Twin Deficit or Twin Divergence?
Fiscal Policy, Current Account, and Real Exchange Rate in the US[a]

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Abstract

In spite of concerns about "twin deficits" (fiscal and the current account deficits) for the United States economy, empirical evidence suggests that "twin divergence" is a more usual feature of the historical data, i.e., when fiscal accounts worsen, the current account improves and vice versa. This paper thus studies empirically the effects of fiscal policy (government budget deficit shocks) on the current account and the real exchange rate, during the flexible exchange rate regime period. Based on VAR (Vector Auto-Regression) models, "exogenous" fiscal policy shocks are identified after controlling for the business cycle effects on fiscal balances. In contrast to the predictions of most theoretical models, the results suggest that an expansionary fiscal policy shock, or a government budget deficit shock, improves the current account and depreciates the real exchange rate. Increases in private savings and falls in investment contribute to the current account improvement while the nominal exchange rate depreciation, as opposed to the relative price level changes, is mainly responsible for the real exchange rate depreciation. The "twin divergence" of fiscal balances and current account balances is also explained by the prevalence of output shocks, i.e. output shocks - more than fiscal shocks - appear to drive the comovements of the current account and the fiscal balance.

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1. Introduction

Questions concerning the relations between fiscal policy, the current account, and the real exchange rate are of great analytical and empirical interest. From the theoretical point of view, numerous models suggest that a fiscal expansion should lead to a worsening of the current account and an appreciation of the real exchange rate. The prime empirical example of such a relation is usually argued to be the experience of the United States with “twin deficits” in the first half of the 1980s. As Figures 1 and 2 show, a worsening of the fiscal balance (as a share of GDP) in the form of lower tax rates and higher military spending was associated with an appreciation of the US nominal and real exchange rates and a sharp worsening of the current account (as a share of the GDP). In recent years, the concerns about “twin deficits” have reemerged as a major worsening of the US fiscal balance (a 6% of GDP turnaround between the large surplus of 2000 and the large deficit of 2004) has been associated with a large and worsening current account balance (reaching about 5% of GDP in 2003 and further deteriorating afterwards).

The US experience, however, is more complex than the simple idea that a fiscal expansion leads to a worsening of the current account and an appreciation of the real exchange rate. Most of the worsening of the fiscal deficit in the early 1980s may have been due to the 1980-82 recession; overall public savings started to improve from 1983 while the current account worsened in the 1982-1986 period mainly because investment rates recovered after the slump of the 1980-82 recession. In addition, in the 1989-1991 period, the current account improved while the fiscal balance tended to worsen again. More importantly, between 1992 and 2000, the US fiscal balance dramatically improved from a negative savings of 5% of GDP to a positive savings of 2.5% of GDP, while the current account worsened from -1 % of GDP to - 4.5% of GDP. Regarding the real exchange rate, the fiscal contraction and return to budget surpluses in the 1990s was associated with a real appreciation. Although the real dollar appreciation between 2000 and 2002 was observed in a period when budget deficits reemerged in a major way, the real exchange rate depreciated between 2002 and 2004 at a time when the budget deficit was further worsening.

These empirical facts are somewhat puzzling since most theoretical models suggest that a positive government budget deficit shock should lead to a current account worsening and a real exchange rate appreciation.[1] General equilibrium endowment economy models of small open economy with optimizing individuals and no capital account restrictions (Sachs, 1982, for a one-good model and Frenkel and Razin, 1996, for both one and two-goods models), standard Keynesian models such as the Mundell-Fleming model and its rational expectations variants such as Dornbusch (1976), and calibrated international real business cycle models with investment such as Baxter (1995), Kollmann (1998), and Erceg, Guerrieri, and Gust (2005) tend to provide such predictions in most cases, although the precise effects depend on various

[1] See Kim and Roubini (2006) for a more detailed discussion of the predictions of various analytical models. In later sections of this paper, we discuss some cases in which the theoretical predictions are different from the traditional analytical benchmark.

factors such as the nature of government budget deficit (e.g., government spending shocks or net tax shocks, the persistence of shocks), the characteristics of countries (e.g., large or small), the international asset market structure (e.g., complete markets or incomplete markets), and specifications of the model (e.g. endogenous or fixed labor input, the existence of investment and capital accumulation).[2]

The lack of strong positive correlation between government budget deficits and current account deficits may be explained by endogenous movements of the government budget and the current account. These endogenous movements are analytically and empirically crucial. During economic recessions (or booms), output falls (or rises) and the fiscal balance worsens (or improves). At the same time, the current account can improve when the fall in output leads to a fall in investment that is sharper than the fall in national savings. In particular, if there is a technology shock, as in the case of the US New Economy and IT boom in the 1995-2000 period, there will be an investment boom that will tend to worsen the current account. At the same time this economic boom will lead to an improvement of the fiscal balance (given automatic stabilizers on the tax and spending side). This may explain why the current account worsened in the US in the 1990s while the fiscal balance was improving. Therefore, the current account can improve (or worsen) as the fiscal balance worsens (or improves). One can observe a "twin divergence," rather than a "twin deficit" when the main driver of the two balances is an output shock.

To evaluate these issues, this paper presents an empirical analysis of the relation between the fiscal balance, the current account, and the real exchange rate for the US, for the Post Bretton Woods period of flexible exchange rates. We examine the effects of government budget deficit shocks on the current account and the real exchange rate, and also derive the general relationship among those variables. To identify government budget deficit shocks that control for business cycle effects, VAR (Vector Auto-Regression) models are employed. One new and somewhat paradoxical empirical result of our study is that contrary to most economic models, expansionary fiscal shocks or government budget deficit shocks are associated with an improvement of the current account and a depreciation of the real exchange rate. This is especially interesting because this paradoxical correlation occurs even after we control for the effects of the business cycle or output shocks that are likely to generate "twin divergence." That is, even "exogenous" fiscal deficit shocks seem to be associated with an improvement of the current account.

An extended analysis show that a combination of factors, such as (1), an investment crowding out effect caused by an increase in the real interest rate and (2), a partial Ricardian movement in private savings, can account for the empirical paradox. This result may also be related to one special characteristic of the U.S. economy, namely a relatively closed large open economy. In such an economy, a fiscal

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[2] Some recent New Open Economy Macroeconomics (NOEM) models such as those in Obstfeld and Rogoff (1995) also consider the effects of fiscal policy on the current account and the real exchange rate. In later sections of this paper, we discuss the theoretical predictions of the basic NOEM model in Obstfeld and Rogoff (1995). A more realistic, calibrated version of NOEM models analyzing fiscal policy and the current account has studied only very recently (e.g., Müller, 2005 and Corsetti and Müller, 2006).

expansion may lead to an increase in the real interest rate (such as the one observed in the US in the early 1980s), which may in turn crowd out private investment but stimulate private savings.[3]

Moreover, sticky prices seem to play an important role in the result of a real exchange rate depreciation following a government deficit shock, as the nominal exchange rate is also found to depreciate following such a shock. There are some explanations of this result that are related to characteristics of the U.S. economy. First, fiscal deficits leading to a crowding out of investment may reduce the long run rate of productivity growth of the economy and thus lead to a weakening of the value of the currency. Second, the U.S. has been piling up net foreign liabilities via persistent current account deficits. Indeed, by the end of 2001, the US was the largest net debtor in the world with net foreign liabilities close to 20% of its GDP. Moreover, current account deficits of the order of 5% or more per year will eventually increase the foreign debt to GDP ratio to much higher levels in the next decade. This rise in the debt ratio may eventually increase the default risk premium and depreciate the nominal and real exchange rates. Alternatively, a reduction in the US current account deficit may be necessary to reverse this unsustainable long-run debt dynamics; but this improvement in the external balance will require a sustained real depreciation of the US dollar.

There are other empirical studies in this area. First, there are simulation exercises that have used large scale structural models based on different versions of the Mundell-Fleming-Dornbusch model (for example, studies in Bryant et al., 1988; and Taylor, 1993) or that used calibrated dynamic stochastic general equilibrium models (for example, Baxter, 1995; Kollmann, 1998; Betts and Devereux, 2000b; and McKibbin and Sachs, 1991). However, most models in these studies are based on a large number of identifying restrictions implied by theory; thus, the evidence may not serve as data-oriented empirical evidence. Second, a few studies such as Ahmed (1986, 1987) examined the long run relation between government spending and the current account. They employed a static single equation method by using a long horizon dataset with annual frequency covering many exchange rate regimes. However, their results have limitations as dynamic interactions between variables are not considered and as such studies did not use a sample period with an unchanged exchange rate regime. Third, a few studies have used VAR models that employ minimal identifying restrictions and that do not depend on specific theoretical models (for example, Clarida and Prendergast, 1999; and Rogers, 1999). However, these studies have examined the effects on the real exchange rate only with low frequency data.[4] In contrast, our paper provides data-

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[3] In a recent study, Corsetti and Müller (2006) showed that a fiscal expansion can lead to an improvement of current account if an economy is sufficiently closed and if fiscal shocks are not too persistent.

[4] Some very recent studies such as Corsetti and Müller (2006) and Monacelli and Perotti (2006) reexamined the empirical results of this paper on the effects of fiscal policy shocks on the real exchange rate and the current account (or the trade balance) using VAR models. For the U.S., Corsetti and Müller (2006) reconfirmed the qualitative result of this paper while Monacelli and Perotti (2006) found a qualitatively different result. We discuss Monacelli and Perotti (2006) in Section 3.2.

oriented empirical evidence on the effects of fiscal policy on the current account and the real exchange rate using VAR models that allow for dynamic interactions among variables and employ minimal identifying restrictions which do not depend on a specific theoretical model. We employ a quarterly dataset, which is the typical frequency investigated in business cycle studies. We perform our analysis for periods of homogeneous exchange rate arrangements (that is, floating exchange rate regime only) since the effects may be different under different exchange rate regimes.

The paper is structured as follows. Section 2 provides the empirical evidence based on VAR models. Section 3 presents some extended robustness tests. Finally, Section 4 concludes with a summary of our results.

2. Empirical Analysis

2.1. Preliminary Statistics and Issues

We first present some basic properties of the data and some stylized facts that help to understand the co-movements among the government budget deficit, the current account, and the real exchange rate. The current account is often called net foreign investment. Conceptually, it is equal to the difference between saving and investment, although the actual data contain non-negligible statistical discrepancies. Saving is further divided into private saving and government saving (or government budget balance or the negative of the government budget deficit). Government saving is further divided into government net interest receipts and the government primary budget balance (or negative of the government primary budget deficit). That is,

(1) Current Account = Saving – Investment + Statistical Discrepancy
= Private Saving – Government Primary Budget Deficit + Government Net Interest Receipts - Investment + Statistical Discrepancy

Figure 1 shows the two main components of the current account (investment and saving plus statistical discrepancy), government saving, and the current account for the US for the recent floating exchange rate regime period (1973-2004:1). “Gov Sav/GDP,” “Sav&SD/GDP,” “Cur Acct/GDP,” and “Inv/GDP” denote government saving, saving and statistical discrepancy, the current account, and investment, respectively (all as a percentage of GDP).[5]

The second part of the identity relationship in (1) is often used as the basis for the “twin deficit hypothesis” or a positive relation between the current account and government saving (or a positive

On the other hand, there are several recent empirical VAR studies on the effects of fiscal policy in closed economies, for example, Fatas and Mihov (2001), Blanchard and Perotti (2000), Mountford and Uhlig (2002), Edelberg et al (1999), and Burnside et al (2000).

relation between the current account deficit and the government budget deficit). That is, ceteris paribus, government savings and the current account should move together: an increase in government deficit will lead to a worsening of the current account. However, as discussed in the Introduction, such a positive relation is hard to find in the data and the correlation appears to be negative in Figure 1. Table 1 reports the correlation between the current account and government saving over the whole sample period. The correlation is indeed weakly negative, –0.11. The correlation between the current account and the primary government budget balance is even more negative, -0.16. This confirms that the government budget and the current account do not move in the same direction in general. That is, "twin divergence" rather than "twin deficit" is the more regular pattern of the data over the whole sample period.

