

*Twin Sons of Different Mothers:
The Long and the Short of the Twin Deficits Debate*

By

Kevin Grier
Department of Economics
University of Oklahoma

&

Haichun Ye
Department of Economics
Florida Atlantic University

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Abstract:

Interest in the twin deficits hypothesis fluctuates in tandem with the US current account deficit. Surprisingly though, a statistically robust relationship between budget and trade deficits has been difficult to pin down. We argue that a big part of this difficulty is due to the failure to allow for structural breaks in the series when (either explicitly or implicitly) modeling their time series properties. We show that both series are break stationary (and conditionally heteroskedastic) and argue that while there is no common pattern in the long run, the short run dynamics reveal a sizeable and fairly persistent positive relationship between budget deficit shocks and current account deficit shocks.

The relationship between the government budget deficit and the current account deficit has been a contentious subject in empirical macroeconomics for at least the last 20 years. Papers have variously found a positive link, no link and three recent pieces even find a negative link between the two. There are, however, some things that almost all these studies have in common. For example, they ignore the possibility of structural breaks in the series when examining their time series properties. Most previous studies treat the variables under study as being integrated of order one, which is to say as having a unit root. This is a hard assumption to square with the fact that the variables are measured as fractions of GDP and have, over the last half century at least, shown no inclination toward typical unit root behavior. By contrast, in three recent pieces (Kim and Roubini, 2004; Corsetti and Muller, 2006; Muller, 2006), the two series are simply treated as pure stationary processes without any pre-testing, which obviously conflicts with results from the traditional unit root tests.

In this paper, we show that both the budget deficit and the current account deficit are stationary around an occasionally shifting mean (which is to say they have structural breaks, but are stationary after allowing for those breaks). Since it is well known that traditional unit root tests have little power when the underlying data contain structural breaks, this explains the puzzling finding that the budget deficit and the current account deficit expressed as fractions of GDP test out as $I(1)$ series in practice. Our findings also cast doubt on the validity of assuming the two series are purely stationary processes.

Given our framework, a simple test for the existence of a long-run equilibrium relationship between budget and current account deficits is to compare the number and

timing of their structural shifts. We find that the two series are not closely related either in their number of breaks or in their timing of structural shifts. We thus conclude that over the long run (genetically?), the deficits are not twins.

Another factor that existing studies have in common is their treatment the error structure of the model as homoskedastic, despite relatively clear visual evidence of volatility clustering (conditional heteroskedasticity) in least squares residuals. When we consider the short-run dynamics of the de-meaned variables via a VAR analysis, we show that the error covariance of this VAR model is significantly conditionally heteroskedastic and go on to specifically account for this phenomenon with a VAR-GARCH model. We consider a trivariate model that also includes the real interest rate. Here we find a significant and sizeable positive short-run effect of budget deficit innovations on the current account deficit in both the impulse response functions and variance decompositions of the model.

Our answer to the question of the paternity of the two deficits thus depends on the horizon studied. Each series has structural breaks that are largely independent of each other so they are not twins at all over the long run. However, once we allow for these secular shifts, the short-run dynamics reveals a very strong family resemblance indeed.

The rest of the paper is organized as follows. In section 2, we review some of the existing empirical literature. Section 3 discusses the time series properties of the data and presents our results about the long-run evidence on the twin deficits question. Section 4 sets out our VAR-GARCH model and presents our results on short-run twin deficits behavior. Section 5 is a brief conclusion.

2. An Overview of the Empirical Literature

The relationship between current account deficits and government budget deficits has been a subject of extensive study. Early studies, such as Milne (1977) and Bernheim (1987), usually apply ordinary least-square (OLS) regressions to cross-country data. They both find positive and statistically significant relationship between current account deficits and budget deficits. There are also some other early studies (Bryant, Holtham and Hooper 1988, Ziet and Pemberton 1990) which employ simulation techniques and provide supportive evidence for the twin deficits hypothesis.

Recently, vector autoregression (VAR) models have been widely used to examine the relationship between the two deficits. Abell (1990) estimates a seven-variable VAR system with first differenced data for the US over the period 1979 – 1985. Based on Granger causality tests as well as impulse response analysis, he suggests that the two deficits are twins and further indicates that budget deficits affect current account deficits through the transmission mechanisms of interest rates and exchange rates. Bachman (1992) and Rosensweig and Tallman (1993) also estimate unrestricted VAR in differences and find that government budget deficits have a sizable effect on trade deficits. Using quarterly data from 1947 to 1987 in the U.S., Enders and Lee (1990) estimate a six-variable structural VAR with the differenced data. However, their study supports the Ricardian Equivalence hypothesis, as it finds no evidence that budget deficits raise the trade deficit.

Since traditional unit root tests always find the two deficits to be nonstationary, another approach is to look for cointegration between them. Bachman (1992) conducts

cointegration tests for the US current account and government budget deficits but fails to find any evidence of cointegration while Dibooglu (1997) does find evidence of cointegration, and argues that budget deficits and increases in real interest rates are associated with current account deficits.

More recently, Kim and Roubini (2004) estimate a VAR in levels for the post-Bretton-Woods period, and find that increases in the US government budget deficits actually improve the US current account balance, which is completely opposite to the standard theoretical predictions. Following Kim and Roubini's method, Corsetti and Muller (2006) and Muller (2006) also provide supportive evidence for the negative relationship between the US current account and government budget balance.

The studies reviewed above have used different samples, variables and econometric models and generate mixed results. As far as econometric techniques are concerned, however, these studies share two factors in common. The first is a failure to allow for structural breaks in the two deficits series when examining the time series properties of the two variables. As we show below, the current account balance and the government budget balance in the US both follow break-stationary processes. This explains why they fail traditional unit root tests and indicates that using either VARs in first differences or VARs in raw levels is inappropriate.

