net trade/GDP ratio to a monetary policy shock over the recent sample. The results confirm the findings of Kim (2001) and Boivin and Giannoni (2005): An unexpected temporary tightening of the federal funds rate by 50 basis points leads to a hump-shaped decline in real GDP of maximally 30 to 40 basis points and a very gradual (but not significant) decline in the GDP deflator. More importantly for our purposes, the nominal net trade/GDP ratio improves significantly in the second year following the shock. According to these estimates, a 50 basis point policy easing leads to a maximum deterioration of the net trade/GDP ratio of 0.2 percentage points after two years. These multipliers are both statistically and economically significant and appear to be quite robust with respect to adding additional variables. It will therefore be interesting to see how much the monetary policy easing of the early millennium can contribute to the deterioration of the trade balance during that period. This will be discussed in the next section.[24]

## 3. The contribution of technology and policy to US current account developments

In the previous section, we analyzed the effects of technology and policy shocks on the trade balance in separate VARs by following and extending the existing VAR literature. This allowed us to keep the size of the VARs relatively small, which is important given the relatively limited sample size. However, in order to assess the relative contributions of technology versus policy shocks in driving external trade and current account developments, it is crucial to put the various shocks into one VAR. This is what we do in this Section. In order to maintain enough degrees of freedom, we restrict the number of variables in the VAR to eight and the number of identified shocks to four. First, the price of equipment is included in order to identify the embodied technology shock. Second, we use non-farm business sector labour productivity to identify the multi-factor productivity shock. As before, both technology shocks are identified using long-run restrictions. Third, in line with the twin-deficit hypothesis we combine the government spending and revenue shock into one government deficit shock by constructing an adjusted government deficit measure which takes into account the short-run automatic multipliers of the deficit with respect to output and inflation. Fourth, monetary policy developments are captured by the federal funds rate. As before, both policy shocks are identified using short-run restrictions. In addition to the four variables that are necessary to identify the four shocks, we add real private consumption and real private investment (which together form domestic private absorption), the change in the GDP deflator and the net external trade/GDP ratio. More details regarding the identification scheme are given in the appendix.

[24] Adding financial variables to the VAR, we also found that the long-term rate does significantly rise in response to the monetary policy tightening. The effect of a 50 basis point increase is to raise the 10-year bond yield temporarily by 10 basis points. Moreover, the policy tightening also leads to a fall in real house prices by about 2 percent. However, this effect is only significant at the 10% confidence level.

{Insert Figure 5}

Figure 5 reports the impulse responses of the nominal net trade/GDP ratio to each of the four identified shocks (together with two standard deviation confidence bands) in two versions of the 8-variable VAR. The upper panel is based on a VAR that includes a drift term (or constant) in the equation for the change in the net trade/GDP ratio. This drift term captures the secular fall in the net trade/GDP ratio over the sample period by about 0.20 percentage points per year. As the constant is not significantly different from zero, we also report the results of a similar VAR without such a drift term in the lower panel of Figure 5. Such a VAR allows us to investigate to what extent the four structural shocks can contribute to the secular fall in the net trade/GDP ratio over the full sample. It is easy to verify that in both cases the overall effects of the four structural shocks on net trade are very similar to what we found in the more specialized VARs discussed in Section 2. This shows that the estimated effects are quite robust with respect to the choice of variables that are included in the VAR. As before, it turns out that a one-standard deviation multi-factor productivity and monetary policy shock have the largest and most significant effect on the net trade/GDP ratio.

{Insert Table 2}

How much of the swings in the US external trade balance over the past two decades can the four structural shocks account for? Table 2 gives the contribution of each of the shocks to the forecast error variance of changes in the net trade/GDP ratio at various horizons. It turns out that the fiscal, monetary policy and technology shocks each explain between 8 and 12 percent of the forecast variance at business cycle frequencies. Figure 6 plots the actual net trade/GDP ratio as well as the joint contribution of the four shocks and the baseline over the full sample period in the VARs with and without a drift term in net trade. This figure also plots the contribution of the four shocks to the growth of domestic absorption, the inflation rate and the federal funds rate. Comparing the contribution to net trade in both VARs (Figure 6), it is clear that the VAR with a drift term is better able to account for the secular fall in net trade over the sample period. However, it is also clear that the main failure of the VAR without a drift term to account for this trend is located in the 1990s. In fact, it is worth distinguishing three episodes, which are analysed in more detail in Figures 7a and 7b. The first episode covers the 1980s. In this period, the four structural shocks are able to explain the drop in the net trade balance in the early 1980s and the subsequent increase in the second half of the 1980s and the beginning of the 1990s. Looking at the contribution of the shocks separately (Figure 7a,b), it appears that technology developments and to a lesser extent a reversal of loose fiscal policy have contributed to a return of the net trade deficit to almost balance. The second episode covers most of the 1990s. In contrast to the 1980s, the structural shocks can not explain the large deterioration of the net trade balance in the 1990s (in particular the three percentage point deterioration since 1997). It is interesting to see that in this period, both inflation and the nominal interest rate are overpredicted. Moreover, the structural shocks can not explain the investment boom associated with the dot-com bubble in the late 1990s either, the period with the most rapid deterioration of net trade in the United States. As discussed in the introduction, a number of other not necessarily US driven developments have been proposed to explain the growing imbalances. Three of those are worth mentioning. First, following the Asian crisis in 1997-1998, a number of Asian countries such as Korea, Malaysia, Thailand and Indonesia experienced a sharp and persistent drop in investment rates, coupled with temporarily high savings rates. These developments coincided with a build up of official reserves as of 1999. These changes coincide with the emergence of a large gap between actual net trade developments in the US and the part explained by our US shocks (see Figure 7) and therefore may explain part of this gap. Second, the rapid accumulation of reserves in China following strong growth in exports under its mercantilist policy only took off in 2001 and therefore is unlikely to explain what happened in the second subperiod. Finally, most recently more emphasis has been put on the recycling of petrodollars as a factor behind the growing global imbalances. However, also this factor only became relevant after 1999, suggesting that it can not explain the gap in Figure 7 in the 1997-2000 period.

