Synchronization between South Africa and the U.S.: A Structural Dynamic Factor Analysis

Alain Kabundi[1]

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[1] Department of Economics, University of Johannesburg

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Abstract

This paper studies the synchronization of economic variables between South Africa and the US. In addition it examines transmission channels through which supply and demand shocks from the US affect economic activity in South Africa. We use a structural dynamic factor model approach, instead of the well known structural vector autoregressive method, as it accommodates a large panel of time series variables. The paper contains four findings. First, using the full-sample period, US supply shocks are transmitted to South Africa through business confidence and imports of goods and services; while US demand shocks are transmitted via interest rates, stock prices, exports of goods and services, and real effective exchange rates. Second, there is a decrease in integration over time as the common component of GDP drops in the reduced sample. The impact of an increase in comovement of GDP is outweighed by several factors resulting from the structural reforms initiated by the government after the end of apartheid. Thirdly, in the latter period the South African economy is mainly affected by the US supply shocks through a variety of channels. For this latter period, US supply shocks are forcefully transmitted to South Africa via consumer and business confidence, stock prices and real effective exchange rates. Finally, the idiosyncratic component still plays an important role in the South African economy. Structural reforms are crucial to make the domestic economy competitive internationally.

KEYWORDS;Dynamic factor models, international business cycles, sign restrictions.

JEL Classification Numbers: C3, E32, F00, E5

1 Introduction

This paper provides a thorough analysis of synchronization between the South African and US economies. Furthermore, it emphasizes South African reaction to shocks originating from the US. Besides the traditional channels – trade and financial linkages – underpinning the comovement of economic variables between the two economies this paper studies other channels of transmission.

We use a structural dynamic factor model, which accommodates a large panel of South African and the US variables. Sign restriction techniques allows the identification of two shocks from the US, supply and demand, that explain more than 90 percent of variance of the US GDP over five years.

*Department of Economics, University of Johannesburg

The paper contains four findings. First, using the full-sample period, US supply shocks are transmitted to South Africa through business confidence and imports of goods and services; while US demand shocks are transmitted via interest rates, stock prices, exports of goods and services, and real effective exchange rates. Second, there is a decrease in integration over time as the common component of GDP growth drops in the reduced sample. The impact of an increase in comovement of GDP growth is outweighed by several factors resulting from the structural reforms initiated by the government after the end of apartheid. Most importantly, the new monetary policy advocating a more freely floating exchange-rate regime, trade openness, and liberalization of capital markets have made the country more vulnerable to external shocks, increasing the weight of some channels of transmission, such as interest rates and exchange rates. Thirdly, in the latter period the South African economy is mainly affected by the US supply shocks through a variety of channels. For this latter period, US supply shocks are forcefully transmitted to South Africa via consumer and business confidence, stock prices and real effective exchange rates. Finally, a lower variance share of the common component output growth implies that the idiosyncratic component still plays an important role in the South African economy. Structural reforms are crucial to make the domestic economy competitive internationally.

Section 2 gives a brief history of economic relations between South Africa and the US. A detailed literature on synchronization and dynamic factor model is outlined in section 3. Section 4 provides a summary of the empirical methods used in the investigating economic integration of South Africa into the global market. It contains the theoretical ground of the Structural Dynamic Factor Model by Forni et al. (2005) using the identification procedure of Peersman (2005) and Uhligh (2003). Section 5 covers sources of data included in this study, their transformation, and the estimation of model. Section 6 discusses the empirical results. It examines the degree of integration and the transmission of US shocks to South Africa. Section 7 concludes and discusses policy implications.

2 Trade and Financial Linkages between South Africa and the U.S.

The USA is South Africa's second trading partner after Germany, accounting for 8.7 percent of total trade (Exports + Imports) in 2006. South Africa is the largest trading partner of the US in Sub-Saharan Africa. US exports to South Africa are the highest, while its imports from South Africa are second after Nigeria. Like many African countries, the US–South Africa trade relation is a classic example of North–South relationship. South Africa imports manufactured goods, including aircraft and parts, industrial machinery and parts, electric machinery, motor vehicles and parts, and telecommunication equipment, whilst its exports are mainly commodity-based. Precious stones and metals constitute approximately 40 percent of total exports to the US. South Africa benefited from the Generalized System of Preferences (GSP) granted by the US through a reduction of tariffs on approximately 4600 products. Furthermore, the African Growth and Opportunity Act (AGOA) gives South Africa access to the world's largest economy. In addition, the AGOA allows for the duty-free access of 1800 products. Under the AGOA exports of manufactured products, such as motor vehicles and parts, textiles and clothing, and agricultural products have increased considerably. For nearly six years now, trade has been in South Africa's favour, with a trade surplus increasing since 2000. Recently the country benefited from high commodity prices; nevertheless this advantage was tempered by the appreciation of the domestic currency and the high oil price.

US companies use South Africa as an entry port to the untapped African market. The country

benefits from this strategy because of its geographical location and its dominance in the region. It is the region's largest economy, with a sound financial system, adequate infrastructure, stable political institutions, and vibrant economy. South Africa uses its leadership position in negotiating free trade agreements between SADC and SACU, on the one hand, and with the United States, on the other hand. SACU member states, through the AGOA, have access to the larger US market.

Trade plays a crucial role in attracting direct investments. FDI inflows are somewhat dependent on the degree of openness of the recipient country (Markusen, 2002). The higher the trade barriers, the less FDI the country will receive and the less integrated it will be with the rest of the world. Conversely, economic integration will promote market accessibility, which in turn will boost FDI flows, leading to more trade.

Many US firms have taken advantage of preferential access to the US and EU markets by increasing their investment in the South African textile and clothing industries. Generally, FDI inflows support US trade with South Africa. The US is the second source of FDI after the UK. In contrast with many African countries, where inflows from the US occurred in the natural resources sector, FDI flows to South Africa are more diversified. Recently the net investment from the US has come under pressure due to a large disinvestment from Telkom. Since 2000, however, investments in the automotive industry have increased substantially. The net investment in the automotive sector from the US is much larger than the investment from the EU. Also, as with trade, US companies use South Africa as a first step into exploring the African market. The Lesotho and Swaziland textile and clothing industries have gained a lot from FDI inflows from the US.

The relaxation of capital controls has given South African companies the opportunity to diversify their portfolios and take advantage of investment opportunities offshore. Currently six South African companies (AngloGold Ashanti, Gold Fields, Harmony Gold, Telkom, Sappi, and Sasol) have listed on the New York stock exchange. Since the South African stock market is still very small, dual listings contribute to the dependence of the Johannesburg Stock Exchange on the New York Stock Exchange. Cross-border diversification enhances the synchronization of equity returns, which in turn emerges as a potential source of transmission of financial shocks. Another factor explaining comovement of equity prices is the presence of a considerable number of multinational companies in South Africa, which are benefiting from its sound financial system. Most these companies are listed in both countries. Finally, financial market linkages have facilitated the possibility of cross-border arbitrage through derivatives or hedging. Hence, South African stock prices seem to react more to global factors than to idiosyncratic factors.

Furthermore, the gradual removal of capital controls has encouraged inflows of short-term capital in the country. The favourable external environment accompanied by the rise in commodity prices and a vibrant domestic expenditure have boosted portfolio inflows recently. This rise in inflows has created a capital account surplus. Importantly, the capital account surplus of 2006 is primarily due to both portfolio and direct investment flows. It has played a crucial role in offsetting the current account deficit. But short-term inflows surpass direct investment. This situation makes the South African economy vulnerable to external shocks.

The US constitutes approximately 30 percent of global demand. It is the world's largest economy; therefore it influences the global economy to a large extent. A buoyant American economy has positive effects in most parts of the world. For example, the productivity shocks of the 1990s influenced the South African economy positively. Ever since, the country has enjoyed a long and lasting expansionary period. The burst of technological bubble was also felt in South Africa. Conversely, a downswing in the American economy slows the domestic activity too. Global current-account imbalances present a major concern to the local economy and should be monitored closely. So far,

higher commodity prices and strong economic growth from emerging markets have dampened the negative effects of these imbalances.

Consumer confidence and business confidence are non-negligible channels through which shocks are transmitted across countries. Anderton, di Mauro and Moneta (2004) and IMF (2001) find strong comovements in confidence indices across major advanced economies and evidence of confidence spillovers. Sentiments of economic agents about the current and the future state of the economy in one country can affect opinions of agents in another country. Consumer confidence tends to influence consumption, while business confidence impacts investment. For example, the events of 11 September 2001 in the US affected business confidence in America, and South African business sentiment was then also affected. The overall results were a decrease in economic activity in the US first, followed by a decline in economic activity in South Africa. Similarly, productivity shocks in the US brought about positive sentiments of agents about the US economy. These sentiments were also felt in South Africa.

3 Literature Review

There is an ongoing debate involving the public, academics and policymakers about economic integration or the effect of globalization on developed and developing economies. There is a consensus in the literature that globalization has largely positive effects on economies. However, the theoretical point of view is still unclear about the effect of globalization on economies.

Globalization fosters comovement of macroeconomic variables across countries through trade integration and financial market integration (IMF, 2001 and Imbs, 2004). Trade integration is a result of the gradual removal of barriers among countries to allow free circulation of goods and services. An increase in exports in one country can trigger a rise in the demand for imports and boost the economic activity of the recipient country (Canova and Dellas, 1993 and IMF, 2001). Such spillover effects result in an increase in trade linkages, which in turn leads to high correlation of business cycles across countries.