The other common factor is a failure to allow for the existence of volatility clustering in current account deficits and government budget deficits. As we will also show below, the two series in fact exhibit significant conditional heteroskedasticity. This finding suggests that, by using OLS estimation, the estimated coefficients in a VAR

model are inefficient and the subsequent variance decompositions and impulse response functions may not be optimal.

3. Testing for and comparing structural breaks in the two deficits

Our first goal is to determine if the current account balance and government budget balance in the United States have experienced structural shifts in their respective mean processes, and if so, to compare those shifts in order to provide long-run evidence on the twin deficits proposition. We use the global optimization method developed by Bai and Perron (1998, 2003) (BP hereafter) to estimate the number and location of breakpoints in the two series. An advantage of this methodology is that the number and location of breakpoints are determined endogenously rather than by prior choice of a researcher.

We estimate a simple mean shift model with $m + 1$ regimes as follows:

$$y_t = z_t \delta_j + v_t, \quad t = T_{j-1} + 1, \dots, T_j, \quad j = 1, \dots, m + 1 \quad (1)$$

Here y_t is the observed dependent variable, z_t is a constant equal to one, and

(T_1, T_2, \dots, T_m) represents the location of breakpoints. The number of breakpoints is determined based on the $SupF_T(l)$ combined with the sequential $SupF_T(l+1|l)$ tests while a dynamic programming algorithm is utilized to find the breakpoints that globally minimize the sum of squared residuals.¹

The sample consists of quarterly observations for the US over the period from 1948Q1 to 2005Q1. The seasonally adjusted current account balance, government budget

¹ The term $SupF$ refers to the supremum of a series of individual F tests. This statistic does not have a standard F distribution, but appropriate critical values are provided by Bai and Perron. We allow up to 8 breaks and set the trimming value equal to 0.1 so that each regime has at least 22 observations. Serial correlation in the errors and heterogeneous variances of the residuals across regimes are also allowed in the estimation.

balance and GDP data are obtained from Bureau of Economic Analysis (BEA). Both the current account balance and government budget balances are expressed as shares of GDP².

Table 1 reports our estimates of the number and location of the breakpoints in the current account balance and government budget balance. Panel A shows the estimated number and location of the breakpoints in the current account balance. The $SupF_T(l)$ tests and the double maximum tests (UD max and WD max) all reject the null of no break at the 1% significance level. The sequential $SupF_T(l+1|l)$ tests reject one break in favor of two but fail to reject two in favor of three, leading us to conclude that the optimal number of breaks is two. Using BP's global optimization algorithm, we find that these two breaks in current account balance occur in 1982Q4 and 1999Q2, respectively. Figure 1A presents the estimated structural shifts in the US current account balance.

The results from our structural breaks analysis of the US government budget balance are reported in Panel B of Table 1. The $SupF_T(l)$ tests and the double maximum tests (UD max and WD max) all suggest the existence of structural breaks in this series. Furthermore, the sequential $SupF_T(l+1|l)$ tests fail to reject one break in favor of two, which indicates that there is only one significant break in the government budget balance series. The location of this breakpoint uncovered with BP's method is 1974Q2. Figure 1B illustrates the structural changes in the US government budget balance.

Given the presence of two structural breaks in the current account balance yet one break in the government budget balance, we apply Lee and Strazicich's (2003) LM test to the current account balance, and Perron's (1989) modified ADF tests to the government

² A positive sign indicates a surplus and a negative sign indicates a deficit.

budget balance. We find that both series are indeed break-stationary. Table 2 reports the LM test statistic and Perron's t-statistic as well.

Given the findings above, we can view each of these series as consisting of stationary short run dynamics around an infrequently shifting mean, which means that there are two types of relationships between them. First there is a potential long run relationship between the means, and second there is a potential short run relationship in the dynamics. We begin here with the first potential relationship between the long run means. We argue that if these series are related in the long run, that is to say, if secular changes in the budget deficit are related to secular changes in the trade deficit, then the regime shifts in these series should be related. Ideally, for the twin deficit hypothesis, we should see that every mean shift in the government budget deficit is accompanied by a shift in the trade deficit.

Here we compare the estimated structural breaks in the current account balance to those in government budget balance from two perspectives; the number of breaks and the timing of the breaks. First, the two series have different number of breaks. There is one break in the government budget balance but two breaks in the current account balance. Second, we consider whether the timing of breakpoints in the two series matches. If the budget balance is indeed the driving force behind movements in the current account balance, we would expect the dates of breakpoints in the two series to be quite close. However, the 95 percent confidence intervals for the breakpoint in the government

³ While this is a relatively new way to consider looking for long run relationships, Rapach and Wohar (2005) do something very similar in that they argue that inflation causes real interest rate changes by showing that the number and timing of structural breaks in the real rate match up closely with the number and timing of structural breaks in inflation for several countries.

budget balance is 1971Q3 – 1976Q2, which does not include either of the two estimated break dates for the current account (which are 1982Q4 and 1999Q2).

Based on the above comparison of the two series' secular behavior, we conclude that there is no long-run connection between the current account balance and the government budget balance in the US. There is a budget balance mean shift with no corresponding trade balance shift and two subsequent trade balance mean shifts occur while the budget balance displays a constant secular mean.⁴

We now consider the short-run dynamics between the two series using VAR analysis on the demeaned data and allowing for conditional heteroskedasticity when estimating the VAR coefficients.