Figure 2 shows a log plot of the real and nominal effective exchange rates of the US versus other major industrial countries (note that an increase is a depreciation), primary government saving, and government saving.[6] Nominal and real effective exchange rates are highly correlated and commoving together; and so are also primary government savings and overall government savings. However, it is not so easy to find a clear comovement pattern between the real exchange rate and the government budget. In Table 1, the correlation between the real exchange rate and the government budget (the primary government budget) is -0.08 (0.03).

As discussed in the Introduction, one important reason why the current account and government savings do not have a positive relation is the endogenous response of the government saving and the current account to output fluctuations. It is well known that the government budget balance, especially the revenue part, is pro-cyclical, while both the traditional current account theory and the modern international business cycle theory predict a counter-cyclical behavior of the current account when output or productivity shocks occur. Therefore, in order to identify the effects of government deficit shocks on the current account, it is important to control for the endogenous movements of the government budget balance and the current account, especially in the presence of output shocks. The empirical model that we will present in the next section is designed to control for this endogenous nature of the government budget and the current account and to identify exogenous components of the government budget balance. We use a structural VAR model since the VAR framework has been useful in controlling for the endogenous components and isolating their exogenous components.[7] Our framework utilizes the information on various macro variables, their interactions, and their dynamic relationship to construct the exogenous part of the government budget deficit and to analyze the effects of exogenous government budget deficit shocks on the current account and the real exchange rate.

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[5] Details on the data series are found in Appendix 1.

[6] The nominal and real effective exchange rates are re-scaled in Figure 1. The initial levels at the first quarter of 1973 are set to 0, and the values at other dates are the percentage deviations from the initial level, divided by four.

[7] For example, see the literature on identifying (exogenous) monetary policy shocks such as Christiano et al. (1999), Leeper et al. (1996), and Kim (1999).

2.2. Basic Identification Scheme

The basic model includes five variables, {RGDP, GOV, CUR, RIR, RER}, which are the log of the real GDP, a government budget related variable as a percentage of GDP, the current account as a percentage of GDP, the 3-month (ex-post) real interest rate, and the log of the real exchange rate, respectively. In the basic model, the primary government budget deficit is expressed as GOV. GOV, CUR, and RER are the main variables of interest in this study. RGDP is the key macro variable representing the general economic performance. RGDP is included to control for the cyclical components of the government budget deficit. RIR is also an important macro variable that can provide a clue to the transmission of fiscal policy. This variable, RIR, may be related to monetary policy actions that we would also like to control for.

Our basic identification scheme uses a recursive VAR model (proposed by Sims (1980)) in which the ordering of the variables is {RGDP, GOV, CUR, RIR, RER}, where the contemporaneously exogenous variables are ordered first. In the model, the (exogenous) government deficit shocks are extracted by conditioning on the current and lagged RGDP and all other lagged variables. We condition on the current RGDP since government budget (deficit) is likely to be endogenously affected by the current level of economic activity within a quarter. In particular, elements of government revenue such as sales taxes and income taxes are very likely to depend on the current level of economic activity within a quarter. This assumption is supported by Blanchard and Perotti (2002) who found a non-zero effect of output on net taxes within a quarter.[8] In addition, the government budget deficit may also depend on the lagged level of various variables. For example, some elements of government revenue such as the income tax may depend on the lagged level of economic activity. However, we do not condition on current variables other than RGDP considering the non-trivial decision lags in fiscal policy. That is, conditioning on current real GDP is essential to control the current endogenous reactions of the government primary deficit to current economic activity; while not conditioning on other current variables is reasonable to identify exogenous or discretionary changes in the government deficit since such changes are less likely to depend on other current variables due to the decision lags of fiscal policy.[9]

The estimation period is the recent floating exchange rate regime period (1973-2004:1). Quarterly data are used. A constant term is included in the model, and four lags are chosen.[10]

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[8] In addition, since we use the ratio of the government primary budget deficit to the GDP, controlling for the current GDP may be better.

[9] Note that we order CUR first, and then RIR and RER, by assuming that the real sector variable, CUR, is contemporaneously exogenous to the financial sector variables, RIR and RER, following Sims and Zha (2006), Kim (1999), and Kim and Roubini (2000). At any rate, the effects of government deficit shocks on those variables are the same in theory, regardless of the ordering among CUR, RIR, and RER (see Christiano et al, 1999).

[10] The Schwartz criterion suggests 1 lag and the Akaike criterion suggests 2 lags. However, the likelihood ratio test (with a correction to improve the small sample properties suggested by Sims, 1980) suggests that the models with 1, 2, and 3 lags are rejected against the model with 4 lags at the 1, 3, and 3% significance levels, respectively. In addition, the lag length of 1 or 2 is often regarded as too short to capture enough economic interactions among

2.3. Basic results

Figure 3 shows the impulse responses of each variable to each structural shock over four years with one standard error deviation bands (68% probability bands).[11] The names of structural shocks are denoted at the top of each column and the responding variables are denoted at the far left of each row. The same scale is applied to graphs in each row to easily compare the size of each variable's responses under different structural shocks.

The impulse responses of the government budget deficit to each structural shock (in the second row) show that overall movements of the government budget deficit due to non-government budget deficit shocks, especially resulting from output shocks, are far larger than those due to government budget deficit shocks, except for very short horizons. The forecast error variance decomposition of the government budget deficit in Table 2 (the numbers in parenthesis are 68% error bands) provides clearer evidence of this result. The contribution of (exogenous) government budget deficit shocks to its own fluctuations is 42.8% at a four quarter horizon and far less than that at longer horizons. That is, the exogenous part is far less than a half of the total government budget deficit movements. On the other hand, the contribution of output shocks is more than 50% at all horizons reported in Table 2. This suggests that our empirical model takes account of the substantial endogeneity of the government budget deficit, especially the endogenous components of the fiscal balance with respect to output shocks.

The effects of output (RGDP) shocks are worth considering with some attention. In response to a positive output shock, the government budget deficit decreases (or the government budget improves) for several years. This is consistent with the automatic-stabilizer role of the government budget and the pro-cyclical behavior of the government budget. In response to a positive output shock, the current account worsens, the real exchange rate appreciates (or decreases), and the real interest rate increases. This counter-cyclical current account movement is consistent with both traditional and modern theories of the current account. In terms of the former, an increase in output increases the demand for foreign goods and worsens the current account. In terms of the latter, the output shocks may be regarded as a productivity shock. A positive, persistent productivity shock may increase investment strongly and worsen the current account. These effects generate a counter-cyclical behavior in the current account as suggested by

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variables for a model with quarterly data. On the other hand, the likelihood ratio test also suggests that the model with 4 lags is not rejected against the models with 5, 6, 7, and 8 lags at any conventional significance level. Therefore, the model with 4 lags is chosen. At any rate, the models with 1, 2, 3, 4, 5, 6, 7 and 8 lags have also been estimated; the impulse responses show that the initial increase in the current account is different from zero at the 68% probability level in all cases except for the model with 1 lag (in which the responses are not much different from zero) and the increase in the real exchange rate is different from zero at the 68% probability level in all cases.

[11] Our statistical inference is not affected by presence of unit roots and cointegrating relations since we follow a Bayesian inference to construct standard errors of impulse response functions and forecast error variance decomposition. The standard errors are constructed by Monte Carlo integration with the Jeffrey's prior as in Doan (2004). See Sims (1988) and Sims and Uhlig (1991) for general discussion on Bayesian inference in the presence of unit roots and cointegrating relations.

Mendoza (1991) and Backus et al., (1992). An increase in the real interest rate is also a likely response to a positive, persistent productivity shock (for example, see King and Rebelo, 1999). The appreciation of the real exchange rate is also consistent with several theoretical models (for example, see Finn, 1999). Overall, the impulse responses are consistent with the idea that output shocks generate a negative/divergent comovement between the current account and government saving. In addition, these results suggest that our model accounts to a large extent for the endogenous current account and government deficit movements (especially those driven by output shocks). In general, these results support our empirical framework for examining the causal relation between the exogenous budget deficit shocks and the current account.

Now we turn to our main focus: the effects of government deficit shocks. In response to a positive primary government deficit shock, output increases persistently and the real interest rate increases. These effects are consistent with standard theory. On the other hand, the effects on the current account and the real exchange rate are quite surprising. The current account improves for about a year. The change is different from zero with a 95% probability. The real exchange rate depreciates persistently. The change is different from zero with a more than 68% probability at most horizons. These effects on the current account and the real exchange rate are different from the standard prediction of most theoretical models.

We try to infer the persistence of these shocks from the impulse responses of the government budget deficit, as the predictions of the theoretical models are sometimes different depending on the actual persistence of the fiscal shocks. About 50% of the initial increase in the budget deficit dissipates in about four quarters (that is, the half life is about four quarters) and about 75% dissipates in six or seven quarters. This is roughly the persistence of an AR-1 process with a 0.8 AR-1 coefficient. Therefore, fiscal shocks seem to be quite persistent although clearly less persistent than a unit root case.

We also provide a brief interpretation on the effects of other structural shocks although it is not easy to clearly interpret other structural shocks. A positive shock to the real interest rate appreciates the real exchange rate, which is consistent with the theoretical implications of a real uncovered interest parity condition (UIPC). The real interest rate shocks may be proxying for monetary policy shocks since the monetary authority can be viewed as controlling the short-term real interest rate by changing the nominal interest rate, given the current inflation rate (as in sticky price models). The impulse responses to real interest rate shocks are consistent with such an interpretation in that a monetary contraction (an increase in the real interest rate) leads to an output fall, which increases the government deficit, and lead to a real exchange rate appreciation. The current account response to this shock, a short-run improvement followed by a long-run worsening, is also similar to the effects of monetary policy shocks documented in previous studies such as Kim (2001). Kim (2001) found that current account dynamics can be explained by a short-run income absorption effect and a long-run expenditure switching effect based on the traditional sticky price model and the interplay of saving and investment based on the intertemporal model. Finally, a positive shock to the real exchange rate (depreciation) improves the current account, which is consistent with the expenditure-switching effect.

2.4. Effects on Components of the Current Account and Real Exchange Rate

In the previous section, we reported the surprising result of government deficit shocks improving the current account and depreciating the real exchange rate. This section further investigates why and how such effects are found by investigating the effects of these fiscal shocks on detailed components of the current account and the real exchange rate.

First, we examine how each component of the current account responds. We extend the basic five-variable model to include another variable, CURA, which is a component of the current account. Now we have the model {RGDP, GOV, CUR, CURA, RIR, RER}. By dividing investment into government investment and private investment, equation (1) becomes:

(2) Current Account = Private Saving – Primary Government Budget Deficit
+ Government Net Interest Receipts - Private Investment
- Government Investment + Statistical Discrepancy

Based on equation (2), we use private saving, government net interest receipts, private investment, government investment, and statistical discrepancy (all as a percentage of GDP) in turn as CURA (note that the primary government budget deficit is already included in the system as GOV). In addition, to further infer household behavior, we also include consumption (as a percentage of GDP) as CURA. Second, we replace the real effective exchange rate in the basic model with the nominal effective exchange rate in order to examine the role of nominal exchange rate changes in driving the real exchange rate movements (compared to the role of relative price level changes).