The integration of financial markets has also contributed to the synchronization of business cycles through the opening of countries' capital accounts. Financial integration facilitates diversification of risks by the agents through investment across borders. Financial prices have become more synchronized through arbitrage, i.e. volatility in one market spreads easily to other markets. Brooks, Forbes, and Mody (2003) summarize some important stylized facts on comovement between the G-7 countries and emerging-market economies. This is based on the outcomes of a conference where research focused on the strength, nature and sources of comovement in financial markets. The stylized facts are as follows: firstly, financial comovements tend to be substantially larger than comovements in the real economy. Secondly, financial comovement has increased for financial markets in developed as well as in emerging-market economies. Lastly, no clear evidence exists on the comovement in the real economy. Brooks et al. (2003) conclude that, in contrast with clear and relatively consistent evidence on financial comovement, evidence on real comovement is "blurred and controversial". For example, the Asian crisis of 1997-1998 spread rapidly to most developing countries because of synchronization of their financial markets. Furthermore, the global slowdown of 2000-2001 was caused by the crash of the technology stock market in the US.

On the empirical front, most findings show increasing synchronization of economic variables across countries. Kose, Otrok, and Whiteman (2005) use the Bayesian Dynamic Factor Model to study the changes in the nature of G-7 business cycles over time. They extract common components in output, consumption, and investment. They find that the degree of synchronization of business

cycles of major macroeconomic aggregates across G-7 countries has increased during this period. On the nature of shocks that drive the comovement, they find that the oil-price shocks are behind synchronization of cycles during the "common shocks" period.

Nadal-De Simone (2002) used a concordance index proposed by Harding and Pagan (2002) and the dynamic factor model of Stock and Watson (1991) to analyze synchronization of output cycles between EU countries and the US. Results support the evidence of a global component as well as a regional component that explains comovement between European economies themselves and with the US. The author found that idiosyncratic components matter for France. In the same vein, Monfort et al. (2004), Kose et al. (2003a), Malek Mansour (2003), Yang (2003), Lumsdaine and Prasad (2003), Bordo and Helbling (2004), and Canova et al. (2007) support the view that fluctuations of most macroeconomic variables across developed countries are mainly driven by a global factor. The existence of a common business cycle or world cycle is evidence of linkages of macroeconomic variables across countries: in other words, it is substantial proof of economic integration among high-income economies.

On the other hand, Kose and Yi (2006), Kose et al. (2003b), Stock and Watson (2003), and Heitz et al. (2004) find that, despite large increases in trade and openness, G-7 business cycles have become less synchronized. The reason is that trade flows could lead to increased specialization of production resulting in changes in the nature of business cycles. In this case trade ties are closely related to a rise in inter-industry specialization across nations, and then industry-specific shocks are the main driving forces of business cycles. Therefore the synchronization of business cycle might decrease. Similarly, international financial linkages could also stimulate production through the reallocation of capital in a manner consistent with countries' comparative advantage in the production of different goods (Imbs, 2004). Financial integration tends to result in specialization of economies, which in turn reduces business cycle synchronization.

However, there still is a gap in the literature on economic integration of developing countries. Lee, Park and Shin (2004) find that synchronization of business cycles in East Asia is comparable to Europe. They argue that regional integration is mainly influenced by trade integration rather than financial integration. They observe that financial liberalization in East Asia has led to global integration rather than regional integration. Therefore, they suggest that the successful formation of a currency union will foster the process of integration. However, Kim, Kim, and Wang (2005) show that besides trade, financial integration in Asia has increased the synchronization of business cycles. Also, business cycles of five of Asian crisis countries are not only highly synchronized among themselves, but follow the Japanese cycle. Contrary to Lee et al. (2004), Kim et al. (2005) find that rapid financial market liberalization of 1990s has contributed substantially to an increase in comovement of business cycles across countries in the region. Furthermore, the 1997 Asian crisis has induced policymakers to come up with some initiatives encouraging cooperation and synchronization of policies among the ASEAN+3[1] countries (Sakakibara and Yamakawa, 2003).

Unlike the East Asian region, the Latin American region is not economically integrated (Machinea and Rozenwurcel, 2006). These countries have repeatedly experienced long periods of political instability and economic crises. Although policymakers have taken deliberate initiatives to induce cooperation in the region, intra-regional trade is almost entirely lacking. An attempt to increase trade in the region failed after the 1998 crisis. Canova (2005) finds a significant comovement of output and inflation in Latin America driven by US monetary disturbances. Similarly, financial

[1] ASEAN (Association of Southeast Asian Nations) + 3 comprises Brune Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam; and the following three countries, China, Japan, and Republic of Korea.

integration in Latin America is still in its infancy, the reason being that there is an insignificant flow of capital across countries. On the one hand, most of the regional multinational companies are either listed in the US or in the EU; on the other hand, FDI flows in from abroad (IADB, 2002). As Latin American countries share the same external vulnerability, negative international shocks tend to have the same impact across the region. Hence, international financial crises spread easily in the region without a priori financial integration (Machinea and Rozenwurcel, 2005). Aiolfi, Catão, and Timmermann (2006) also find that trade and financial linkages in the region have remained small. However, they identify the existence of a sizeable regional component in Latin American business cycles. Instead of a regional factor, like Canaova (2005), they find that global factors are the main driving forces of common business cycle components in the region.

Africa seems to be a region that is under-researched in terms of regional and global integration. Like Latin America, trade and financial integration in Africa is virtually non-existent. Recently, there has been an increase in trade among CEFA-zone countries, SACU countries, and COMESA members.[2] Despite the theoretical linkages between Sub-Saharan African countries and EMU, Nyembwe and Kholodilin (2005) find that EMU has had only a limited impact on a few African countries. But they observe a lagged impact of European monetary policies on Sub-Saharan African countries. The impact becomes somewhat stronger with CFA-zone countries, as they peg their domestic currencies to the Euro. Kose and Riezman (2001) investigated the link between external shocks and the high volatility of macroeconomic fluctuations in Africa. They argue that trade rather than financial shocks plays a more important role. Trade shocks account for approximately half of the volatility of macroeconomic variables. Like Latin American countries, African countries are heterogeneous, which makes economic integration difficult to achieve (Jenkins and Thomas, 1998). Furthermore, countries import and export much the same products – manufactured products and natural resources, respectively. There is a consensus among academics (Mason and Patillo, 2005, and Arora and Vamvakidis, 2005) that the overlapping of memberships between different regional organizations hinders regional integration considerably. These academics suggest a sequencing of integration, starting with regional organizations that are more or less integrated, such as the SACU, the CFA zone, and COMESA.

4 Methodology

The methodology used in this paper comprises two main steps: first, an estimation of the common components of a large panel of data; and, second, the identification of a limited number of structural shocks that explain the common components of the variables of interest. In brief, the estimation procedure requires the following:

- Use of a large panel of data fulfilling the condition that the number of time series is "much larger" than the number of observations (in a sense to be made clear below);
- Decomposition of each time series into two unobserved parts: a common component, driven by shocks common to all series, and an idiosyncratic component;

[2] SACU – the South African Customs Union – comprises South Africa, Botswana, Lesotho, Namibia and Swaziland. COMESA – the Common Market for Eastern and Southern Africa – includes Angola, Burundi, Comoros, DRC, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Seychelles, Sudan, Rwanda, Swaziland, Uganda, Zambia, and Zimbabwe. The EAC comprises Kenya, Tanzania, and Uganda.

- Writing of the series' common components as a VAR of low order (often of order one) to represent the reduced form of the model;
- Estimation of the VAR to obtain the coefficients matrix and the reduced-form residuals.
- Orthogonalization of these residuals to obtain the impulse-response functions and forecast error variances;
- Assuming that the orthogonalized residuals are linearly correlated to a vector of "fundamentals" driving the variable of interest via a matrix such that the first shock explains as much as possible of the forecast error variance of the common components; the second one explains as much as possible of the remaining variance, and so on;
- Computation of the impulse-response functions and the variance decomposition of the first few principal component shocks (e.g., the first two, neglect others);
- Recovery of the *structural shocks* that explain the principal component shocks by rotating a matrix such that orthogonal structural shocks produce impulse responses satisfying a set of economically meaningful (sign) restrictions; and
- Construction of confidence intervals for the impulse responses using bootstrapping so as to account for biases in the VAR coefficients and the agnostic nature of the model.

The estimation procedure is explained in detail below. The reader not interested in technical details can skip the remainder of this section.

4.1 The Model

This paper uses a large dimensional approximate dynamic factor model. This paper uses the static factor model of Stock and Watson (1998 and 2002). This model is closely related to the traditional factor models of Sargent and Sims (1977) and Geweke (1977), except that it admits the possibility of serial correlation and weak cross-sectional correlation of idiosyncratic components, as in Chamberlain (1983) and Chamberlain and Rothschild (1983). Similar models have recently been used by Giannone, Reichlin, and Sala (2002), Forni and others (2005), and Eickmeier (2007).

The intuition behind the approximate dynamic factor model analysis is simple. A vector of time series $Y_t = (y_{1t}, y_{2t}, \ldots, y_{Nt})$ can be represented as the sum of two latent components, a common component $X_t = (x_{1t}, x_{2t}, \ldots, x_{Nt})'$and an idiosyncratic component $\Xi_t = (\varepsilon_{lt}, \varepsilon_{2t}, \ldots, \varepsilon_{Nt})'$.

$$Y_t = X_t + \Xi_t \tag{1}$$

$$Y_t = CF_t + \Xi$$

where $F_t = (f_{lt}, f_{2t}, \ldots, f_{rt})'$is a vector of r common factors and $C = (c_1', c_2', \ldots, c_N')'$ is a Nxr matrix of factor loadings, with $r << N$. The common component X_t, which is a linear combination of common factors, is driven by a limited number of common shocks, which are the same for all variables. Nevertheless, the effects of the common shocks differ from one variable to another due to different factor loadings. In this framework and in contrast to standard common component analysis, the idiosyncratic component is driven by idiosyncratic shocks, which are specific to each variable. The static factor model used here differs from the dynamic factor model in that it treats

lagged or dynamic factors F_t as additional static factors. Thus, common factors include both lagged and contemporaneous factors.