{Insert Figure 6}

{Insert Figure 7}

Finally, turning to the most recent period since 2000, it turns out that the three types of shocks have all contributed to the further deterioration of the net trade/GDP ratio.

Depending on the VAR specification, positive technology developments, easy fiscal policy and loose monetary policy have each lead to an increase of the trade deficit by about 0.50 to 1 percentage point in this period.

## Conclusions

In this paper we have examined the relative role of technology and policy in the deterioration of the US net trade/GDP ratio since the second half of the 1990s. Understanding the sources behind the rise of the US external deficit is crucial for understanding whether the large deficit is sustainable and what policy measures are needed to ensure an orderly adjustment process. Using identified VARs estimated over the 1982:2-2005:4 period, we found that since the start of the new millennium both positive technology developments and easy fiscal and monetary policy in the US have played a role. The part due to technological progress should be less of a concern to the extent that higher future growth is likely to increase savings rates in the future. However, after playing a stabilizing role in the second half of the 1990s, both monetary and in particular fiscal policy turned very loose at the beginning of the millennium and also contributed considerably to the deterioration of the trade balance. As those policies are normalized, they could contribute to an improvement of the external balance of around 2 percentage points. Somewhat surprisingly, the estimated structural shocks can, however, not explain the significant deterioration in the late 1990s. One possibility is that our identification scheme fails to capture the impact of embodied technological progress in this period. Another possibility is that other factors such as the Asian crisis and its impact on excess global savings are important determinants in this period. An extension of the VAR methodology to account for such shocks would be a useful area for future research.

Of course, the analysis can be further extended and improved in a number of ways. First, the robustness of the results reported in this paper need to be further checked, for example by using alternative identification schemes. Second, we need to investigate more closely what are the channels through which the identified shocks affect the overall trade balance. In particular, it would be important to understand the role of the exchange rate and the terms of trade adjustments in response to the various shocks. We also need to analyze to what extent the estimated effects are consistent with modern intertemporal open-economy macro models in order to increase our confidence in the estimated effects.

## Appendix: The identification scheme of the VAR estimated in Section 3

In Section 3 we estimated the following reduced form VAR:

$$Y_t = B(L)Y_{t-1} + u_t, Eu_t u'_t = \Sigma,$$
$$B(L) \equiv B_1 + B_2 L + ... + B_q L^{q-1},$$
$$Y_t = \begin{bmatrix} \Delta \log p_t \\ \Delta \log z_t \\ \Delta BD_t \\ X_t \\ i_t \\ \Delta NX_t \end{bmatrix}.$$

First, the price of equipment $p_t$ is included in order to identify the embodied technology shock. Second, we use non-farm business sector labour productivity $z_t$ to identify the multi-factor productivity shock. Third, in line with the twin-deficit hypothesis we combine the government spending and revenue shock into one government deficit shock by constructing an adjusted government deficit measure which takes into account the short-run automatic multipliers of the deficit with respect to output and inflation, $BD_t$. Fourth, monetary policy developments are captured by the federal funds rate $i_t$. In addition to the four variables that are necessary to identify the four shocks, we include in vector $X_t$ the growth rate of real private consumption and real private investment (which together form domestic private absorption) and the change in the GDP deflator, and finally the net external trade/GDP ratio.

As before, both technology shocks are identified using long-run restrictions, while both policy shocks are identified using short-run restrictions. Concretely, we proceed in the following way. First, in order to identify the two technology shocks we estimate the corresponding two columns of the $C$ matrix by a straightforward generalization of the procedure described in Section 2.1. The two long-run restrictions imply that the long-run responses of the above system satisfy:

$$\mathrm{P} \equiv [I - B(1)]^{-1} C = \begin{bmatrix} r_{p1} & 0 & \underset{1x(N-2)}{0} \\ r_{z1} & r_{z2} & \underset{1x(N-2)}{0} \\ \underset{(N-2)x1}{R_{Z,1}} & \underset{(N-2)x1}{R_{Z,2}} & \underset{(N-2)x(N-2)}{R_{Z,.}} \end{bmatrix},$$

where now *Z* denotes the vector including the non-technology variables in the VAR, namely $\Delta BD_t$, $X_t$, $i_t$, and $\Delta NX_t$. As before, the 0's reflect the assumption that only the embodied technology shock has a long-run impact on the relative price of equipment and only the embodied and neutral productivity shocks have a long-run impact on labour productivity. Again this structure of P implies that the two columns of interest of *C* can be retrieved from the first two columns of the Choleski decomposition of PP*'*:

$$\mathrm{PP}' \equiv [I - B(1)]^{-1} CC' [I - B(1)']^{-1}.$$

Notice that differently from Section 2.1 in this case we do not impose Fisher (2006) over-identifying restriction as it is rejected by the data.