Figure 4 illustrates the results. In response to primary government budget deficit shocks (government saving decreases), private saving increases sharply to compensate for the government saving decrease. That is, a strong "Ricardian" effect is found. However, such an effect is partial. The private saving increase is smaller than the government deficit increase. Consumption increases slightly in the short run. In addition, government deficit shocks crowd out private investment in the short run which may be the result of the increased real interest rate. Overall, the private saving increase and the private investment decrease outweigh the government deficit increase in the short run. As a result, the current account improves in the short run. Other components such as government net interest payments and statistical discrepancy do not change much.[12]

[12] Government net interest receipts decrease over time, which may be due to the government budget deficit increase.

On the other hand, we observe that the nominal exchange rate also depreciates substantially. Therefore, we can infer that the real exchange rate depreciation, following the government deficit shocks, is mainly because of the nominal exchange rate depreciation. Price stickiness may play an important role in this effect.

2.5. Components of the Government Budget

Using the basic model, we examined the effects of government budget deficit shocks. However, each component of the government budget, in particular, the expenditure and revenue sides, may have different effects, although both may increase the government deficit. In fact, analytical models often predict different effects of government expenditure and net tax shocks on the current account. Therefore, investigating the effects of each component separately may help to understand the paradoxical results above.

First, we examined the effects of government spending or government purchase shocks. A few past studies, such as Blanchard and Perotti (2002), Edelberg et al., (1999), Ramey and Shapiro (1997), and Fatas and Mihov (2001), examined the effects of government spending or purchase shocks. Blanchard and Perotti (2002) - by carefully examining the details of the US institutional fiscal framework - assumed that government spending is contemporaneously exogenous to other non-government variables in a system. Citing Blanchard and Perotti (2002), Fatas and Mihov (2001) also assumed that government spending is contemporaneously exogenous to other variables in the system. These studies used the real value of government spending, instead of the ratio of government spending to GDP. To be consistent with these models, we constructed the model, {GOV, RGDP, CUR, RIR, RER}, where the log of real government consumption was used as GOV.

Second, we examined the effects of net transfer shocks (or negative net tax shocks). As in our basic model, we assumed that the net transfer is contemporaneously affected by RGDP, i.e., {RGDP, GOV, CUR, RIR, RER}. We used the ratio of net transfer to GDP.

The results on the effects of the net transfer shocks are reported in the first two columns of Figure 5. The effects of the net transfer shocks are similar, although slightly weaker, than those of the government budget deficit shocks; a positive net transfer shock improves the current account temporarily and depreciates the real exchange rate. We further examined the components of the current account to infer why the current account improves. The results are again similar to the basic model. Consumption increases slightly, but only temporarily. Private saving increases to offset most of the government deficit while investment falls.

Next, as shown in the last two columns of Figure 5, the direction of the effects of government purchase shocks on the real exchange rate and the current account is similar to that of the government budget deficit shocks, but the effect is stronger, especially in the long run. A positive government purchase shock improves the current account and depreciates the real exchange rate persistently and significantly.

We also examined the components of the current account to infer why the current account improves following this shock. Private savings increase modestly while investment falls significantly and persistently. Both of these effects contribute to the improvement of the current account.[13]

In the theoretical literature, there are two interesting cases where a government budget deficit shock may improve the current account. First, Baxter (1995) showed that tax rate shocks may improve the current account. In a calibrated two-country real business cycle model in which real investment opportunity is available and labor is endogenous, a transitory reduction in distortionary tax rates on labor income, that is financed by a lump-sum tax in the future, may improve the current account but worsens the government budget. As individuals work more and earn more labor income while they smooth consumption over the infinite horizon, a transitory tax rate cut increases private saving by more than the fall in public saving. On the other hand, investment increases as labor input increases. However, the positive effect on investment is small because the tax rate cut is transitory. Overall, the current account improves. This analytical result by Baxter (1995) is not fully consistent with our empirical results since our empirical results show that investment falls and that the increase in private saving does not fully offset the fall in public saving. In general, the analytical result of Baxter (1995) does not seem to be realistic in practice because tax rate cuts are likely to be persistent in the real world and revenue neutral tax rate changes are not often observed in practice.[14]

Second, in the recent New Open Economy Macroeconomics (NOEM) models of Obstfeld and Rogoff (1995) and Betts and Devereux (2000a) (that however do not introduce investment in their analytical framework) permanent government spending increases may be associated with an improvement of the current account. When a permanent government spending increase occurs, Ricardian effects lead to a one-to-one fall in consumption and the current account does not change, ceteris paribus. However, in these sticky price models a spending increase tends to stimulate output in the short run as output is demand determined. Therefore, the current account improves when consumers smooth consumption as net output decreases over time.[15] In addition, a government spending increase may depreciate the nominal and real exchange rate. The reason is that in a large economy a fiscal expansion increases the real interest rate, which, in turn, leads to a fall in private consumption. Since the demand for money is assumed to depend

[13] The substantial increase in statistical discrepancy is also an important reason for the improvement in the current account. However, it is not certain whether it is a consequence of a decrease in the investment or an increase in saving.

[14] In Baxter (1995), a persistent/permanent tax rate cut worsens the current account since the positive investment effect dominates the positive effect on saving in that case. On the other hand, international RBC models for large open economies with fixed labor input (such as Kollmann, 1998) might explain the results under temporary shocks (although Kollmann, 1998, did not experiment with temporary shocks), since investment may decrease as a result of an increase in the real interest rate and the private saving responses are likely to be positive.

[15] If the model is extended with investment, investment might also be crowded out and may strengthen the current account improvement. On the other hand, a transitory increase in government spending worsens the current account in Obstfeld and Rogoff (1995).

on private consumption in such a model, a fall in consumption leads to a depreciation of the nominal exchange rate, as well as the real one as prices are assumed to be sticky.

While these NOEM models offer some cases where a positive government spending shock may improve the current account and depreciate the real exchange rate, our empirical results are not fully consistent with their theoretical predictions. First, increases in private saving and total saving fully explain the current account improvement in the theoretical model, but the private saving increase is too small and total saving falls in the empirical results. Second, a fall in private consumption mainly explains the depreciation of the nominal and real exchange rates in the theoretical model, but the consumption fall is far too small to explain the substantial exchange rate depreciation in the empirical results. Also, the non-conventional analytical results of these NOEM models on the effects of government spending shocks on the nominal and real exchange rates depend on two crucial assumptions. First, these models assume that the marginal propensity to import of the government is the same as that of the private sector. However, the popular assumption in most previous models (both optimizing RBC and traditional Keynesian ones) is that the marginal propensity to consume imported goods is higher for the private sector than for the public sector. In fact, this is the important channel through which most previous models obtain a real appreciation following a government spending shock. This assumption is validated by empirical evidence: governments tend to buy more of non-traded goods or traded goods that are produced at home than private consumers do. Second, in these NOEM models the functional form for money demand depends on private consumption. If money demand depended on income (or both private and government consumption), the conventional result on the effects of fiscal policy on the nominal and real exchange rate would be obtained.

To summarize our empirical results, government spending shocks and government net transfer shocks improve the current account and depreciate the real exchange rate, consistently with the original results for government budget deficit shocks. We also found that both a fall in investment and a rise in private saving contribute to this current account improvement. These results are not easily explained by existing analytical models.

2.6. Comovement Decomposition

In this section, we systematically examine the comovement properties of the government budget, the current account, and the real exchange rate, generated by each structural shock. We address, for example, what types of shocks may generate a “twin deficit” or “twin divergence” and what is the contribution of each shock to the comovement properties. Although impulse response functions provide some information on the comovement properties, we apply the generalized forecast error variance decomposition developed by Kim (2006) to infer the exact role of each structural shock in explaining the comovement properties.

Kim (2006) showed that the unconditional second moments (of forecast errors), such as covariance, auto-covariance, correlation, auto-correlation and cross-correlation, can be decomposed into the contribution of each structural shock in the VAR model. This decomposition can be regarded as a generalized version of the variance decomposition by which the unconditional variance (of forecast errors) can be decomposed into the contribution of each structural shock. Kim (2002) also suggested that calculating the second moment conditional on each structural shock is important because this conditional moment often helps to understand the role of each shock in generating the particular moment. Refer to Kim (2006) and Appendix 2 for more details on the generalized forecast error variance decomposition.

Table 3 (1) reports the results of the decomposition that is applied to the comovement property of the current account and government deficit with 68% probability bands. The first column shows the forecast horizon; the second, the unconditional (i.e., in the presence of all shocks) correlation of forecast errors; the third, the names of shocks; the fourth, the conditional (i.e., in the presence of only one shock) correlation; the fifth, the correlation decomposition which shows the role of each structural shock in explaining the unconditional correlation (the role of each structural shock sums to unconditional correlation); and the last, the decomposition which shows the percentage contribution of each structural shock in explaining the unconditional covariance (the role of each structural shock sums to 100%).[16]

The unconditional correlation of the forecast errors for the current account and the government deficit is 0.42 and 0.34 at four and eight quarter horizons, respectively. This positive correlation suggests that at short- and medium-run horizons, the government deficit and the current account tend to move together ("twin divergence"). RGDP shocks generate a nearly perfect positive correlation ("twin divergence") of 0.97 and 0.98 for four and eight quarter horizons, respectively. The GOV shocks also generate high positive correlation ("twin divergence") of 0.70 and 0.63 for the four and eight quarter horizons, respectively. CUR and RIR shocks also generate some positive correlation while RER shocks generate negative correlations.

Overall, the positive co-movement (or unconditional comovement) is mainly the result of output shocks: in the correlation term, the contribution of output shocks is 0.33 out of 0.42 (78%) and 0.40 out of 0.34 (117.5%) at the four and eight quarter horizons, respectively. Government deficit shocks also make a contribution of 0.10 out of 0.42 (22.7%) and 0.06 out of 0.34 (16.4%) at the four and eight quarter horizons, respectively. Therefore, we can conclude that output shocks are the most important source of the "twin divergence" phenomenon observed in the data. But to some extent, government budget deficit shocks also contribute to the "twin divergence."

Table 3 (2) reports the comovement decomposition of the real exchange rate and the government budget deficit. The unconditional correlation of forecast errors is 0.09 and 0.05 at four and eight quarter horizons, respectively. RGDP and GOV shocks generate a high positive correlation that is offset by a high negative correlation generated by RIR and RER shocks. The resulting unconditional correlation is not

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[16] The number also shows the percentage contribution of each structural shock in explaining unconditional correlation, which is the ratio of the number in the fifth column to the number in the second column.

different from zero with a 68% probability. At a four quarter horizon, GOV and RGDP shocks are equally important for explaining the positive comovement while at an eight quarter horizon the contribution of RGDP shocks is larger than that of GOV shocks.