Identification of the common components requires the number of series to be much larger than the number of observations. Stock and Watson demonstrate that by using the law of large number (as $T, N \longrightarrow \infty$), the idiosyncratic component, which is weakly correlated by construction, vanishes; and therefore, the common component can be easily estimated in a consistent manner by using standard principal component analysis. The first r eigenvalues and eigenvectors are calculated from the variance-covariance matrix $cov(Y_t)$.

$$X_t = VV'Y_t \tag{2}$$

and since the factor loadings $C = V$, Equation (1) becomes,

$$F_t = V'Y_t \tag{3}$$

From (1), the idiosyncratic component is

$$\Xi_t = Y_t - X_t \tag{4}$$

From all the more or less formal criteria to determine the number of static factors r, Bai and Ng (2002) information criteria were selected. As in Forni and others (2005), F_t was approximated by an autoregressive representation of order one[3] :

$$F_t = BF_{t-1} + u_t \tag{5}$$

where β is a $r\ xr$ matrix and u_t a $r\ x\ t$ vector of residuals. Equation (5) is the reduced form model of (1). For details on the economic conditions for identification, see Appendix A.

5 Data and Estimation Technique

5.1 Data Discussion

This paper uses large panel data containing 277 quarterly series ($N = 277$) of the United States, aggregate series of the European Monetary Union (EMU), the United Kingdom, and South Africa; observed from 1985Q1 to 2003Q4 ($T = 75$). In addition, a set of global variables such as crude oil prices and commodity industrial inputs price index is included. The dataset contains real and nominal variables: for example, GDP, consumption, investment and prices; as well as the external side of each country. Furthermore, the panel also comprises portfolio flows and FDI flows, financial variables and confidence indices. Most of series are taken from the International Financial Statistics (IFS) of the International Monetary Fund and the OECD statistics.

To evaluate the dynamics of integration, the study is conducted on a shorter sample period including the same quarterly series. This new sample contains observations for the period 1995Q1-2003Q4. This choice coincides with the new era in South African economy symbolized by the end of apartheid. The comparison of these two periods will indicate as to whether the degree of synchronization has increased over time.

[3] VAR(1) provides a dynamic representation, which is parsimonious and quite general when its order is at most equal to the number of factors (for more details, see Gianonne et al., 2002, and Stock and Watson, 2005).

Outliers are removed and all series are transformed into natural logarithms, except those in percentages and with negative values. All series are seasonally adjusted and covariance stationary. The more powerful DFGLS test of Elliott, Rothenberg, and Stock (1996), instead of the most popular ADF test, is used to assess the degree of integration of all series. All nonstationary series are made stationary through differencing and/or deterministic detrending. The Schwarz information criterion is used in the selecting the appropriate lag length in such a way that no serial correction is left in the stochastic error term. Where there were doubts about the presence of unit root, the KPSS test proposed by Kwiatowski, Phillips, Schmidt, and Shin (1992), with the null hypothesis of stationarity, was applied. All series are standardized to have a mean of zero and a constant variance. The Appendix B to this paper contains details about the statistical treatment of all data.

5.2 Estimation

As discussed earlier in this section 4, the first step of dynamic factor modeling is the determination of the number of factors to include. In the absence of a formal statistical procedure to determine the number of factors, there are two methods that are mostly used: the Bai and Ng (2002) approach and the static principal component method. Following Bai and Ng (2002), there is no consensus as to the choice of the number of factors to include. PC_{p1} suggests six factors, while PC_{p2}, and PC_{p3} propose five and eight factors, respectively. Furthermore, according to the IC_{p1} and IC_{p2} criteria, three factors are optimal, while IC_{p3} proposes five factors. Importantly, Bai and Ng (2002) suggest that IC_{p1} and IC_{p2} are more robust than PC_{p1} and PC_{p2}. We propose four factors based on static principal component analysis. Table 1 reports cumulated variance share by 10 principal components. Using the principal component approach, the first four principal components explain 31 percent of the total variance. The variance explained by the additional principal component is less than five percent benchmark. These results differ somewhat from Kabundi and Nadal De Simone (2007), and Eickmeier (2007), who suggest five and eight common factors, respectively, for the US market. One possible explanation of such difference is our restricted sample size.

Following the identification procedure of Uhlig (2003) on the common component of US GDP, a reduced number of structural shocks that maximizes the explanation of its forecast error variance over 20 periods is computed. It results in the identification of only two structural shocks which explain 96 percent of the forecast error variance of the common component of US GDP. In the reduced sample, the percentage remains the same, it drops to 89.

To avoid commonly used zero restrictions, which are sometimes very restrictive, the study uses sign restrictions proposed by Peersman (2005). This method imposes sign restrictions on impulse-response functions based on a typical aggregate-demand, aggregate-supply diagram. To account for uncertainty in the factor estimation, a bootstrap technique based on Kilian (1998) is implemented, which is necessary in constructing confidence bands. The paper uses a 90 percent confidence interval. However, in most cases confidence intervals seem wider. The draws recover a set of shocks that satisfy the restrictions. In total the bootstrap was made up of 500 shocks.[4]

[4] 510 draws were needed.

6 Empirical Results

6.1 US Shocks

A bivariate analysis as depicted in Figure 1 shows the comovement of GDP growth rates of South Africa and the US, with the US leading. The two countries experienced a downturn in the beginning of 1990s. The South African recession was deeper and long-lived. The only difference in the cycle occurs in 1997. This was caused by the Asian crisis, which did not affect most of the advanced economies. In addition, it shows a relative strong comovement with the South African growth rate and the common component. However, the bivariate analysis does not provide a complete picture of the synchronization of cycles. It is silent as to whether the South African cycle is influenced by the US cycle. It is essential to use a more advanced technique that can simultaneously assess different channels of transmission underpinning synchronization of cycles between South Africa and the US.

A Structural VAR approach is not appropriate in this instance as it does not incorporate a large panel of time series due to the degree-of-freedom constraint. Instead, the paper uses a structural dynamic factor model, which is quite similar to the above approach, with the main difference that the latter accommodates large a cross-section of time series. As with the SVAR, the structural dynamic factor model uses impulse-response functions and variance decomposition to study the impact of shocks across countries. Tables 2 and 3 show the variance decomposition and the forecast error variance of the common components of US and South African variables explained by the two identified US shocks. On the other hand, Figure 2 depicts the impulse-response functions of the U.S. shocks and their impact on US and South African variables.

Following Uhlig (2003), the model extracts the two identified shocks that explain as much as possible of forecast error variance of the common component of US GDP. The US GDP represents economic activity in the United States. Kabundi and Nadal De Simone (2007), Eickmeier (2007), and Uhlig (2003) also find that two shocks explain an important portion of variation in the US GDP. Table 2a indicates that the two shocks explain 96 percent of forecast error variance of the common component of US GDP for both the full sample period, and it drops to 89 percent for the reduced sample. The identified supply shocks account for 47 percent of the error variance of the common component of the US GDP over five years, while the demand shocks account for 49 percent. The variance share of US GDP explained by the common component is 50 percent for the full-sample period; it increases to 71 percent for the reduced-sample period.[5] In addition, the percentage explained by supply shocks increases to 54 percent, and demand shocks explain only 35 percent of the error variance. From Table 2a it is evident that private investment, employment, capacity utilization, short-term interest rates, and exports score higher variance, which is explained by the common component for the full-sample period. Of these, the supply shocks seem to affect personal consumption expenditure and consumer confidence more. This is in line with what is discussed above, i.e. consumer confidence tends to affect primarily consumer behaviour. Demand shocks have strong effects on private investment, capacity utilization, short- and long-term interest rates, M1 money supply, stock prices, wages, exports, imports, real effective exchange rates, and inward FDI.

The picture is somewhat different for the period 1995-2003. Table 3a shows that most variables have higher variance shares of the common components. This time, private investment, personal consumption expenditure, government disbursements, stock prices, and outflow of FDI react more

[5] See Table 3a

to supply shocks. These can be seen as productivity shocks that affected the American economy in the 1990s. In turn, demand shocks influence only consumer confidence, business confidence, and the real effective exchange rates.

From Figure 2 it is clear that supply shocks are productivity-driven, i.e. positive supply shocks from the US increase productivity permanently. There is also a permanent rise in output, investment, personal consumption expenditure; capacity utilization decreases and employment rises slowly. Consumer confidence reacts positively, while the impact on business confidence is somewhat opposite to expectations. Share prices also react favourably. The effect on prices is negative, pushing monetary authorities to decrease interest rates initially and increase them later in reaction to wage increases.[6] The rise in the money supply is short-lived. The effect on imports is stronger than on exports, resulting in current account deficit. Positive supply shocks attract more FDI into the country, while the effects on terms of trade and real effective exchange rates seem mild.

Effects of demand shocks on output, investment, personal consumption expenditure, productivity, and consumer confidence are short-lived. Conversely, they have a long-term positive impact on capacity utilization, prices, wages and share prices. Monetary authority increases short-term interest rates as a reaction to increases in prices and wages. Exports and imports are on the rise, but imports increase more than exports, leading to a current account deficit. Finally, demand shocks encourage inflows and outflows of foreign investments.

6.2 Transmission of US Shocks to South Africa

This section studies South African reaction to US shocks. Table 2b depicts the variance share by the common component and forecast error variance explained by US supply and demand shocks. The full-sample analysis displays a variance share of common component of the South African economic growth of 54 percent; which suggests a close synchronization of the two economic cycles. The transmission channels that matter are consumer and business confidence, consumer prices, short- and long-term interest rates, and real effective exchange rates, with relatively high variance share of common components. It is evident that except for consumer and business confidence, financial channels seem more important than trade channels.

