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AN ECONOMETRIC ANALYSIS ON THE TWIN DEFICITS HYPOTHESIS

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF ECONOMICS

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ABSTRACT

This study empirically revisits the twin deficits debate in the United States over the period from 1948:1 to 2005:1. New econometric techniques are employed in this study to formally address the problems of break stationarity and conditional heteroskedasticity in the series under study.

Using the multiple structural break analysis recently developed by Bai and Perron, I show, for the first time, that the US current account balance and government budget balance series are actually stationary around an infrequently shifting mean. A further comparison between the breakpoints in these two series reveals that there is no long-run relationship between the US current account balance and government budget balance at all.

To investigate the short-run relationship between these two series, I remove the shifting means from the series and use the demeaned series to estimate a multivariate VAR-GARCH model which can capture the conditional heteroskedasticity presented in the data. The generalized impulse response functions and variance decompositions on the basis of the multivariate VAR-GARCH model suggest that shocks to the US government budget balance do have strong positive effects on current account balance in the short run. This finding is quite robust to different model specifications.

Since my estimation methods depart greatly from the usual methods employed in the literature, I then compare the preferred model to a homosekdastic demeaned VAR, a differenced VAR and a level VAR to explain how I get these results. It turns out that previous findings are less reliable due to their failure to take account of the presence of both break stationarity and conditional heteroskedasticity.

Given the short-run twin relationship between the US government budget deficits and current account deficits, I further examine whether their relation is causal. While the causality-in-mean tests uncover a unidirectional causality from the government budget balance to the current account balance, the causality-in-variance tests indicate no causal relation between their volatilities at all.

In the end I also extend similar analysis to five OECD countries and show that, in all five selected OECD countries, there is a fairly tenuous connection between the current account balance and the government budget balance in both the long run and short run.

Chapter I

Introduction

In the early 1980s, the United States witnessed an unprecedented increase in both the current account deficit and the government budget deficit. From 1981 to 1986, the government budget deficit rose dramatically from about 2.5 % of GDP to over 5% of GDP while the US current account deficits grew sharply from nearly zero to around 3% of GDP. More recently, a similar picture has emerged again: as the US government budget has worsened from a surplus in 2000 to a deficit of about 4% of GDP in 2005, the current account deficits have further deteriorated to approximately 6% of GDP in 2005. Given these historical resemblances, one might posit that increased government budget deficits were a primary cause of the massive US current account deficits. When the years between 1992 and 2000 are examined, however, there appears to be a different story: while the US current account performance kept deteriorating over time, the government budget deficits disappeared and instead turned into a surplus. This observation is obviously inconsistent with the posited causal relationship between the two deficits. Then, what exactly is the relationship between the two deficits? Do government budget deficits really lead to higher current account deficits?

As far as economic theories are concerned, these questions on the relationship between government budget deficits and current account deficits have remained controversial and unsolved. According to the traditional static Keynesian models, increased government budget deficits tend to put upward pressure on real interest rates, which induces capital inflows and eventually causes increases in current account deficits. Thus, the Keynesian view predicts a twin relationship between the two deficits, namely, the twin deficits. The twin deficits notion does not command universal acceptance. One seemingly compelling objection to the twin deficits hypothesis is known as the Ricardian Equivalence Hypothesis, which states that, due to rational expectation, an increase in government budget deficits caused by a tax cut will not affect consumer spending and therefore have no impact on current account balance. Based on this reasoning, the two deficits should be independent of each other. Another argument on the connection between the two deficits goes as follows: government budget deficits have positive effects on current account deficits in the short run but ambiguous impacts in the long run.

This debate over the twin deficits relation is ultimately an empirical issue. 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. Unfortunately, there is much less unanimity than one would like about the relation between the two deficits. The suggested effects of government budget deficits on current account deficits are wide ranging. While some papers find a positive association between the two deficits, others show no link between them at all, and three recent pieces even suggest a negative effect of government budget deficits on current account deficits.

There are, however, some things that almost all these studies have in common. First, 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.[1] 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, I 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. Furthermore, my findings also cast serious doubt on the validity of assuming the two series as stationary processes without mean shifts.

Given my 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. I find that the two series are not closely related either in their number of breaks or in their timing of structural shifts. I conclude that over the long run, the two deficits are not twins.

[1] I conducted Augmented Dickey-Fuller (ADF) unit root tests on the US current account balance and government budget balance (scaled to GDP), and find unit roots in both series. The ADF t-statistics for the current account balance and the government budget balance are 0.295 and -0.848, respectively. The 5% and 10% critical values are -1.942 and -1.616.

Second, existing studies treat the error structure of the model as homoskedastic, despite relatively clear visual evidence of volatility clustering, or conditional heteroskedasticity in least squares residuals. When I consider the short-run dynamics of the demeaned variables via a VAR analysis, I 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. I consider a trivariate model that also includes the real interest rate. Here I find a significant and sizeable positive short-run effect of budget deficit innovations on the current account deficit in both the generalized impulse response functions and variance decompositions of the model. To check the robustness of my results for the short-run relationship, I relax the constant conditional correlation assumption imposed on the covariance structure and employ the BEKK representation which has more general form for the covariance structure. Another robustness check is conducted by controlling the possible effects of business cycles. My results from the two robustness show that my finding of the short-run twin relation between the two variables is very robust.

Thus, my answer to the question of the connection between the two deficits 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 twin relationship between the two deficits.

Another important question related to the twin deficits hypothesis is whether there is a causal relation between government budget deficits and current account deficits. This question is of great importance because it has critical policy implications: if the government budget deficits do have a strong causal relation with the current account deficits, it would be necessary to reduce budget deficits in order to restore current account balance; if not, fiscal policy alone cannot help to resolve the external imbalance. In this study I not only examine the Granger-causality in mean between the two deficits but also investigate their Granger-causality in variance. It turns out that there does exist a unidirectional causality in mean running from the government budget balance to current account balance but no causality in variance between them at all.

To explore the twin deficits issue in other industrial countries than the US, I extend similar analyses to five OECD countries: Australia, Finland, Germany, Spain and the UK. By comparing the structural breaks in the two series in these five countries, I show that there is no strong positive connection between the current account balance and the government budget balance in the long run. The generalized impulse responses and variance decompositions on the basis of our demeaned VAR models that allow for conditional heteroskedasticity generally reject the existence of a short-run twin relation between the two series for all five countries. Furthermore, my Granger-causality tests reveal no causal connection in mean or variance between the two variables in the selected countries except Finland and the UK. Therefore, I can generally reject the twin deficits hypothesis in these five OECD countries.

The rest of this study is organized as follows. Chapter II briefly reviews the theories as well as empirical literature on the twin deficits debate. Chapter III investigates the long-run relationship between the current account balance and the government budget balance in the United States under the framework of multiple structural break analysis. In Chapter IV, I first examine the short-run dynamics of the current account balance and the government budget balance via a VAR-GARCH model with the constant conditional correlation assumption. I then compare our preferred model to a homeskedastic demeaned VAR, a differenced VAR and a level VAR to highlight the importance of modeling break-stationarity and conditional heteroskedasticity. Moreover, I also estimate a BEKK MGARCH model and a structural component model to check the robustness of our results. Finally, I conduct Granger causality tests for the two series not only in terms of their conditional means but also from the perspective of their conditional variances. Chapter VI briefly reviews the existing international comparative studies on the twin deficits debate and extends our analysis to five OECD countries. In Chapter VII, I offer my conclusions.

Chapter II

What Do We Already Know About the Twin Deficits?

The relationship between current account deficits and government budget deficits has been a subject under extensive study. In this chapter I provide a review of what we have learned so far about the twin deficits issue from the perspectives of both theoretical and empirical literature.

2.1 Theoretical understandings of the twin deficits

A suitable starting point of the theoretical literature review is the canonical Mundell-Fleming model, which illustrates how fiscal expansion affects an open economy under fixed and flexible exchange rate regimes. Assuming perfect capital mobility, Mundell (1963) demonstrates that an increase in debt-financed fiscal deficits induces capital inflows from abroad by putting an upward pressure on domestic interest rates and thereby results in higher trade deficits. Under flexible exchange rate systems, since there is no change in income or saving or taxes, an increase in fiscal deficits leads to a one-to-one increase in trade deficits. In the case of fixed exchange rates, however, the rise of fiscal deficits raises income and saving, which causes the induced change in trade deficits to be less than that in fiscal deficits. In short, Mundell's theoretical model predicts a twin relationship between fiscal deficits and trade deficits.

However, the twin deficits proposition was soon challenged by the Ricardian equivalence theorem. Based on the assumption of infinite horizons and rational expectations, proponents of this theorem (Barro, 1974) argue that, in response to an increase in debt-financed budget deficits, the public will save more to compensate for the higher future taxes that are associated with the need to service the debt created by current budget deficits. As a result, the increase in budget deficits will not change aggregate demand and correspondingly not lead to an increase in current account deficits at all.

Another criticism of the Mundell-Fleming model is that this framework inappropriately specifies capital flows as a function of interest rate, which is inconsistent with modern portfolio theory. Following a portfolio balance approach, Rogriguez (1979) modifies the Mundell-Fleming model by explicitly incorporating the capital stocks and expressing the stock of assets rather than the flows as a function of the interest rate. In the short-run scenario, his theory tells a similar story to the original Mundell-Fleming model: expansionary fiscal policy would put upward pressure on the domestic interest rates, which causes an inflow of foreign capital and an appreciation in domestic currency, and eventually the current account balance deteriorates. When it comes to the long run, however, Rodriguez demonstrates a completely different pattern. Since portfolio holders will maintain the level and composition of their assets in the long-run equilibrium, there will be no capital flows in the steady state, which means that the induced capital inflows by a fiscal expansion in the short-run will be reversed over time. As a consequence, the expansionary fiscal policy will improve the current account performance in the long run.

Still another commonly recognized weakness of the Mundell-Fleming model is its static analysis and no consideration of individual optimizing behavior. With the theoretical advancement since the late 1970s, open-economy macroeconomic researches have moved beyond the classical Mundell-Fleming framework towards a dynamic, utility-maximizing model where long-rung budget constraints are satisfied. Frenkel and Razin (1986) develop a two-country general equilibrium model with flexible prices and wages. Assuming that individuals face a given probability of death, they show that a current budget deficit arising from lowering taxes will increase domestic wealth but decrease foreign wealth and thus worsen domestic country's current account balance. However, they also point out that the long-run effects of the cumulative past budget deficits on domestic and foreign wealth are ambiguous and thereby there is no clear-cut relation between fiscal deficits and current account deficits. Instead of assuming flexible prices and wages, Obstfeld and Rogoff (1995) introduce short-run nominal price rigidities into their two-country general equilibrium model. Assuming that a government's spending falls on both domestic and foreign goods and that taxes are used to finance government expenditure (no budget deficits in this case), they suggest that a transitory expansion in government spending will cause the domestic country to run current account deficits and yet an unexpected fiscal expansion can produce a surplus or deficit in the domestic current account.

In addition to the inter-temporal optimization approach, the relationship between fiscal policy and current account performance is also studied in the framework of real business cycle (RBC) models. As Baxter (1995) presents, in an incomplete market, an increase in fiscal deficits is strongly associated with a rise in current account deficits no matter if the fiscal shock is transitory or permanent. Using calibration, she further shows that an increase in the budget deficit equivalent to 1% of GDP would induce the current account balance to decline by about 0.5% of GDP.

To sum up, a variety of macroeconomic models, including traditional static Keynesian models, dynamic general equilibrium models as well as RBC models, are used to derive the relationship between fiscal deficits and current account deficits. Until now, however, a unanimous conclusion has not yet been drawn.

2.2 A survey of empirical literature

The relationship between current account balance and government budget balance is ultimately an empirical issue, and it has triggered a large set of empirical studies on this issue. While each of these empirical works has contributed important insights into the connection between these two variables, no consensus has been reached yet on the debate over the twin deficits hypothesis.

Early studies usually apply ordinary least-square (OLS) regressions to cross-country data, including Milne (1977) and Bernheim (1987). 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 dynamic relationship between the two deficits. Abell (1990) estimates a seven-variable VAR model to investigate the linkages between the US government budget deficits and trade deficits from1979:2 to 1985:2 when the US witnessed an unprecedented increase in both deficits. Since his dataset consists of the levels of government budget deficits and current account deficits, first differences are taken for the two series to achieve stationarity. Results from his Granger causality tests show that government budget deficits Granger-cause trade deficits indirectly via interest rates as well as exchange rates rather than in a direct way. Yet he finds the direct causality running from trade deficits to government budget deficits. Furthermore, his evidence from the impulse response functions also confirms that the twin deficits are connected through the transmission mechanisms of interest rates and exchange rates.

Following a very similar approach to Allen's, Bachman (1992) presents even stronger supportive evidence for the twin deficits hypothesis in the US over the period 1974—1988. Instead of using the raw levels of the two deficits, he measures the government budget balance and current account balance as percentages of GNP to eliminate the size effect. After finding a unit root in the series, he first tests for a cointegrating relationship between the two series but fails to reject the null hypothesis of no cointegration. Then he carries out Granger causality tests and impulse response analysis on the basis of bivariate VAR models. In doing so, he shows that there is only a uni-directional Granger-causality from government budget balance to current account balance and that shocks to government budget balance have a large positive effect on the current account balance. Based on this evidence, he proposes that the US must reduce the government budget deficits to restore its external balance.

Another piece of supportive evidence for the twin deficits hypothesis is provided by Rosensweig and Tallman (1993). They first pretest the stationarity of the two series using the classical Dickey-Fuller type tests and find both of them to be random walk processes. Instead of including first differenced data into their estimation, however, they employ a VAR in levels based on the fact that the posterior probabilities generated from their Monte Carlo integration prefer the level specification to the first-difference specification. One prominent contribution of their study is that, by normal approximation, they construct confidence intervals for both the variance decompositions as well as impulse response functions to assess significance. Their empirical evidence generally supports the twin deficits hypothesis by showing that government budget deficits contribute to trade deficits.

In contrast to the empirical studies reviewed above, Enders and Lee's (1990) analysis favors the Ricardian equivalence hypothesis over the twin deficits hypothesis. They first develop a two-country model that is consistent with the Ricardian equivalence hypothesis. Under this theoretical framework, they then proceed to conduct their empirical analysis with quarterly US data from 1947Q3 to 1987Q1. While their unrestricted VAR model reveals that not only shocks to government spending can cause persistent current account deficits but also government debt shocks raise current account deficits, they argue that this unrestricted VAR model can not reflect the optimal consumption rules implied by the Ricardian equivalence hypothesis. Therefore, they impose a set of restrictions on certain group of variables in the VAR system according to their theoretical model and apply generalized method of moments (GMM) procedure to estimate the restricted model. Given the results that their restricted model fail to reject the null hypothesis of valid constraints at the conventional significance levels, they thus conclude that the data are more consistent with the Ricardian equivalence hypothesis than the twin deficits hypothesis.

More recently, Kim and Roubini's (2004) VAR analysis provides the surprising finding that there is no twin deficit but rather twin divergence between the current account and government budget balance in the US during the post-Bretton-Woods period. Their finding is obviously contradictory to the predictions of either the twin deficits hypothesis or the Ricardian equivalence hypothesis. How do they obtain this striking result then? Kim and Roubini use the levels of the two deficits in their reduced-form VAR model without any pretests of stationarity for the two series. By applying Cholesky decomposition, which implicitly assumes the government budget deficits to be exogenous to the current account deficits, they obtain the impulse response functions and show that an increase in government budget deficits would significantly improve the current account performance. Yet it is worth mentioning that Kim and Roubini assess the significance on the basis of one-standard-deviation bands (approximately 68% confidence intervals). Following a very similar estimation procedure to Kim and Roubini's, Corsetti and Muller (2006) and Muller (2006) also find negative relationships between the US current account and government budget balance in the post-1970s period.

Since traditional unit root tests always find the two deficits to be nonstationary, another popular approach to testing the twin deficits hypothesis is to seek for a cointegrating relationship between them. While Bachman's (1992) cointegration tests indicates no cointegration between the US government budget deficits and current account deficits, Dibooglu (1997) does find evidence of cointegration between the two variables. Given the obtained long-run equilibrium relationship between the two deficits, he then estimates a dynamic vector error-correction model (VECM) and performs innovation accounting. Results from his impulse response functions as well as variance decompositions suggest that budget deficits are associated with current account deficits. This therefore lends some support to the twin deficits hypothesis.