Second, in order to identify the policy shocks we assume again a recursive structure for the remaining columns of *C,* according to which the (adjusted) budget deficit responds contemporaneously only to both technological variables, while the federal fund rate responds also to all the variables included in $X_t$. It can be shown that these assumptions, plus knowledge of the two columns of *C* obtained with long-run restrictions, yields enough restrictions (namely N(N-1)/2) to exactly solve the matrix equation $\Sigma = CC'$ and thus estimate the effects of the two policy shocks (see e.g. Altig et al. (2005)).

It is important to notice that relative to Section 2.2 we are allowing fiscal variables to contemporaneously react to technology shocks beyond what would be implied by Perotti (2005) multipliers on prices and GDP. However, we do not impose these further over-identifying restrictions, as they are rejected by the data, and thus keep working with a just identified system.

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Table 1

**U.S. trade balances with geographical counterparts (bn USD, excl. services)**

| Trade partner | Accumulated trade balance, 1991-1997 | Accumulated trade balance, 1998-2004 | Change in the trade balance | Contribution to the change (%) |
|---|---|---|---|---|
| All countries | -930.2 | -3070.4 | -2140.3 | 100% |
| G7, excl. Canada&UK | -528.3 | -894.6 | -366.4 | 17% |
| *Japan* | *-381.2* | *-499.5* | *-118.3* | *6%* |
| *Germany* | *-83.2* | *-230.9* | *-147.7* | *7%* |
| *France* | *-15.3* | *-65.5* | *-50.2* | *2%* |
| *Italy* | *-48.6* | *-98.7* | *-50.2* | *2%* |
| Major oil suppliers | -236.3 | -924.7 | -688.3 | 32% |
| *NAFTA* | *-136.2* | *-547.8* | *-411.5* | *19%* |
| *Other** | *-120.4* | *-351.0* | *-230.6* | *11%* |
| *United Kingdom* | *20.3* | *-25.9* | *-46.2* | *2%* |
| China | -206.2 | -681.5 | -475.2 | 22% |
| S. E. Asia, excl. Japan&China | -182.4 | -400.8 | -218.4 | 10% |
| *Korea, Malaysia, Thailand, Indonesia, Philippines* | *-108.7* | *-328.0* | *-219.3* | *10%* |
| *Taiwan, Singapore, Hong Kong* | *-73.7* | *-72.8* | *0.9* | *0%* |
| Rest of Europe | 90.3 | -83.2 | -173.6 | 8% |
| All other coutries | 132.7 | -85.6 | -218.3 | 10% |

* include Saudi Arabia, Venezuela, Irag, Nigeria, Algeria, Angola, Russia, Norway, Kuwait, Gabon, Columbia and Equadora.

Table 2: Contribution of the four shocks to the variance of changes in net trade/GDP

(a) 8 variable VAR with drift term

| | Forecast variance at indicated horison | | | | |
|---|---|---|---|---|---|
| Variable | 1 | 4 | 8 | 12 | 20 |
| Fiscal policy | 4.9 | 9.8 | 8.3 | 8.3 | 8.3 |
| Embodied technology | 4.0 | 4.7 | 4.8 | 5.2 | 5.2 |
| Neutral technology | 1.4 | 5.2 | 6.5 | 7.3 | 7.2 |
| Monetary policy | 4.1 | 9.8 | 10.1 | 10.0 | 10.0 |

(b) 8 variable VAR without drift term

| | Forecast variance at indicated horison | | | | |
|---|---|---|---|---|---|
| Variable | 1 | 4 | 8 | 12 | 20 |
| Fiscal policy | 6.3 | 10.4 | 9.0 | 8.9 | 8.9 |
| Embodied technology | 2.9 | 4.1 | 4.2 | 4.6 | 4.6 |
| Neutral technology | 0.0 | 4.2 | 5.4 | 6.0 | 5.9 |
| Monetary policy | 4.4 | 10.5 | 10.6 | 10.3 | 10.3 |

Figure 1


Current account and trade deficits in the U.S.
% of GDP
current account
net trade
2
1
0
-2
-3
-4
-5
-6
-7
1980q1
1981q2
1982q3
1985q1
1986q2
1987q3
1988q4
1990q1
1991q2
1992q3
1995q1
1996q2
1997q3
1998q4
2000q1
2001q2
2002q3
2003q4
2005q1