US supply shocks are transmitted more forcefully to South African GDP than US demand shocks. US supply shocks explain 29 percent of the error variance of South African GDP common components while US demand shocks explain 2 percent. Only imports of goods and services, and business confidence matter for transmission of supply shocks. However, almost all channels matter for the transmission of demand shocks. Demand shocks explain 56 percent and 85 percent of error variance of South African short- and long-term interest rates, respectively; while supply shocks explain 33 percent and 6 percent. The percentage of error variance explained by stock prices is 21 percent for demand shocks as against 0 percent for supply shocks. While demand shocks explain only 14 percent of error variance of imports, they explain 77 percent of error variance of exports, in contrast to 3 percent for supply shocks. Lastly, the real effective exchange rate serves as a demand than a supply channel, scoring the error variance of 80 percent, as against 3 percent for supply shocks.

Alongside the analysis of variance decomposition, impulse-response functions in Figure 2 provide a picture of transmission channels of US shocks to South Africa. US supply shocks are transmitted

[6] Surprisingly, the short- and long-term interest rates display unusual behavior after a supply shock; they stay high after a gradual increase and do not come back to the baseline. Several attempts to achieve a response in line with theoretical models were not successful.

gradually but permanently to the South African economic growth rate, output, investment, personal consumption expenditure, and government expenditure. Impulse-response functions have negative effects on consumer and business confidence; but these effects are statistically insignificant. CPI and ULC decrease at the moment of the shock, putting pressure on monetary authorities to reduce short-term interest rates. Furthermore, US supply shocks are favourable to South African imports of goods and services. The effects on exports, terms of trade, real effective exchange rates, and the current accounts are statistically insignificant.

Against the above, US demand shocks have immediate but short-lived impacts on economic growth rate, output, investment, personal consumption expenditure, and government expenditure. Consumer and business confidence react positively. There is a gradual increase in CPI and M1 money supply, leading to a slow increase in short-term interest rates. Share prices increase immediately after the shock and remain high. Similarly, imports increase on impact, while exports increase steadily. Consequently, the terms of trade are favourable, the current account worsens, and the rand depreciates.

6.3 Evolution of Integration

Output and economic growth rates show a drop in their variance share of their common components, suggesting at first glance a decrease in synchronization of cycles between South Africa and the US.[7] These results are consistent with du Plessis (2006) who didn't a significant comovement with the US cycle. The drop in integration is justified by the fact that the end of apartheid brought some challenges which required political and economic reforms. The first democratic government embarked in pro-poor reforms based on redistribution of resources to correct the wrong doing of the past, but these reforms were less popular to most businesses. The reason was that the reconstruction and development policy (RDP) was demand-led with high government expenditure, which in turn put high pressure on prices, resulting in high inflation. Thus, the first round of reforms did little to stimulate the economy. The second democratic government initiated further economic reforms that were this time market friendly, focusing on stimulating growth through trade and financial openness, fiscal discipline and sound monetary policy. During this period the country experienced its first ever long expansionary period. Yet, these reforms were still not enough to achieve an economic growth necessary to solve the numerous problems the country is facing. Also the economic performance is still lagging behind other emerging economies of Latin America or Asia. For the last eight years the average GDP growth rate was 3.7 percent. Hence, the decrease in synchronization indicates a catching-up process of the South African economy due to structural reforms – such as a new monetary regime, openness of trade and capital markets, increase in political stability and reduced uncertainty, all of which the country initiated after the end of apartheid. These factors outweigh the increase in comovement of South Africa GDP with the US.

For this latter period, consumer confidence and business confidence play important as channels of transmission of shocks. Sentiments of economic agents about the current and the future state of the economy in US affect opinions of agents in South Africa. Consumer confidence tends to influence consumption, while business confidence impacts investment. Furthermore, the new monetary regime advocating a freely floating exchange rate associated with a gradual liberalization of capital markets, influences interest rates and exchange rates, and stock prices more than in the past, making the South African capital market more integrated in the world financial market. On the other hand,

[7] See variance shares of common component in Table 3b.

the role played by trade openness seems small, even though the variance shares of imports and exports show a small increase.

US supply shocks are forcefully transmitted to South Africa via consumer and business confidence – with error variance shares of 36 percent and 57 percent, respectively. Moreover, stock prices and real effective exchange rates also have higher error variance of supply shocks – 28 percent and 16 percent – compared to the error variance of demand shocks of 6 percent and 0 percent, respectively. On the other hand, demand shocks are transmitted through exports and imports of goods and services.

7 Conclusion

This paper studies the synchronization of economic variables between South Africa and the US. In addition it examines transmission channels through which supply and demand shocks from the US affect economic activity in South Africa. First, the bivariate analysis shows evidence of synchronization of South African economic growth with that of the US. Second, the structural dynamic factor model applied to a large panel of economic variables extracts the common components of all series. From this analysis, it emerges that the South African growth rate and its common component comove, suggesting a synchronization of output growth. The variance share of common component obtained from the multivariate analysis shows variation in the domestic growth, and this is explained somewhat by the common component. Furthermore, the variance shares of the common components reveal consumer and business confidence, consumer prices, short- and long-term interest rates, and real effective exchange rate are the main channels of transmission of shocks.

This study also finds, using the full-sample period that US supply shocks are transmitted to South Africa through business confidence and imports of goods and services, while U.S. demand shocks are transmitted via interest rates, stock prices, exports of goods and services, and real effective exchange rates. This paper also indicates a decrease in integration over time as the common component of GDP drops in the reduced sample. The reduced-sample analysis reveals that channels of transmission change, due to the structural reforms the country undertook after apartheid was eliminated. Most importantly, the new monetary policy, advocating a more flexible exchange rate regime, trade openness, and liberalization of capital markets, has made the country more vulnerable to external shocks, increasing the weight of some channels of transmission, such as interest rates and exchange rates. Hence, for this latter period, the South African capital market is more integrated in the world financial market. On the contrary, trade liberalization has not yet played a significant part in the integration process.

Given these findings, and because of the vulnerability of the economy to shocks from the US, South African policymakers should closely monitor developments in the US economy. Failure to do this would make the domestic policy ineffective. However, the idiosyncratic component still plays an important role in the South African economy. Structural reforms are crucial to make the domestic economy competitive internationally.

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Table 1: Determining r

k	*PCp1*	*PCp2*	*PCp3*	*ICp1*	*ICp2*	*ICp3*	Cumulated Variance Share
1	0.9090	0.9110	0.9033	-0.0644	-0.0603	-0.0759	0.11
2	0.8565	0.8605	0.8452	-0.0993	-0.0911	-0.1223	0.20
3	0.8346	0.8406	0.8176	-0.1035*	-0.0913*	-0.1381	0.26
4	0.8198	0.8277	0.7971	-0.1032	-0.0870	-0.1493	0.31
5	0.8069	0.8169*	0.7787	-0.1049	-0.0846	-0.1626*	0.35
6	0.8061*	0.8180	0.7721	-0.0919	-0.0676	-0.1611	0.39
7	0.8090	0.8229	0.7694	-0.0757	-0.0472	-0.1563	0.42
8	0.8136	0.8296	0.7684*	-0.0591	-0.0266	-0.1513	0.45
9	0.8211	0.8391	0.7702	-0.0399	-0.0034	-0.1437	0.48
10	0.8299	0.8498	0.7733	-0.0208	0.0198	-0.1361	0.50

Note: *denotes the minimum based on Bai and Ng (2002) criteria

Table 2a. Forecast Error Variance of the Common Component of USA Variables Explained by the USA Supply and the Demand Shock, 1985-2003 1/

	Variance Shares of the Common Components	Supply Shocks	Confidence Intervals		Demand Shocks	Confidence Intervals	
			Lower Bound	Upper Bound		Lower Bound	Upper Bound
GDP	0.50	0.47	0.06	0.85	0.49	0.10	0.78
Private investment	0.73	0.19	0.01	0.75	0.60	0.07	0.81
Personal consumption expenditure	0.25	0.65	0.07	0.90	0.04	0.03	0.45
Employment	0.59	0.34	0.01	0.76	0.43	0.11	0.86
Productivity	0.17	0.28	0.02	0.85	0.02	0.01	0.49
Capacity Utilization	0.79	0.02	0.00	0.26	0.95	0.43	0.96
Government current disbursements	0.14	0.15	0.00	0.76	0.11	0.01	0.39
Government current receipts	0.20	0.07	0.01	0.57	0.86	0.36	0.96
Consumer confidence	0.09	0.50	0.04	0.88	0.08	0.03	0.35
Business confidence	0.11	0.10	0.03	0.73	0.14	0.01	0.51
Consumer prices	0.43	0.22	0.02	0.81	0.36	0.01	0.70
Short-term interest rates	0.59	0.09	0.01	0.56	0.84	0.33	0.96
Long-term interest rates	0.24	0.06	0.01	0.44	0.75	0.24	0.95
M1	0.51	0.01	0.02	0.47	0.55	0.04	0.76
Stock prices	0.12	0.00	0.00	0.44	0.82	0.11	0.86
Wages	0.42	0.05	0.01	0.53	0.93	0.36	0.96
Exports total	0.51	0.02	0.00	0.49	0.71	0.19	0.95
Imports total	0.41	0.26	0.04	0.77	0.64	0.10	0.85
Terms of trade	0.09	0.06	0.01	0.69	0.05	0.02	0.66
Real effective exchange	0.38	0.02	0.00	0.66	0.43	0.00	0.47
Current account balance	0.16	0.34	0.02	0.86	0.14	0.03	0.46
FDI out	0.01	0.02	0.02	0.51	0.12	0.01	0.65
FDI in	0.04	0.08	0.02	0.63	0.85	0.13	0.89