The studies reviewed above have used different samples, variables and econometric models and generate mixed results. 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 I show below, current account balance and government budget balance in the US both follow break-stationary processes. This means that using a VAR in first differences or a VAR in levels or cointegration is inappropriate. The second is a disregard for the existence of volatility clustering in current account deficits and government budget deficits. As I 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.

Chapter III

The Long-Run Connection between the Current Account Balance and the Government Budget Balance in the United States

In this chapter, I shall take a new approach to investigating the long-run relationship between the current account balance and the government budget balance in the United States. I start with the multiple structural break analysis recently developed by Bai and Perron to determine if the current account balance and government budget balance have experienced structural shifts in their respective mean processes. If so, I then compare the number and timing of the breaks between the two series to present some long-run evidence on the twin deficits hypothesis.

3.1 Testing for structural breaks in the two series

To see if there are structural shifts in the mean processes of the current account balance and the government budget balance in the United States , I 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. A remarkable advantage of this methodology is the endogenous determination of breakpoints rather than a prior choice of a researcher.

Following BP's method, I estimate a simple mean shift model with $m+1$ regimes as follows:

$$y_t = z_t`\delta_j + \nu_t, \quad t = T_{j-1}+1,....T_j, \quad j = 1,....m+1 \qquad (3.1)$$

where y_t is the observed dependent variable, z_t is a constant equal to one, and $(T_1, T_2, ...T_m)$ represents the location of breakpoints. The number of breakpoints is determined based on the $SupF_T(l)$ test, the double maximum tests and 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.[2]

My sample consists of quarterly observations for the US over the period from 1948:1 to 2005:1. The seasonally adjusted current account balance, government budget balance and GDP data are obtained from the Economic Bureau of Analysis. Both the current account balance and government budget balance are expressed as shares of GDP[3].

Table 3.1 reports the statistical 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, I find that the two breaks in the current account balance occur in 1982:4 and 1999:2, respectively. Figure 3.1A presents the estimated structural shifts in the US current account balance.

[2] 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.
[3] A positive sign indicates a surplus and a negative sign indicates a deficit.

The results from structural breaks analysis of the US government budget balance are reported in Panel B of Table 3.1. 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 1974:2. Figure 3.1B illustrates the structural changes in the US government budget balance.

Given the presence of structural breaks in current account balance and government budget balance, I then apply Perron's (1989) modified ADF tests and find that both series are break-stationary. Table 3.2 reports Perron's t-statistics for current account balance and government budget balance.

3.2 The long-run evidence on the twin deficits hypothesis

To examine the long-run connection between the current account balance and the government budget balance in the United States, I then compare the estimated structural breaks in the current account balance to those in the government budget balance from two perspectives.

First, I compare the number of breaks in the current account balance and the government budget balance. I notice that there the two series have different number of breaks, one break in the government budget balance and yet two breaks in the current account balance. If the two series do have a close connection, it would be the case that they have same number of structural breaks.

Second, I 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 budget balance are 1971:3 – 1976:2, which does not include either of the two estimated break dates for the current account (which are 1982:4 and 1999:2).

Based on the above comparison of the two series' behavior, I conclude that there is no long-run connection between the current account balance and the government budget balance in the US. That is to say, the twin deficits hypothesis does not hold in the US in the long run.

Chapter IV

The Short-Run Dynamics between the Current Account Balance and the Government Budget Balance

I 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 chapter I present reduced form VAR evidence on the short-run dynamics of the two series. As shown in Chapter 3, both the current account balance and the government budget balance are actually stationary yet with structural breaks in their mean processes. With this in mind, I remove the shifting means for these two series instead of first differencing the data, and then estimate a reduced form VAR model using the demeaned data. I also include real interest rates in 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 US real interest rates follow a break-stationary process, I also estimate structural breaks for the quarterly US real interest rate series with BP's method and then remove its shifting mean.[4] I use an ex post real interest rate defined as the difference between nominal interest rates and actual inflation rate.[5] Three-month Treasury bill rates are used as nominal interest rates and inflation rates are calculated by using quarterly CPI. Both

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

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

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:

$$X_t = \beta_0 + \sum_{i=1}^{p} \beta_i^{'} X_{t-i} + \varepsilon_t \qquad (4.0)$$

where $X_t = \begin{bmatrix} (CA_t - \overline{CA}) & (GB_t - \overline{GB}) & (RI_t - \overline{RI}) \end{bmatrix}'$, *CA*, *GB* and *RI* denote the current account balance, government budget balance and real interest rates. 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 five.

Under the assumption that the error terms are serially uncorrelated with constant variance, this VAR model can be estimated simply using OLS, which can yield 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 potential volatility clustering, I employ diagnostic tests of conditional heteroskedasticity. Since univariate ARCH tests that applied independently to individual series disregard the contemporaneous correlation of disturbances in these series, I use the multivariate Ljung-Box portmanteau tests developed by Hosking (1980) to detect conditional heteroskedasticity.[6] After obtaining standardized residuals from the VAR model given in equation (4.0), I calculate the Ljung-Box test statistics at four, eight and twelve lags for the levels and squares of these residuals, respectively.

Table 4.1 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 constant error variance is rejected at the 1% level for the fourth- and eighth-order serial correlation, which provides strong evidence for the presence of conditional heteroskedasticity in the series under study. This means that the OLS estimation of the VAR model may produce extremely inefficiently estimated coefficients and also calls into question much inference, including impulse responses and variance decompositions, based on these OLS estimates.

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 VAR-GARCH model, which allows for simultaneous estimation of conditional variance equations as well as mean equations for the 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

[6] See Hosking (1980) and Bauwens, Laurent and Rombouts (2006) for details.

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

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

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

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

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

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

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

$$h_{12,t} = \rho_{12} \sqrt{h_{1t}} \sqrt{h_{2t}} \tag{4.7}$$

$$h_{13,t} = \rho_{13} \sqrt{h_{1t}} \sqrt{h_{3t}} \tag{4.8}$$

$$h_{23,t} = \rho_{23} \sqrt{h_{2t}} \sqrt{h_{3t}} \tag{4.9}$$

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 the demeaned current account balances, government budget balance and real interest rates, respectively.

Equations (4.4) to (4.6) describe the conditional variance of the 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 conditional correlation models of the covariance among the three variables.[7]

I assume that the three error terms, ε_1, ε_2 and ε_3 have a joint normal distribution with mean equal to zero and conditional variance-covariance matrix specified as above. Following the Berndt et al. (1974) numerical optimization algorithm (BHHH), I obtain the maximum likelihood estimates of the parameters in the VAR-GARCH model. As mentioned 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 mysample size (more than 200 observations) is relatively large, the estimated asymptotic t-statistics should be fairly accurate.

Estimates of the model are shown in Table 4.2. The estimated coefficients in the three conditional variance equations are generally significant at the 5% level, which further confirms the existence of conditional heteroskedasticity in the current account balance, government budget balance as well as real interest rates. Figure 4.1 presents the estimated conditional variances of these series.

The estimated conditional correlation coefficient between shocks to the current account balance and government budget balance is statistically insignificant

[7] 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.

at the 10% level. While the conditional correlation coefficient between current account balance and real interest rates is statistically insignificant, the conditional correlation between government budget balance and real interest rates 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, I 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 4.3 show that these tests can no longer reject homoskedasticity.

4.3 Impulse responses 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, I employ impulse response functions and variance decompositions to examine whether shocks to the government budget balance have significant impacts on the current account balance. Instead of using the Choleski decomposition to identify the impulse responses, I construct generalized impulse response functions, which are independent of the ordering of the variables in the VAR.[8]

Figures 4.2 displays the point estimates of the impulse responses of the US current account balance along with their bootstrapped 95% confidence intervals for the estimates. Given a one-standard-deviation shock to the government budget balance at time period zero, the current account balance first rises and then falls.

[8] See Pesaran and Shin (1998) for detailed discussion on generalized impulse response analysis.

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 effect of the budget balance shock on the current account balance is statistically significant, and it takes over five years for the effect to disappear. In addition, shocks in real interest rates have significantly positive effects on the current account balance only in the first two quarters but becomes statistically insignificant thereafter.

Panel A of Table 4.4 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 less and 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. Besides, the explanatory power of real interest rates remains very small over time, accounting for less than 8% of the forecast error variances of the current account balance.

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. That is to say, 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 very 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 in the US.

4.4 Discussions on the estimation methodologies

I 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 government budget deficit driving increases in the current account deficit. In doing so, I have departed from the usual methods used in the literature. In this section, I show how the results change if our methodological points about the importance of allowing for break stationarity and conditional heteroskedasticity are ignored. I focus on the main relationship we find, the positive effect of budget shocks on the current account.

To highlight the importance of modeling conditional heterosedasticity, here I compare the results from the VAR model on the demeaned series estimated with no allowance for conditional heteroskedasticity to those from my VAR-GARCH (1,1) model.

Results from the demeaned VAR with homosekdastic variance of errors are reported in Panel A of Figure 4.3. Compared to my preferred results, we observe two big differences. One is that the homoskedastic VAR model produces a negative effect of budget shocks on the current account balance in the first two quarters after the shock. The other is that 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 with only one half of that in our preferred model. A variance decomposition of this homoskedastic VAR is reported in Panel B of Table 4.4, 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.

Another important step I take away from the existing literature is that I allow for mean shifts in the series under study and use demeaned data in my estimation. In most previous studies, the current account balance and the government budget balance are considered to be nonstationary and the first-differenced data are utilized in estimation while, more recently, some papers (Kim and Roubini, 2004; Corsetti and Muller, 2006; Muller, 2006) treat the two series as pure stationary processes and simply include the levels of the two variables into their estimation. Obviously, neither first-differencing nor using levels could capture the mean shifts in the current account balance and the government budget balance, which I have identified in Chapter III. I will formally address the critical importance of allowing for the break-stationarity of these series in the following part of this section.

If I simply consider standard ADF and co-integration tests, I find that each series is I(1) but that there are no conintegrating relationships between them. I then estimate a VAR in the first differenced data which produces the impulse responses shown in Panel B of Figure 4.3 and variance decomposition in Panel C of Table 4.4. I find that the effects of budget shocks on the current account balance changes signs within the first four years after shocks. Within the first quarter after the shock to the government budget balance, there is a tiny but statistically significant negative effect of the budget shock on the current account balance. From the 3rd to 7th quarter, we do observe a significantly positive effect of budget shocks. As compared to my preferred results, however, this positive effect is small and transient. After this positive effect, we see again a minute negative effect lasting four quarters. As for the variance decomposition, we again find that shocks to the government budget balance have much weaker ability in explaining the fluctuations in the current account balance when compared to our preferred results.

If I skip the traditional unit root tests and simply proceed to treat the series as pure stationary processes, I estimate a VAR model with levels of the current account balance and the government budget balance (scaled to GDP). The impulses responses and the variance decomposition are presented in Panel C of Figure 4.3 and Panel D of Table 4.4, respectively. In this case, budget shocks turn out to have permanent and significantly positive effects on the current account balance. With regard to the variance decomposition in this level VAR, we see a very similar picture again: budget shocks account for only a tiny proportion of the forecast error variance of the current account balance.

All in all, the prominent differences revealed above suggest that modeling the conditional heteroskedasticity and break-stationarity of the series has strong implications for testing the twin deficits hypothesis. On the one hand, ignoring the conditional heteroskedasticity presented in the data would produce an incorrect negative relationship between the two deficits variables. On the other hand, simply estimating a differenced VAR or a VAR in levels that disregards the structural breaks in the mean processes of the current account and government budget balance would lead to false conclusions that either there is no systematic positive connection between the two variables or budget shocks have permanent positive effects on the current account. Therefore, in order to uncover the true relationship between the current account and government budget balance, we have to take into account both the conditional heteroskedasticity and the break-stationarity of the two series.

4.5 Robustness checks for the short-run evidence on the twin deficits hypothesis

In this section, I investigate the robustness of the results obtained from our VAR-GARCH(1,1) model to two different model specifications. First, in order to see if my preferred results are sensitive to alternative specification of the covariance structure, I employ the BEKK representation to model the covariance structure of the errors. Second, I re-examine the twin deficits hypothesis by controlling the cyclical nature of the current account balance and government budget balance. In doing so, I can check whether my preferred results still hold after eliminating the influence of business cycles.

4.5.1 Evidence from a BEKK MGARCH model

Although the constant conditional correlation parameterization for the covariance structure adopted in Section 4.2 has great computation convenience, it is a restricted parameterization. Given this limitation, one might suspect that the short-run positive relation between the current account and government budget balance may be driven by the restricted assumption of constant conditional correlation. To test the robustness of my findings, I re-estimate the multivariate GARCH model with the BEKK representation (Engel and Kroner, 1995), which is a more general parameterization for the conditional covariance structure. [9]

4.5.1.1 The BEKK representation and estimation

One pronounced property of BEKK models is that its parameterization for the conditional covariance matrix is able to ensure positive definiteness. Another advantage of this BEKK model is that it is relatively parsimonious. In the context of our three-variable system where the conditional variance follows a GARCH (1, 1) process, the full model requires the estimation of 78 parameters, whereas there are only 24 parameters in the BEKK model. [10] Moreover, in contrast to the constant conditional correlation model, the BEKK model dispenses with the assumption of constant correlation and produces quite rich interactions between the conditional volatilities.

Since my goal here is to check the robustness of my results to different representations of the conditional covariance matrix, we still utilize the same VAR (5) system to model the conditional mean and yet a BEKK MVGARCH (1, 1) representation to model the conditional variance for our three-variable system. The conditional mean and variance equations are specified in (4.5.1) and (4.5.2), respectively:

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[9] The acronym, BEKK, comes from synthesized work on multivariate models by Baba, Engle, Kraft and Kroner (1990).

[10] In a general VEC (1, 1) model for a system of N variables, the total number of parameters is $N(N+1)(N(N+1)+1)/2$ (e.g. for N=3 it is equal to 78) while the number of parameters in the BEKK model is $N(5N+1)/2$ (e.g. for N=3, it is equal to 24).

$$\begin{bmatrix} CA_t \\ GB_t \\ RI_t \end{bmatrix} = \sum_{p=1}^{5} \begin{bmatrix} \phi_{11}^p & \phi_{12}^p & \phi_{13}^p \\ \phi_{21}^p & \phi_{22}^p & \phi_{23}^p \\ \phi_{13}^p & \phi_{23}^p & \phi_{33}^p \end{bmatrix} \begin{bmatrix} CA_{t-p} \\ GB_{t-p} \\ RI_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \tag{4.5.1}$$

$$H_t = C'C + A'(\mathrm{E}_{t-1}\mathrm{E}_{t-1}^{'})A + B'H_{t-1}B \tag{4.5.2}$$

where $H_t = \begin{bmatrix} h_{11t} & h_{12t} & h_{13t} \\ h_{21t} & h_{22t} & h_{23t} \\ h_{31t} & h_{32t} & h_{33t} \end{bmatrix}$, $\mathrm{E}_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$, $C = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{bmatrix}$,

$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$, and $B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$, with $\mathrm{E}_t \mid I_{t-1} \sim (0, H_t)$. Maximum likelihood estimates for this model are obtained by using a nonlinear optimization routine based on the Broyden, Fletcher, Goldfarb, and Shannon (BFGS) algorithm. To conserve space, the estimated coefficients in this BEKK MGARCH(1,1) model are not reported in the context.

The estimated conditional variances of the current account balance, the government budget balance and the real interest rates are plotted in Figure 4.4. When comparing these plots to those based on the constant conditional correlation model, we observe that the BEKK representation produces a very similar pattern for the volatilities of current account balance and those of government budget balance. As far as the estimated real interest rate volatilities are concerned, they generally have the similar patterns in both models except that the BEKK model produces a higher peak around the mid-1970s than the constant conditional correlation model.

4.5.1.2 Impulse responses and variance decompositions

With the estimated parameters in the BEKK model, I now proceed to obtain the impulse response functions and variance decompositions and compare them to those from the constant conditional correlation model. In so doing, we can see whether the short-run relationship between the current account and government budget balance is sensitive to different specifications of the conditional covariance structure.

Generalized impulse responses, along with their bootstrapped 95% confidence intervals, of the US current account balance are presented in Figure 4.5. Very similar to the constant conditional correlation model, the BEKK model shows that shocks to the government budget balance have statistically significant and positive effects on the current account balance. These positive responses of the current account balance also last about five years after shocks.