3. Extended Experiments and Robustness Tests

3.1. Alternative Definitions of Variables, Alternative Identification Schemes, and Extended Models

We examined the robustness of our main results in various dimensions. First, we examined whether our results are robust under different definitions of government budget deficit/balance and components of the government budget. Second, we experimented with alternative definitions of the real effective exchange rate. Third, we considered alternative identifying assumptions by changing the ordering of the variables in the system. Fourth, we considered other methods to calculate the real interest rate. Fifth, we experimented with alternative measures of the current account. In all cases, the current account improved, the real exchange rate depreciated, and the short run effects were different from zero at a 68% probability level. In many cases, the real exchange rate depreciation was different from zero at a 68% probability level even in the long run. [17]

We also considered some extended models. First, we constructed a six variable model that included an additional variable such as public debt ("Debt" in Figure 6) and a term spread ("Spread"). Public debt was included since it is an important state variable that may affect tax and government spending. A term spread is often regarded as an indicator of the monetary policy stance. [18] We included

[17] See Kim and Roubini (2006) for the results. While we used the primary government budget deficit in the basic model, we considered the government budget deficit (government net interest payments were added to the primary government budget deficit) and the government net borrowing (the government budget deficit plus consumption of fixed capital and net capital transfers received minus gross investment and net purchases of nonproduced assets). Regarding the components of the government budget, we considered log of real primary government budget deficit (instead of the ratio to the GDP), log of real government consumption and investment spending, the ratio of the government consumption to GDP, the ratio of the government consumption and investment to the GDP, and log of real net transfers. The list of the real effective exchange rates experimented is reported in Appendix 1.

Regarding the alternative measures of the current account, we experimented with three alternative measures: the difference between log of exports of goods and services in real term and log of imports of goods and services in the real term, the ratio of real net exports of goods and services to real potential GDP from the Congressional Budget Office, and the ratio of real net exports of goods and services to the real trend GDP constructed by using the HP filter. Regarding the alternative measures of the real interest rate, first, we used CPI inflation rate, instead of GDP deflator inflation rate that was used in the basic model. Second, we used ex-ante real interest rate by constructing the expected inflation rate. To construct the expected quarterly inflation rate, we assumed that the log of GDP deflator follows a five-variable VAR process (with 4 lags) that includes three-month Treasury bill rate, log of M2, log of GDP deflator, log of real GDP, and the primary government deficit to GDP ratio. The VAR process was estimated for the 1972-2004:1 period.

Regarding the changes in the ordering of the variables, first, the information on the current real interest rate was used to identify the government budget deficit shocks, by changing the ordering of the basic model to {RGDP, RIR, GOV, CUR, RER}, since there might be some endogenous components of government budget deficit which react to the economic condition that is not captured by the current RGDP movements but by the real interest rate (for example, the monetary policy stance). Second, we consider the ordering of {GOV, RGDP, CUR, RIR, RER} to allow the possibility that the government budget deficit shocks may affect the real economy contemporaneously.

[18] For example, refer to Bernanke (1990) and Bernanke and Blinder (1991).

the term spread in the model to identify government deficit shocks after explicitly controlling for the monetary policy stance. We considered two types of identification schemes; one where an additional variable is assumed to be contemporaneously exogenous to the primary government budget deficit ("Scheme 1") and the other where the primary government budget deficit is assumed to be contemporaneously exogenous to the additional variable ("Scheme 2"). Second, we considered a model that includes a measure of structural primary government budget deficit ("Structural"), which excludes the cyclical components of the primary government budget deficit. Although the VAR model under consideration is supposed to exclude cyclical movements of the primary government budget deficit by conditioning on output shocks, we wanted to examine the robustness of the results by considering other measures of the primary structural government budget deficit. The primary government deficit is regressed on cyclical output and then the residuals from the regression are used as structural primary government deficits. To construct cyclical output, we used two measures of trend output, the one from the congressional budget office ("CBO") and the other by using the Hodrick-Prescott filter ("HP").

Finally, the US real exchange rate and the US current account represent an economic relationship between the U.S. and the rest of the world. However, the basic VAR model may not properly capture foreign economic conditions since it does not include foreign variables. To control for these foreign variables, we constructed two extended models. First, we constructed a model that included each variable as its deviation from the aggregate of non-US G-5 countries ("Deviations"). The model included the following variables, {RGDP-RGDP*, GOV-GOV*, TB5, RIR-RIR*, RER5}, where RGDP* is the log of the real GDP of non-US G-5 countries; GOV* is the ratio of the primary government deficit to GDP of non-US G-5 countries; TB5 is the ratio of the U.S. trade balance against non-US G-5 countries to U.S. GDP (here trade balance is used as a proxy for current account); RER5 is the real effective exchange rate of the U.S. against non-US G-5 countries; and the contemporaneously exogenous variables are ordered first. Second, the previous model is useful but it is limited in that the model cannot separate the effects of the US government deficit shocks from non-US government deficit shocks. Therefore, we constructed another model that included the U.S. government deficit and non-US government deficit separately ("7 VAR"). The variables in this model are {RGDP, RGDP*, GOV*, GOV, TB5, RIR-RIR*, RER5} where the contemporaneously exogenous variables are ordered first. Note that GOV* is ordered before GOV in order to identify the US government deficit shocks that are not correlated with non-US government deficit changes. In addition, RGDP and RGDP* are also separately included in order to construct the U.S. government deficit shocks by properly conditioning on RGDP shocks.[19]

Figure 6 reports the results for these extended models. The graphs in the first two columns show the responses of the current account while the graphs in the last two columns show the responses of the

[19] The results are very similar to those of the six variable model of {RGDP-RGDP*, GOV*, GOV, TB5, RIR-RIR*, RER5}.

real exchange rate. In most cases, the current account improves and the real exchange rate appreciates. These effects in the short run are different from zero at a 68% probability level in most cases.[20]

3.2. Further Experiments on Components of Government Budget

In Section 2.5, we examined the effects of two components of the government budget: spending and net taxes. In this section, we further examine the effects of these two components by employing different methods. First, we consider a non-recursive identification scheme ("Non-Recursive") in which both government spending and net transfers are included in one model. A non-recursive model is attractive in that it allows a different treatment of the two components of the government budget. In addition, a non-recursive model can resolve one important drawback of the previous recursive models as it can allow contemporaneous feedback relations between the output and the government deficit, which the recursive structure cannot.

{GOV1, GOV2, RGDP, CUR, RIR, RER} are included in the model, where the real government spending is used as GOV1 and the ratio of the net transfer to the GDP is used as GOV2.[21] In this model, the contemporaneous effects of government spending and net transfers to the output level are allowed, as are the contemporaneous effects of the output level to net transfers. The structure of the model is similar to the model of Blanchard and Perotti (2002). The exact identification scheme is reported in Appendix 1.

Second, some past studies used dummy variables to identify the government purchase shocks. Ramey and Shapiro (1997) used a "narrative approach" to isolate three arguably exogenous events of large military buildups (the Korean War, the Vietnam War, and the Carter-Reagan buildup - 1950:3, 1965:1, 1980:1). They regarded these dates as the dates when exogenous shocks to government purchases occurred. Built on the models of Ramey and Shapiro (1997), Edelberg et al. (1999) constructed a VAR model and identified exogenous shocks to government purchases with dummy variables from the Ramey-Shapiro episodes. They included four basic variables in the model, the log of real GDP, the three month Treasury bill rate, the log of the producer price index of crude fuel, and the log level of the Ramey-Shapiro measure of real defense purchases, as well as an additional variable of interests. We used Edelberg, Eichenbaum, and Fisher's ("EEF") model to examine the effects of government purchase shocks on the current account. We included two more variables, the government purchase and the current account, in addition to the four basic variables used by EEF. The government purchase is included to infer the nature of the shocks by examining the responses of the government purchase. The current account is included to examine the

[20] The only exception is the real exchange rate response in the five-variable model that includes the variables as deviations from the non-US G-5 countries. In this case, the responses are not different from zero with a 68% probability. However, as discussed, this five variable model may not properly identify the US government deficit shocks. We rely more on the results of the seven variable model.

[21] We also considered government consumption and investment instead of government consumption. In addition, we considered log of real net transfers, instead of the ratio of net transfers to GDP. In these experiments, the results on the effects of fiscal shocks on the current account and the real exchange rate are qualitatively similar in most cases.

effect of the shocks on the current account that is the main topic of concern in this paper. The estimation period (1948-1996) is the same as that in the EEF model.[22]

Figure 7 illustrates the results. The first column, labeled “Non-Recursive,” shows the results from the non-recursive model. At the top of each graph, we note the name of shocks (either government spending (“GOVS”) or net transfer (“TRANS”)) and the responding variable name. The second column shows the effects of fiscal dummies from the extension of the EEF model. The responding variable name is denoted at the top of each graph.

In all cases, the current account improvement and the real exchange rate depreciation were found. As in the previous models, the effects of government spending shocks on the current account tended to be more persistent than those of net transfer shocks. In the EEF model, the current account worsens in the first period. This seems to result from the initial decrease in government purchase (shown in the first row). From the next period on government purchases starts to increase, and the current account also starts to improve. Therefore, the results seem to be consistent with the previous result, i.e., positive government purchase shocks improve the current account strongly and persistently.[23]

Finally, a recent paper by Monacelli and Perotti (2006) criticized our basic model for two main reasons: (1) contemporaneous effects of government deficit shocks on output are not allowed in the system, and this can cause a bias in the empirical result given that especially government spending shocks are likely to affect output contemporaneously (2) GDP is an endogenous variable and should not appear at the denominator of the fiscal variables whose shocks we are studying. However, our main results are robust to these two critiques since our empirical results are qualitatively robust under alternative empirical specifications that allow for the contemporaneous effect of government deficit shocks on output and that use shocks to actual (non-GDP scaled) measures of fiscal variables.[24]

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[22] The real exchange rate data is not available for the whole sample period.

[23] Another interesting issue is that the effects of fiscal policy may hinge on whether fiscal policy is Ricardian or non-Ricardian and on whether monetary policy is active or passive (refer to Leeper, 1991, Sims, 1994, Woodford, 1995). Many past studies (e.g., Clarida, Gali, and Gertler, 2000) suggested that monetary policy is active during the recent period. On the other hand, some past studies (e.g. Woodford, 1996, and Kim, 2003) suggested that the 1940’s and the 1950’s can be described as a non-Ricardian regime in which monetary policy is passive and fiscal policy is active. However, there have not been any open economy studies on this issue, which could address the effects of the government budget deficit shocks on the current account, although there are some studies such as Woodford (1996), Leeper (1993) and Kim (2003) dealing with a closed economy. At any rate, we also estimated the basic model for the period of 1982:4-2004:1 during which there has often been the claim that homogenous monetary policy was adopted; we found that the government deficit shocks improved the current account in the short-run which we found to be consistent with the results of the basic model.

[24] Monacelli and Perotti (2006) reported that the U.S. trade balance worsens in response to a positive government spending shocks, although the magnitude of the effect is small. The discrepancy between their empirical result and ours may results from various sources, for example, different sample periods, different definitions of government spending and the current account, and different identifying assumptions. However, given that we considered many variants of our empirical model, we conjecture that the difference in the results might be due to a problematic identifying assumption of Monacelli and Perotti (2006).

4. Conclusion

In this paper, we have examined the effects of government deficit shocks on the current account and the real exchange rate in the United States, based on VAR models, for the flexible exchange rate regime period. The empirical model identified the government budget deficit shocks after controlling for the sources of endogenous government budget movements such as output shocks.

The empirical results suggest that the government deficit shocks improve the current account and depreciate the real exchange rate in the short run. These results are contrary to the predictions of most theoretical models. This finding is robust under many different specifications – alternative measures of the government budget deficit, alternative identifying assumptions, various components of government budget, and alternative empirical models.

Detailed empirical analysis further shows that the current account improvement results from a partial Ricardian behavior of private saving (that is, private saving increases) and a fall in investment (a crowding-out effect which is likely to be the result of an increase in the real interest rate), while the real exchange rate depreciation is mainly the result of a nominal exchange rate depreciation. Although a few analytical models do suggest that government budget deficit shocks may lead to a current account improvement and real exchange rate depreciation, they cannot fully match the details of the evidence presented in this paper. Future theoretical research that tries to match the empirical findings of this paper will be fruitful, as will future empirical studies that try to further highlight the transmission mechanism.