1/ Forecast horizon is 20 quarters and refers to the levels of the series. Confidence intervals are constructed using Kilian's (1998) bootstrapping technique

Table 2b. Forecast Error Variance of the Common Component of South Africa Variables Explained by the USA Supply and the Demand Shock, 1985-2003 1/

	Variance Shares of the Common Components	Supply Shocks	Confidence Intervals		Demand Shocks	Confidence Intervals	
			Lower Bound	Upper Bound		Lower Bound	Upper Bound
GDP	0.17	0.29	0.02	0.69	0.02	0.01	0.42
Gross Fixed Investment	0.12	0.05	0.01	0.50	0.28	0.02	0.66
Personal consumption expenditure	0.02	0.16	0.01	0.63	0.49	0.08	0.86
Government consumption expenditure	0.01	0.21	0.03	0.83	0.50	0.02	0.54
Consumer confidence	0.38	0.02	0.02	0.52	0.01	0.01	0.56
Business confidence	0.42	0.13	0.02	0.54	0.04	0.01	0.52
Consumer prices	0.60	0.08	0.00	0.65	0.01	0.00	0.34
Short-term interest rates	0.49	0.33	0.03	0.80	0.56	0.01	0.53
Long-term interest rates	0.38	0.06	0.01	0.50	0.85	0.10	0.84
M1	0.04	0.24	0.01	0.61	0.39	0.09	0.84
Stock prices	0.07	0.00	0.00	0.56	0.21	0.02	0.63
Unit Labour Cost	0.24	0.14	0.00	0.72	0.01	0.00	0.34
Exports total	0.01	0.03	0.01	0.45	0.77	0.09	0.85
Imports total	0.01	0.82	0.08	0.91	0.14	0.05	0.62
Terms of trade	0.34	0.00	0.00	0.56	0.14	0.02	0.65
Real effective exchange	0.62	0.03	0.00	0.37	0.80	0.08	0.80
Current account balance	0.13	0.02	0.00	0.33	0.89	0.18	0.87
Economic growth	0.54	0.12	0.01	0.55	0.06	0.01	0.54

1/ Forecast horizon is 20 quarters and refers to the levels of the series. Confidence intervals are constructed using Kilian's (1998) bootstrapping technique

Table 3a. Forecast Error Variance of the Common Component of USA Variables Explained by the USA Supply and the Demand Shock, 1995-2003 1/

	Variance Shares of the Common Components	Supply Shocks	Confidence Intervals		Demand Shocks	Confidence Intervals	
			Lower Bound	Upper Bound		Lower Bound	Upper Bound
GDP	0.71	0.54	0.01	0.76	0.35	0.11	0.96
Private investment	0.70	0.63	0.01	0.79	0.11	0.02	0.90
Personal consumption expenditure	0.24	0.68	0.01	0.81	0.05	0.03	0.88
Employment	0.57	0.30	0.02	0.58	0.02	0.03	0.78
Productivity	0.61	0.36	0.02	0.71	0.48	0.04	0.74
Capacity Utilization	0.94	0.13	0.00	0.71	0.02	0.00	0.78
Government current disbursements	0.24	0.70	0.01	0.87	0.02	0.01	0.83
Government current receipts	0.25	0.03	0.01	0.61	0.01	0.01	0.76
Consumer confidence	0.16	0.19	0.01	0.45	0.70	0.16	0.93
Business confidence	0.19	0.02	0.01	0.67	0.73	0.04	0.81
Consumer prices	0.42	0.44	0.01	0.63	0.03	0.01	0.44
Short-term interest rates	0.67	0.20	0.01	0.58	0.26	0.07	0.86
Long-term interest rates	0.18	0.27	0.01	0.53	0.34	0.09	0.87
M1	0.37	0.01	0.01	0.70	0.01	0.01	0.65
Stock prices	0.43	0.58	0.01	0.86	0.02	0.01	0.84
Wages	0.80	0.49	0.02	0.74	0.02	0.02	0.83
Exports total	0.64	0.08	0.01	0.61	0.22	0.04	0.81
Imports total	0.55	0.41	0.01	0.69	0.12	0.04	0.84
Terms of trade	0.45	0.18	0.01	0.58	0.16	0.01	0.54
Real effective exchange	0.17	0.03	0.01	0.75	0.75	0.01	0.55
Current account balance	0.28	0.01	0.01	0.63	0.02	0.01	0.53
FDI out	0.15	0.49	0.01	0.78	0.27	0.01	0.55
FDI in	0.16	0.14	0.01	0.73	0.21	0.01	0.65

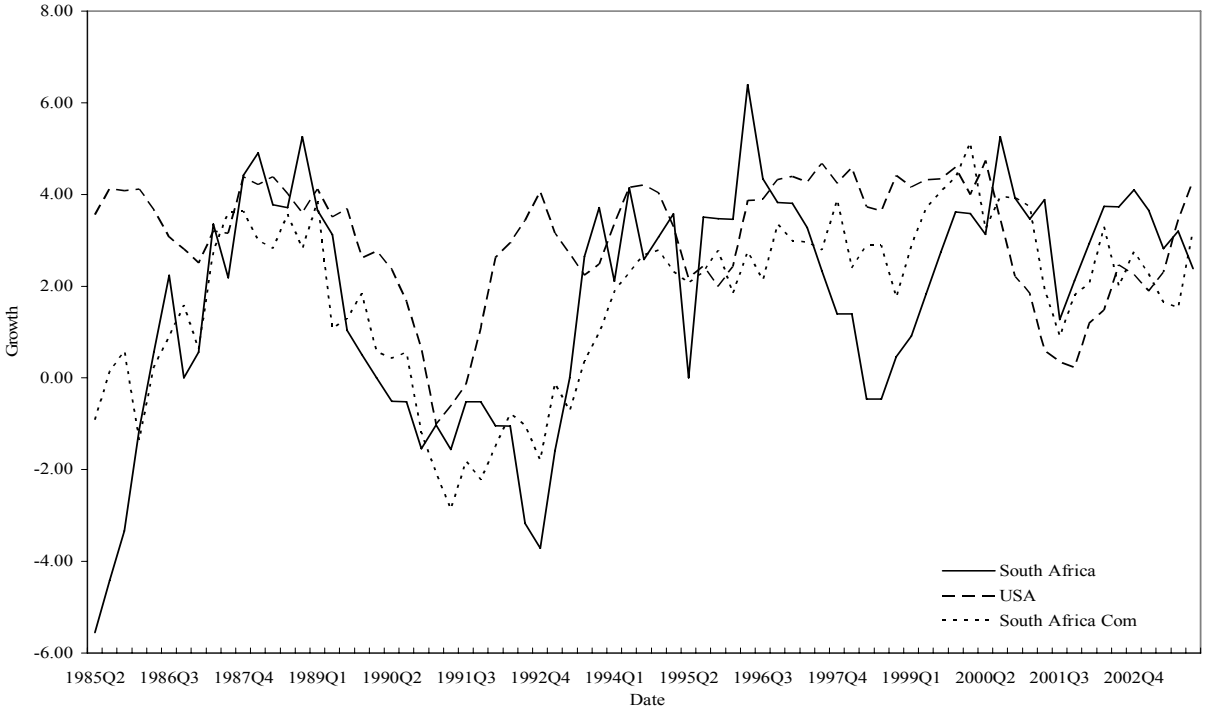
1/ Forecast horizon is 20 quarters and refers to the levels of the series. Confidence intervals are constructed using Kilian's (1998) bootstrapping technique

Table 3b. Forecast Error Variance of the Common Component of South Africa Variables Explained by the USA Supply and the Demand Shock, 1995-2003 1/

	Variance Shares of the Common Components	Supply Shocks	Confidence Intervals		Demand Shocks	Confidence Intervals	
			Lower Bound	Upper Bound		Lower Bound	Upper Bound
GDP	0.05	0.17	0.01	0.67	0.02	0.01	0.51
Gross Fixed Investment	0.13	0.30	0.01	0.74	0.30	0.01	0.58
Personal consumption expenditure	0.18	0.04	0.01	0.73	0.79	0.03	0.81
Government consumption expenditure	0.09	0.34	0.01	0.87	0.60	0.01	0.62
Consumer confidence	0.50	0.36	0.01	0.68	0.02	0.01	0.71
Business confidence	0.58	0.57	0.01	0.69	0.04	0.01	0.71
Consumer prices	0.25	0.50	0.01	0.72	0.23	0.02	0.67
Short-term interest rates	0.55	0.29	0.01	0.77	0.03	0.00	0.75
Long-term interest rates	0.60	0.02	0.00	0.65	0.04	0.01	0.75
M1	0.05	0.19	0.01	0.77	0.01	0.01	0.68
Stock prices	0.11	0.28	0.02	0.64	0.06	0.01	0.61
Unit Labour Cost	0.14	0.48	0.02	0.64	0.03	0.01	0.45
Exports total	0.04	0.21	0.01	0.67	0.22	0.04	0.88
Imports total	0.19	0.02	0.01	0.66	0.29	0.01	0.60
Terms of trade	0.30	0.33	0.01	0.84	0.02	0.01	0.63
Real effective exchange	0.69	0.16	0.01	0.83	0.00	0.00	0.78
Current account balance	0.50	0.08	0.01	0.76	0.03	0.01	0.78
Economic growth	0.42	0.33	0.01	0.62	0.03	0.01	0.51

1/ Forecast horizon is 20 quarters and refers to the levels of the series. Confidence intervals are constructed using Kilian's (1998) bootstrapping technique