Figure 2

## Impulse responses to an embodied and neutral technology shock
## Estimation period: 1982:2 - 2005:4

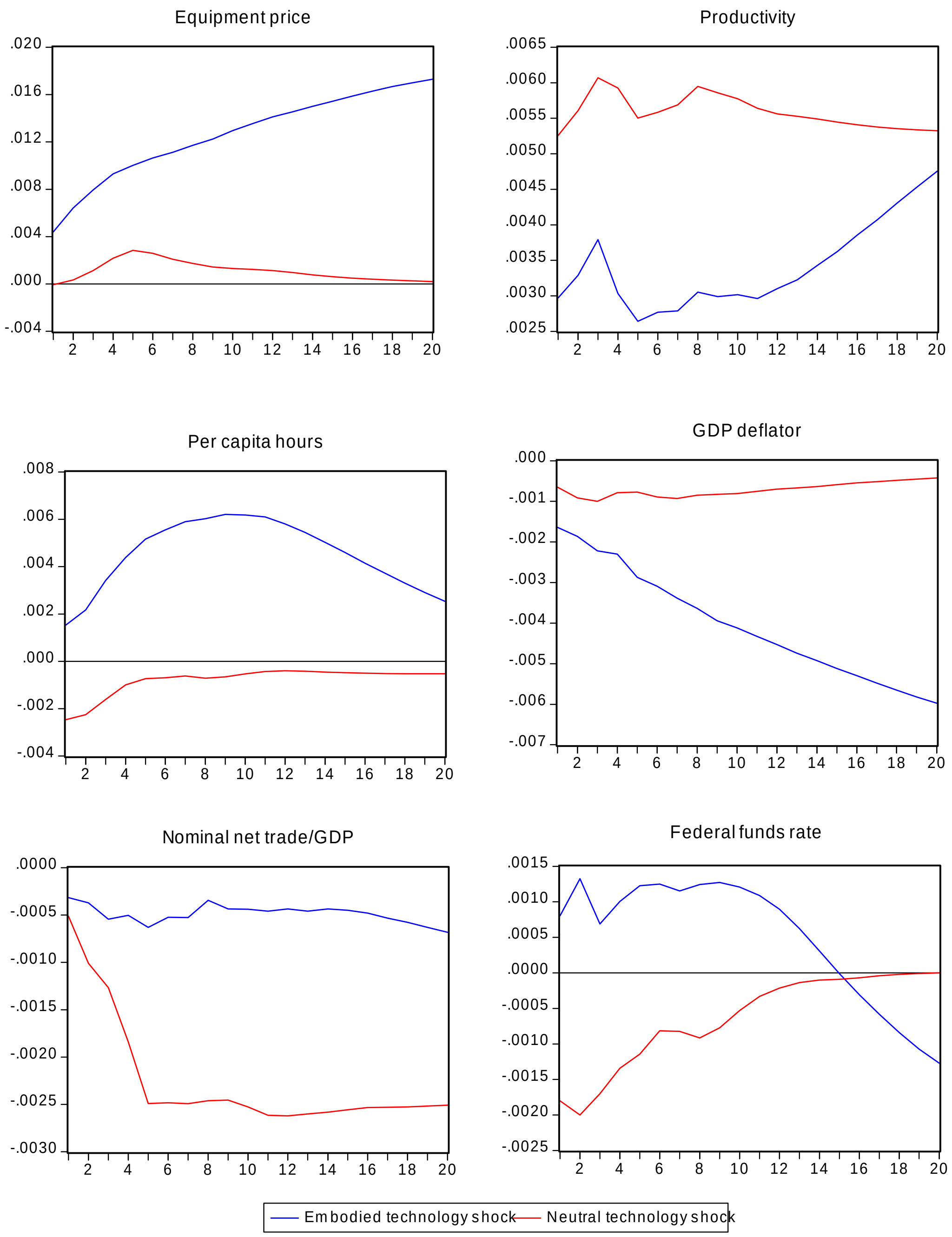


Figure 3

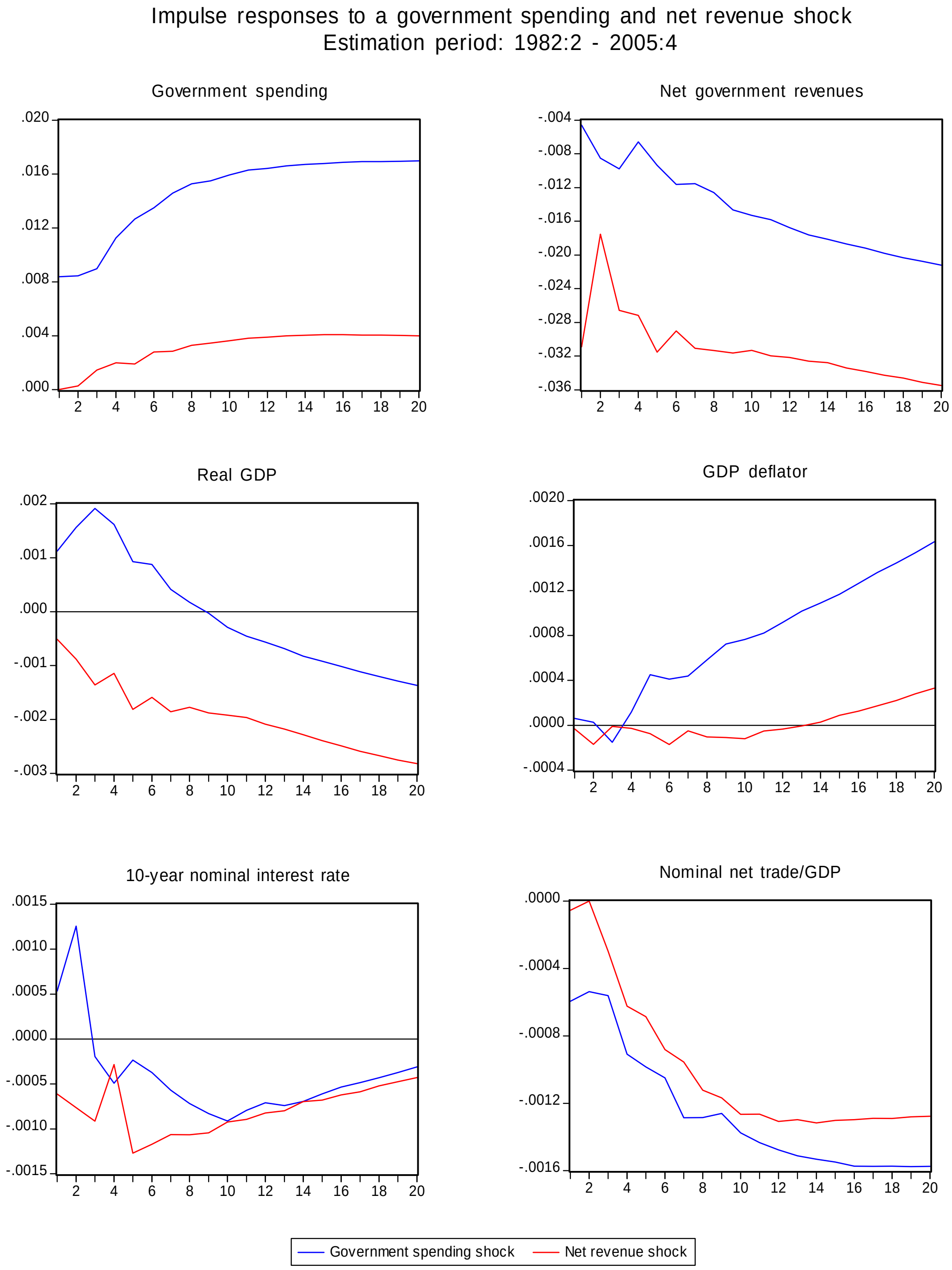
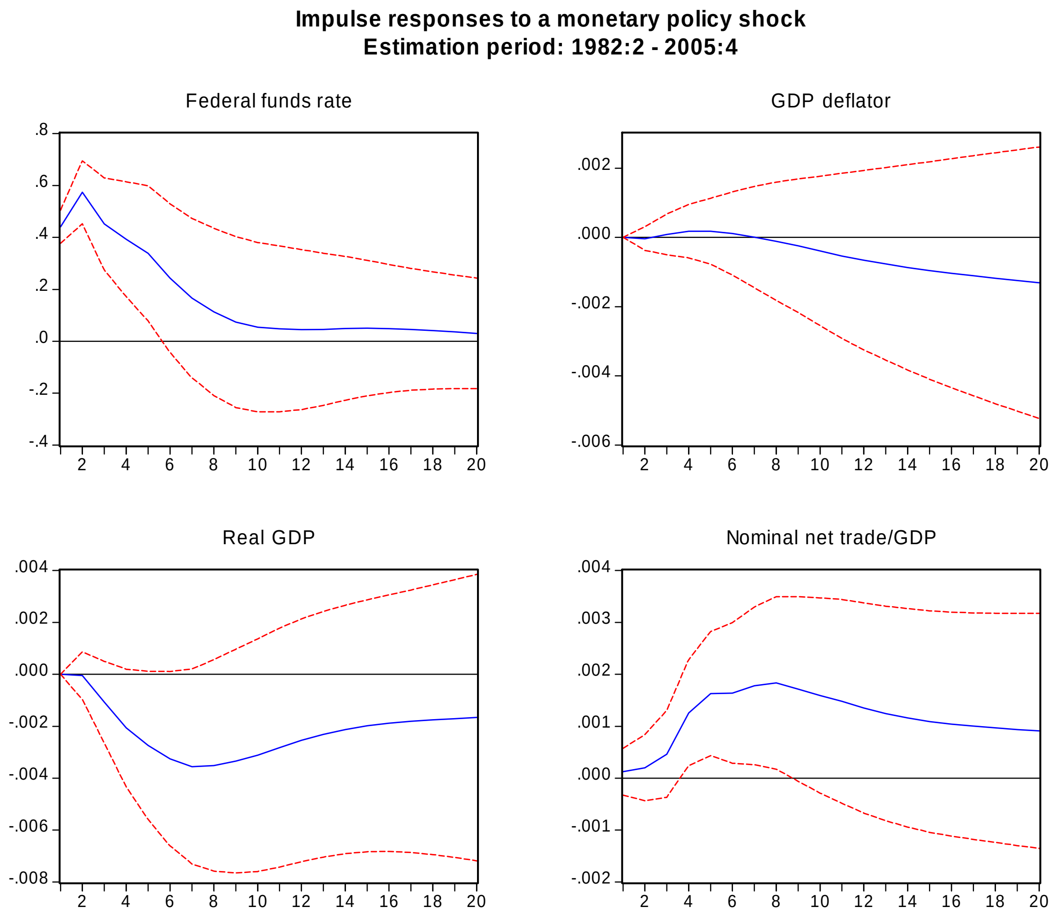