The results presented here also suggest that "twin divergence", rather than "twin deficits", seems to be the more regular pattern in the data. A divergent movement of the fiscal balance and the current account is what one would expect when there are cyclical shocks to output and/or productivity shocks. Indeed, most of the positive comovements of the fiscal balance and current account balance seem to be driven by such output/productivity shocks. Nevertheless, "twin divergence" occurs even when we consider "exogenous" fiscal shocks. While the contribution of exogenous fiscal shocks to the "twin divergence"

Monacelli and Perotti (2006) used various external information to construct the elasticities of net taxes and government spending to GDP, instead of estimating the elasticities in the empirical model. It appears that the value of the elasticity of net taxes to GDP is assumed to be too high (although the exact value is not reported in the paper), which might result from some problems in that procedure. In their baseline result, a persistent positive government spending shock generates a very temporary government deficit, which looks strange. Given the low correlation between innovations in government spending and innovations in net tax (as reported in Blanchard and Perotti, 2002) and the assumed zero elasticity of government spending to GDP, this result seems to be due to a very high elasticity of taxes to GDP assumed in their empirical model. That is, the budget deficit is forced to be very temporary because a very high elasticity of taxes to GDP is assumed. This, in turn, is likely to force the trade balance to move into deficit in the short-run since temporary budget deficit shocks are more likely to lead to trade balance deficit.

Overall, we view their empirical result as at best the one produced by one particular set of identifying assumptions on government spending shocks, and thus their empirical results cannot dismiss our main empirical findings that are supported by numerous specifications of the empirical models.

phenomenon is relatively small, compared to that of output shocks, the results suggest the need for an analytical reconsideration of how fiscal policy affects the current account.

Appendix 1. Non-Recursive Model

The non-recursive identification scheme (in Section 3.2.) is represented by the following equations.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & g_{23} & 0 & 0 & 0 \\ g_{31} & g_{32} & 1 & 0 & 0 & 0 \\ g_{41} & g_{42} & g_{43} & 1 & 0 & 0 \\ g_{51} & g_{52} & g_{53} & g_{54} & 1 & 0 \\ g_{61} & g_{62} & g_{63} & g_{64} & g_{65} & 1 \end{bmatrix} \begin{bmatrix} GOV1_t \\ GOV2_t \\ GDP_t \\ CUR_t \\ RIR_t \\ RER_t \end{bmatrix} = G^0(L) \begin{bmatrix} GOV1_{t-1} \\ GOV2_{t-1} \\ GDP_{t-1} \\ CUR_{t-1} \\ RIR_{t-1} \\ RER_{t-1} \end{bmatrix} + \begin{bmatrix} e_{GOV1} \\ e_{GOV2} \\ e_{GDP} \\ e_{CUR} \\ e_{RIR} \\ e_{RER} \end{bmatrix}$$

Refer to Kim (2001) or Kim and Roubini (2000) for more details on this representation and the non-recursive methodology.

Appendix 2. Comovement Decomposition

The analysis starts from the structural vector moving average representation in which structural shocks are mutually and serially uncorrelated: $y_t = \Psi_0 \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \Psi_3 \varepsilon_{t-3} + \dots$, $E_t\left(\varepsilon_t \varepsilon_t^{'}\right) = \Sigma$, where y is a k-dimensional vector of variables; ε is a serially uncorrelated k-dimensional vector of structural disturbances; Ψ_j is a $k \times k$ dimensional matrix of structural parameters; and Σ is a $k \times k$ dimensional diagonal matrix. For simplicity, constant terms and dummies are dropped.

The variance of the s-period-ahead forecast error of the i-th element of y, y_i, is:

$$VAR_s(y_i) \equiv E\left[\left(y_{i,t+s} - E_t y_{i,t+s}\right)\left(y_{i,t+s} - E_t y_{i,t+s}\right)^{'}\right] = \sum_{l=1}^{k} VAR_{s,l}(y_i)$$

where $VAR_{s,l}(y_i) \equiv \Sigma_{ll}\left(\left(\Psi_{0,il}\right)^2 + \left(\Psi_{1,il}\right)^2 + \left(\Psi_{2,il}\right)^2 + \dots + \left(\Psi_{s-1,il}\right)^2\right)$ is the contribution of the l-th structural shock; Σ_{ll} is the l-th diagonal element of Σ (variance of the l-th element of ε); $\Psi_{j,il}$ is the i-th row and the l-th column element of Ψj. This is the well-known "Forecast Error Variance Decomposition."

Similarly, the covariance between the s-period ahead forecast error of y_i and the s-period ahead forecast error of y_j can be decomposed into a part due to each structural disturbance as follows.

$$COV_s(y_i, y_j) \equiv E\left[\left(y_{i,t+s} - E_t y_{i,t+s}\right)\left(y_{j,t+s} - E_t y_{j,t+s}\right)^{'}\right] = \sum_{l=1}^{k} COV_{s,l}(y_i, y_j)$$

where $COV_{s,l}(y_i, y_j) \equiv \Sigma_{ll}\left(\Psi_{0,il}\Psi_{0,jl} + \Psi_{1,il}\Psi_{1,jl} + \Psi_{2,il}\Psi_{2,jl} + \dots + \Psi_{s-1,il}\Psi_{s-1,jl}\right)$. Further, by dividing the covariance by the standard deviations of the forecast errors, the correlation can be analyzed as follows.

$$\frac{COV_s(y_i, y_j)}{\sqrt{VAR_s(y_i)}\sqrt{VAR_s(y_j)}} = \sum_{l=1}^{k}\left[\frac{COV_{s,l}(y_i, y_j)}{\sqrt{VAR_{s,l}(y_i)}\sqrt{VAR_{s,l}(y_j)}}\sqrt{\frac{VAR_{s,l}(y_i)}{VAR_s(y_i)}}\sqrt{\frac{VAR_{s,l}(y_j)}{VAR_s(y_j)}}\right].$$

Therefore, the contribution of each structural disturbance to the correlation is composed of three parts: the correlation conditional on each structural shock, the square root of the relative contributions of each structural shock to the forecast error variance of y_i, and the square root of the relative contribution of each structural shock to the forecast error variance of y_j.

Similar methods can be applied to decompose any second moments such as cross-correlation and auto-correlation (or auto-covariance), which was called “Generalized Forecast Error Variance Decomposition” in Kim (2006).

Appendix 3. Data

This appendix describes the variable definitions and data sources. Data on output, the current account, government budget balance, and their components is obtained from National Income and Product Accounts (NIPA) tables at the Web page of the U.S. Bureau of Economic Analysis (http://www.bea.gov). The following variables are used as the components of the current account and government balance, as appear in equations (1) and (2). The names in the parentheses are the exact names of the items listed in the NIPA tables. Current Account (Net Saving – Net Investment + Statistical Discrepancy), Saving (Net Saving), Investment (Net Investment), Statistical Discrepancy, Private Saving (Net Private Saving), Government Primary Budget Deficit (-Government Net Saving + Income Receipt on Asset, Interest and Miscellaneous – Interest Payment), Government Net Interest Receipt (Income Receipt on Asset, Interest and Miscellaneous – Interest Payment), Private Investment (Gross Private Domestic Investment – Consumption of Fixed Capital, Private), Government Investment (Gross Government Investment – Consumption of Fixed Capital, Government, Federal – Consumption of Fixed Capital, Government, State and Local). In Section 2.5., government net transfer is constructed by subtracting government consumption from government net saving. When these variables are used as the ratio to the GDP, variables in current dollars are used. When these variables in real terms are used, variables in constant year 2000 dollars are used.

Data on effective exchange rates are collected from two sources, *International Financial Statistics* from the IMF and *Federal Reserve Statistical Releas*e from the Web page of the Federal Reserve Board. From *Federal Reserve Statistical Releases*, trade weighted nominal and real exchange rate index against major currencies (“Major Currencies”) and against a large group of trade partners (“Broad”) are obtained. From *International Financial Statistics*, Nominal Effective Exchange Rate Index Based on Unit Labor Cost (111..NEUZF…), Real Effective Exchange Rate Index Based on Normalized Unit Labor Cost (111..REUZF…), and Real Effective Exchange Rate Index Based on Unit Labor Cost (11165UM.ZF110) are obtained. In the basic model, the trade weighted real exchange rate index against major currencies from the *Federal Reserve Statistical Releases* is used. For the extension of the basic model, with the nominal exchange rate, in Section 2.4., the corresponding nominal exchange rate is used.

Other data such as the interest rates, CPI, potential GDP, and public debt are collected from *FRED*. To construct the real interest rate in the basic model, the annualized quarterly GDP deflator inflation rate is subtracted from three month Treasury bill rate. The term spread is constructed by the difference between the US Treasury constant maturities, 10 year, and three month Treasury bill rates. On the other hand, the real defense purchase is obtained from CITIBASE.

Finally, data for the VAR model, that included non-US aggregates in Section 3.2., was collected from the following source. Note that the US data is newly collected from similar sources, to be consistent with non-US data. The ratio of the primary government balance to the GDP was collected from the *OECD Economic Outlook*. The GDP in constant and current local currency units, exports and imports of goods and services in the current local currency unit, and the GDP deflator were collected from the *OECD Quarterly National Accounts* for the US, Germany, and UK, and from *International Financial Statistics* for France and Japan. The three-month Treasury bill rates and the exchange rates against the US dollar (period average) were collected from *International Financial Statistics*. For Japan, the three-month Treasury bill rate was not available, so the money market rate from *International Financial Statistics* was used. For German national income data, the unified German data was not available for the period before 1991. First, West German data was used to calculate the growth rates. Then, the value for the period before 1991 was approximated based on the growth rate. The US exports and imports, against each of the non-US G-5 countries were collected from *FRED*. The real exchange rate was constructed by multiplying the nominal exchange rate by the ratio of the GDP deflator. The (ex-post) real interest rate was constructed by subtracting the GDP deflator inflation rate from the three-month Treasury Bill rate. The log of real effective exchange rate of the US against non-US G-5 countries was constructed as the weighted average of the log of the real exchange rate of the U.S. against each of the non-US G-5 countries where the trade share is used as the weight. The trade share was calculated as the average of the sum of US exports and imports against each country to the sum of US exports and imports against these four countries over the period from 1974 to 2004. The calculated weights were: France (0.1085), Germany (0.2005), Japan (0.5089), and UK (0.1821). For other aggregate non-US G5 variables (such as the ratio of government primary budget deficit to GDP, the real interest rate, and the log of real GDP), the weighted average was used, and the weight was constructed based on the average GDP (based on PPP) shares over the same period, where the data was collected from *World Development Indicators*. The calculated weights were: France (0.141), Germany (0.203), Japan (0.505), and UK (0.151). The results using the trade weights for these variables were very similar.

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Table 1. Basic Correlation

	Correlation with CUR	Correlation with RER
Government Saving/GDP	-0.11	-0.08
Primary Government Saving/GDP	-0.16	0.03

* 'CUR' indicates the current account (% of GDP) while 'RER' indicates the real effective exchange rate.