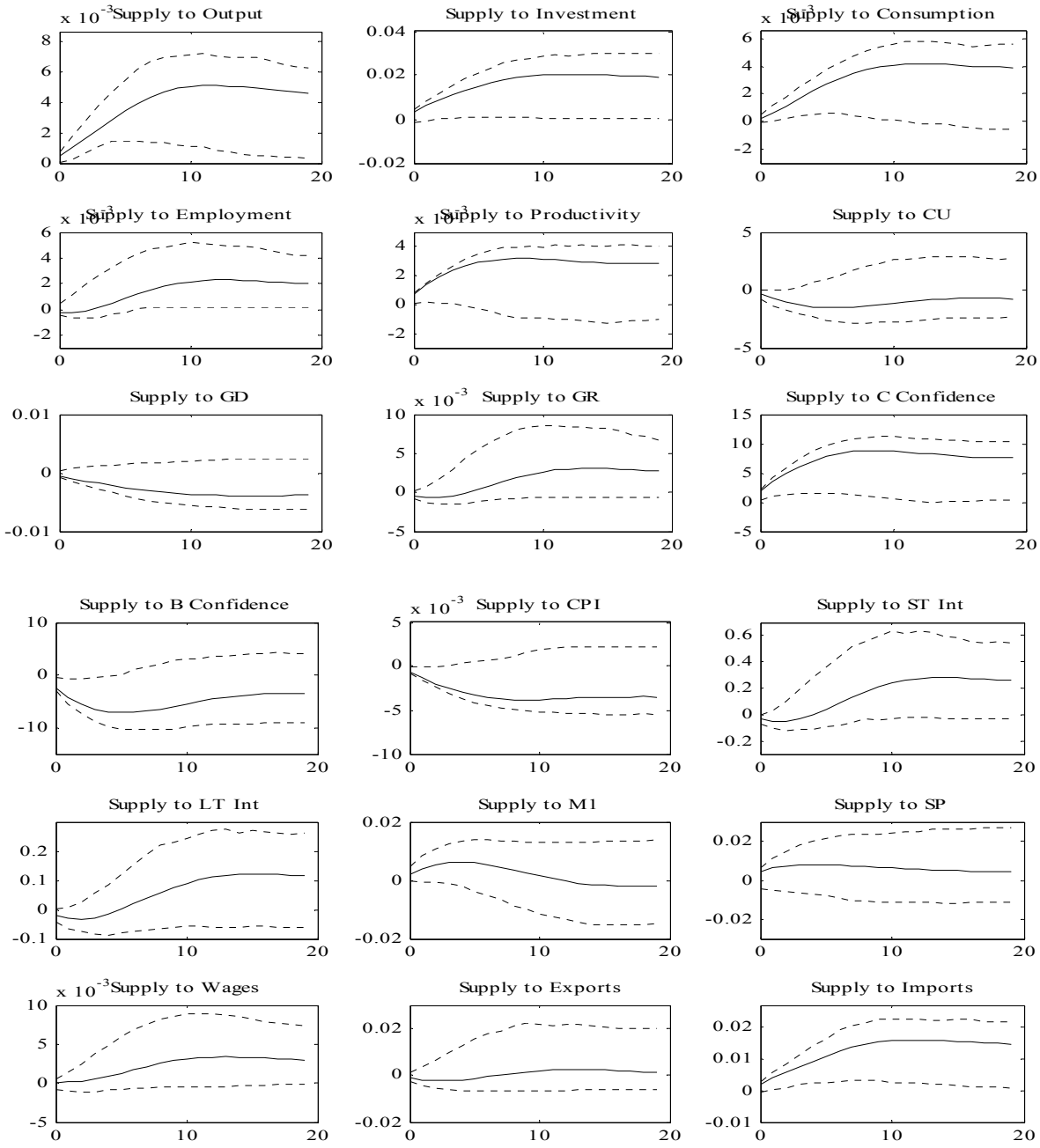
Figure 1: Economic Growth Rates – South Africa, the US, Common Component

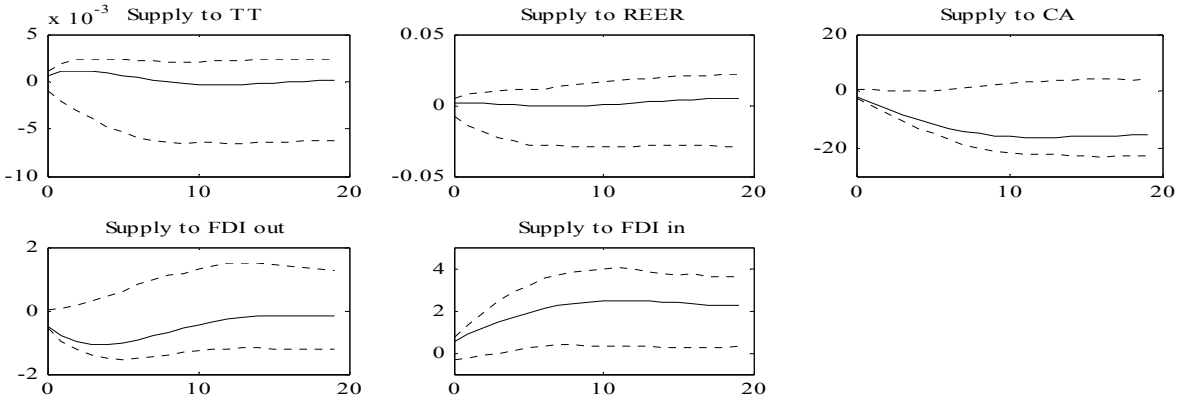


Source: OECD and IFS, Author calculations

Figure 2: Impulse-Response Functions – Sample 1985-2003

USA Supply Shock → USA Variables

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Supply to REER
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Supply to CA
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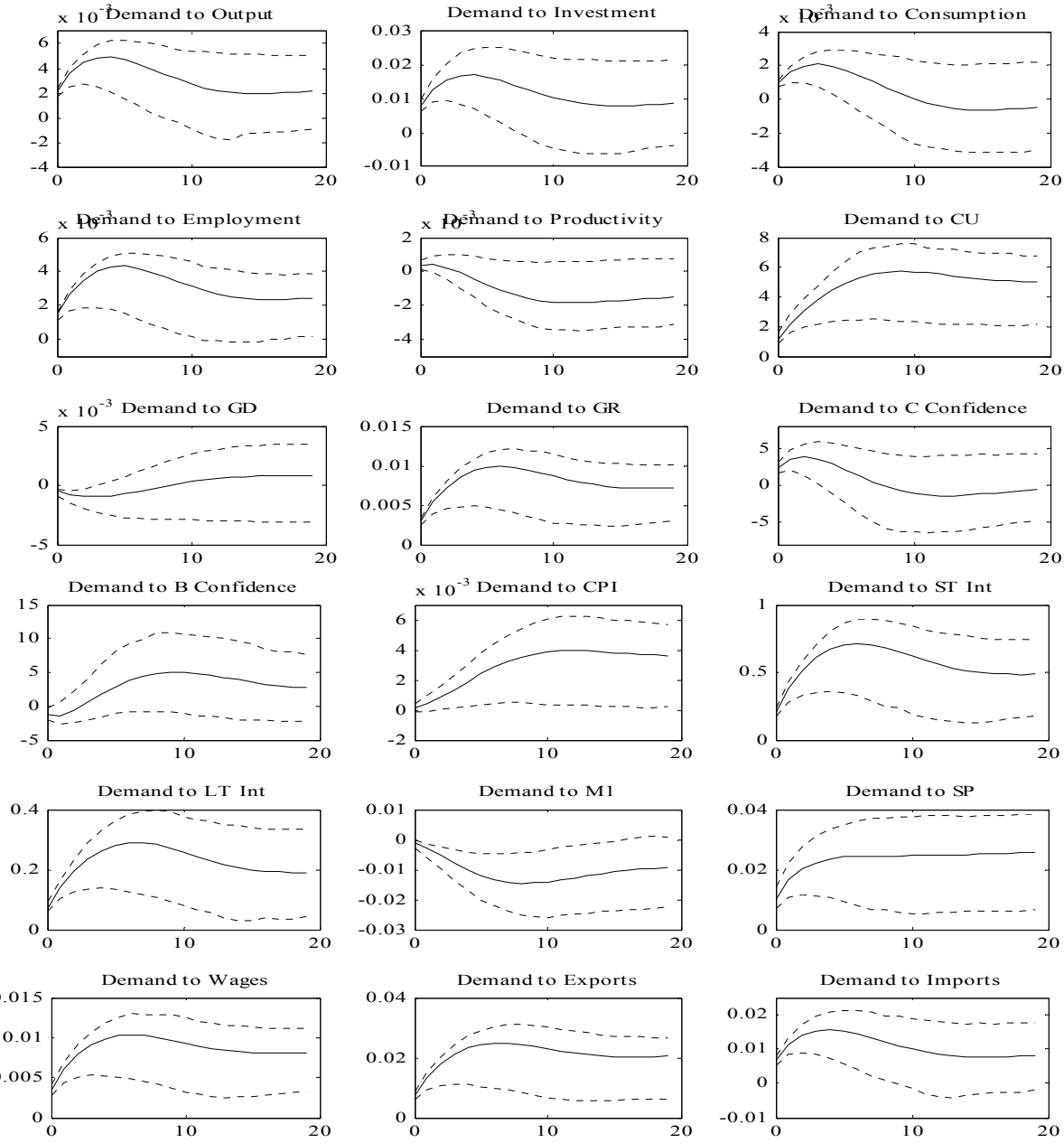
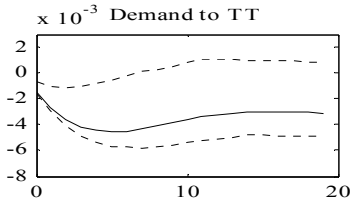
10
20
Supply to FDI out
2
0
-2
0
10
20
Supply to FDI in
4
2
0
0
10
20