4. A VAR-GARCH Model of the short-run dynamics of the “twin” deficits

We have shown that, at least in the long run, there is no connection between the current account balance and government budget balance in the US. In this section we present VAR evidence on the short-run dynamics of the series. As shown in Section 3, both the current account balance and the government budget balance are actually stationary with structural breaks in their mean processes. Therefore, instead of first differencing the data, we remove the shifting means for these two series and then estimate a VAR model using the de-meanned data. We also include real interest rates into

⁴ It has been suggested to us that the trade balance “should” show a break at the end of the Bretton Woods era in 1973. While we agree that the effect that trade deficits have on other variables might change when the exchange rate regime changes, that is not the same as saying that the secular mean of the trade deficit should change when the exchange rate regime changes. An inspection of the trade balance data in Figure 1A shows that trade balance fluctuations in the 1970s look very similar to those of the 1950s. While a full analysis of the possible determinants of these breaks is beyond the scope of this paper, the break in the budget deficit series in 1974 corresponds with the post-Watergate elections of a wave of younger, more liberal democratic members in the House of Representatives and the passage of the so called “sub-committee bill of rights” and the abolishment of the strict use of seniority in assigning leadership positions in House committees.

the VAR model, based on the literature that current account balance and government budget balance are related by changes in real interest rates.

Since previous empirical studies have shown that the US real interest rates follow a break-stationary process, we also estimate structural breaks for the real interest rate series with BP's method and then remove its shifting mean.⁵ We use an ex post real interest rate defined as the difference between nominal interest rates and actual inflation rate.⁶ Three-month Treasury bill rates are used as nominal interest rates and inflation rates are calculated by using quarterly CPI. Both Treasury bill rates and CPI are obtained from the Federal Reserve Bank of St. Louis' FRED dataset.

The three-variable unrestricted VAR model is thus specified as follows:

$$X_t = \beta_0 + \sum_{i=1}^p \beta_i' X_{t-i} + \varepsilon_t \quad (3)$$

where $X_t = \left[(CA_t - \overline{CA}(l)) \quad (GB_t - \overline{GB}(j)) \quad (RI_t - \overline{RI}(k)) \right]'$, CA denotes the current

account balance (as a share of GDP), GB denotes the government budget balance (as a share of GDP), and RI denotes the real interest rate. Here $l=1-3$, $j=1-2$, and $k=1-4$ to account for the regime specific means in each series.

Before estimating the VAR model, lag length tests are used to select the appropriate lag length. Based on both the sequential modified LR test statistic and Akaike Information Criterion (AIC), the lag length is set to 5. Under the assumption that the error terms are serially uncorrelated with a constant variance, this VAR model can be

⁵ See Bai and Perron (2003), Caporale and Grier (2000, 2005) for detailed discussion on structural breaks in the US real interest rates. In our extended sample (1948Q1~2005Q1), we identified three breakpoints in the US real interest rates at 1972Q2, 1980Q2 and 1986Q2, respectively.

⁶ As ex ante real interest rates are based on expected inflation rates that are difficult to measure, we use actual inflation rates to compute ex post real interest rates, assuming people have rational expectations.

estimated simply using OLS, which yields consistent and asymptotically efficient estimates. However, we believe that these series are conditionally heteroskedastic and that a VAR-GARCH model will provide efficiency gains in estimation.

4.1 Testing for Conditional Heteroskedasticity

To test for the possibility of conditional heteroskedasticity, we use the multivariate Ljung-Box portmanteau test developed by Hosking (1980).⁷ After obtaining standardized residuals from the VAR model given in equation (3) above, we calculate the Ljung-Box test statistics at four, eight and twelve lags for the levels and squares of these residuals, respectively.

Table 3 reports the results from the multivariate Ljung-Box portmanteau tests. As far as the levels of the standardized residuals are concerned, none of the test statistics are significant at the 10% level, which means that there is no serial correlation among the levels of residuals. When the squares of the standardized residuals are examined, however, the null hypothesis of a constant error variance is rejected, which provides strong evidence for the presence of conditional heteroskedasticity in the series. This means that the OLS estimation of the VAR model may produce extremely inefficiently estimated coefficients which degrade the value of any inference done using impulse responses and variance decompositions based on these OLS estimates.⁸

4.2 The statistical model

To explore the short-run relationship between current account balance and government budget balance under the condition of volatility clustering, we estimate a

⁷ See Hosking (1980) and Bauwens, Laurent and Rombouts (2006) for details.

⁸ As shown by Engel (1982), in the presence of conditional heteroskedasticity, using ARCH instead of OLS can generate very large gain in efficiency. Grier and Perry (1993) provide an illustrative empirical example of the importance of using ARCH estimation over OLS estimation when conditional heteroskedasticity appears in the data.

VAR-GARCH model, which allows for simultaneous estimation of conditional variance equations as well as mean equations for current account balance, government budget balance and real interest rates. Since the correlation in squared residuals in this multivariate context is somewhat persistent, we model the conditional variance of each series with a GARCH (1, 1) process. For the covariance structure, we use Bollerslev's (1990) model which allows for time-varying conditional covariance but a constant correlation matrix. This method is commonly used in estimating multivariate GARCH models due to its computational convenience. The VAR-GARCH (1, 1) model of current account balance, government budget balance and real interest rates is specified as follows:

$$CA_t = \sum_{i=1}^p \phi_{11,i} CA_{t-i} + \sum_{i=1}^p \phi_{12,i} GB_{t-i} + \sum_{i=1}^p \phi_{13,i} RI_{t-i} + \varepsilon_{1t} \quad (4.1)$$

$$GB_t = \sum_{i=1}^p \phi_{11,i} CA_{t-i} + \sum_{i=1}^p \phi_{12,i} GB_{t-i} + \sum_{i=1}^p \phi_{13,i} RI_{t-i} + \varepsilon_{2t} \quad (4.2)$$

$$RI_t = \sum_{i=1}^p \phi_{11,i} CA_{t-i} + \sum_{i=1}^p \phi_{12,i} GB_{t-i} + \sum_{i=1}^p \phi_{13,i} RI_{t-i} + \varepsilon_{3t} \quad (4.3)$$

$$h_{1t} = \omega_1 + \alpha_1 \varepsilon_{1,t-1}^2 + \beta_1 h_{1,t-1} \quad (4.4)$$

$$h_{2t} = \omega_2 + \alpha_2 \varepsilon_{2,t-1}^2 + \beta_2 h_{2,t-1} \quad (4.5)$$