Variance decompositions based on the BEKK model are shown in Panel A of Table 4.5, which further confirms that the government budget balance is positively associated with the current account balance in the short run though now the explanatory power of budget shocks is slightly lower. The above evidence thus leads us to believe that the positive and persistent short-run relationship between the US current account balance and government budget balance is robust to different specifications of the conditional covariance structure.

In addition, we also notice that, in the BEKK model, real interest rate shocks have relatively larger effects on the current account balance. The impulse responses of the current account balance reveals that real interest rate shocks now have larger and more persistent effects on the current account. This finding is also supported by the results from variance decompositions. In this BEKK model, real interest rate shocks now have modestly larger explanatory power for the fluctuations in the current account balance than in the constant conditional correlation model.

4.5.2 Evidence from a structural component model

It is widely believed that both the current account balance and the government budget balance have some cyclical nature: government budget balances are pro-cyclical while the current account is counter-cyclical. Given their cyclical nature, one might suspect that, after controlling the effects of business cycles, we should observe even stronger positive short- run relationship between the current account balance and the government budget balance. In the following part of this section, I will investigate this possibility and see if our preferred results are still robust.

As a first step, I regress the demeaned current account balance (the demeaned government budget balance) on the cyclical component of the output to extract the structural (non-cyclical) component. A simple OLS regression is employed here:

$$CA_t = \alpha_1 + \beta_1 GDPC_t + \varepsilon_{1t} \tag{4.5.3}$$

$$GB_t = \alpha_2 + \beta_2 GDPC_t + \varepsilon_{2t} \tag{4.5.4}$$

where GDPC is the cyclical component of the output and is obtained by using Hodrick-Prescott (H-P) filter. While the fitted values from the above two regressions represent the cyclical components of the current account balance and the government budget balance, I use the estimated residuals as our measures of their structural component.[11] Not surprisingly, the cyclical component of GDP has significantly negative effect on the current account balance and positive effect on the government budget balance, which apparently proves that the current account balance is counter-cyclical while the government budget balance is pro-cyclical.

With the structural components of the two variables in hand, I now move to the second step: estimating a VAR-GARCH (1,1) model with the constant conditional correlation assumption.[12] Figure 4.6 exhibits the estimated volatility of the series under examination. A visual inspection suggests that the behavior of their volatilities bears a strong resemblance to that in our preferred model.

Since my main focus is whether budget shocks have same positive impacts on the current account balance, I again perform the impulse response analysis and variance decompositions for the current account balance, which are presented in Figure 4.7 and Panel B of Table 4.5, respectively. Clearly, there is a lot of resemblance in both the impulse responses and variance decompositions between this structural component model and our preferred model. We observe a even more lasting positive effect of budget shocks on the current account balance. Furthermore, we also find that the positive effects of real interest rates shocks are slightly larger than our preferred results yet far more persistent. As for the variance decomposition, budget shocks now can explain around 40% of the movements in the current

[11] Results from the simple OLS regressions are not presented due to space but are available upon request.

[12] Multivariate Ljung-Box portmanteau tests find significant evidence for conditional heteroskedasticity in the structural components of the two variables. I also include the demeaned real interest rates into our model.

account balance over time while real interest rates shocks can account for more than 20% of the forecast error variance of the current account balance.

Generally speaking, the results from the structural component model tell a very similar story as my preferred model: budget shocks do have strong and persistent positive impacts on the current account balance in the short run, which proves the robustness of my preferred results.

4.6 Summary

This chapter sets out to examine the short-run dynamic connection between the current account balance and government budget balance in the US. To allow for both the break stationarity as well as the conditional heteroskedasticity in the series, I employ a constant conditional correlation VAR-GARCH model with the demeaned data. Based on both generalized impulse response functions as well as variance decompositions, I find a statistically significant and positive effect of government budget shocks on the US current account balance. My finding of the short-run twin relationship between the US current account balance and government budget balance is further confirmed by the BEKK representation and the structural component model as well.

To highlight the importance of modeling break stationarity and conditional heteroskedasticity, I then compare the results from my preferred model to those from a homoskedastic demeaned VAR, a differenced VAR and a level VAR. Results from my comparisons suggest that either ignoring the conditional heteroskedasticity or disregarding the break stationarity would lead to an incorrect conclusion on the short-run relationship between the US current account balance and the government budget balance.

Chapter V

Causality Tests: Additional Evidence on the Twin Deficits Hypothesis Debate

In Chapter IV, I investigated the short-run relationship between the US current account balance and the government budget balance while allowing for both the break stationarity and the conditional heteroskedasticity. I show that, in the short run, government budget shocks have strong and lasting positive influences on the current account balance in the US, which implies that the twin deficits hypothesis holds in the short run for the US.

Another approach to test the twin deficits hypothesis is to check if there are any causal relations between the US current account balance and the government budget balance. A standard way to examine the causality between variables is to apply Granger-causality tests. As Granger-causality is usually defined in terms of conditional expectations, we can test for causality in mean and causality in variance between two time series variables as follows: if $E(y_{t+1} \mid y_t, y_{t-1}, ...) \neq E(y_{t+1} \mid y_t, y_{t-1}, ..., x_t, x_{t-1}, ...)$, x_t is causal for y_t in mean; if $E(y_{t+1}^2 \mid y_t, y_{t-1}, ...) \neq E(y_{t+1}^2 \mid y_t, y_{t-1}, ..., x_t, x_{t-1}, ...)$, x_t is causal for y_t in variance. In this chapter, I shall investigate the causal relationship between the current account balance and the government budget balance by carrying out Granger-causality tests in terms of both conditional mean and conditional variance.

5.1 Granger-causality in mean

The twin deficits hypothesis states that an increase in government budget deficits is always associated with an increase in current account deficits. This hypothesis suggests that there should be some causality in mean between the current account deficits and the government budget deficits. At the least, we would expect to see causality running from the government budget deficits to the current account deficits. Is this really the case for the US data?

To answer this question, I conduct Granger-causality tests between the mean of the US current account balance and that of the government budget balance. Since I have shown in Chapter III that the two series are actually stationary around infrequently shifting means, I shall use the demeaned data in our causality-in-mean test, which allows me to investigate if there are any short-run causal relations between the two variables.

I start with an estimation of a bivariate VAR model using the demeaned current account balance and the demeaned government budget balance. Based on the sequential loglikelihood ratio test, Akaike information criterion as well as Schwarz information criterion, we select two lags for the bivariate VAR model. Given the VAR(2) process, I then write out its MA representation as follows:

$$\begin{bmatrix} CA_t \\ GB_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \tag{5.1}$$

where u_{1t} and u_{2t} are white noise processes. To test the null hypothesis of no Granger-causality in mean from the government budget balance to the current account balance, we simply need to test zero constrains on $\Phi_{12}(L)$.[13] A Wald test can thus be constructed to test the causality-in-mean.

Results from the Wald tests are reported in Table 5.1. Since the test statistic for the null of Granger-noncausality from the government budget balance to the current account balance is statistically significant at the 1% level, I thus conclude that, in the short run, there is a Granger-causal relation from the mean of the government budget balance to the mean of the current account balance. This result further confirms my previous findings of existence of twin deficits hypothesis in the US in the short run. Another interesting finding is that there seems to be no Granger-causality-in-mean running from the current account to the government budget balance in the US, at least in the short run.

5.2 Granger-causality in variance

While the existing empirical studies over the twin deficits debate have explored the relationship between the current account deficits and the government budget deficits from the perspective of the first order moment (i.e. mean), little has been done yet so far to investigate their relationship in terms of the second order moment (i.e. variance). If we could find some interactions between their volatility as well, there would be more supportive evidence for the twin deficits hypothesis.

To explore this possibility of higher-order dependence, I test for causality in variance between the current account balance and the government budget balance in the United States. In general, there are two important approaches that have been

[13] Similarly, if we need to test the causality-in-mean from the current account balance to the government budget balance, we should test for zero constrains on $\Phi_{21}(L)$

widely followed in testing for causality in variance. One is the two-stage cross-correlation function (CCF) test proposed by Cheung and Ng (1996), which is conducted in a univariate framework. The other is the likelihood ratio (LR) test developed by Caporale et al (2002), which is carried out in a multivariate environment. In this section, I shall apply both the CCF test and the LR test. Since the US current account balance and the government budget balance are break stationary, I use the demeaned series.

5.2.1 The two-stage cross correlation function test

Building upon the Granger causality-in-mean test, Cheung and Ng (1996) propose a two-stage procedure to test for causality-in-variance that is robust to the distributional assumption.[14] The first step of their procedure involves estimating a univariate (G)ARCH model which allows for variation in both the conditional mean and variance. As a second step, cross-correlations in the squares of the standardized residuals from the univariate models are calculated, and a chi-square test statistic with degree of freedom equal to k is constructed to test the null hypothesis of Granger-noncausality: $S = T\sum_{i=1}^{k} Corr_i^2$ where T is the sample size and $Corr_i$ is the cross-correlation in the squares of the standardized residuals at a specified lag i.

I now apply this CCF test to the US current account balance and the government budget balance series. I specify an AR(2) with GARCH(1,1) model for the current account balance, and an AR(3) with GARCH(1,1) model for the government budget balance. Table 5.2 presents maximum likelihood estimates and

[14] See Cheung and Ng (1996) for detailed discussion on this issue.

diagnostic statistics of the models. The parameters in both models are generally significant at the 5% level. The Ljung-Box portmanteau test statistics for the level and squares of the standardized residuals are found to be insignificant at the conventional significance levels. This means that my models are adequate to describe the conditional mean and variance of the two individual series.

Results from the two-stage cross correlation function tests are reported in Table 5.3. The calculated chi-square test statistics are all statistically insignificant, which leads us to conclude that there is no Granger-causality in variance between the current account balance and the government budget balance in the US.

5.2.2 The likelihood ratio test

An alternative way to test Granger-causality in variance is to use the likelihood ratio test recently developed by Caporale et al (2002). Their procedure involves estimating, as a first step, a multivariate GARCH (1, 1) model with BEKK representation for the conditional covariance structure, and imposing, as a second step, zero restrictions on certain parameters of the model. The likelihood ratio test for the null hypothesis of no Granger causality in variance thus can be carried out by comparing the log-likelihood of the restricted model to that of the unrestricted one.

Now I apply this likelihood ratio test to investigate the causal relationship between the current account balance and the government budget balance in the United States. Similarly, I use the demeaned data in my tests. I estimate a reduced form bivariate VAR with five lags as our mean equation and a BEKK-GARCH (1, 1) model as my conditional variance equation:

$$\begin{bmatrix} CA_t \\ GB_t \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} CA_{t-1} \\ GB_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} CA_{t-2} \\ GB_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{5.2}$$

$$H_t = C'C + A'(\mathrm{E}_{t-1}\mathrm{E}_{t-1}^{'})A + B'H_{t-1}B \tag{5.3}$$

where $H_t = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix}$, $\mathrm{E}_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$, $C = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}$, $A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$,

and $B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$, with $\mathrm{E}_t \mid I_{t-1} \sim (0, H_t)$. To test the causality in variance, I then alternatively constrain the matrices A and B to be upper triangular or lower triangular, thereby allowing for uni-directional causality in variance between the current account balance and the government budget balance.[15] By comparing the log-likelihood of the restricted BEKK model to that of the unrestricted one, we can construct the likelihood ratio test statistics.

The calculated LR test statistics and their p-values are reported in Table 5.4. Clearly, all the test statistics are statistically insignificant at the 5% level. Therefore, I can conclude that there is no Granger-causality in variance running either from the government budget balance or the other way around. These results further confirm my findings based on the CCF tests.

5.3 Summary

In this chapter, I first test for Granger causality between the levels of the current account balance and the government budget balance in the US in the short

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[15] To test the null hypothesis that the government budget balance volatility does not Granger cause the current account balance volatility, we impose the following restrictions: restrict matrices A and B to be upper triangular. Alternatively, we constrain matrices A and B to be lower triangular to test the null of no Granger causality running from the current account volatility to the budget volatility.

run. I employ a Wald test to check the Granger-causality in mean between the two variables and find a unidirectional causality running from the government budget balance to the current account balance, which lends some support to the twin deficits hypothesis.

Second, and perhaps more importantly, I, for the first time in the literature, investigate the Granger causality in variance between the two variables by using both the cross-correlation function test and the multivariate likelihood ratio test. Results from both types of tests suggest that there is no Granger causality in variance between them, which rejects the higher-order dependence between the two variables.

To sum up, my Granger causality tests show that the twin deficits hypothesis might hold in terms of their first order moments but not with regard to their second order moments.

Chapter VI

International Evidence on the Twin Deficits Hypothesis

In previous chapters I have examined the relationship between the current account balance and government budget balance in the United States from 1948:1 to 2005:1 and found that the twin deficits hypothesis holds only in the short run but not in the long run. When the causal linkage between the US government budget balance and its current account balance are examined, we find Granger causality existing only in mean but not in variance.

In this chapter I shall extend similar econometric analysis to five OECD countries to see if there is any international evidence for the twin deficits hypothesis. First, I perform Bai and Perron's multiple structural breaks analysis for the two series in each country. By comparing the shifts in their respective mean processes, we can gain some insights into the long-run connection between current account balance and government budget balance in these industrial countries. Second, I estimate VAR models with the mean-corrected series and then conduct impulse responses analysis and variance decompositions to uncover the short-run relation between the two series. Last, I employ Granger causality-in-mean and causality-in-variance tests to examine the possible causal relationship between the two series in the selected five OECD countries.

My sample constructed for this international study involves five OECD countries: Australia, Finland, Germany, Spain and UK, with quarterly observations from the 1970s to year 2003.[16] Similar to the previous analysis on the US, I include three variables in my study: the current account balance, the government budget balance, and real interest rates. The current account balance and government budget balance are seasonally adjusted and scaled relative to nominal GDP. Ex post real interest rates are utilized, which are calculated by subtracting actual inflation rates from nominal interest rates. Inflation rates are computed based on quarterly CPI, and money market rates are used as the nominal interest rates. All the data are collected from the IMF International Financial Statistics (IFS) CD-ROM as well as various issues of IFS Yearbook.

6.1 A brief review of international evidence on the twin deficits hypothesis

As compared to the large body of empirical studies on the relationship between the current account balance and government budget balance in the US, a relatively smaller set of papers have tested the twin deficits hypothesis in other industrial countries and developing countries. So far these cross-country studies have provided conflicting evidence on the debate over the relationship between current account deficits and government budget deficits.

Kearney and Monadjami (1990) estimate unrestricted VAR models for eight OECD countries over the period from 1972:1 to 1987:2. Without any pretest for stationarity of the series under study, they simply assume the series to be purely stationary and include them into their VAR models. Based on impulse response

[16] Due to data availability, different sample periods are used for these five OECD countries. The sample of Australia starts at 1970:1 and ends at 2003:1. The sample periods examined for Finland, Spain and UK are from 1978:1 to 2003:4. The sample of Germany covers the period from 1974:1 to 2003:1.

functions and variance decompositions, they find a temporary but impersistent twin relationship between the two deficits. Furthermore, they suggest that the twin relationship between government budget deficits and current account deficits varies in magnitude and duration across countries. Finally, they also provide some evidence for Granger-causality running uni-directionally from current account deficits to government budget deficits.

Instead of testing for the twin deficits hypothesis in industrial countries, Anoruo and Ramchander (1998) study the relationship between the two deficits in five Southeast Asian developing economies. Since their ADF tests find unit roots in the two series, they estimate VAR models with the first differenced data and carry out the Granger-causality tests to pin down the direction of causality between the two deficits series. Surprisingly, they find a Granger causality running from the current account deficits to the government budget deficits yet not the other way around.

To present an even broader picture about the relationship between the two deficits in the countries all over the world, Khalid and Guan (1999) select five developed countries and five developing countries and employ both cointegration techniques as well as causality tests to investigate the connection between the two deficit series in these countries. Using Dickey-Fuller, Augmented Dickey-Fuller, and Phillips-Perron tests, they find that the two series are generally integrated with order of one. Correspondingly, they adopt the cointegration technique to analyze the long-run equilibrium relationship between the two deficits. While their results reveal a twin relationship between the two deficits in the long run equilibrium in the developing countries, they find no long-run relationship between the two deficits in the developed countries. Furthermore, they also attempt to detect the causal relationship between the two deficits in the framework of first-difference VAR models. Results from their Granger-causality tests show that there is a causal relationship between the two deficits series in most of the sample countries.