USA Demand Shock → USA Variables




x 10^-3 Demand to TT
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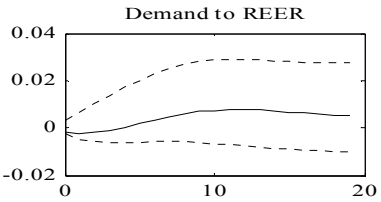
0
-2
-4
-6
-8
0
10
20


Demand to REER
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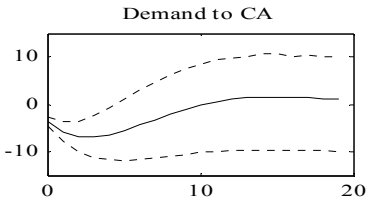
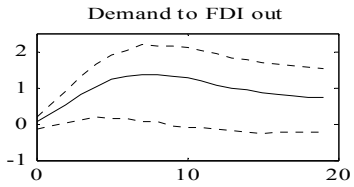
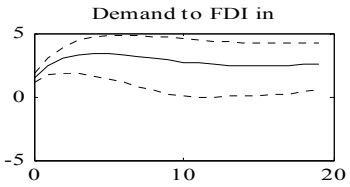
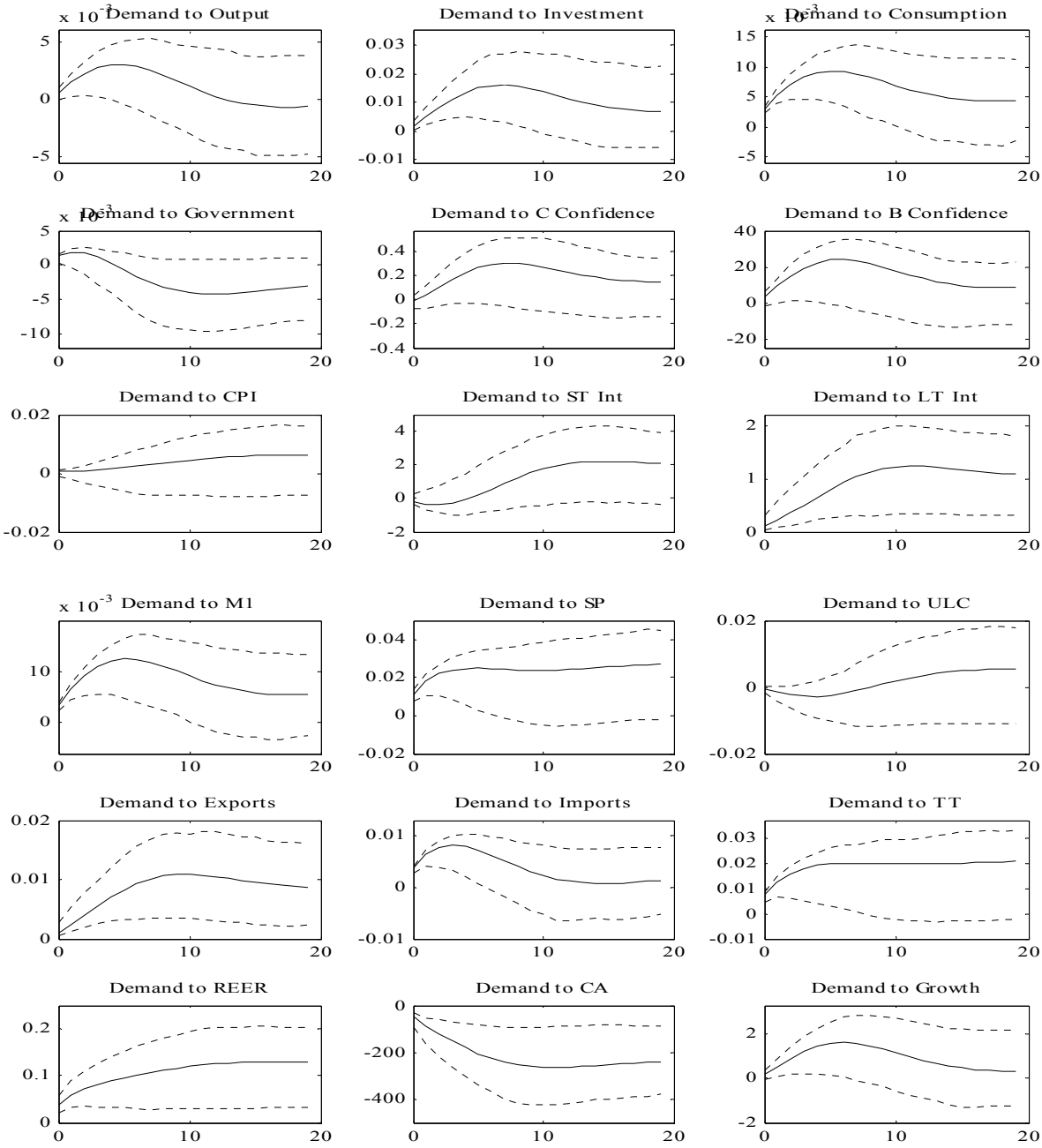
0.02
0
-0.02
0
10
20


Demand to CA
10
0
-10
0
10
20


Demand to FDI out
2
1
0
-1
0
10
20


Demand to FDI in
5
0
-5
0
10
20

USA Demand Shock → South Africa Variables



Appendix A

Economic conditions for identification

Once the process followed by the common components is postulated, structural shocks have to be identified. The identification of structural shocks is achieved by focusing on the reduced form VAR residuals of (5). Following Eickmeier (2007), the identification scheme has three steps. First, as in Uhlig (2003), rather than identifying a shock as, say, a productivity shock, and calculate its contribution to the variance of the *k*-step ahead prediction error of, say, US GDP, a few major shocks driving GDP are identified.[1] This implies maximizing the explanation of the chosen variance of the *k*-step ahead forecast error of GDP with a reduced number of shocks.[2] To this end, k-step ahead prediction errors u_t are decomposed into k mutually orthogonal innovations using the Cholesky decomposition. The lower triangular Cholesky matrix A is such that $u_t = Av_t$ and $E(v_t v_t') = I$. Hence,

$$\text{cov}(u_t) = AE(v_t v_t')A' = AA'. \tag{A.1}$$

Next, impulse-response functions are calculated. Following the example in which the variable of interest is US GDP, the impulse-response function of y_{it} in period k to the identified shock is obtained as follows:

$$R_{ik} = c_i B^k A \tag{A.2}$$

[1] Uhlig (2003) shows that two shocks are sufficient to explain 90 percent of the variance at all horizons of real US GNP.

[2] If, for example, two orthogonal shocks are identified, it is incorrect to identify the first shock as the one corresponding to the first eigenvalue and the second orthogonal shock as the one corresponding to the second eigenvalue (see Uhlig, 2003). The two orthogonal shocks identified *together* generate the total variation, the explanation of which is being maximized. However, there are multiple possible combinations of those orthogonal shocks all of which will still explain the total variation chosen: as an illustration, and measuring angles in degrees, the pairings of orthogonal shocks with rotation angles {0,90} or {10,100} or {80,170} would be equally acceptable. The grid of the angle of rotation can be different, of course. Hence, the number of possibilities is vast. This study uses a grid of 30 degrees.

with c_i the *ith* row of factor loadings of C and with a corresponding variance-covariance matrix $\sum_{j=0}^{k} R_{ij} R_{ij}'$.

Second, suppose that an identified shock is linearly correlated to the fundamental forces $\omega_t = (\omega_{1t}, \omega_{2t}, ..., \omega_{rt})'$ behind US GDP, through the $r \times r$ matrix Q. Thus,

$$v_t = Q\omega_t . \tag{A.3}$$

The identification procedure involves maximizing the forecast error variance of the variable of interest. The intuition of the procedure is to select Q in such a way that the first shock explains as much as possible of the forecast error variance of the U.S. GDP *common component* over a certain horizon k, and the second shock explains as much as possible of the remaining forecast error variance. Focusing on the first shock, the task is to explain as much as possible of its error variance

$$\sigma^2(k) = \sum_{j=0}^{k} (R_{ij} q_1)(R_{ij} q_1)' \tag{A.4}$$

where i is, in our example, US GDP, and q_1 is the first column of Q. The column q_1 is selected in such a way that $q_1' \sigma^2 q_1$ is maximized, that is

$$\begin{aligned} \sigma^2(k) &= \sum_{j=0}^{k} (R_{ij} q_1)(R_{ij} q_1)' \\ &= q_1' S_{ik} q_1 \end{aligned}$$

where $S_{ik} = \sum_{j=0}^{k} (k + 1 - j) R_{ij}' R_{ij}$.

The maximization problem subject to the side constraint $q_1'q_1 = 1$, can be written as the Lagrangean,

$$L = q_1' S_{ik} q_1 - \lambda(q_1' q_1 - 1) \qquad \text{(A.5)}$$

where λ is the Lagrangean multiplier. From (A.5), q_1 is the first eigenvector of S_{ik} with eigenvalue λ and, therefore, the shock associated with q_1 is the first principal component shock. Q is the matrix of eigenvectors of S, ($q_1, q_2, \ldots, q_r$), where q_l ($l=1,...,r$) is the eigenvector corresponding to the l^{th} principal component shock. Along the lines of Uhlig (2003), Eickmeier (2007), and Altig and others (2002), it is posed: $k=0$ to $k=19$, i.e., five years, which covers short- as well as medium-run dynamics.