Table 2. Forecast Error Variance Decomposition of GOV

Horizon\shocks	RGDP	GOV	CUR	RIR	RER
4 quarters	53.1(42.4,60.6)	42.8(33.0,49.7)	0.8(0.6,3.1)	0.5(0.4,2.3)	2.7(0.8,6.6)
8 quarters	62.9(48.1,69.3)	28.2(19.3,36.7)	0.6(0.6,4.1)	1.8(0.7,5.7)	6.5(1.7,14.6)
12 quarters	61.2(44.0,68.3)	24.2(15.2,32.3)	0.6(0.8,5.1)	2.5(0.9,8.3)	11.6(3.2,22.7)
16 quarters	57.9(39.0,66.0)	22.6(13.5,30.2)	0.7(1.0,6.2)	3.1(1.2,11.0)	15.7(5.1,28.2)

* This table shows forecast error variance decomposition of primary government budget deficit with 68% probability bands. The first column shows the forecast horizon. 'RGDP,' 'GOV,' 'CUR,' 'RIR,' and 'RER' denotes real GDP, the primary government budget deficit (% of GDP), the current account (% of GDP), the real interest rate, and the real effective exchange rate.

Table 3. Comovement Decomposition

(1) CUR and GOV

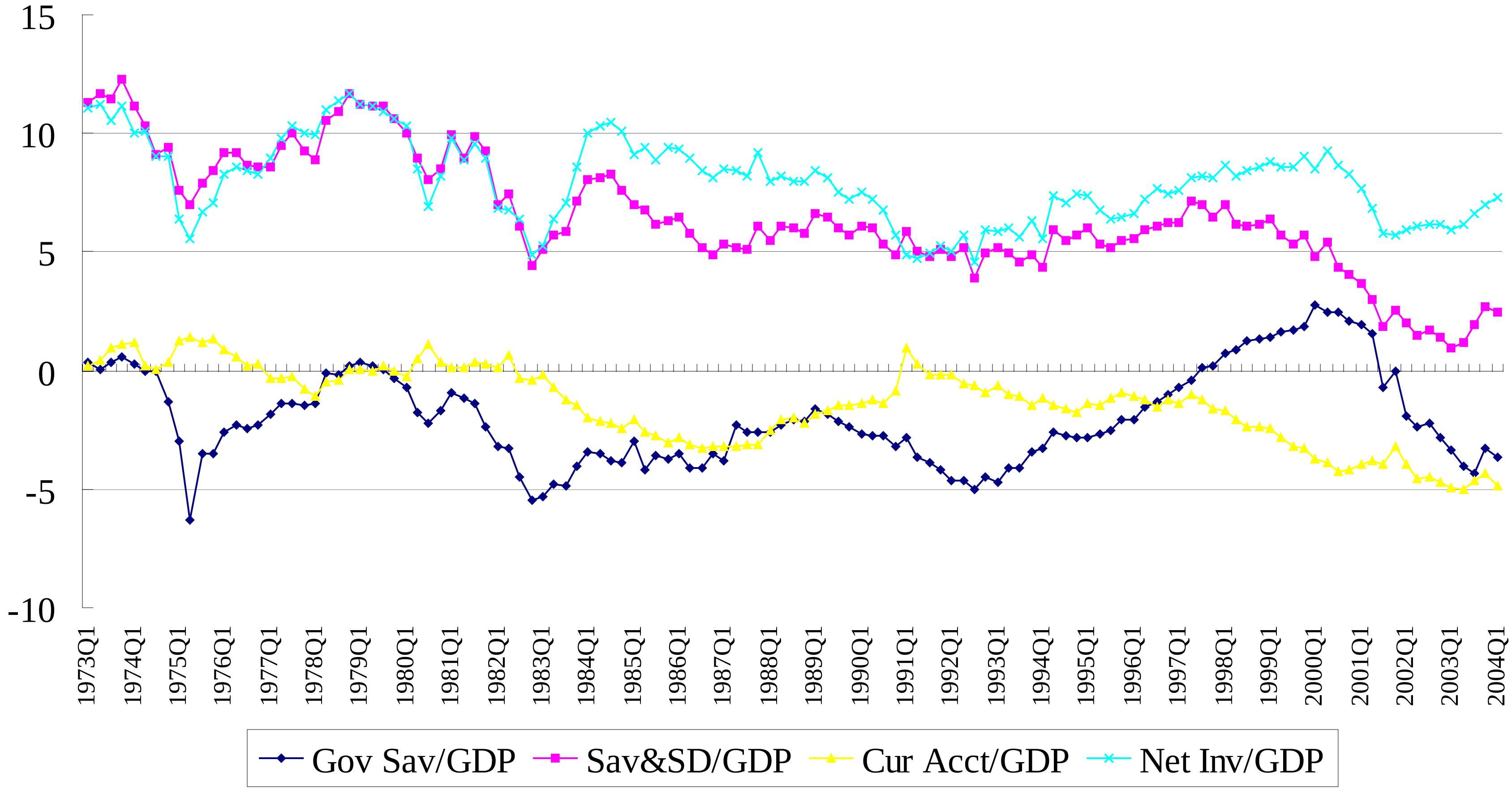
Horizon	Uncond. Correlation	Shock	Conditional Correlation	Correlation Decomposition	Covariance Decomposition
4 quarters	0.42 (0.31, 0.51)	RGDP	0.97 (0.90,0.98)	0.33 (0.23, 0.39)	78.0 (60.2, 95.1)
		GOV	0.70 (0.27,0.83)	0.10 (0.16, 0.03)	22.7 (7.4, 36.1)
		CUR	0.25 (-0.14,0.58)	0.02 (-0.01, 0.06)	4.4 (-3.4, 15.8)
		RIR	0.52 (-0.46,0.89)	0.01 (-0.01, 0.03)	1.6 (-1.5, 6.2)
		RER	-0.98(-0.47,-0.97)	-0.03(-0.04,-0.01)	-6.8 (-13.0,-1.2)
8 quarters	0.34 (0.48, 0.18)	RGDP	0.98 (0.92,0.98)	0.40 (0.27, 0.45)	117.5(83.6, 167.0)
		GOV	0.63 (0.01,0.79)	0.06 (0.00, 0.10)	16.4 (0.4, 34.2)
		CUR	0.05 (-0.24,0.55)	0.00 (-0.02, 0.04)	0.7 (-8.9, 16.0)
		RIR	0.30 (-0.39,0.72)	0.01 (-0.01, 0.03)	1.8 (-2.9, 9.9)
		RER	-0.97(-0.97,-0.73)	-0.12(-0.17,-0.05)	-36.4(-76.5,-10.0)

(2) RER and GOV

Horizon	Uncond. Correlation	Shock	Conditional Correlation	Correlation Decomposition	Covariance Decomposition
4 quarters	0.09 (-0.05,0.22)	RGDP	0.99 (0.79,0.99)	0.14 (0.04, 0.21)	153.5(-75.4,195.6)
		GOV	0.93 (0.20,0.94)	0.14 (0.09, 0.25)	97.5 (-31.4,139.9)
		CUR	0.11 (-0.69,0.69)	0.00 (-0.01, 0.01)	1.1 (-10.1,12.7)
		RIR	-0.36 (-0.81,0.62)	-0.01 (-0.03, 0.01)	-9.6 (-32.3,27.8)
		RER	-0.85(-0.87,-0.72)	-0.13(-0.18,-0.05)	-142.6(-202,185)
8 quarters	0.05 (-0.14,0.25)	RGDP	0.93 (0.78,0.96)	0.22 (0.09, 0.31)	404.8(-195,259)
		GOV	0.84 (0.10,0.87)	0.07 (0.00, 0.11)	120.5(-44.8,102.4)
		CUR	0.41 (-0.65,0.73)	0.00 (-0.01, 0.02)	9.0 (-9.3, 16.5)
		RIR	-0.82(-0.90,-0.03)	-0.01 (-0.03, 0.01)	-73.9(-49.7,59.1)
		RER	-0.90(-0.91,-0.75)	-0.20(-0.26,-0.08)	-260.4(-219,252

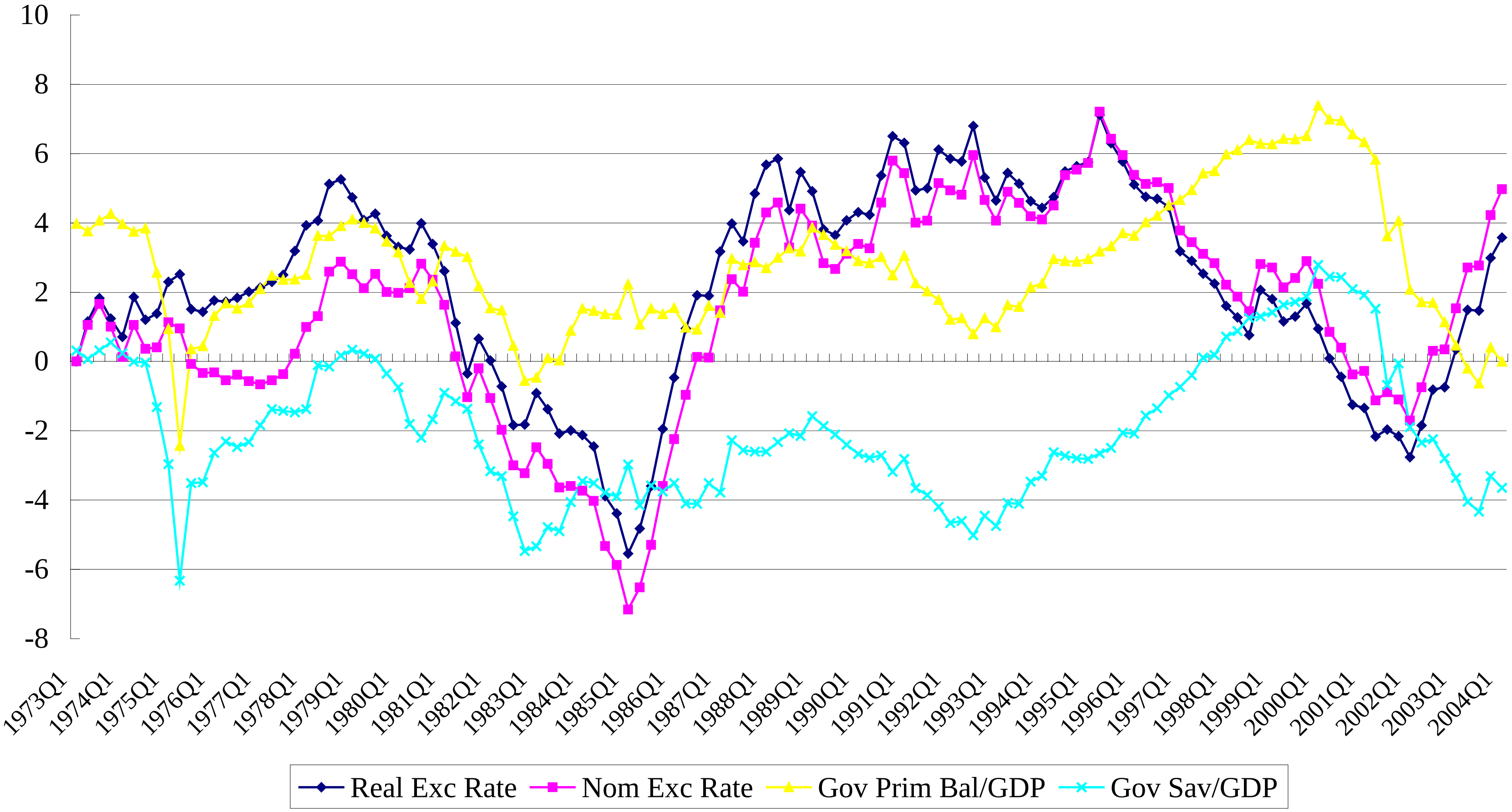
* These tables show the comovement decompositions of CUR (the current account as % of GDP) and GOV (the primary government budget deficit as % of GDP) and of RER (the real effective exchange rate) and GOV, with 68% probability bands. The first column shows the forecast horizon; the second, the unconditional correlation of forecast errors; the third, the name of shock; the fourth, the conditional correlation; the fifth, the correlation decomposition which shows the role of each structural shock in explaining unconditional correlation; and the last, the decomposition which shows the percentage contribution of each structural shock in explaining unconditional covariance. 'RIR' and 'RGDP' denote the real interest rate and the real GDP, respectively.