Impulse responses to a government spending and net revenue shock
Estimation period: 1982:2 - 2005:4
Government spending
.020
.016
.012
.008
.004
.000
2 4 6 8 10 12 14 16 18 20
Net government revenues
-.004
-.008
-.012
-.016
-.020
-.024
-.028
-.032
-.036
2 4 6 8 10 12 14 16 18 20
Real GDP
.002
.001
.000
-.001
-.002
-.003
2 4 6 8 10 12 14 16 18 20
GDP deflator
.0020
.0016
.0012
.0008
.0004
.0000
-.0004
2 4 6 8 10 12 14 16 18 20
10-year nominal interest rate
.0015
.0010
.0005
.0000
-.0005
-.0010
-.0015
2 4 6 8 10 12 14 16 18 20
Nominal net trade/GDP
.0000
-.0004
-.0008
-.0012
-.0016
2 4 6 8 10 12 14 16 18 20
Government spending shock
Net revenue shock

Figure 4

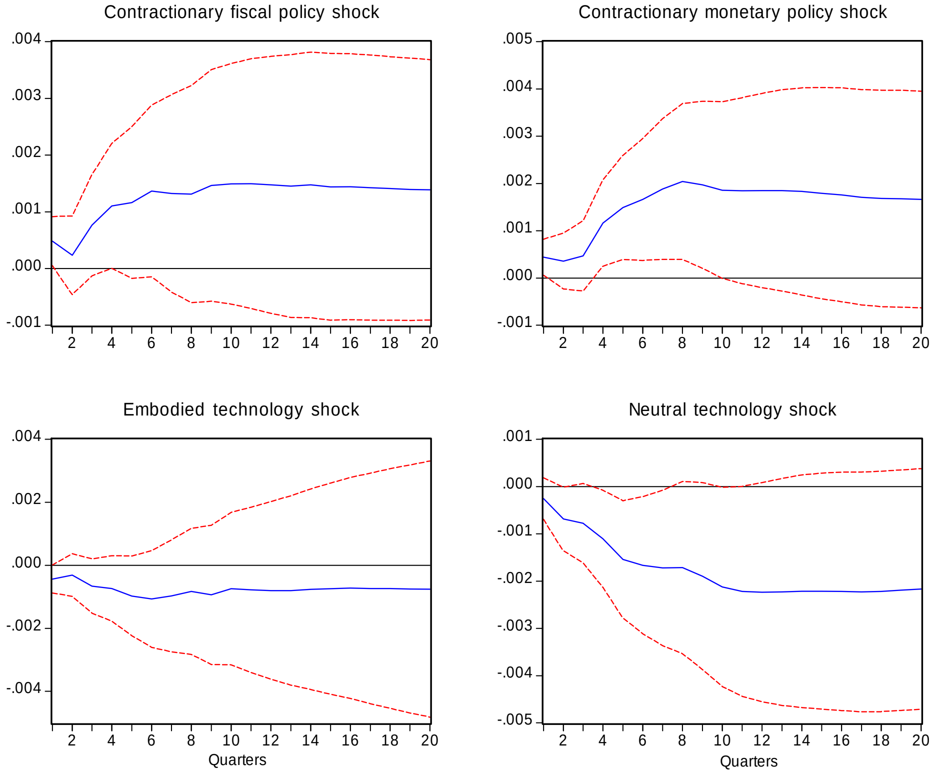


Impulse responses to a monetary policy shock
Estimation period: 1982:2 - 2005:4
Federal funds rate
.8
.6
.4
.2
.0
-.2
-.4
2 4 6 8 10 12 14 16 18 20
GDP deflator
.002
.000
-.002
-.004
-.006
2 4 6 8 10 12 14 16 18 20
Real GDP
.004
.002
.000
-.002
-.004
-.006
-.008
2 4 6 8 10 12 14 16 18 20
Nominal net trade/GDP
.004
.003
.002
.001
.000
-.001
-.002
2 4 6 8 10 12 14 16 18 20

Figure 5

Impulse responses of nominal net trade.GDP (Estimation period: 1982:2 – 2005:4)

8-variable VAR (with drift term in net trade)