Based on a more comprehensive dataset including both 18 industrial and 71 developing countries over the period from 1971 to 1995, a recent international study by Chinn and Prasad (2003) provide some supportive empirical evidence for the twin relationship between the current account and government budget. They first estimate a cross-sectional OLS regression using the full-sample averages of the data for each country and show that the government budget balance has significant and positive effect on the current account balance. Next they estimate panel regressions with non-overlapping 5-year averages of the data for each country. Their results suggest that, while there is still a strong positive relation between the two deficits in developing countries, the twin relation between the two deficits is no longer statistically significant in the industrial countries.

Unlike the above two cross-country studies that involve both developed and developing countries, Fidrmuc (2003) revisits the twin deficits issue with quarterly data instead of annual data. He examines the twin deficits problem in 10 OECD countries as well as transition economies of Central and Eastern Europe between 1970 and 2001. Based on Augmented Dickey-Fuller unit root tests, Fidrmuc shows that the two deficits series in most of the sample countries follow random walk processes. Therefore, he proceeds to perform cointegration analysis to explore the long-run equilibrium (cointegrating) relationship between the current account balance and the government budget balance in these sample countries. His results suggest that there is a positive long-run relationship between the two series in the 1980s but less evidence for their twin relationship in the 1990s.

In spite of conflicting evidence on the twin deficits debate, the above international comparative studies share two common factors in terms of econometric techniques. One is that they generally disregard the possibility of structural breaks in the mean processes of the series under study when performing unit root tests. As I will show below, the current account balance and government budget balance are actually stationary around infrequently shifting means in most of the five OECD countries. Another factor is that their VAR estimation usually does not take into account the potential presence of conditional heteroskedasticity in the data. However, my empirical evidence below clearly indicates that the two series exhibit significant volatility clustering in most countries.

6.2 The long-run evidence from five OECD countries

Following Bai and Perron's multiple structural break analysis presented in Chapter III, I first check the existence of structural breaks in the current account balance and government budget balance for each country and then estimate the number and locations of structural breaks. I allow up to 5 breaks in the series and set the trimming value equal to 0.15 so that each regime has at least 15 observations.[17] Serial correlation in the errors and heterogeneous variances of the residuals across regimes are also allowed in our estimation.

[17] In the case of Australia and Germany, each regime has at least 19 and 17 observations, respectively.

Table 6.1 and 6.2 report the results of structural break estimation for the current account balance and government budget balance, respectively. As far as the current account balance series is concerned, there is one breakpoint in the UK, two breakpoints in Germany, and three breakpoints in Finland, yet no breakpoints in both Australia and Spain. As for the government budget balance series, I find structural breaks in all five countries, one breakpoint in Australia, Germany and the UK; two breakpoints in Spain; and three breakpoints in Finland. Given the presence of structural breaks in these two series, I again employ Perron's modified ADF test to check stationarity. Not surprisingly, the two series in the five countries are stationary when allowing for structural breaks.[18]

Next I compare the number and timing of shifts in the two series for each country in order to reveal the long-run relations between the current account balance and the government budget balance in the five countries. In the case of Australia and Spain, I find structural breaks in the government budget balance series but not in the current account balance series, which implies that the structural changes in these two countries' government budget balance do not affect their current account balance at all. As for Finland, Germany and the UK, I do identify breakpoints in both series, yet the estimated locations of breakpoints in the two series do not match with each other. In particular, the breakpoints in the series of current account balance even fall outside of the 90% confidence intervals for the breakpoints in the series of government budget balance. Since the number and timing of breakpoints in these two series do not match with each other, I conclude that there is no long-run

[18] Since no break is found in the current account balance series in Australia and Spain, I apply the traditional unit root tests and find them to be stationary.

relation between the current account balance and the government budget balance in the five OECD countries, either.

6.3 The short-run evidence from the five OECD countries

To explore the short-run dynamic relation between the current account balance and the government budget balance, I first remove the shifting means from the series under study and then construct impulse responses and variance decompositions based on VAR models which allow for potential conditional heteroskedasticity.[19]

As a first step, I estimate unrestricted VAR models with the demeaned data for each of the five countries, and then obtain the residuals to test if the data exhibit volatility clustering.[20] Table 6.3 reports the results from the multivariate Ljung-Box Portmanteau tests. The residuals are not serially correlated for all five countries, yet the squared residuals present significant evidence of the classic volatility clustering for Australia, Germany, and Spain. We can generally reject the null hypothesis of constant variance in errors at the 5% level for Australia, and at the 1% level for Germany and Spain. In the cases of Finland and the UK, however, we fail to reject the null, which means that there is no conditional heteroskedasticy in these two countries' data.

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[19] Since there is no break in the current account balance in Australia and Spain, I simply remove the sample mean. I also apply BP's structural break analysis to real interest rates, and find structural breaks in all countries except Germany. Similarly, I remove the sample mean from the real interest rates series in Germany.

[20] The lag length in the VAR models for the five countries is determined by the sequential modified LR test statistic and Akaike Information criterion. I select one lag for Spain, four lags Finland, five lags for both Australia and Germany, and eight lags for the UK.

Since there is significant conditional heteroskedasticity in the data of Australia, Germany, and Spain but not in the data of Finland and the UK, I estimate VAR-GARCH models for the former three countries and unrestricted homoskedastic VAR models for the latter two countries. Since the mean equations in the VAR-GARCH models take the form of VAR systems, the lag length is selected based on the sequential modified LR test statistic and Akaike Information criterion. With respect to the volatility equations, I use a GARCH (1, 1) specification of the error variances for Australia and Spain, and an ARCH (1) specification for Germany. Combined with Bollerslev's constant correlation model, all the MGARCH models are estimated with the BHHH numerical optimization algorithm.

After fitting these MGARCH models to the data, I again calculate the multivariate Ljung-Box Portmanteau test statistics for the levels and squares of the standardized residuals from the estimated MGARCH models to ensure that the specified models are adequate to capture the conditional heteroskedasticity. The results in Table 6.4 confirm the adequacy of my VAR-GARCH models.

As my main goal is to examine if there is a short-run twin relation between the current account balance and the government budget balance, I shall focus on the generalized impulse responses and variance decompositions of the current account balance to shocks in the government budget balance in these five countries. Figure 6.1 through 6.5 plot the generalized impulse response functions of current account balance along with the bootstrapped 95% confidence intervals for the impulses in Australia, Finland, Germany, Spain, and the UK, respectively. Given a positive shock in the government budget balance of Australia and Finland, the impulse responses of current account balance in these two countries rise first and then fall. When the bootstrapped 95% confidence intervals are considered, the government budget balance shock has no significant impact on the current account balance. In the case of Spain, the effects of government budget balance shocks on current account balance are insignificantly different from zero. When it comes to Germany and the UK, however, the impulse responses of current account balance are slightly different. Within 13 quarters after a positive shock to government budget balance, the impulse responses of current account balance in Germany are statistically insignificant from zero. After the 14th quarter, however, the impulses start to fluctuate frequently from negative to positive. As for the UK, shocks to its government budget balance have no statistically significant effects on its current account balance at the 5% level from the first quarter to the 10th quarter. After that, we observe similar oscillations in the impulse responses of current account balance to those in Germany yet with much lower frequency. In general, the evidence from the generalized impulse responses of current account balance to shocks in government budget balance suggests that no twin relationship exists in the short run between current account balance and government budget balance in the five OECD countries.

Proportions of forecast error variance of current account balance in the five OECD countries due to various shocks are reported in Table 6.5. For all five countries, the majority of the movements in current account balance are caused by its own shocks. Concerning the bootstrapped 95% confidence intervals, shocks to government budget balance have no statistically significant explanatory power for the fluctuations in current account balance in Australia, Finland, Germany, and Spain. The variance decomposition of current account balance in the UK is an exception: shocks to government budget balance have statistically significant effect on current account balance.

To sum up, both impulse response analysis and variance decompositions suggest that, in Australia, Finland, and Spain, government budget balance is not related to current account balance in the short run at all. As for Germany and the UK, though there are oscillating impulses of current account balance in response to shocks in government budget balance, these impulses are totally different from the consistent positive responses predicted by the twin deficits hypothesis.

6.4 Causality tests of the relationship between current account balance and government budget balance in five OECD countries

In this section, I conduct Granger-causality tests to examine whether there are any causal relationships between the current account balance and the government budget balance and to underpin the direction of such causality, if any, in the five OECD countries. As my results in Section 6.1 have shown that the two series are either pure stationary or stationary around occasionally shifting means in the five OECD countries, I shall remove their (shifting) means and use the demeaned series in my causality tests. Since the main focus of this study is the twin deficits relationship, I perform Granger-causality tests on the basis of bivariate VAR models. The optimal lag lengths of the VAR models are determined by the sequential modified LR test statistic, Akaike information criterion (AIC), and schwarz information criterion (SIC).[21] Under this framework, I not only test for Granger-causality in mean between current account balance and government budget balance but also check the Granger-causality in variance between the two series in the five OECD countries.

6.4.1 Granger-causality in mean

Here I apply the same Wald-type tests as I have done in the case of the US to test for Granger-causality in mean between the current account balance and the government budget balance under the framework of bivariate VAR models.

The results of Granger-causality-in-mean tests for the five OECD countries are summarized in Table 6.6. The second column reports the chi-square test statistics as well as their P-values for the null hypothesis of non-Granger-causality in mean from government budget balance to current account balance while the last column presents the results for the null hypothesis of non-Granger-causality in mean from current account balance to government budget balance. Among the five OECD countries, the test statistics are not statistically significant at the conventional significance level for Australia, Finland, Germany and Spain, yet the test statistics for both null hypotheses are statistically significant at the 5% level in the UK. The above evidence thus leads us to believe that there is no causal relationship between the means of the two series in the sample countries except for the UK where we do

[21] For Australia, Finland, Germany, Spain, and UK, the lag lengths of the VAR models are 5, 1, 2, 2, and 1, respectively.

observe bi-directional causality in mean between the current account balance and the government budget balance.

6.4.2 Testing for Granger-causality in variance

To test for higher-order dependence between the current account balance and the government budget balance, in this subsection I carry out Granger-causality-in-variance tests for these two series. Similarly, I employ two types of causality-in-variance tests, the cross correlation function test as well as the likelihood ratio test, to ensure the robustness of my results.

I start with the two-stage cross correlation function tests for each of the five OECD countries. In the first stage, I estimate a univariate time series model for each of the two demeaned series, which allows for time variation in both conditional means and conditional variances. In the second stage, I then obtain new series of squared residuals standardized by conditional variances and construct chi-square test statistics using the cross correlation functions between the two series of squared standardized residuals.

Sample cross correlations of the resulting squared standardized residuals and the test statistics are reported in Table 6.7 and 6.8. As seen in both tables, the cross correlations of the squared standardized residuals reveal no evidence of feedback in variance either from government budget balance to current account balance or the other way around in Australia, Germany, Spain, and the UK. In contrast, I do find some bidirectional feedbacks in variances of the two series in the case of Finland.

Next I conduct the likelihood ratio test to investigate the causal relationship between the variances of the two series. The first step of my likelihood ratio test involves the estimation of bivariate BEKK GARCH (1,1) models, in which the mean equations take the form of VAR models as those in my Granger-causality-in-mean tests. The multivariate Ljung-Box portmanteau tests suggest that the BEKK-GARCH(1,1) specification is appropriate for the conditional variance in each model. As a second step, I impose zero restrictions on the parameters in the BEKK representations and construct the likelihood ratio test statistics for the null hypothesis of non-Granger-causality in variance. As Caporale et al (2002) correctly point out, the finite-sample Type-I error probabilities of the LR test differ significantly from the nominal value of 0.05 when sample size is smaller than 5000. I therefore compare the probabilities associated with my test statistics to the empirical probability values provided by Caporale et al (2002) to see if there is any causality in variance between current account balance and government budget balance in the five OECD countries.

Table 6.9 presents the results from my likelihood ratio tests. The null hypothesis that there is no causality in variance from current account balance to government budget balance can not be rejected at the 5% significance level in all five OECD countries, for the probability values associated with the test statistics are all bigger than the empirical probability values. As for the null hypothesis of no causality in variance running from government budget balance to current account balance, I fail to reject this null at the 5% significance level in the five OECD countries except Finland, where there is evidence of causality in variance running from the government budget balance to the current account balance.

In brief, my results from the likelihood ratio tests tell a very similar story to those from the two-stage cross correlation function tests: there is no Granger-causality in variance between current account balance and government budget balance at all in Australia, Germany, Spain as well as the UK while there appears to be a Granger-causal relation running from the volatilities of government budget balance to those of current account balance in Finland.

To sum up, my Granger-causality tests, both in mean and in variance, have brought some new evidence in the debate over the relationship between current account deficits and government budget deficits. If it were the case that increases in government budget deficits lead to higher current account deficits, we should at least expect some causal relation in either mean or variance running from government budget balance to current account balance. My findings, however, suggest that there is neither Granger-causality in mean nor Granger-causality in variance between the two series in the case of Australia, Germany and Spain. This means that the twin deficits hypothesis does not hold in these three countries. In the case of Finland and the UK, things are slightly different: I find some causality in mean running from government budget balance to current account balance in the UK and some causality in variance in Finland. Yet neither of these two countries experience causality in mean and in variance from government budget balance to current account balance simultaneously. This thus leads us to conclude that there is weak evidence for the twin deficits hypothesis at most in Finland and the UK.

6.5 Summary

In this chapter I empirically investigate whether rising government budget deficits have been the primary "cause" of the escalating current account deficits in five OECD countries including Australia, Finland, Germany, Spain, and the UK. First, I apply the multiple structural breaks analysis to examine the time series properties of the two series in each country. Under this framework, I provide some evidence of the long-run equilibrium relationship between current account balance and government budget balance in each of the five countries by comparing the number and location of structural breaks in the mean processes of the two series. My empirical results generally reject the existence of the twin deficits hypothesis in the long run in the five countries.

Second, to investigate the short-run connection between government budget balance and current account balance in the selected countries, I then estimate VAR models with demeaned series while allowing for the presence of conditional heteroskedasticity in the data. The impulse response functions as well as variance decompositions for current account balance do not find strong and consistent positive effect of government budget shocks on current account balance in all five countries. These findings thus suggest that the twin deficits hypothesis does not hold in the short run in these countries, either.

Last, I employ Granger causality in mean tests as well as Granger causality in variance tests to underpin the causal relationship between government budget balance and current account balance in the five OECD countries. Based on bivariate VAR models, my Granger causality in mean tests show that government budget balance does not Granger-cause current account balance in the five OECD countries except the UK. To test for Granger-causality in variance between the two series, I apply both the two-stage cross correlation function test and the likelihood ratio test. My results suggest that there is no Granger-causality in variance between the two series at all in the five countries except Finland.

Chapter VII

Conclusions

The dramatic surge in both the US government budget deficits and current account deficits in the early 1980s sparked heated debates over the twin relationship between the two deficits. More recently, economists have renewed interest in this debate due to the re-emergence of the twin deficits phenomenon in the US since 2002. Despite numerous theoretical and empirical studies on this issue, there is much less solidly based knowledge than one would like about the effects of government budget deficits on current account deficits.

In this dissertation I take a new approach to investigate the relationship between the two deficits in the US as well as five OECD countries. The results from my study not only bring some new evidence on the debate over the relationship between government budget deficits and current account deficits but also have important policy implications. Thus, after reviewing my central findings, this chapter shall lay out the key policy implications for restoring current account balance.

7.1 Empirical evidence from the US

The central question of this study has been an empirical one: Does an increase in government budget deficits lead to a rise in current account deficits? The answer to this question is not simply black or white. Instead, it really depends on the time horizon under consideration, especially in the case of the US. Thus, answering this question entails first decomposing the two deficits series into trend and secular components and then examining their relationship from both the long-run and short-run perspectives.

My study starts with the relationship between the US government budget balance and current account balance. Prior to tackling the relationship between these two series, I carefully examine their time series properties and find that both series are not random walk processes, as most previous studies suggest, but are actually stationary around their occasionally shifting means. Previous studies fail to reach this conclusion because they usually apply the traditional unit root tests which disregard the potential structural breaks in series. Given this new finding on their behavior, I then examine the long-run relationship between the two deficits by comparing the number and timing of their breaks. Since the mean shifts in the two deficit series match in neither the number nor the location of the breakpoints, I thus draw the conclusion that there is no twin relationship between the US current account balance and government budget balance in the long run.