Figure 1. Current Account and Its Components, 1973-2004:1



This graph shows government saving ('Gov/GDP'), net national saving and statistical discrepancy ('Sav&SD/GDP'), current account ('Cur Acct/GDP'), and net investment ('Net Inv/GDP'), all as % of GDP.

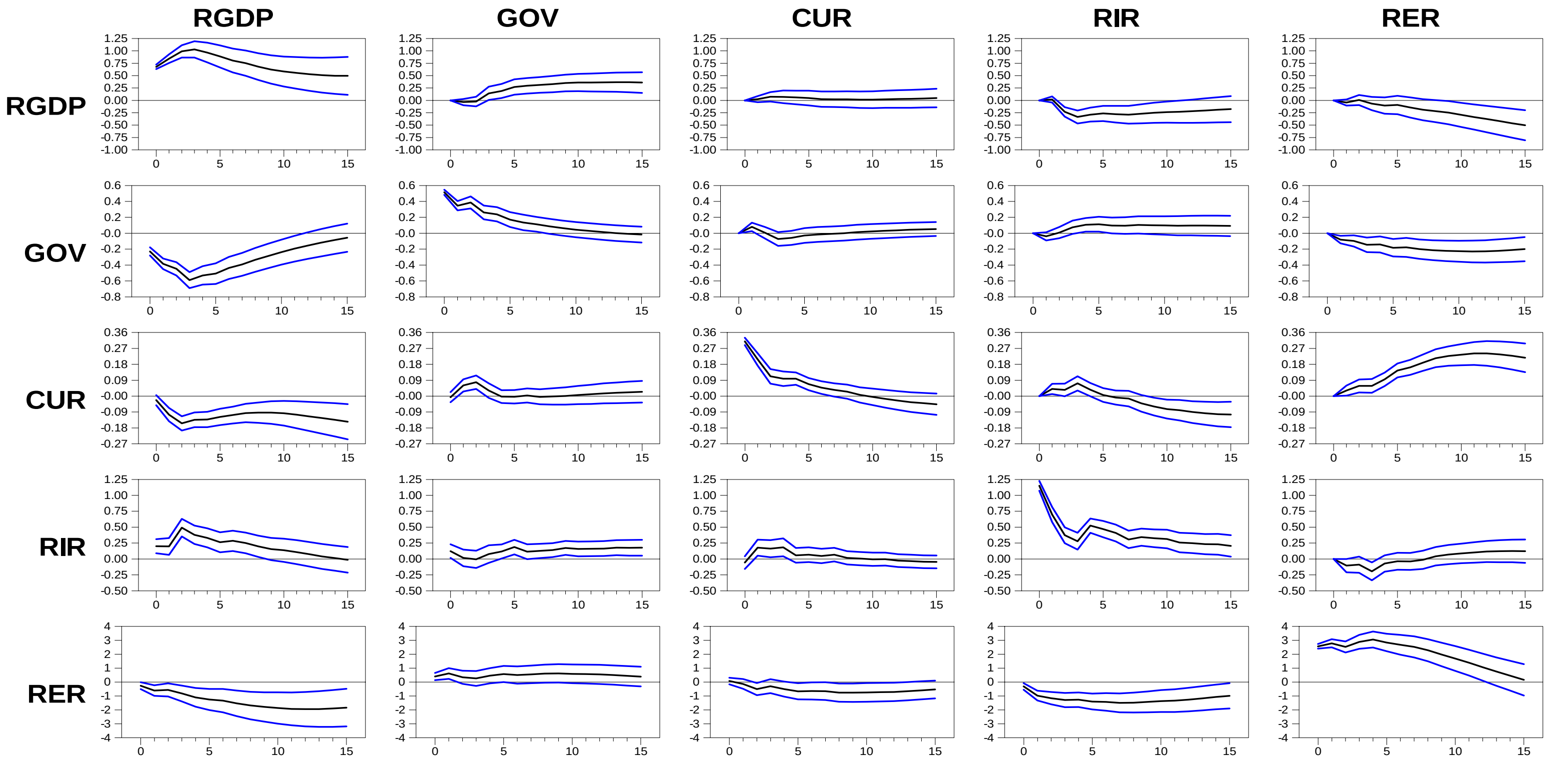
Figure 2. Exchange Rates and Government Saving, 1973-2004:1



This graph shows real effective exchange rate ('Real Exc Rate'), nominal effective exchange rate ('Nom Exc Rate'), government primary budget balance as % of GDP ('Gov Prim Bal/GDP'), and government saving as % of GDP ('Gov Sav/GDP').

Figure 3. Basic Identification Scheme, 1973-2004:1

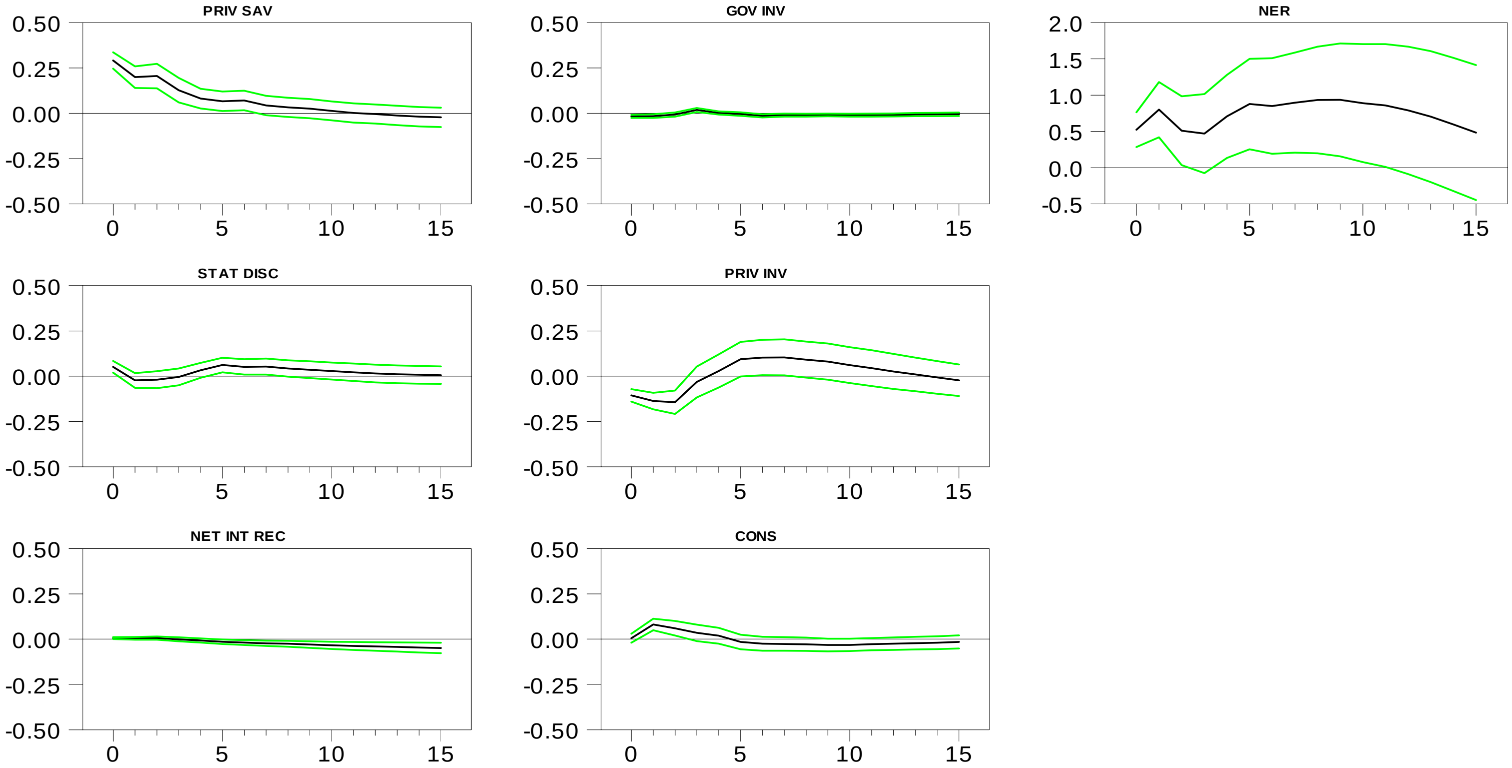
Government Primary Budget Deficit



The graphs show impulse responses to one standard deviation shocks with one standard error bands over four years in the basic five-variable model. The names of structural shocks are denoted at the top of each column and the responding variables are denoted at the far left of each row. ‘RGDP,’ ‘GOV,’ ‘CUR,’ ‘RIR,’ and ‘RER,’ denote real GDP (%), primary government budget deficit (% of GDP), current account (% of GDP), real interest rate (% point), and real effective exchange rate (%), respectively.

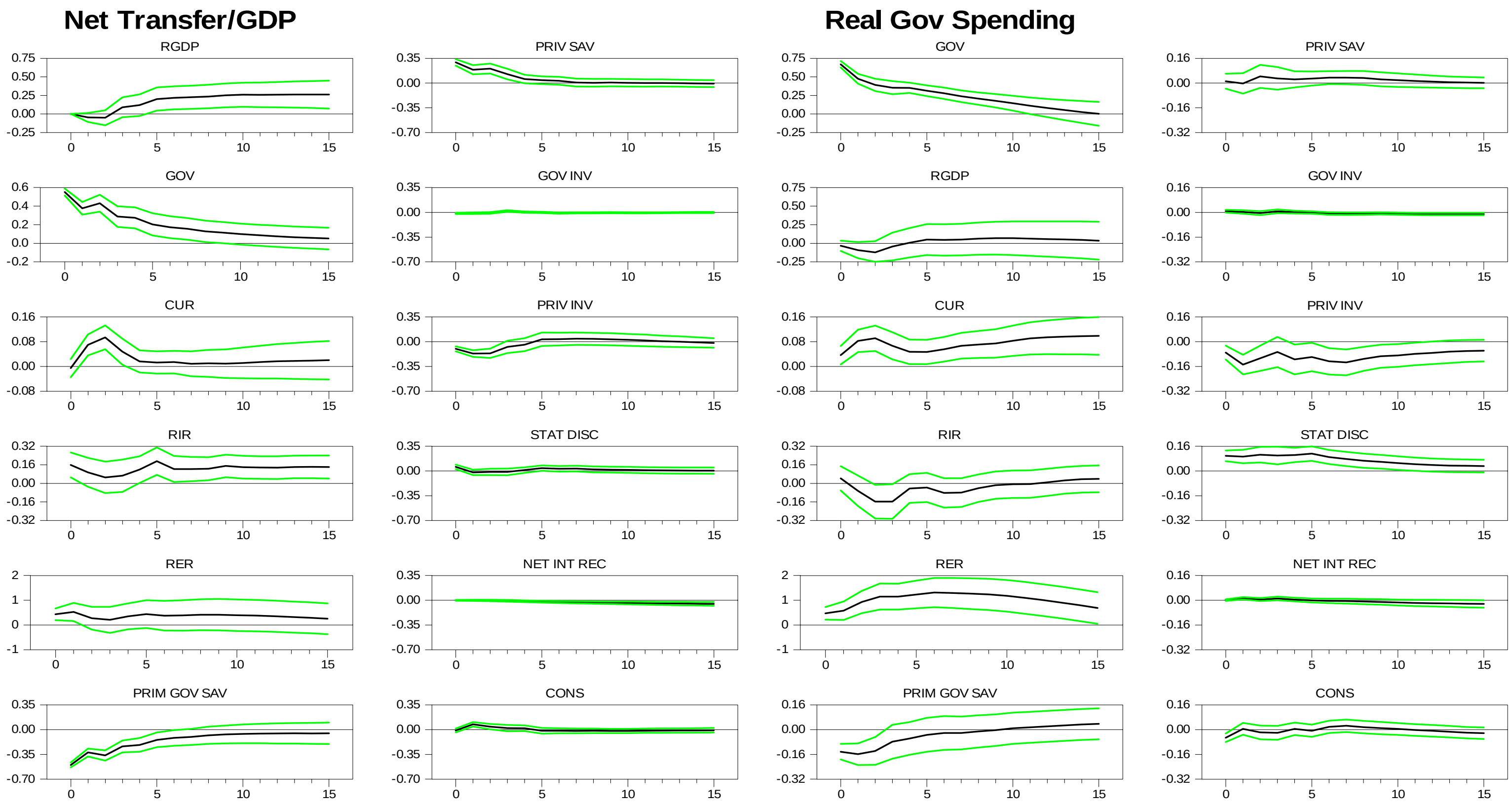
Figure 4. Effects of Primary Government Deficit Shocks