8-variable VAR without drift term in net trade

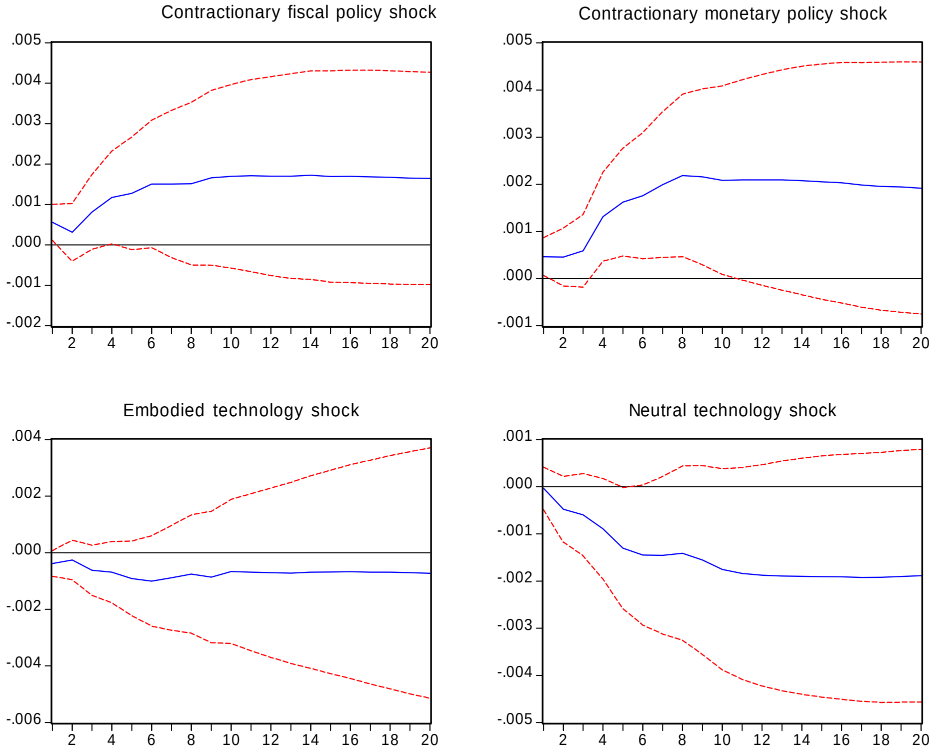
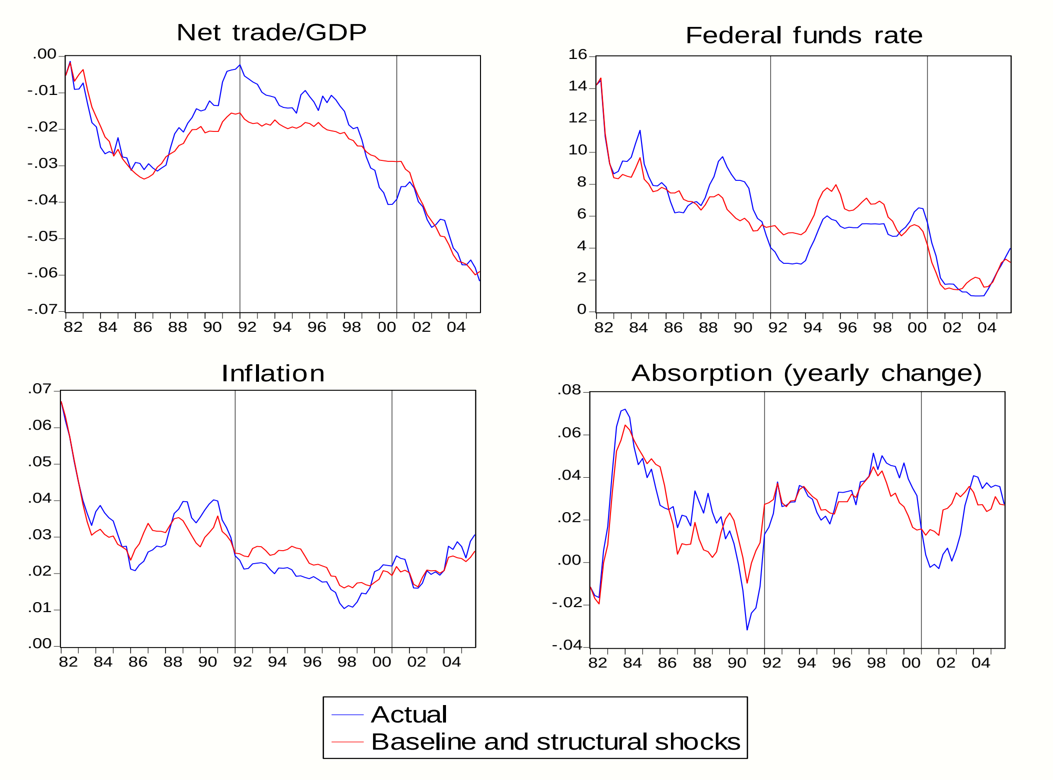


Figure 6

Contribution of structural shocks to net trade, absorption, inflation and interest rate