$$h_{3t} = \omega_3 + \alpha_3 \varepsilon_{3,t-1}^2 + \beta_3 h_{3,t-1} \quad (4.6)$$

$$h_{12,t} = \rho_{12} \sqrt{h_{1t}} \sqrt{h_{2t}} \quad (4.7)$$

$$h_{13,t} = \rho_{13} \sqrt{h_{1t}} \sqrt{h_{3t}} \quad (4.8)$$

$$h_{23,t} = \rho_{23} \sqrt{h_{2t}} \sqrt{h_{3t}} \quad (4.9)$$

Equations (4.1) to (4.3) present the mean equations of current account balance, government budget balance and real interest rates as a three-variable VAR system with lag length of p , where CA , GB and RI denote current account balances, government budget balance and real interest rates, respectively. Equations (4.4) to (4.6) describe the conditional variance of current account balance, government budget balance and real interest rates as ARMA (1, 1) processes, respectively. Equations (4.7) through (4.9) give the constant correlation models of the covariance among the three variables.⁹

We assume that the three error terms, ε_1 , ε_2 and ε_3 have a joint normal distribution with means equal to zero and conditional variance-covariance matrix specified above. Following the Berndt et al. (1974) numerical optimization algorithm (BHHH), we obtain the maximum likelihood estimates of the parameters in the VAR-GARCH model. As shown by Bollerslev (1990), with the above assumptions about the error terms, the BHHH estimate of the asymptotic covariance matrix of the coefficients is consistent. As our sample size (more than 200 observations) is relatively large, the estimated asymptotic t-statistic should be fairly accurate.

Estimates of the model are shown in Table 4. The estimated coefficients in the three conditional variance equations are generally statistically significant at the 5% level, which further confirms the existence of conditional heteroskedasticity in the current account balance, the government budget balance, and the real interest rate as well. Figure 2 presents our estimates of the conditional variances of these series.

⁹ h_{12} and ρ_{12} denote the covariance and correlation between current account balance and government budget balance, respectively. h_{13} and ρ_{13} denote the covariance and correlation between current account balance and real interest rates, respectively. h_{23} and ρ_{23} denote the covariance and correlation between government budget balance and real interest rates, respectively.

The estimated conditional correlation coefficient between shocks to the current account balance and the government budget balance is negative and statistically insignificant at the 10% level. While the conditional correlation coefficient between the current account balance and the real interest rate is statistically insignificant, the conditional correlation between the government budget balance and the real interest rate is significantly negative at the 1% level.

For a basic test of whether this VAR-GARCH specification is adequate to model the conditional heteroskedasticity in the series, we use the standardized residuals from the estimated VAR-GARCH (1, 1) model and again calculate the multivariate Ljung-Box portmanteau Q-statistics at four, eight and twelve lags for the levels and squares of these residuals. The results reported in Table 5 show that these tests no longer reject homoskedasticity.

4.3 Impulse response analysis and variance decompositions

Since the mean equations in the VAR-GARCH (1, 1) model are reduced-form equations and presented in the form of a VAR system, we employ impulse response functions and variance decompositions to examine whether shocks to the government budget balance have significant impacts on the current account balance. Here we follow the recent literature and identify the structural shocks by assuming that the trade deficit and interest rate affect the budget deficit only with a lag. That is to say we employ a Cholesky decomposition to the reduced form residuals with the variables ordering GB , RI , CA .¹⁰

¹⁰ We have also employed Generalized Impulse response functions and the results are basically similar to those reported here except that interest rates have even less impact on the trade deficit in the GIRF case than they do in our reported results in the text.

Figure 3 displays the point estimates of the impulse responses of the US current account balance along with their bootstrapped 95% confidence intervals. Given a positive shock to the government budget balance at period zero, the current account balance first rises for almost two years and then gradually falls to zero. Seven quarters after the shock, the current account balance (share of GDP) is boosted by about 0.24 percentage points. Based on the bootstrapped 95% confidence intervals, the positive effect of the budget balance shock on the current account balance is statistically significant and highly persistent. It takes about five years for the effect to disappear. In addition, shocks to the real interest rate have significantly positive, but relatively small, effects on the current account balance.

Panel A of Table 6 presents the results from variance decompositions of the current account balance based on the estimated coefficients in the VAR-GARCH (1, 1) model. Shocks to the current account balance explain most of its movements in the very short run (within one year) but increasingly less over time. That is to say, shocks to the government budget balance account for statistically significant and increasing proportions of the forecast error variance in current account balance as time passes. By the end of 12 quarters, the government budget balance shocks explain almost half of the variance (around 45%) in current account balance. The explanatory power of real interest rate shocks on the current account is small, accounting for less than 8% of the forecast error variances of the current account balance at any of the time horizons we consider.

The evidence from impulse responses analysis and variance decompositions based on the mean equations in the VAR-GARCH (1, 1) model suggest that, allowing for conditional heteroskedasticity in the data, the government budget balance is significantly

and persistently positively associated with the current account balance in the short run. Thus, with respect to their short-run dynamics, if these series are not twins, they at least bear a considerable family resemblance! Furthermore, changes in real interest rates have only small impacts on the current account balance, which implies that real interest rates are at best a very weak link between the current account balance and the government budget balance.

4.4 Discussion: why do we get these results?

We have shown that although the series are not twins in the long run, they are closely positively related in the short run with increases in the budget deficit driving increases in the current account deficit. In doing so, we have departed from the usual methods used in the literature. In this section, we show how the results change if our methodological points about the importance of allowing for break stationarity and conditional heteroskedasticity are ignored. We focus on the main relationship we find, the positive effect of budget shocks on the current account.