Components of Current Account and Nominal Exchange Rate



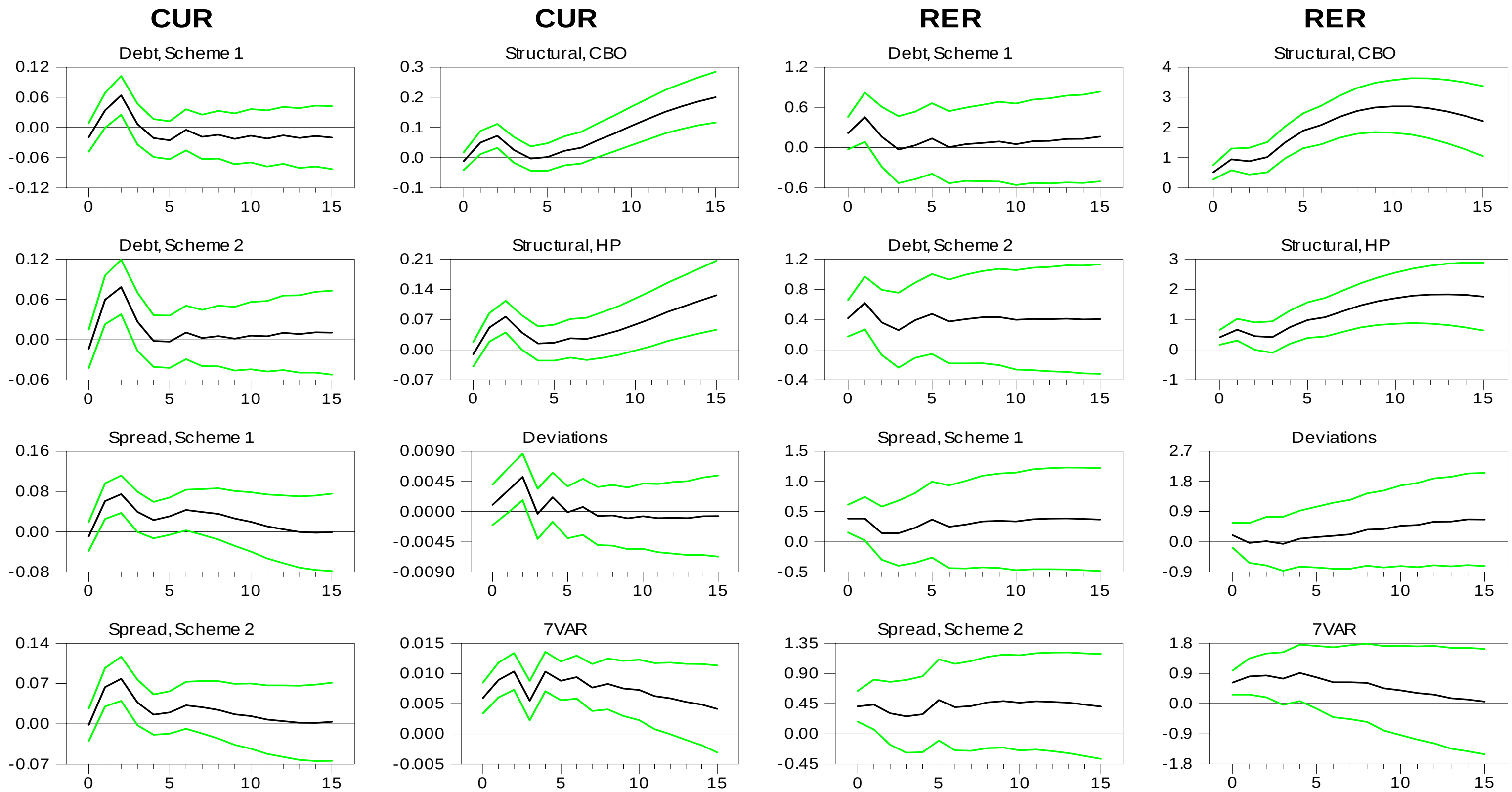
The graphs show impulse responses to one standard deviation primary government budget deficit shocks with one standard error bands over four years in the extended six-variable model. ‘PRIV SAV,’ ‘STAT DISC,’ ‘NET INT REC,’ ‘GOV INV,’ ‘PRIV INV,’ ‘CONS,’ and ‘NER’ denote private saving, statistical discrepancy, government net interests receipts, government investment, private investment, private consumption (all as % of GDP), and nominal effective exchange rate (%), respectively.

Figure 5. Effects of Government Spending and Net Transfer Shocks



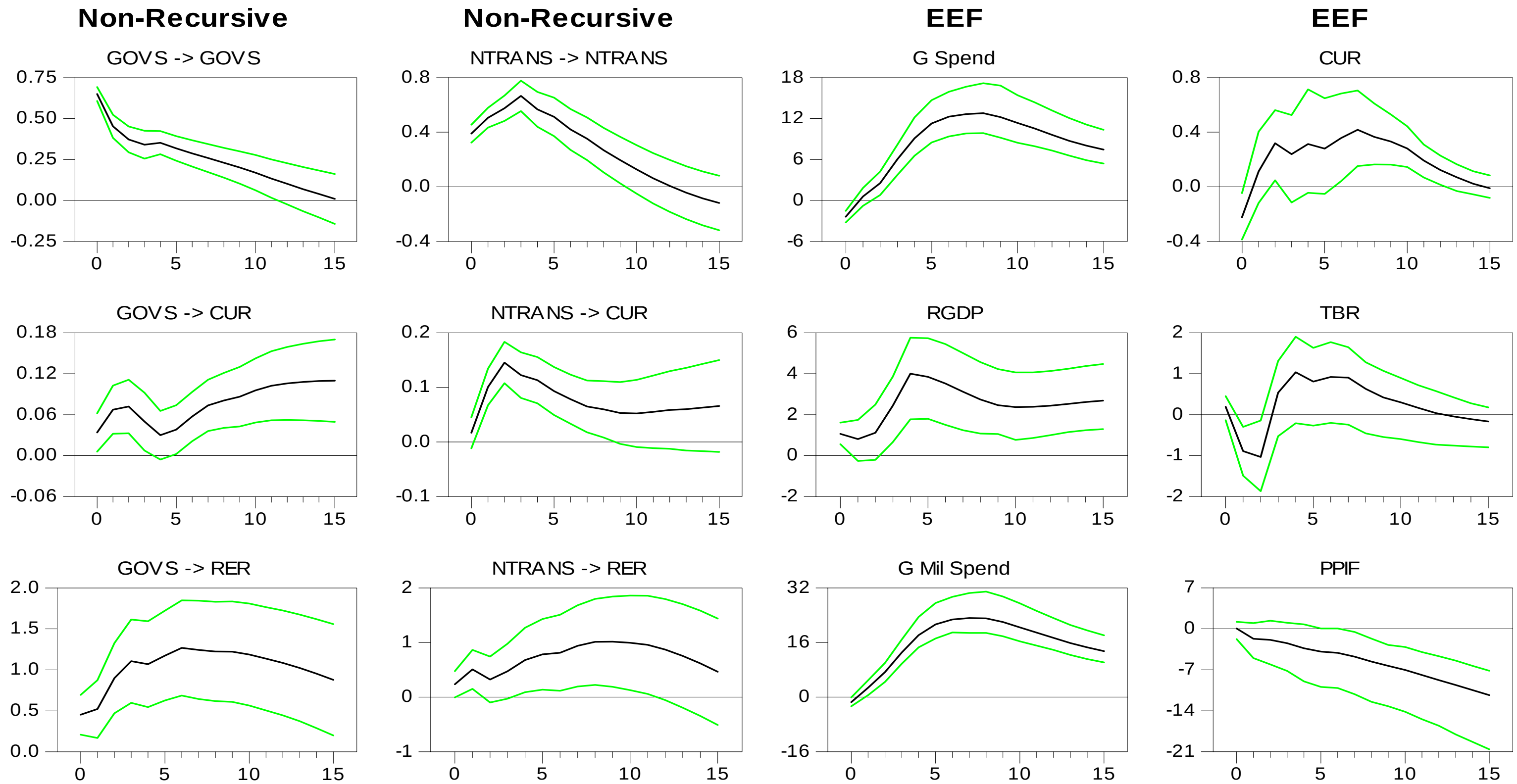
The graphs in the first two and the last two columns show the impulse responses to one standard deviation net transfer (% of GDP) shocks and real government spending shocks, respectively. ‘RGDP,’ ‘CUR,’ ‘RIR,’ ‘RER,’ ‘PRIM GOV SAV,’ ‘PRIV SAV,’ ‘GOV INV,’ ‘PRIV INV,’ ‘STAT DISC,’ ‘NET INT REC,’ ‘CONS,’ denote real GDP, current account, real interest rate, real effective exchange rate, primary government saving, private saving, government investment, private investment, statistical discrepancy, government net interest receipts, and private consumption, respectively, all as % of GDP except for RIR (% point), RER (%). ‘GOV’ denotes government net transfer (% of GDP) in the first column and real government spending (%) in the third column.

Figure 6. Extended Experiments



The graphs show impulse responses to one standard deviation government deficit shocks with one standard error bands over four years in various extended models. The graphs in the first two columns show the responses of the current account (% of GDP) while the graphs in the last two columns show the responses of the real effective exchange rate (%). 'Debt,' 'Spread,' 'Structural,' 'Deviations,' and '7VAR' denote the model with public debt, the model with term spread, the model with structural primary government deficit, the five variable model using deviations from foreign variables, and the seven variable model including foreign variables, respectively.

Figure 7. Extended Experiments



The graphs show impulse responses with one standard error bands over four years. The graphs in the first and the second columns show the responses to one standard deviation real government spending ('GOV,' %) shocks and net transfer ('NTRANS,' % of GDP) shocks in the non-recursive model, respectively. The graphs in the third and fourth columns show the responses to government purchase shocks in the model with fiscal dummies. 'CUR,' 'RER,' 'G Spend,' 'RGDP,' 'G Mill Spend,' 'TBR,' and 'PPIF' denote current account (% of GDP), real exchange rate (%), real government spending (%), real GDP (%), real government military spending (%), three month Treasury bill rate (% point), and producer price index of crude fuel (%).