8-variable VAR with drift term in net trade




8-variable VAR without drift term in net trade

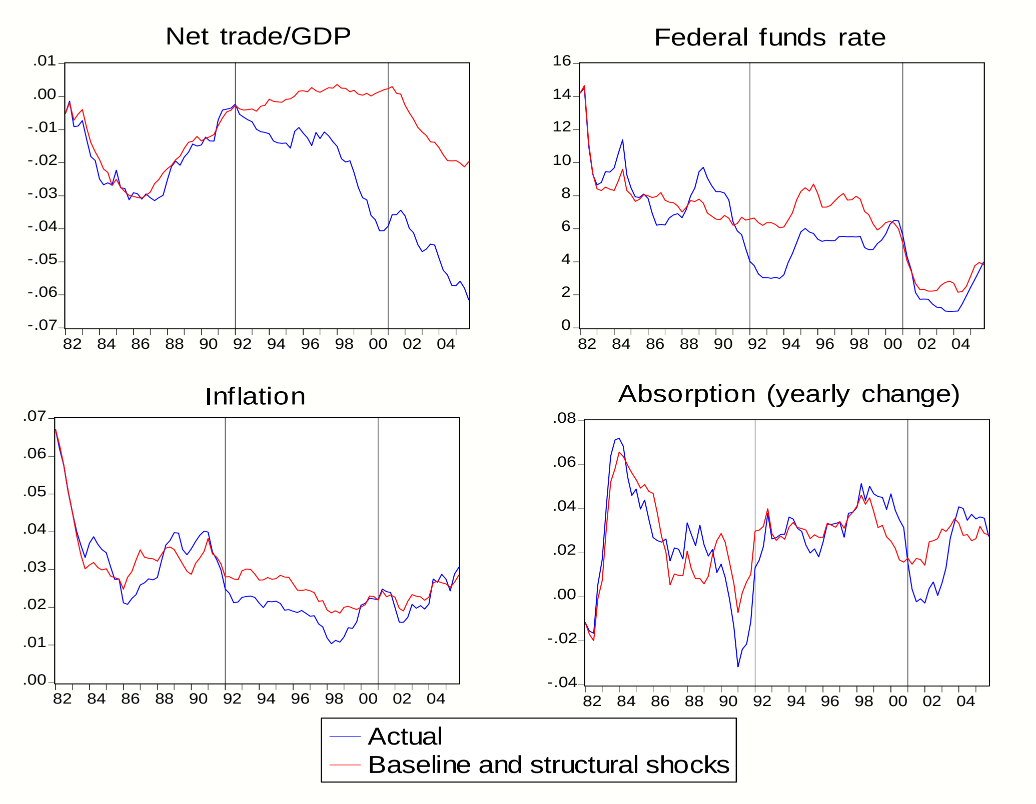


Figure 7a: Contribution of structural shocks to the net trade/GDP ratio: 3 episodes

(8-variable VAR with drift term)

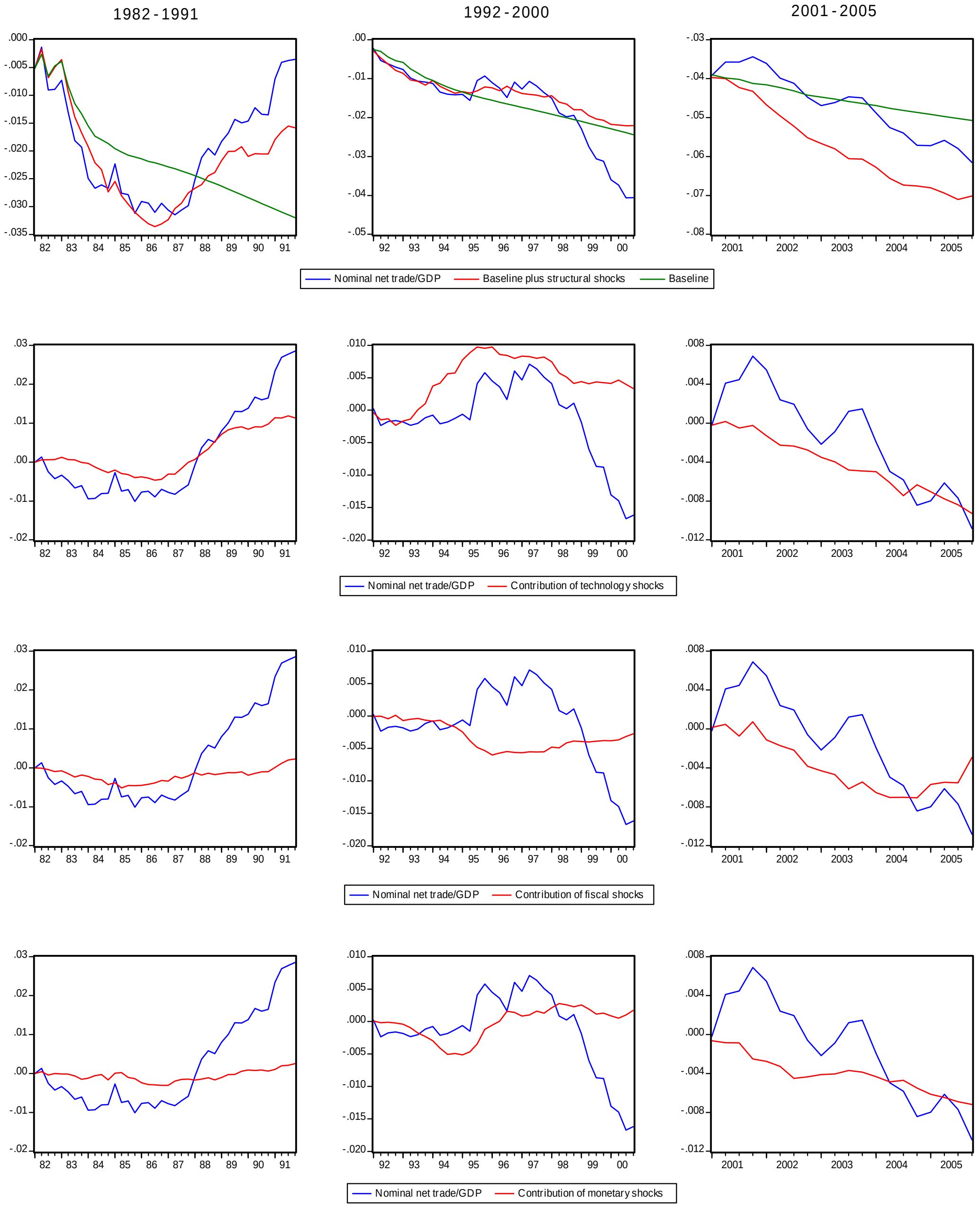


Figure 7b: Contribution of structural shocks to the net trade/GDP ratio: 3 episodes (8-variable VAR without drift term)