Panel A of Figure 4 presents impulse responses of our VAR on the de- (shifting) meaned series estimated with no allowance for heteroskedasticity. Compared to our preferred results, we observe that the homoskedastic VAR model shows an impulse response function where the positive effect of budget shocks on the current account now is less persistent, lasting less than three years, and also much smaller in magnitude. A variance decomposition of this homoskedastic VAR is reported in Panel B of Table 6, which suggests that, when the conditional heteroskedasticity is not considered, budget

shocks have far less explanatory power for the fluctuations in the current account over time.¹¹

We also show what would happen if a researcher were to ignore the break stationarity of these series. If we simply consider standard ADF and co-integration tests, we find that each of our three series is $I(1)$ and that there are no co-integrating relationships between them. In this case, the appropriate technique is to estimate a VAR in the first differenced data, which produces the impulse responses shown in Panel B of Figure 4 and the variance decomposition in Panel C of Table 6. The impulse response functions of the current account balance show that budget shocks first lower, then raise, then lower the current account balance. Compared to our preferred results, the effects in the difference VAR are less consistent in sign, smaller in magnitude and less persistent.¹²

In sum, the modeling of conditional heteroskedasticity and break stationarity each plays a significant role in accurately testing the twin deficits hypothesis.

5. Conclusion

In this paper, we investigate the relationship between the current account balance and the government budget balance in the US from both the long-run and short-run perspectives. Our first important finding is that, instead of being random walks or pure stationary processes, the current account balance and government budget balance are

¹¹ It is also the case that the homoskedastic VARs IRF produces a significantly negative effect of budget shocks on the current account balance in the first two quarters, while in our preferred model, the initial negative effect is not statistically significant.

¹² If we simply estimate a VAR in the levels we find a very small positive effect of budget shocks on the current account balance. K&R (2004) and Mueller (2006) find a small negative effect. However, if we restrict our sample to the same sample that they use we find the same result as they do, namely a small negative effect. Note that in the K&R paper, the negative impulse response reported is only significant using one standard error confidence intervals. Throughout our paper we use two standard error confidence bands.

actually stationary around occasionally shifting means. Furthermore, since neither the number nor timing of the structural shifts in the two series are closely related, we conclude that there is no long-run twin relationship between the current account balance and government budget balance in the United States.

Next we estimate a VAR-GARCH (1, 1) model with demeaned current account balance and government budget balance, which allows us to examine their short-run connection in the presence of conditional heteroskedasticity. Based on both generalized impulse response functions as well as variance decompositions, we find a significantly positive and persistent short-run effect of budget shocks on the current account balance.

To highlight the importance of modeling break stationarity and conditional heteroskedasticity, we then compare the results from our preferred model to those from a de-meaned VAR with homoskedastic error variance, those from a differenced VAR and those from a level VAR. Results from our comparisons show that ignoring the conditional heteroskedasticity and break stationarity in the US current account and government budget balance would lead to a false conclusion on the twin deficits hypothesis.

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Figure 1A. The US Current Account Balance (as a share of GDP)

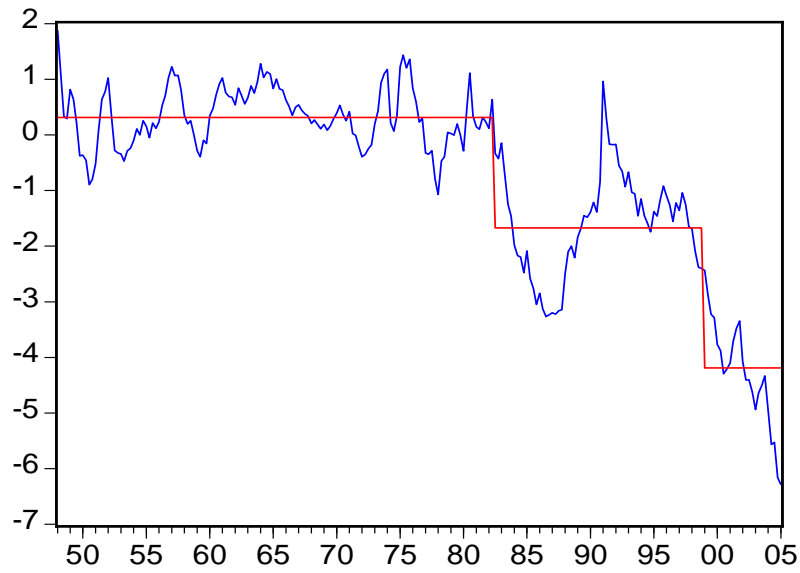


Figure 1B. The US Government Budget Balance (as a share of GDP)