To reveal the short-run dynamics in the relationship between the two deficits, I first remove the shifting means from the series and then use the demeaned data to estimate a VAR-GARCH (1, 1) model which allows for the presence of conditional heteroskedasticity in the series. My generalized impulse response functions as well as variance decompositions suggest that there is a significantly positive and persistent short-run effect of government budget shocks on the current account balance. This finding is proved to be quite robust to different model specifications.

Hence, in the case of the US, my answer to the question posed at the beginning is that there is a twin relation in the short run yet not in the long run. Since my estimation methods deviate far from the conventional procedure, I explain at length why my results differ from previous findings by comparing the results from my VAR-GARCH model to those from a homoskedastic demeaned VAR, a difference VAR, and a level VAR. As compared to my preferred results, it is very clear that previous findings are not that reliable in the sense that they ignore both the structural breaks in the series and the presence of conditional heteroskedasticity in the data.

Another question pertaining to the short-run relationship between the US current account balance and the government budget balance is whether this relation is causal or not. To address this issue, I thus apply the Wald test, the two-stage correlation coefficient function test, as well as the likelihood ratio test, to explore the Granger-causality in terms of both conditional means and conditional variances. While the causality-in-mean tests suggest a unidirectional causality running from the government budget balance to the current account balance, the causality-in-variance tests find no Granger-causality in variance between them at all.

7.2 Empirical Evidence from five OECD countries

In addition to the detailed analysis of the relationship between the US government budget balance and current account balance, one might also want to gain some insights into the connection between the two deficits debate in other industrial countries. To achieve this goal, I select five OECD countries (Australia, Finland, Germany, Spain and the UK) and extend similar analyses to these selected countries.

Both the long-run analysis under the framework of structural shifts in mean and the short-run innovation accounting on the basis of either VAR or VAR-GARCH models suggest that the twin relationship between government budget balance and current account balance is fairly tenuous in all five countries. With regard to the results from Granger-causality-in-mean and Granger-causality-in-variance tests, I find no causal linkage between the two deficits at all in the selected countries except Finland and the UK. While there is only a causal relation between the conditional means of the two series in the UK, Finland only shows some causality in variance between the two deficits.

7.3 Policy implications

The main findings of this study are that the two deficits of the US are twins in the short run but not in the long run, and that the two deficits in other industrial countries turn out to be distant cousins in both the short run and the long run. For policymakers, these results ultimately raise questions about the extent to which a reduction in the government budget deficit can lead to an improvement in the current account performance.

In the case of the US, where the government budget deficits have significant impacts on the current account deficits only in the short run, fiscal policy appears to have an important role to play in the short-run adjustment of its current account balance. When it comes to reducing the current account deficits and restore external balance in the long run, however, attempts to close the huge budget deficits are futile.

With regard to other industrial countries selected in this study, the policy conclusion that emerges from our study is that a tight stance in fiscal position should not be relied upon in isolation to deliver sustained improvement in current account performance.

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Appendices

Figure 3A U.S. Current Account Balance (share of GDP)

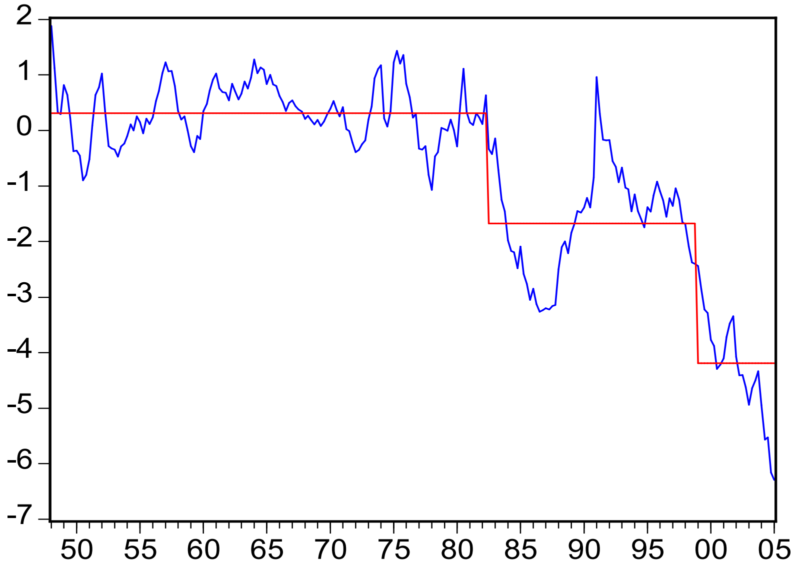


Figure 3B U.S. Government Budget Balances (share of GDP)

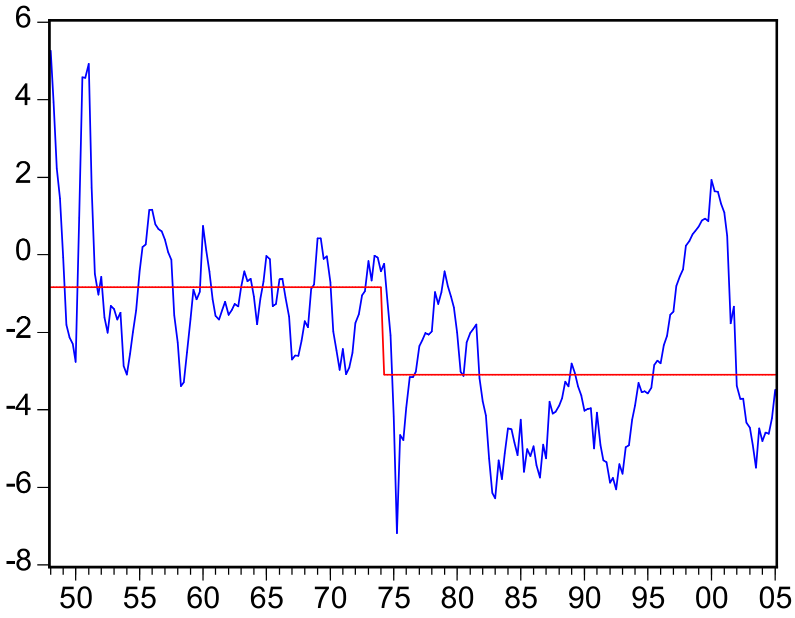
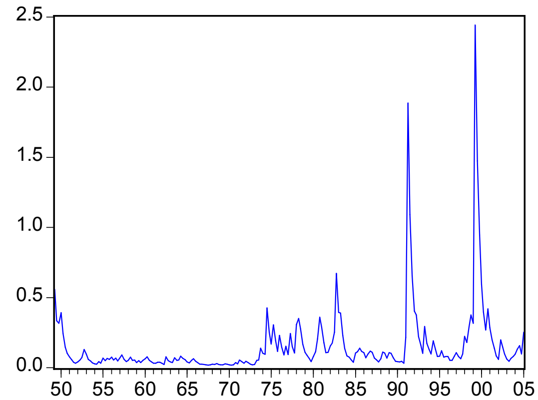
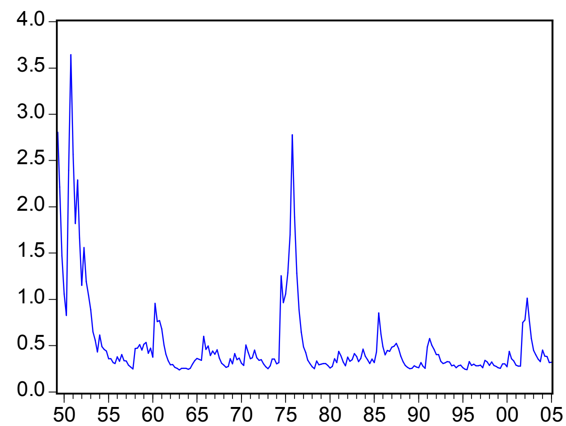


Figure 4.1 Estimated Conditional Variances from VAR-GARCH(1, 1) model

Panel A Estimated Conditional Variances for the US Current Account Balance



Panel B Estimated Conditional Variances for the US Government Budget Balance



Panel C Estimated Conditional Variances for the US Real Interest Rates

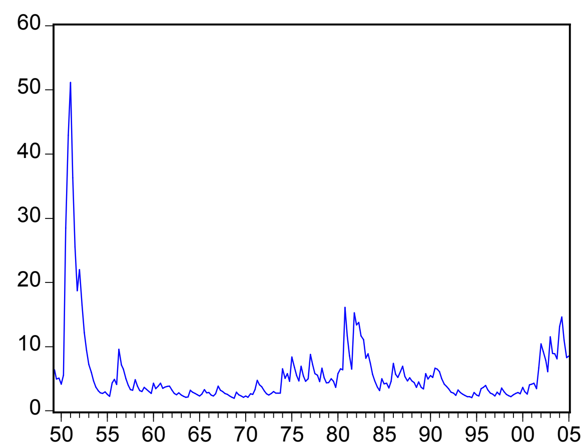
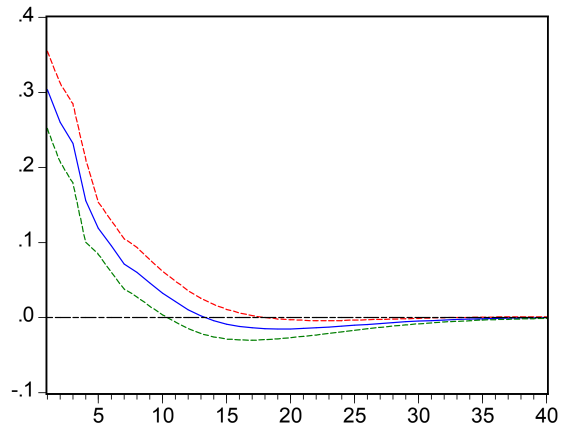
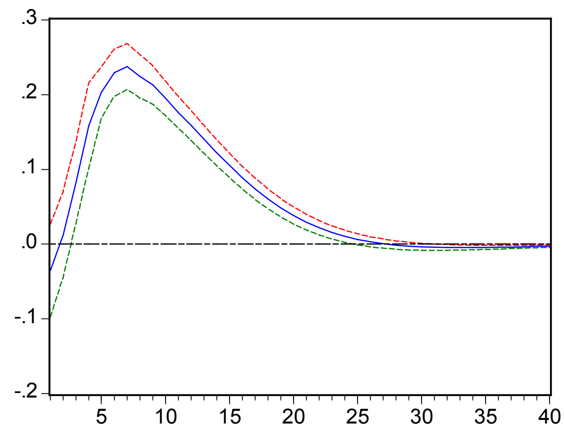


Figure 4.2 VAR-GARCH (1, 1): Generalized Impulse Responses of U.S. Current Account Balance

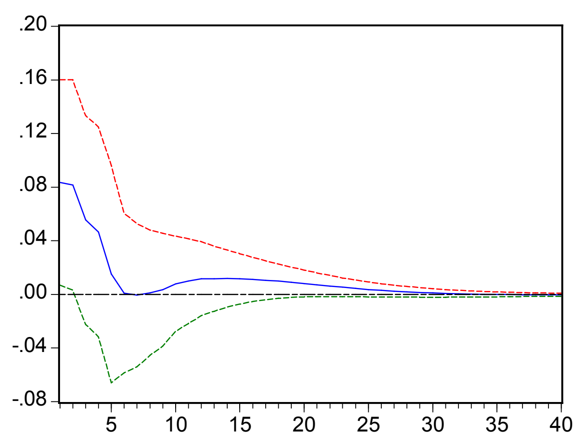
Panel A Response to One S.D. Shocks in Current Account Balance



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



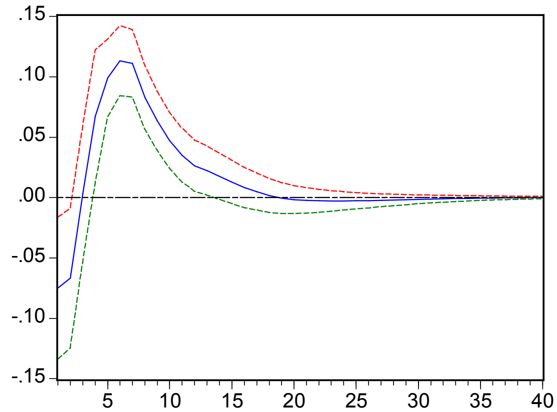
Panel C Response to One S.D. Shocks in Real Interest Rates



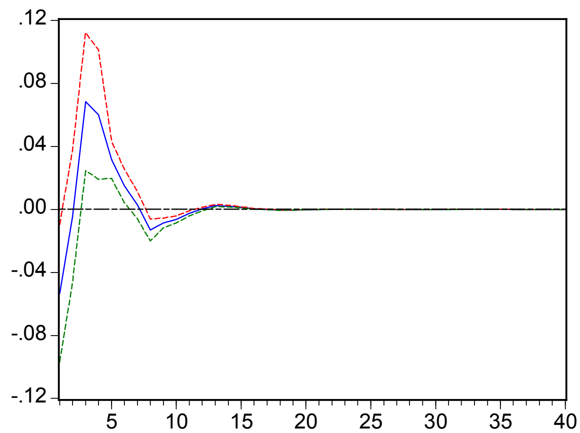
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 4.3 Generalized Impulse Responses of Current Account Balance to One S.D. Shocks in Government Budget Balance

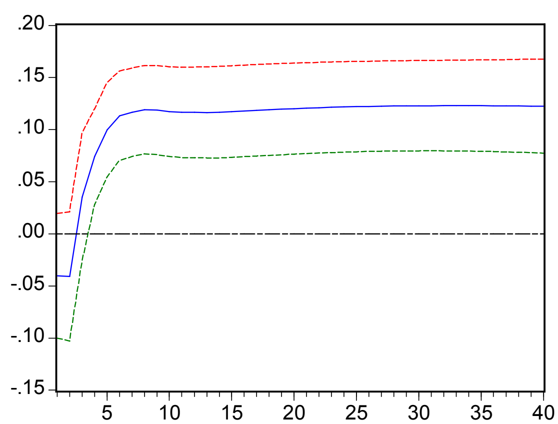
Panel A Demeaned VAR with Homoskedasticity



Panel B Differenced VAR



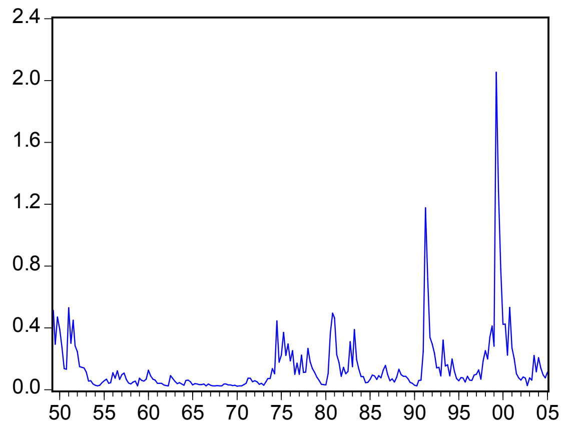
Panel C VAR in Levels



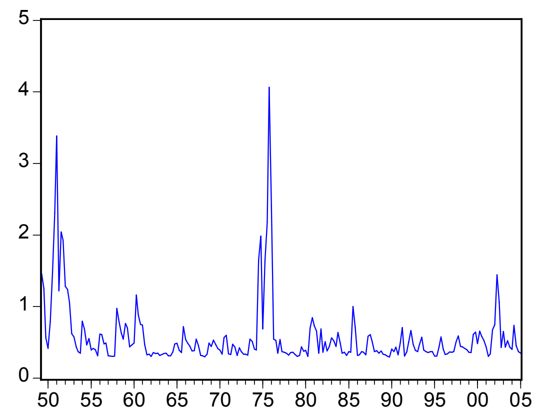
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 4.4 Estimated Volatilities from BEKK MGARCH model