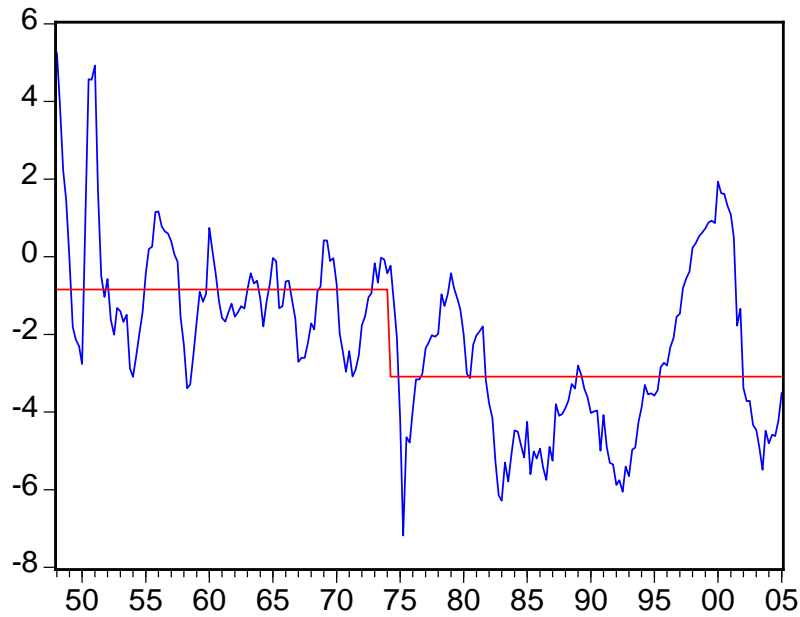
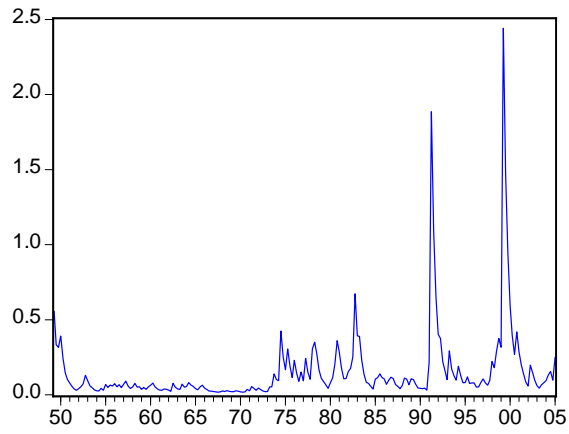
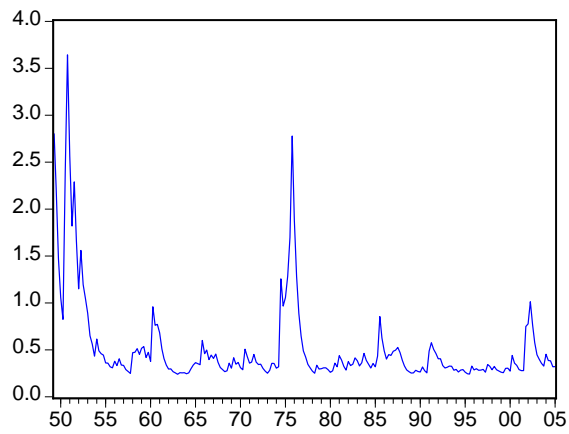


Figure 2. The Estimated Conditional Variances from the VAR-GARCH(1, 1) model

Panel A. The US Current Account Balance



Panel B. The US Government Budget Balance



Panel C. The US Real Interest Rate

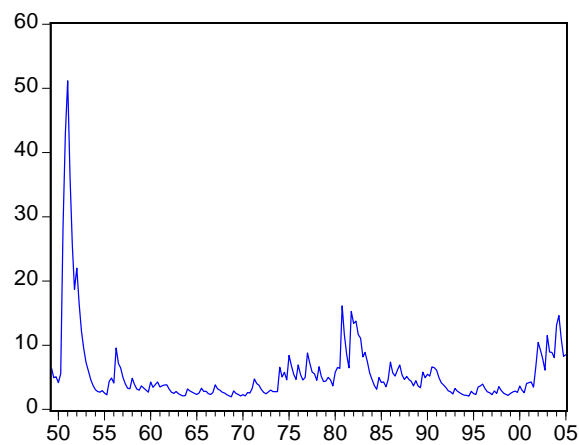
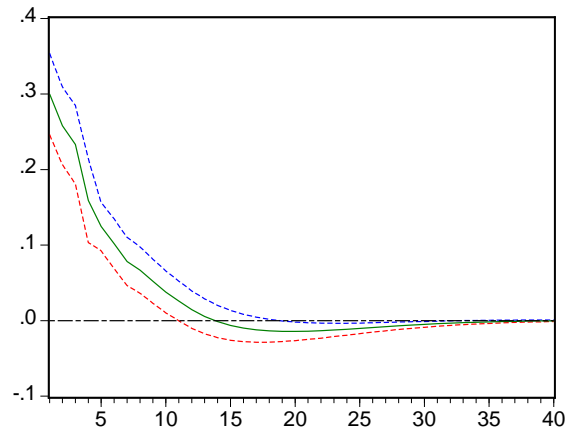
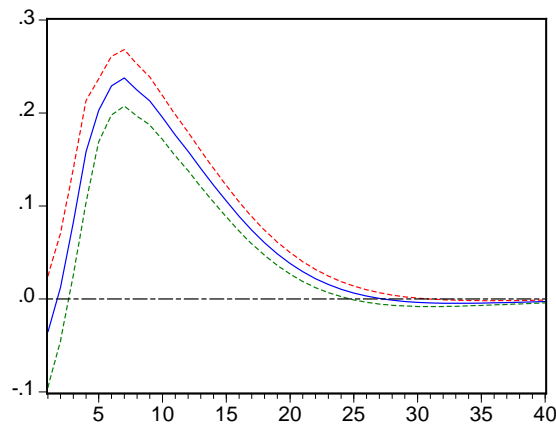


Figure 3. VAR-GARCH (1, 1): Impulse Responses of the US Current Account Balance

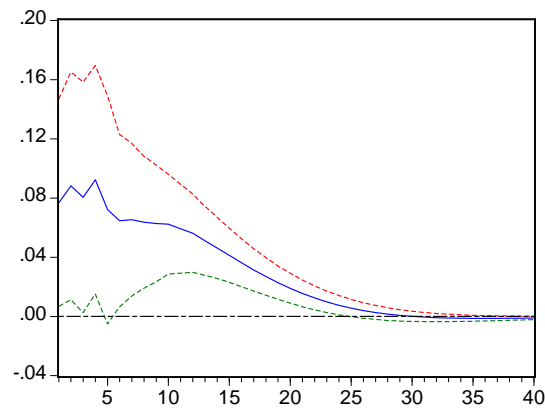
Panel A. Response to One S.D. Shock in Current Account Balance



Panel B. Response to One S.D. Shock in the Government Budget Balance



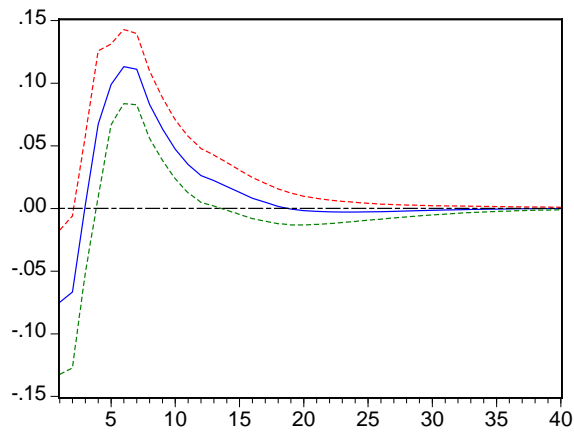
Panel C. Response to One S.D. Shock in the Real Interest Rates



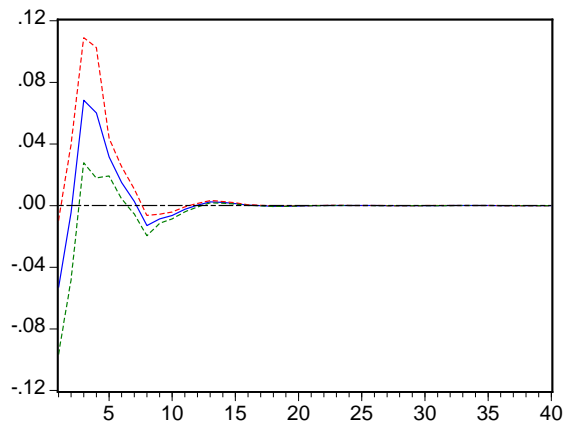
Note: The horizontal axis indicates the time horizon in terms of quarters after shocks. The vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 4. Impulse Responses of Current Account Balance to One S.D. Shock in Government Budget Balance

Panel A. De-meaned VAR with Homoskedasticity



Panel B. VAR in Differences



Note: The horizontal axis indicates the time horizon in terms of quarters after shocks. The vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Table 1. Multiple Structural Breaks Model: 1948Q1 ~ 2005Q1

Panel A: Structural Breaks in the US Current Account Balance

Test Statistics							
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(6)$	$SupF_T(7)$	$SupF_T(8)$
15.77***	77.5***	58.46***	43.17***	37.66***	53.93***	53.39***	46.58***
$SupF_T(2 1)$	$SupF_T(3 2)$	$SupF_T(4 3)$	$SupF_T(5 4)$	$SupF_T(6 5)$	$SupF_T(7 6)$	$SupF_T(8 7)$	
11.12**	4.00	2.88	2.14	0.51	0.3	0.3	
$UDmax$		77.5***		$WDmax$		141.48***	
Number of Breaks Selected							
Sequential Procedure	2						
Estimates with Two Breaks							
$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	\hat{T}_1		\hat{T}_2		
0.31	-1.67	-4.19	1982Q4		1999Q2		
(0.16)	(0.6)	(0.33)	(1965Q1 ~ 1984Q2)		(1998Q2 ~ 2005Q1)		

Panel B: Structural Breaks in the US Government Budget Balance

Test Statistics							
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(6)$	$SupF_T(7)$	$SupF_T(8)$
2.38	14.11***	10.95***	10.66***	16.67***	15.34***	14.59***	12.70***
$SupF_T(2 1)$	$SupF_T(3 2)$	$SupF_T(4 3)$	$SupF_T(5 4)$	$SupF_T(6 5)$	$SupF_T(7 6)$	$SupF_T(8 7)$	
0.92	1.48	1.68	1.39	0.05	0.00	0.00	
$UDmax$		16.67***		$WDmax$		38.58***	
Number of Breaks Selected							
Sequential Procedure	1						
Estimates with One Breaks							
$\hat{\delta}_1$	$\hat{\delta}_2$	\hat{T}_1					
-0.84	-3.09	1974Q2					
(0.52)	(1.35)	(1971Q3 ~ 1976Q2)					

Notes: Standard errors (robust to heteroskedasticity and serial correlation) for $\hat{\delta}_i$ and the 95% confidence intervals for \hat{T}_i are reported in parentheses. *, ** and *** indicate the significance level of 10%, 5% and 1%, respectively.

Table 2. Unit Root Tests in the Presence of Structural Breaks

Panel A. Perron's Modified ADF Tests

		Critical Value	Critical Value
	Perron's t-statistic	(1%)	(2.5%)
Government Budget	-5.054	-4.27	-4.09

Note: The critical values are provided by Perron (1989).

Panel B. Lee and Strazicich's LM Tests

		Critical Value	Critical Value
	LM test statistic	(1%)	(5%)
Current Account	-3.1824	-3.61	-3.047

Note: The critical values are provided by Lee and Strazicich (2003).

Table 3. Ex ante Residual Diagnostics

Panel A. Levels of Residuals

Q(4)	Q(8)	Q(12)
6.6465	33.4690	66.7844

Panel B. Squares of Residuals

Q(4)	Q(8)	Q(12)
78.1333***	100.2208***	119.4766*

Note: The residuals are obtained from the unrestricted VAR (5) and standardized. Q(4), Q(8) and Q(12) are the multivariate Ljung-Box statistics for the fourth-, eighth- and 12th-order serial correlation in the series under consideration. *, **, and *** indicates the 10%, 5%, and 1% significance level.