Panel A Estimated Volatilities for the US Current Account Balance



Panel B Estimated Volatilities for the US Government Budget Balance



Panel C Estimated Volatilities for the US Real Interest Rates

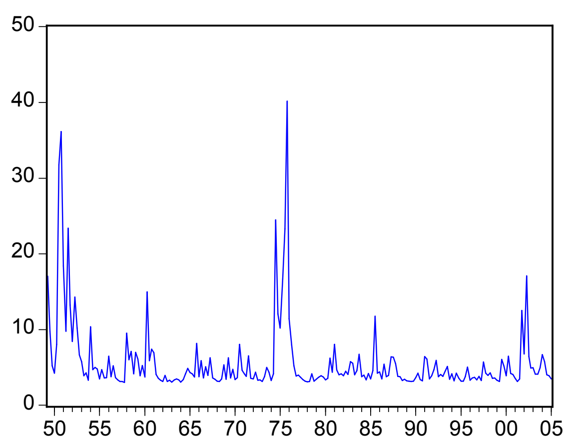
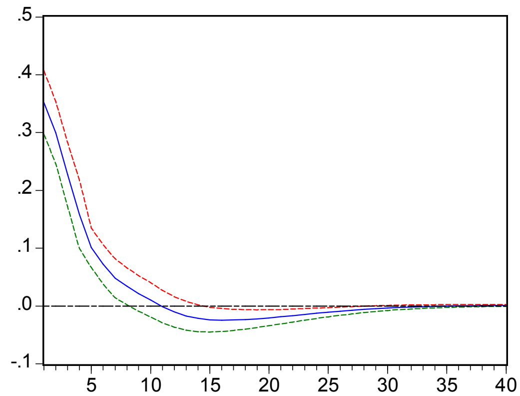
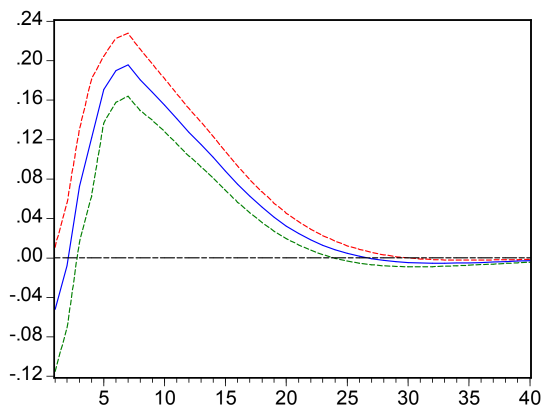


Figure 4.5 BEKK MVGARCH (1,1): Generalized Impulse Responses of U.S. Current Account Balance

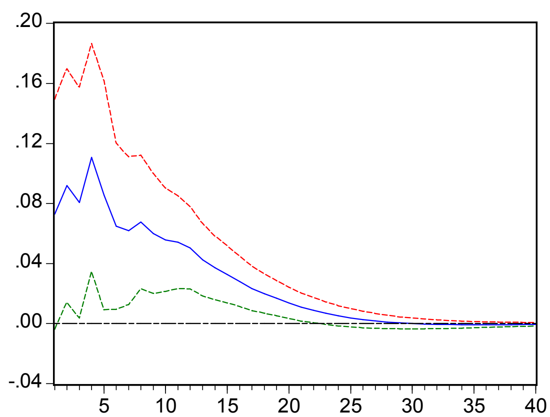
Panel A Response to One S.D. Shocks in Current Account Balance



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



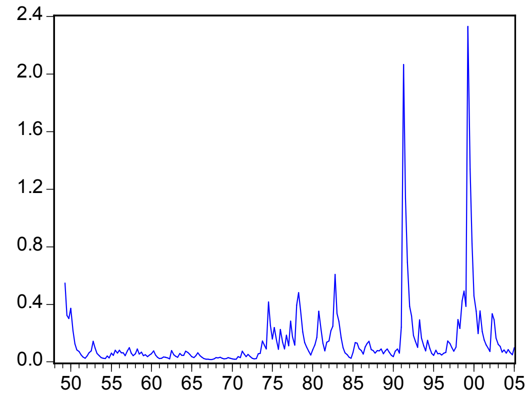
Panel C Response to One S.D. Shocks in Real Interest Rates



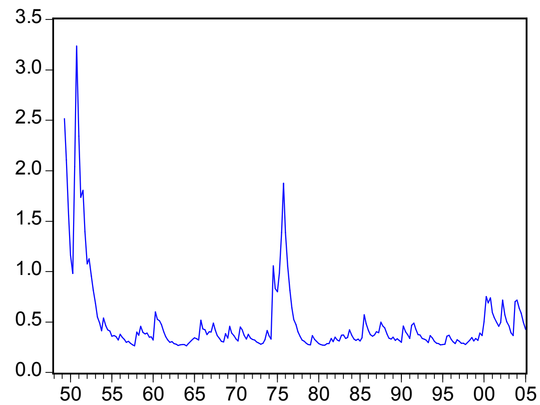
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 4.6 Estimated Volatilities from Structural Component Model

Panel A Estimated Volatilities for the Structural Current Account Balance



Panel B Estimated Volatilities for the Structural Government Budget Balance



Panel C Estimated Volatilities for the US Real Interest Rates

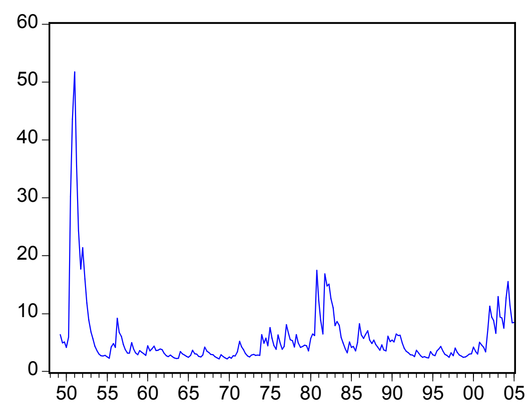
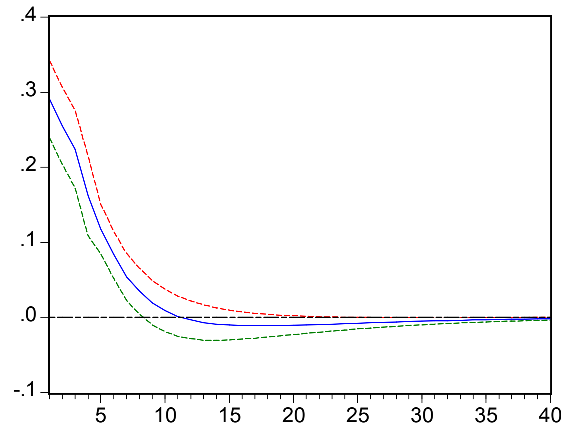
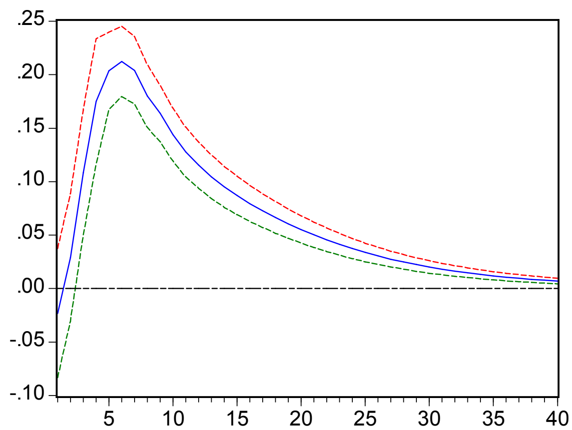


Figure 4.7 Generalized Impulse Responses of Structural Current Account Balance

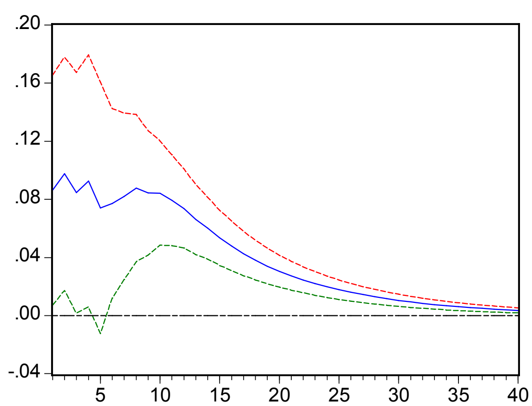
Panel A Response to One S.D. Shocks in Structural Current Account Balance



Panel B Response to One S.D. Shocks in Structural Government Budget Balance



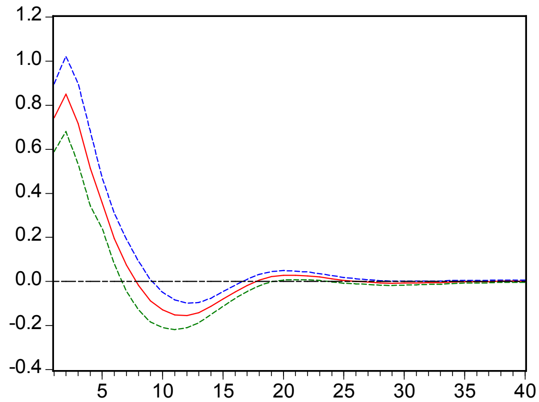
Panel C Response to One S.D. Shocks in Real Interest Rates



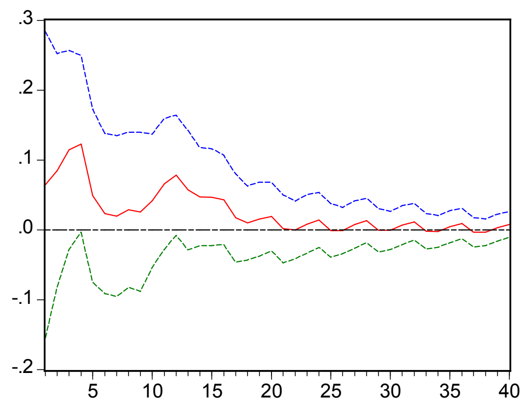
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in structural current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 6.1 MGARCH (1, 1) Model: Generalized Impulse Responses of Australia Current Account Balance

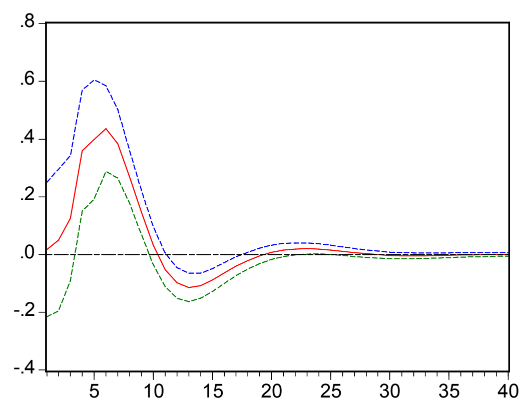
Panel A Responses to One S.D. Shocks in Current Account Balance



Panel B Responses to One S.D. Shocks in Government Budget Balance



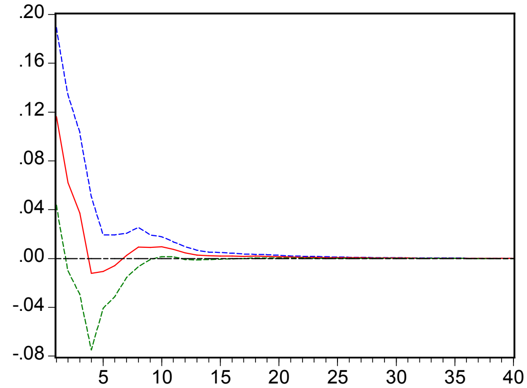
Panel C Responses to One S.D. Shocks in Real Interest Rates



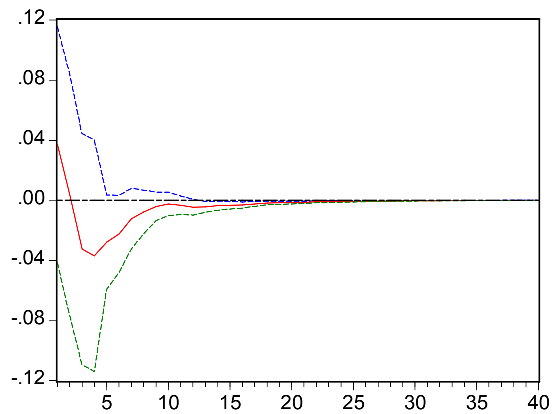
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 6.2 VAR (4) Model: Generalized Impulse Responses of Finland Current Account Balance

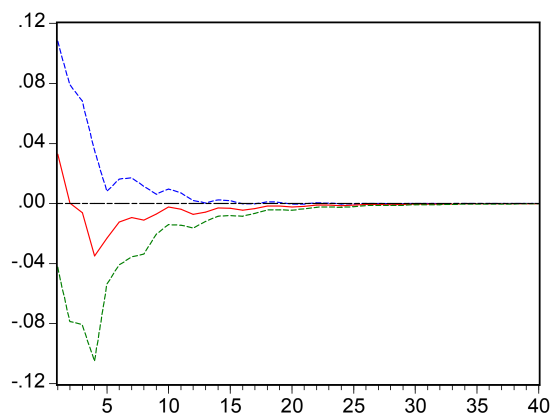
Panel A Responses to One S.D. Shocks in Current Account Balance



Panel B Responses to One S.D. Shocks in Government Budget Balance



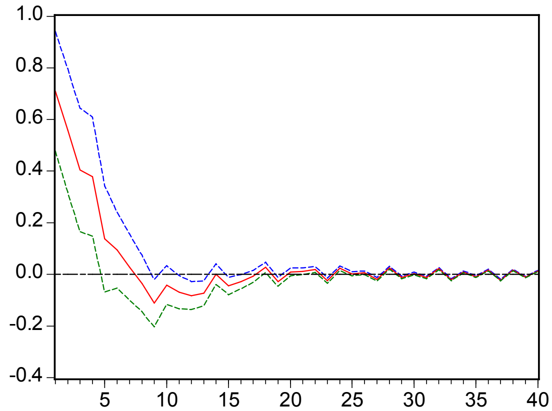
Panel C Responses to One S.D. Shocks in Real Interest Rates



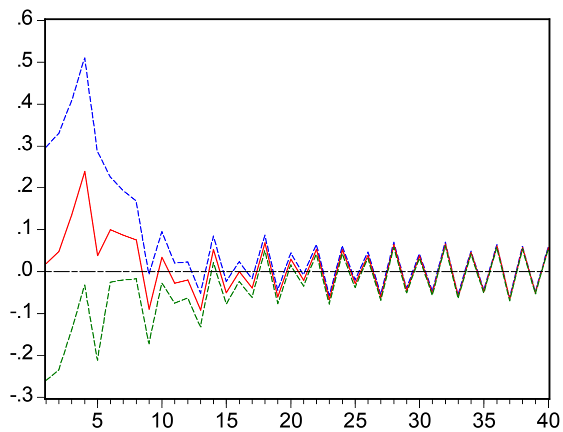
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 6.3 MARCH(1) Model: Generalized Impulse Responses of Germany Current Account Balance

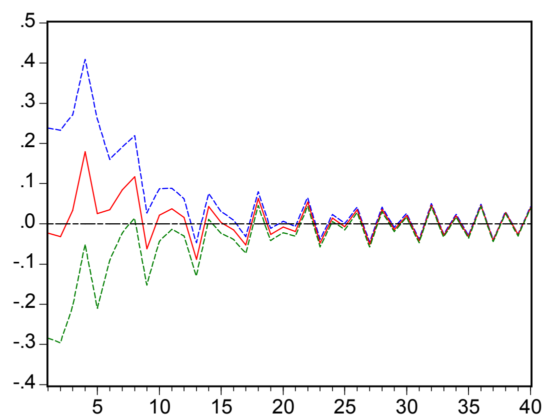
Panel A Responses to One S.D. Shocks in Current Account Balance



Panel B Responses to One S.D. Shocks in Government Budget Balance



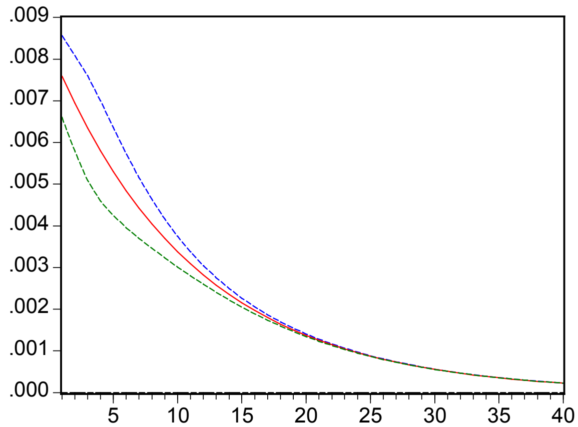
Panel C Responses to One S.D. Shocks in Real Interest Rates



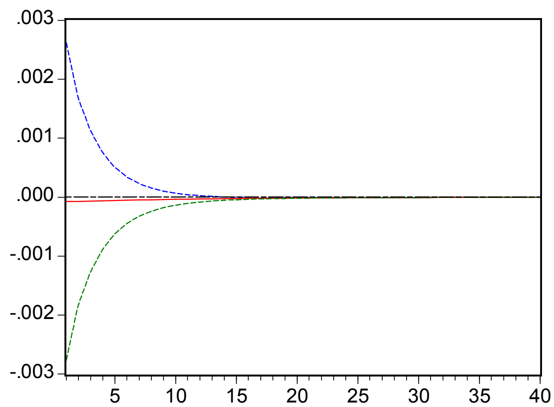
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 6.4 MGARCH (1, 1) Model: Generalized Impulse Responses of Spain Current Account Balance

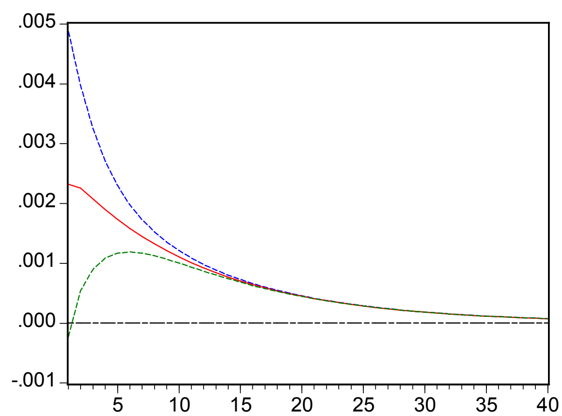
Panel A Responses to One S.D. Shocks in Current Account Balance



Panel B Responses to One S.D. Shocks in Government Budget Balance



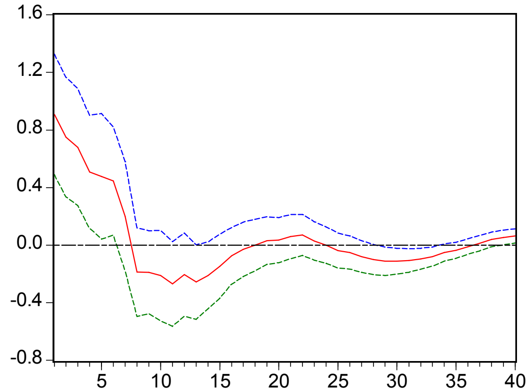
Panel C Responses to One S.D. Shocks in Real Interest Rates



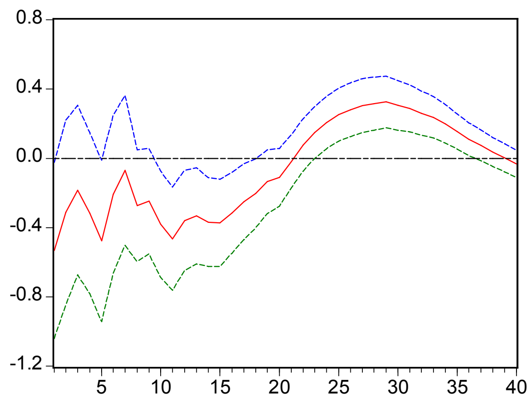
Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. Vertical axis shows the change in current account balance as a percentage of GDP. The dotted lines indicate the bootstrapped 95% confidence intervals for the impulse responses based on 1000 replications.

Figure 6.5 VAR(8) Model: Generalized Impulse Responses of U.K. Current Account Balance

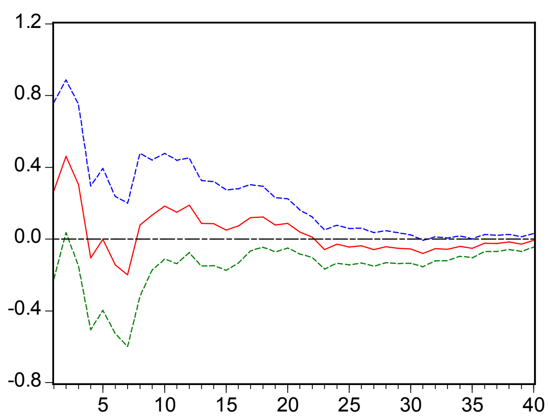
Panel A Responses to One S.D. Shocks in Current Account Balance



Panel B Responses to One S.D. Shocks in Government Budget Balance



Panel C Responses to One S.D. Shocks in Real Interest Rates



Note: Horizontal axis indicates the time horizon in terms of quarters after shocks. 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 3.1 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***
$SupF_T(2\|1)$	$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$SupF_T(6\|5)$	$SupF_T(7\|6)$	$SupF_T(7)$	
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***
$SupF_T(2\|1)$	$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$SupF_T(6\|5)$	$SupF_T(7\|6)$	$SupF_T(7)$	
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 Two 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 3.2 Perron's Modified ADF Tests

	Perron's t-statistic	Critical Value (1%)	Critical Value (2.5%)
Current Account	-4.1847	-4.27	-4.09
Government Budget	-5.054	-4.27	-4.09

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

Table 4.1 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 (4) and standardized. Q(4), Q(8) and Q(12) are the multivariate Ljung-Box statistics for the fourth-, eighth- and 12^{th}-order serial correlation in the series under consideration. *, **, and *** indicates the 10%, 5%, and 1% significance level.

Table 4.2 Current Account Balance, Budget Balance and Real Interest Rates

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

$$(1)\quad CA_t = \underset{(0.02)}{0.004} + \underset{(0.10)}{0.85} CA_{t-1} + \underset{(0.14)}{0.02} CA_{t-2} + \underset{(0.14)}{0.03} CA_{t-3} - \underset{(0.12)}{0.11} CA_{t-4} + \underset{(0.08)}{0.05} CA_{t-5}$$
$$- \underset{(0.036)}{0.007} GB_{t-1} + \underset{(0.05)}{0.06} GB_{t-2} + \underset{(0.047)}{0.04} GB_{t-3} + \underset{(0.05)}{0.000} GB_{t-4} - \underset{(0.03)}{0.04} GB_{t-5}$$
$$+ \underset{(0.008)}{0.03} RI_{t-1} + \underset{(0.010)}{0.006} RI_{t-2} + \underset{(0.01)}{0.001} RI_{t-3} + \underset{(0.009)}{0.009} RI_{t-4} - \underset{(0.009)}{0.008} RI_{t-5} + \varepsilon_{1t}$$

$$(2)\quad GB_t = \underset{(0.05)}{0.024} - \underset{(0.15)}{0.12} CA_{t-1} + \underset{(0.22)}{0.03} CA_{t-2} + \underset{(0.26)}{0.11} CA_{t-3} + \underset{(0.22)}{0.05} CA_{t-4} - \underset{(0.13)}{0.134} CA_{t-5}$$
$$+ \underset{(0.09)}{0.98} GB_{t-1} + \underset{(0.13)}{0.21} GB_{t-2} - \underset{(0.14)}{0.13} GB_{t-3} - \underset{(0.13)}{0.25} GB_{t-4} + \underset{(0.08)}{0.1} GB_{t-5}$$
$$- \underset{(0.02)}{0.04} RI_{t-1} + \underset{(0.02)}{0.009} RI_{t-2} + \underset{(0.03)}{0.05} RI_{t-3} - \underset{(0.03)}{0.007} RI_{t-4} + \underset{(0.03)}{0.01} RI_{t-5} + \varepsilon_{2t}$$

$$(3)\quad RI_t = \underset{0.15}{0.20} - \underset{(0.5)}{0.44} CA_{t-1} + \underset{(0.67)}{0.50} CA_{t-2} - \underset{(0.62)}{0.75} CA_{t-3} + \underset{(0.69)}{0.80} CA_{t-4} - \underset{(0.597)}{0.14} CA_{t-5}$$
$$+ \underset{(0.23)}{0.16} GB_{t-1} - \underset{(0.31)}{0.24} GB_{t-2} + \underset{(0.38)}{0.53} GB_{t-3} - \underset{(0.38)}{0.55} GB_{t-4} + \underset{(0.28)}{0.23} GB_{t-5}$$
$$+ \underset{(0.1)}{0.12} RI_{t-1} + \underset{(0.08)}{0.08} RI_{t-2} + \underset{(0.08)}{0.10} RI_{t-3} + \underset{(0.073)}{0.23} RI_{t-4} - \underset{(0.08)}{0.08} RI_{t-5} + \varepsilon_{3t}$$

$$(4)\quad h_{1t} = \underset{(0.005)}{0.006} + \underset{(0.12)}{0.497} \varepsilon^2_{1,t-1} + \underset{(0.07)}{0.57} h_{1,t-1}$$

$$(5)\quad h_{2t} = \underset{(0.05)}{0.08} + \underset{(0.095)}{0.19} \varepsilon^2_{2,t-1} + \underset{(0.15)}{0.63} h_{2,t-1}$$

$$(6)\quad h_{3t} = \underset{(0.37)}{0.503} + \underset{(0.11)}{0.22} \varepsilon^2_{3,t-1} + \underset{(0.13)}{0.69} h_{3,t-1}$$

$$(7)\quad h_{12,t} = -\underset{(0.08)}{0.02} \sqrt{h_{1t}}\sqrt{h_{2t}}$$

$$(8)\quad h_{13,t} = \underset{(0.109)}{0.06} \sqrt{h_{1t}}\sqrt{h_{3t}}$$

$$(9)\quad h_{23,t} = -\underset{(0.086)}{0.25} \sqrt{h_{2t}}\sqrt{h_{3t}}$$

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 4.3 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 12^{th}-order serial correlation in the series under consideration. *, **, and *** indicates the 10%, 5% and 1% significance level.

Table 4.4 Variance Decompositions of the US Current Account Balance

Panel A VAR-GARCH (1, 1) Model

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	85.79 (79.76 ~ 91.80)	8.57 (3.43 ~ 13.72)	5.63 (4.40 ~ 6.87)
8	58.33 (47.73 ~ 68.94)	35.77 (25.56 ~ 45.97)	5.90 (4.98 ~ 6.82)
12	47.71 (37.72 ~ 57.69)	45.85 (36.14 ~ 55.56)	6.45 (5.54 ~ 7.35)
24	43.71 (34.33 ~ 53.10)	49.21 (40.05 ~ 58.36)	7.08 (6.13 ~ 8.03)
36	43.72 (34.34 ~ 53.11)	49.19 (40.04 ~ 58.34)	7.09 (6.13 ~ 8.04)

Panel B Demeaned VAR with Homoskedasticity

Forecasting Horizons (Quarters)	Current Account Balance	Government Budget Balance	Real Interest Rates
4	92.24 (90.08 ~ 94.40)	2.78 (1.45 ~ 4.11)	4.98 (3.96 ~ 6.01)
8	82.19 (76.27 ~ 88.12)	10.50 (5.54 ~ 15.46)	7.31 (5.88 ~ 8.73)
12	78.20 (71.37 ~ 85.03)	11.36 (5.83 ~ 16.89)	10.45 (8.46 ~ 12.42)
24	76.93 (69.91 ~ 83.96)	11.34 (5.75 ~ 16.93)	11.72 (9.52 ~ 13.93)
36	76.93 (69.90 ~ 83.95)	11.35 (5.76 ~ 16.94)	11.73 (9.52 ~ 13.93)

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

Table 4.4 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	87.34 (83.44 ~ 91.24)	9.80 (7.13~ 12.47)	2.86 (0.97 ~ 4.76)
8	86.08 (81.90 ~ 90.27)	10.88 (7.96~ 13.81)	3.04 (1.04 ~ 5.03)
12	85.98 (81.77 ~ 90.19)	10.97 (8.03 ~ 13.92)	3.05 (1.04 ~ 5.05)
24	85.97 (81.76 ~ 90.18)	10.98 (8.03 ~ 13.93)	3.05 (1.04 ~ 5.05)
36	85.97 (81.76 ~ 90.18)	10.98 (8.03 ~ 13.93)	3.05 (1.04 ~ 5.05)

Panel D VAR in Levels

Forecasting Horizons (Quarters)	Current Account Balance	Government Budget Balance	Real Interest Rates
4	97.22 (96.53 ~ 97.89)	1.75 (1.18 ~ 2.33)	1.03 (0.88 ~ 1.19)
8	93.50 (91.57 ~ 95.43)	5.28 (3.47 ~ 7.08)	1.22 (1.03 ~ 1.41)
12	91.15 (88.54 ~ 93.75)	6.85 (4.45 ~ 9.25)	2.01 (1.69 ~ 2.33)
24	87.13 (83.56 ~ 90.70)	8.49 (5.38 ~ 11.59)	4.39 (3.67 ~ 5.11)
36	84.34 (80.15 ~ 88.54)	9.36 (5.85 ~ 12.87)	6.29 (5.24 ~ 7.35)

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

Table 4.5 Variance Decompositions for the Current Account Balance from the Robustness Checks

Panel A BEKK Model

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	86.26 (81.71 ~ 90.80)	5.45 (2.07 ~ 8.82)	8.30 (6.54 ~ 10.06)
8	61.74 (52.72 ~ 70.76)	23.96 (16.01 ~ 31.91)	14.30 (11.89 ~ 16.72)
12	52.27 (43.13 ~ 61.41)	30.91 (22.61 ~39.21)	16.82 (14.22 ~ 19.42)
24	48.62 (39.71 ~ 57.53)	33.47 (25.26 ~ 41.69)	17.92 (15.25 ~ 20.57)
36	48.62 (39.71 ~ 57.53)	33.48 (25.26 ~ 41.69)	17.91 (15.25 ~ 20.57)

Panel B Structural Component Model

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	79.24 (72.01 ~ 86.47)	10.53 (4.56 ~ 16.51)	10.23 (8.15~ 12.30)
8	53.32 (42.93 ~ 63.71)	29.81 (20.34 ~ 39.29)	16.87 (14.23 ~ 19.51)
12	44.70 (34.87 ~ 54.52)	34.14 (24.99 ~ 43.29)	21.16 (18.08 ~ 24.25)
24	39.83 (30.67 ~ 48.99)	36.39 (27.64 ~ 45.14)	22.91 (19.65 ~ 26.16)
36	39.46 (30.36 ~ 48.55)	36.60 (27.89 ~ 45.31)	23.78 (20.45 ~ 27.11)

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

Table 5.1 Wald Tests for Granger-Causality in Mean

	H_0 : No Granger-causality in mean from *GB* to *CA*	H_0 : No Granger-causality in mean from *CA* to *GB*
χ^2 test statistic	20.6843***	2.4744
P-value	0.0009	0.7803

Notes: The Granger-causality tests are based on a VAR(5) process. P-value indicates the probability associated with the hull hypothesis. *** indicates the 1% significance level.

Table 5.2 Maximum-Likelihood Estimates of Univariate GARCH Models

Panel A US Current Account Balance

$$CA_t = -\underset{(0.029)}{0.01} + \underset{(0.09)}{1.07}\, CA_{t-1} - \underset{(0.09)}{0.25}\, CA_{t-2} + u_t, \qquad u_t \sim N(0, h_t)$$

$$h_t = \underset{(0.02)}{0.17} + \underset{(0.05)}{0.11}\, u_{t-1}^2 - \underset{(0.15)}{0.30}\, h_{t-1}$$

$Q(4)$	1.5147	$Q(8)$	6.1688	$Q(12)$	7.4215
$Q^2(4)$	0.1702	$Q^2(8)$	0.5301	$Q^2(12)$	1.1707
Log-Likelihood	-83.6884				

Panel B US Government Budget Balance

$$GB_t = \underset{(0.05)}{0.02} + \underset{(0.07)}{1.02}\, GB_{t-1} + \underset{(0.11)}{0.09}\, GB_{t-2} - \underset{(0.08)}{0.21}\, GB_{t-3} + v_t, \qquad v_t \sim N(0, g_t)$$

$$g_t = \underset{(0.02)}{0.06} + \underset{(0.03)}{0.10}\, v_{t-1}^2 + \underset{(0.05)}{0.77}\, g_{t-1}$$

$Q(4)$	7.3635	$Q(8)$	11.008	$Q(12)$	15.279
$Q^2(4)$	7.3643	$Q^2(8)$	8.8521	$Q^2(12)$	11.453
Log-Likelihood	-239.5004				

Notes: Asymptotic standard errors computed under the normality assumption are in parentheses. $Q(k)$ and $Q^2(k)$ are the Ljung-Box portmanteau statistics for the first *k* autocorrelations of standardized residuals and their squares, respectively.