Table 4. Current Account Balance, Budget Balance and Real Interest Rates

VAR-GARCH (1, 1) Model with Constant Conditional Correlations

$$(1) \begin{aligned} CA_t = & 0.004 + 0.85 CA_{t-1} + 0.02 CA_{t-2} + 0.03 CA_{t-3} - 0.11 CA_{t-4} + 0.05 CA_{t-5} \\ & - 0.007 GB_{t-1} + 0.06 GB_{t-2} + 0.04 GB_{t-3} + 0.000 GB_{t-4} - 0.04 GB_{t-5} \\ & + 0.03 RI_{t-1} + 0.006 RI_{t-2} + 0.001 RI_{t-3} + 0.009 RI_{t-4} - 0.008 RI_{t-5} + \varepsilon_{1t} \end{aligned}$$
$$(2) \begin{aligned} GB_t = & 0.024 - 0.12 CA_{t-1} + 0.03 CA_{t-2} + 0.11 CA_{t-3} + 0.05 CA_{t-4} - 0.134 CA_{t-5} \\ & + 0.98 GB_{t-1} + 0.21 GB_{t-2} - 0.13 GB_{t-3} - 0.25 GB_{t-4} + 0.1 GB_{t-5} \\ & - 0.04 RI_{t-1} + 0.009 RI_{t-2} + 0.05 RI_{t-3} - 0.007 RI_{t-4} + 0.01 RI_{t-5} + \varepsilon_{2t} \end{aligned}$$
$$(3) \begin{aligned} RI_t = & 0.20 - 0.44 CA_{t-1} + 0.50 CA_{t-2} - 0.75 CA_{t-3} + 0.80 CA_{t-4} - 0.14 CA_{t-5} \\ & + 0.16 GB_{t-1} - 0.24 GB_{t-2} + 0.53 GB_{t-3} - 0.55 GB_{t-4} + 0.23 GB_{t-5} \\ & + 0.12 RI_{t-1} + 0.08 RI_{t-2} + 0.10 RI_{t-3} + 0.23 RI_{t-4} - 0.08 RI_{t-5} + \varepsilon_{3t} \end{aligned}$$
$$(4) \begin{aligned} h_{1t} = & 0.006 + 0.497 \varepsilon_{1,t-1}^2 + 0.57 h_{1,t-1} \end{aligned}$$
$$(5) \begin{aligned} h_{2t} = & 0.08 + 0.19 \varepsilon_{2,t-1}^2 + 0.63 h_{2,t-1} \end{aligned}$$
$$(6) \begin{aligned} h_{3t} = & 0.503 + 0.22 \varepsilon_{3,t-1}^2 + 0.69 h_{3,t-1} \end{aligned}$$
$$(7) \begin{aligned} h_{12,t} = & -0.02 \sqrt{h_{1t}} \sqrt{h_{2t}} \end{aligned}$$
$$(8) \begin{aligned} h_{13,t} = & 0.06 \sqrt{h_{1t}} \sqrt{h_{3t}} \end{aligned}$$
$$(9) \begin{aligned} h_{23,t} = & -0.25 \sqrt{h_{2t}} \sqrt{h_{3t}} \end{aligned}$$

Notes: Maximum likelihood estimates of this constant conditional correlation model are obtained by the BHHH algorithm. The standard errors are reported in the parentheses below the estimated parameters.

Table 5. Ex post Residual Diagnostics

Panel A. Levels of Residuals

Q(4)	Q(8)	Q(12)
18.8178	52.4736	91.5667

Panel B. Squares of Residuals

Q(4)	Q(8)	Q(12)
31.7311	51.9993	86.3769

Note: The residuals are obtained from the VAR-GARCH(1,1) model and standardized. Q(4), Q(8) and Q(12) are the multivariate Ljung-Box statistics for the fourth-, eighth- and 12th-order serial correlation in the series under consideration. *, **, and *** indicates the 10%, 5% and 1% significance level.

Table 6 Variance Decompositions of the US Current Account Balance

Panel A. VAR-GARCH (1, 1) Model

Forecasting Horizons (Quarters)	Current Account Balance	Government Budget Balance	Real Interest Rates
4	85.33 (78.28 ~ 92.37)	7.89 (3.56 ~ 12.22)	6.78 (1.53 ~ 12.03)
8	58.70 (46.04 ~ 71.37)	34.45 (24.00 ~ 44.91)	6.84 (1.59 ~ 12.10)
12	48.16 (31.71 ~ 64.60)	44.57 (30.08 ~ 59.06)	7.27 (1.80 ~ 12.75)
24	44.10 (20.78 ~ 67.41)	48.08 (26.00 ~ 70.17)	7.82 (1.81 ~ 13.83)
36	44.11 (17.36 ~ 70.86)	48.07 (22.35 ~ 73.79)	7.82 (1.53 ~ 14.12)

Panel B. De-measured VAR with Homoskedasticity

Forecasting Horizons (Quarters)	Current Account Balance	Government Budget Balance	Real Interest Rates
4	91.70 (82.63 ~ 100.77)	3.37 (-1.73 ~ 8.47)	4.93 (-2.32 ~ 12.18)
8	82.84 (68.63 ~ 97.06)	9.91 (-0.75 ~ 20.58)	7.24 (-0.45 ~ 14.99)
12	78.94 (61.18 ~ 96.71)	10.68 (-3.58 ~ 24.94)	10.38 (2.10 ~ 18.66)
24	77.66 (55.12 ~ 100.20)	10.68 (-8.69 ~ 30.04)	11.66 (2.15 ~ 21.17)
36	77.66 (52.96 ~ 100.24)	10.68 (-10.98 ~ 32.34)	11.66 (1.58 ~ 21.74)

Note: Bootstrapped 95% confidence intervals are computed based on 1000 replications and reported in the parenthesis.

Table 6 Variance Decompositions of the US Current Account Balance (continued)

Panel C. VAR in Differences

Forecasting Horizons (Quarters)	Current Account Balance	Government Budget Balance	Real Interest Rates
4	87.17 (66.58 ~ 107.76)	9.91 (5.97 ~ 13.85)	2.92 (-17.33 ~ 23.18)
8	85.93 (64.86 ~ 106.99)	10.98 (6.95 ~ 15.01)	3.10 (-17.49 ~ 23.69)
12	85.82 (64.62 ~ 107.03)	11.07 (7.03 ~ 15.11)	3.11 (-17.61 ~ 23.83)
24	85.81 (64.49 ~ 107.14)	11.08 (7.03 ~ 15.12)	3.11 (-17.71 ~ 23.93)
36	85.81 (64.43 ~ 107.20)	11.08 (7.03 ~ 15.13)	3.11 (-17.76 ~ 23.98)

Note: Bootstrapped 95% confidence intervals are computed based on 1000 replications and reported in the parenthesis.