Table 5.3 Cross Correlation Function Tests for Causality in Variance

H_0: No causality in variance from GB to CA			H_0: No causality in variance from CA to GB		
Lag k	Cross-correlation	χ^2 test statistic	Lag k	Cross-correlation	χ^2 test statistic
0	0.072	1.1871	0	0.072	1.1871
1	0.0155	0.0550	1	-0.0012	0.0003
2	-0.0194	0.1412	2	-0.0011	0.0006
3	0.005	0.1469	3	-0.02	0.0922
4	0.0076	0.1602	4	0.1364	4.3527
5	-0.0368	0.4703	5	-0.0133	4.3933
6	-0.0326	0.7136	6	-0.0321	4.6292
7	0.0207	0.8118	7	-0.0405	5.0048
8	-0.0071	0.8233	8	-0.0254	5.1526
12	-0.0457	1.8424	12	0.0467	15.7587
16	-0.0191	2.6744	16	-0.0094	16.0318
20	-0.412	3.5188	20	-0.0084	16.1020

Notes: The chi-square test statistics with larger values of *k* are not statistically significant and, hence, not reported. *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

Table 5.4 Likelihood Ratio Tests for Granger-causality in Variance

	Unrestricted Model	Restricted Model I ($a_{21} = b_{21} = 0$)	Restricted Model II ($a_{12} = b_{12} = 0$)
Log-likelihood	-287.9606	-288.6758	-289.3270

	H_0 : GB volatility does not Granger cause CA volatility	H_0 : CA volatility does not Granger cause GB volatility
LR Test Statistic	1.4304	2.7328
P-value	(0.4891)	(0.2550)

Notes: Maximum likelihood estimates of the BEKK models are obtained by the BFGS algorithm. The empirical Type-I error probabilities at the 5% level are provided by Caporale (2002). Given a sample of 400 observations, the empirical Type-I error probability at the 5% level is around 0.01.

Table 6.1 Breakpoints in Current Account Balance in Five OECD Countries

Test Statistics	**Australia**	**Finland**	**Germany**	**Spain**	**UK**
$SupF_T(1)$	1.25	44.13*	2.26	0.36	11.57**
$SupF_T(2)$	7.24	38.69*	8.99**	0.33	31.55*
$SupF_T(3)$	4.93	62.01*	14.55*	0.34	31.55*
$SupF_T(4)$	5.03	82.12*	7.22*	0.33	23.75*
$SupF_T(5)$	3.97	47.67*	9.74*	0.34	19.85*
UDmax	7.24	82.12*	14.55*	0.36	31.55*
WDmax	8.12	163.05*	24.37*	0.84	51.02*
$SupF_T(2\|1)$	6.56	1.90	9.12***	0.34	4.84
$SupF_T(3\|2)$	0.34	10.17***	2.07	0.36	2.12
$SupF_T(4\|3)$	0.25	1.41	2.82	0.36	1.21
$SupF_T(5\|4)$	0.34	0.00	0.00	0.38	4.68
No. of Breaks	0	3	2	0	1

Structural Break Dates and the 90% Confidence Interval

Finland	1988Q4 (1986Q2~1989Q4), 1992Q4 (1992Q3~1993Q3), 1996Q3 (1996Q2~1999Q3)
Germany	1984Q3 (1984Q2~1986Q3), 1990Q3 (1982Q1~1990Q3)
UK	1986Q1 (1979Q2~1988Q2)

Note: The 90% confidence intervals for estimated breaks are reported in parentheses. *, ** and *** indicate the significance level of 1%, 2.5% and 5%, respectively.

Table 6.2 Breakpoints in Government Budget Balance in Five OECD Countries

Test Statistics	**Australia**	**Finland**	**Germany**	**Spain**	**UK**
$SupF_T(1)$	14.59*	5.68	2.22	6.20	2.23
$SupF_T(2)$	7.84***	53.29*	9.47*	15.45*	7.28***
$SupF_T(3)$	8.56*	42.15*	5.08	11.76*	10.69*
$SupF_T(4)$	6.88*	31.07*	5.35***	9.62*	8.65*
$SupF_T(5)$	5.66*	27.03*	3.54****	7.93*	7.85*
UDmax	14.59*	53.29*	9.47***	15.45*	10.69**
WDmax	14.59*	69.97*	11.84**	20.29*	19.65*
$SupF_T(2\|1)$	3.16	22.60*	2.99	26.68*	2.01
$SupF_T(3\|2)$	3.54	8.78*	1.72	3.89	6.70
$SupF_T(4\|3)$	1.58	1.64	6.31	2.49	1.45
$SupF_T(5\|4)$	0.97	0.00	0.00	0.07	0.00
No. of Breaks	1	3	1	2	1

Structural Break Dates and the 90% Confidence Interval

Australia	1996Q4 (1993Q3~1998Q2)
Finland	1991Q2 (1990Q4~1991Q3), 1995Q1 (1994Q3~1995Q4), 1998Q4 (1997Q4~2001Q2)
Germany	1982Q3 (1978Q1~1984Q1)
Spain	1981Q3 (1980Q3~1981Q4), 1985Q4 (1983Q4~1986Q3)
UK	1997Q2 (1991Q2~2002Q4)

Note: The 90% confidence intervals for estimated breaks are reported in parentheses. *, **, *** and**** indicate the significance level of 1%, 2.5%, 5% and 10%, respectively.

Table 6.3 Five OECD Countries: Ex ante Residual Diagnostics

Panel A Levels of Residuals

	Q(4)	Q(8)	Q(12)
Australia	12.5290	48.9322	95.6430
Finland	9.42346	35.2772	79.0208
Germany	11.1656	44.3511	74.7905
Spain	33.9814	96.2242	132.2975
UK	27.0343	48.4360	77.0933

Panel B Squares of Residuals

	Q(4)	Q(8)	Q(12)
Australia	41.1061**	81.2487***	127.7807**
Finland	29.6409	47.3828	121.4028
Germany	73.9413*	119.6141*	146.6849*
Spain	105.1955*	161.1507*	257.1781*
UK	32.7719	73.7651	103.3559

Note: The residuals are obtained from unrestricted VAR models and standardized. Q(4), Q(8) and Q(12) are the multivariate Ljung-Box statistics for the fourth-, eighth- and 12^{th}-order serial correlation. *, **, and *** indicate the 1%, 5% and 10% significance level, respectively.

Table 6.4 Five OECD Countries: Ex post Residuals Diagnostics

Panel A Levels of Residuals

	Q(4)	Q(8)	Q(12)
Australia	32.6458	70.1435	109.9365
Germany	27.2645	55.7744	82.9006
Spain	28.6670	89.9045	116.6677

Panel B Squares of Residuals

	Q(4)	Q(8)	Q(12)
Australia	37.3499	72.04281	103.55023
Germany	34.9886	72.3669	91.1999
Spain	25.9867	52.6727	72.8919

Note: The residuals are obtained from MVGARCH models and standardized. Q(4), Q(8) and Q(12) are the multivariate Ljung-Box statistics for the fourth-, eighth- and 12^{th}-order serial correlation.

Table 6.5 Variance Decompositions for Five OECD Countries

Panel A Proportions of Forecast Error Variance in Australia Current Account Balance

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	90.59 (83.86 ~ 97.32)	2.54 (0.36 ~ 4.72)	6.87 (0.48 ~ 13.26)
8	76.13 (66.94~ 85.32)	2.20 (-1.60 ~ 6.00)	21.67 (13.15 ~ 30.19)
12	75.61 (65.79 ~ 85.43)	2.39 (-2.71 ~ 7.48)	22.01 (13.50 ~ 30.52)
24	74.72 (64.15 ~ 85.29)	2.55 (-3.65 ~ 8.74)	22.73 (14.24~ 31.22)
36	74.70 (64.02 ~ 85.39)	2.56 (-3.82 ~ 8.94)	22.74 (14.26 ~ 31.22)

Panel B Proportions of Forecast Error Variance in Finland Current Account Balance

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	96.14 (88.68~ 103.61)	2.73 (-4.75 ~ 10.21)	1.13 (1.05~ 1.2)
8	94.51 (88.16~ 100.86)	3.76 (-2.62 ~ 10.15)	1.73 (1.48 ~ 1.97)
12	94.35 (88.01~ 100.68)	3.79 (-2.59 ~ 10.17)	1.86 (1.59 ~ 2.14)
24	94.20 (87.86 ~ 100.54)	3.84 (-2.54 ~ 10.22)	1.96 (1.68 ~ 2.24)
36	94.19 (87.86 ~ 100.53)	3.84 (-2.54 ~ 10.22)	1.96 (1.68 ~ 2.24)

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

Table 6.5 Variance Decompositions for Five OECD Countries (continued)

Panel C Proportions of Forecast Error Variance in Germany Current Account Balance

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	96.42 (88.77 ~ 104.07)	1.94 (-4.37 ~ 8.24)	1.65 (-2.68 ~ 5.98)
8	95.07 (86.71 ~ 103.44)	2.72 (-4.11 ~ 9.54)	2.21 (-2.69 ~ 7.11)
12	94.68 (86.15~ 103.21)	2.96 (-3.94 ~ 9.86)	2.36 (-2.67 ~ 7.39)
24	93.05 (84.43 ~ 101.67)	4.05 (-2.90 ~ 10.99)	2.91 (-2.19 ~ 8.00)
36	91.78 (83.15 ~ 100.41)	5.09 (-1.86 ~ 12.05)	3.13 (-1.97 ~ 8.22)

Panel D Proportions of Forecast Error Variance in Spain Current Account Balance

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	96.28 (92.44~ 100.12)	0.77 (-2.15 ~ 3.69)	2.95 (0.34~ 5.55)
8	95.85 (91.90 ~ 99.81)	0.85 (-2.17 ~ 3.86)	3.30 (0.63 ~ 5.98)
12	95.72 (91.76 ~ 99.68)	0.87 (-2.15 ~ 3.89)	3.41 (0.74 ~ 6.09)
24	95.63 (91.66 ~ 99.59)	0.89 (-2.14 ~ 3.91)	3.49 (0.81 ~ 6.17)
36	95.62 (91.65 ~ 99.58)	0.89 (-2.13 ~ 3.91)	3.50 (0.82 ~ 6.18)

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

Table 6.5 Variance Decompositions for Five OECD Countries (continued)

Panel E Proportions of Forecast Error Variance in UK Current Account Balance

Forecasting Horizons (Quarters)	Current Account Deficits	Budget Deficits	Real Interest Rates
4	88.30 (82.95 ~ 93.65)	5.29 (3.04 ~ 7.55)	6.40 (2.23 ~ 10.58)
8	83.70 (73.79 ~ 93.62)	9.41 (0.29 ~ 18.54)	6.89 (1.93 ~ 11.85)
12	74.30 (65.60 ~ 83.01)	18.21 (7.15 ~ 29.28)	7.48 (2.44 ~ 12.53)
24	66.47 (62.27 ~ 70.68)	26.19 (17.34 ~ 35.04)	7.34 (0.07 ~ 14.61)
36	60.68 (56.41 ~ 64.94)	32.51 (23.60 ~ 41.43)	6.81 (-0.55 ~ 14.17)

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

Table 6.6 Wald Tests for Granger-Causality in Mean

	H_0 : No Granger-causality in mean from *GB* to *CA*	H_0 : No Granger-causality in mean from *CA* to *GB*
Australia	6.4208 (0.2674)	5.2393 (0.3874)
Finland	3.0332 (0.5523)	4.7307 (0.3161)
Germany	6.1965 (0.2876)	2.7844 (0.7332)
Spain	7.6460 (0.5702)	9.7778 (0.3688)
UK	16.2217** (0.0393)	16.1151** (0.0408)

Notes: The Granger-causality-in-mean tests are based on VAR models. The chi-square test statistics are reported. The P-values are presented in the parentheses below. ** indicates the 5% significance level.

Table 6.7 Cross Correlation Function Tests: Non-Causality in Variance from Government Budget Balance to Current Account Balance

Lag k	Australia		Finland		Germany		Spain		UK	
	Corr	χ^2	*Corr*	χ^2	*Corr*	χ^2	*Corr*	χ^2	*Corr*	χ^2
1	-0.038	0.197	0.004	0.002	-0.024	0.069	-0.082	0.702	-0.038	0.147
2	-0.032	0.330	0.065	0.444	-0.035	0.208	-0.136	2.621	0.024	0.205
3	-0.049	0.643	0.036	0.576	0.024	0.277	-0.002	2.622	-0.154	2.669
4	-0.043	0.891	-0.071	1.093	-0.015	0.302	-0.056	2.950	-0.037	2.813
5	-0.009	0.901	0.133	2.923	0.215	5.698	-0.012	2.964	0.025	2.876
6	-0.120	2.801	0.327	14.02**	-0.098	6.810	-0.093	3.863	0.093	3.773
7	0.016	2.834	-0.036	14.15**	-0.018	6.849	-0.077	4.477	-0.059	4.130
8	-0.024	2.910	-0.019	14.19**	-0.025	6.922	0.125	6.111	-0.095	5.069
12	0.049	3.398	-0.059	16.191	0.065	8.833	-0.081	8.195	-0.077	8.762
16	0.217	11.40	0.037	17.229	-0.053	9.671	0.006	9.209	-0.166	11.959
20	0.078	11.88	0.003	17.778	0.032	10.57	0.013	29.34*	0.119	16.330

Notes: The null hypothesis for the Granger-causality-in-variance test is that there is no Granger causality in variance from government budget balance to current account balance. *Corr* represents the cross correlation. Chi-square test statistics are reported. ** and * indicate the 5% and 10% significance levels, respectively.

Table 6.8 Cross Correlation Function Tests: Non-Causality in Variance from Current Account Balance to Government Budget Balance

Lag k	**Australia**		**Finland**		**Germany**		**Spain**		**UK**	
	Corr	χ^2	*Corr*	χ^2	*Corr*	χ^2	*Corr*	χ^2	*Corr*	χ^2
1	-0.071	0.677	0.154	2.461	0.026	0.077	0.155	2.508	0.150	2.328
2	-0.073	1.390	0.026	2.531	0.130	2.056	-0.102	3.586	-0.062	2.725
3	0.042	1.625	-0.070	3.033	-0.071	2.649	-0.090	4.435	-0.040	2.895
4	-0.004	1.627	-0.031	3.131	0.021	2.701	0.051	4.700	0.137	4.851
5	0.038	1.816	-0.060	3.502	0.002	2.702	-0.011	4.713	0.138	6.817
6	-0.071	2.491	-0.018	3.534	-0.071	3.294	-0.062	5.109	-0.064	7.237
7	-0.032	2.625	-0.078	4.162	0.043	3.508	-0.051	5.378	-0.025	7.302
8	0.085	3.586	-0.057	4.495	-0.026	3.587	-0.002	5.379	0.117	8.732
12	0.137	16.67	-0.088	37.1***	0.015	5.962	0.074	8.127	-0.050	9.099
16	-0.041	17.26	0.116	39.4***	-0.083	6.922	0.101	12.302	0.021	11.193
20	-0.042	18.47	-0.046	40.4***	-0.043	7.634	0.024	12.528	0.001	11.554

Notes: The null hypothesis for the Granger-causality-in-variance test is that there is no Granger causality in variance from current account balance to government budget balance. *Corr* represents the cross correlation. Chi-square test statistics are reported. ***, ** and * indicate the 1%, 5% and 10% significance levels, respectively.

Table 6.9 Likelihood Ratio Tests for Granger-causality in Variance

	Log-likelihood Unrestricted	Restricted $(a_{21} = b_{21} = 0)$	Restricted $(a_{12} = b_{12} = 0)$	H_0: No causality-in-variance from GB to CA	H_0: No causality-in-variance from CA to GB
Australia	-230.337	-227.957	-230.290	-4.7615 (1.000)	-0.096 (1.000)
Finland	-263.416	-268.954	-266.622	11.0774** (0.004)	6.4137 (0.040)
Germany	-307.604	-310.308	-308.757	5.4086 (0.067)	2.3064 (0.316)
Spain	84.562	84.434	80.905	0.2553 (0.880)	7.3135 (0.026)
UK	-334.270	-337.830	-335.428	7.1200 (0.028)	2.3149 (0.3143)

Notes: Maximum likelihood estimates of the BEKK models are obtained by the BFGS algorithm. The empirical Type-I error probabilities at the 5% level are provided by Caporale (2002). Given a sample of 400 observations, the empirical Type-I error probability at the 5% level is around 0.01. ** indicates the 5% significance level.