Orthogonal shocks are finally identified by rotation. If two shocks are identified, following Canova and de Nicoló (2003), the orthogonal shocks vector $\omega_t = (\omega_{1t}, \omega_{2t})'$ is multiplied by a 2×2 orthogonal rotation matrix P of the form:

$$P = \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix},$$

where θ is the rotation angle; $\theta \in (0, \pi)$ produces all possible rotations and varies on a grid. If θ is fixed and $q=5$, there are $q(q-1)/2$ bivariate rotations of different elements of the VAR. Following the insights of Sims (1992); and as in Peersman (2005), Canova and de Nicoló (2003), and Eickmeier (2007), the number of angles between 0 and π is assumed to be 12: this implies 6,191,736,421x10^{10} (12^{10}) rotations. Hence, the rotated factor $w_t = Pw_t$ explains in total all the variation measured by the first two eigenvalues. This way, the two principal components ω_i are associated with the two structural shocks w_i through the matrix P, and the impulse-response functions of the two structural shocks on all the fundamental forces can be estimated.

A sign-identification strategy is followed to identify the shocks. The method was developed by Peersman (2005). This strategy imposes inequality sign restrictions on the impulse-response functions of variables based on a typical aggregate demand and aggregate supply framework.[3] Only those rotations among all possible $q \times q$ rotations that have a structural meaning are chosen. The text table displays the sign restrictions for the identification of shocks that are imposed contemporaneously and during the first year after the shock.[4]

Identification Inequalities

	Positive Supply Shock	Positive Demand Shock	Monetary Policy Tightening
GDP	≥ 0	≥ 0	≤ 0
Prices	≤ 0	≥ 0	≤ 0
Interest rate	≤ 0	≥ 0	≥ 0

The variance share of the common component of South African GDP growth is used to assess the degree of integration of South Africa in the global economy, and the variance shares of the common components of other variables are used to assess the relative strengths of the channels of transmission of shocks. Moreover, the variances shares of the common components are calculated on the rates of growth of the variables whereas the variances of forecast errors are calculated on the basis of the levels of the variables. The latter is used to evaluate the relative strengths of shocks (supply or demand) on variables.

[3] See Peersman (2005) for more technical details.

[4] Note that inequalities include zero responses, some of which are usually excluded in the VAR literature. As shown by Peersman (2005), the latter may sometimes be unduly restrictive. Peersman shows, for example, that oil prices do react within one quarter to demand and monetary policy shocks. In contrast, imposing the standard contemporaneous zero restriction on oil prices make them appear as exogenous rather than as endogenous responses of an asset price to demand disturbances and monetary policy shocks.

Appendix B

Macroeconomic Series

Number	Country	Variable Name	Unit Root	Log	Treatment
1	EMU	Production in total manufacturing sa	1	l	3
2	EMU	Sales of total manufactured goods (Value) sa	1	l	3
3	EMU	Permits issued for dwellings sa	1	l	3
4	EMU	PPI Total Manufacturing - Domestic Market	1	l	3
5	EMU	Monetary aggregate M1 sa	1	l	3
6	EMU	Monetary aggregate M3 sa	1	l	3
7	EMU	MFI Credit to the non-MFI sector sa	1	l	3
8	EMU	ECU-EUR/USD exchange rate monthly average	1	l	3
9	EMU	Gross domestic product, Constant Prices	1	l	3
10	EMU	Private final consumption expenditure, Constant Prices	1	l	3
11	EMU	Government final consumption expenditure, Constant Prices	1	l	3
12	EMU	Gross fixed capital formation, Constant Prices	1	l	3
13	EMU	Exports of goods and services, Constant Prices	1	l	3
14	EMU	Imports of goods and services, Constant Prices	1	l	3
15	EMU	Gross domestic product, Implicit price deflator	1	l	3
16	EMU	Net exports of goods and services, Constant Prices	1	nl	2
17	EMU	Manufacturing - Orders inflow/Demand: tendency sa	0	nl	0
18	EMU	Manufacturing - Rate of capacity utilization sa	0	l	1
19	EMU	Changes in inventories, Constant Prices	0	nl	0
20	Japan	Balance of income, value, balance of payments basis	1	nl	2
21	Japan	Current account, value	1	nl	2
22	Japan	Government consumption of fixed capital, value	1	l	3
23	Japan	Private final consumption expenditure, volume \	1	l	3
24	Japan	Dependent employment \ Persons	1	l	3
25	Japan	Dependent employment of the business sector \ Persons	1	l	3
26	Japan	Government employment \ Persons	1	l	3
27	Japan	Self-employed \ Persons	1	l	3
28	Japan	Total employment \ Persons	1	l	3
29	Japan	Employment of the business sector \ Persons	1	l	3
30	Japan	Exchange rate, index of US$ per local currency \ Index	1	l	3
31	Japan	Real Effective exchange rate, 2000 = 100, ULC-based	1	l	3
32	Japan	Gross domestic product, volume, market prices \	1	l	3
33	Japan	Private non-residential fixed capital formation, volume \	1	l	3
34	Japan	Fixed investment of government enterprises, volume \	1	l	3
35	Japan	Government fixed capital formation, volume \	1	l	3
36	Japan	Private residential fixed capital formation, volume	1	l	3
37	Japan	Industrial production \ Index	1	l	3
38	Japan	Private total fixed capital formation, volume \	1	l	3
39	Japan	Long-term interest rate on government bonds \	1	nl	2
40	Japan	Gross total fixed capital formation, volume \	1	l	3
41	Japan	Capital stock of the business sector, volume \	1	l	3
42	Japan	Capital stock, housing, volume \	1	l	3

Number	Country	Variable Name	Unit Root	Log	Treatment
43	Japan	Labour force \ Persons	1	l	3
44	Japan	Labour force participation rate	1	nl	2
45	Japan	Imports of goods&services, volume, national accounts basis \	1	l	3
46	Japan	Money supply, broad definition: M2 or M3	1	l	3
47	Japan	Factor income paid abroad, volume,	1	l	3
48	Japan	Labour productivity of the total economy \ Index	1	l	3
49	Japan	Labour productivity of the business economy	1	l	3
50	Japan	Government saving(net), value	1	nl	2
51	Japan	Household saving, value \	1	l	3
52	Japan	Household saving ratio \	1	nl	2
53	Japan	Unit labour cost of the total economy \ Index	1	l	3
54	Japan	Unit labour cost of the manufacturing sector \ Index	1	l	3
55	Japan	Unemployment \ Persons	1	l	3
56	Japan	Unemployment rate \	1	nl	2
57	Japan	Velocity of money	1	l	3
58	Japan	Wages, value \	1	l	3
59	Japan	Wage rate of the business sector \ Index	1	l	3
60	Japan	Compensation rate of government employees	1	l	3
61	Japan	Wage rate of the manufacturing sector, hourly earnings \ Index	1	l	3
62	Japan	Compensation rate of the business sector \	1	l	3
63	Japan	Compensation of employees, value \	1	l	3
64	Japan	Exports of goods&services, volume, national accounts basis \	1	l	3
65	Japan	Factor income from abroad, volume,\	1	l	3
66	Japan	Household disposable income, real \	1	l	3
67	Japan	Property income received by households, value \	1	l	3
68	Japan	Government current disbursements, value \	1	l	3
69	Japan	Current disbursements of households, value \	1	l	3
70	Japan	Government current receipts, value \	1	l	3
71	Japan	Current receipts of households, value \	1	l	3
72	Japan	Self-employment income received by households, value	1	l	3
73	Japan	Direct Investment Abroad	1	nl	2
74	Japan	Portfolio Investment Assets	1	nl	2
75	Japan	Financial Account	1	nl	2
76	Japan	Exports Prices	1	l	3
77	Japan	Imports Prices	1	l	3
78	Japan	Terms of Trade	1	l	3
79	Japan	Call Money Rate	1	nl	2
80	Japan	Share Prices	1	l	3
81	Japan	PPI /	1	l	3
82	Japan	CPI	1	l	3
83	Japan	Other Investment Liab	1	nl	0
84	Japan	Increase in stocks, volume \	0	nl	0
85	Japan	Current transfers received by households, value	0	l	1

Number	Country	Variable Name	Unit Root	Log	Treatment
86	Japan	Direct Investment in Republic	0	nl	0
87	Japan	Portfolio Investment Liab	0	nl	0
88	South Africa	Industrial production: manufacturing sa	1	l	3
89	South Africa	Production in total mining	1	l	3
90	South Africa	Unit labour cost: manufacturing sa	1	l	3
91	South Africa	Producer prices: manufacturing	1	l	3
92	South Africa	Producer prices: mining	1	l	3
93	South Africa	Producer prices: industry	1	l	3
94	South Africa	Producer prices: Elec. gas & water	1	l	3
95	South Africa	Consumer prices: All items	1	l	3
96	South Africa	Consumer prices: Food	1	l	3
97	South Africa	Consumer prices: Fuel and Electricity	1	l	3
98	South Africa	Consumer prices: Total goods	1	l	3
99	South Africa	Consumer prices: Services	1	l	3
100	South Africa	Monetary aggregate (M1) sa	1	l	3
101	South Africa	Monetary aggregate (M2)	1	l	3
102	South Africa	Monetary aggregate (M2) sa	1	l	3
103	South Africa	Monetary aggregate (M3) sa	1	l	3
104	South Africa	Yield 10+-year government bonds	1	nl	2
105	South Africa	ZAR/USD exchange rate end period	1	l	3
106	South Africa	BOP Current account balance	1	nl	2
107	South Africa	BOP Cap. and fin. balance incl. reserves	1	nl	2
108	South Africa	Exports of goods and services, constant prices	1	l	3
109	South Africa	Imports of goods and services, constant prices	1	l	3
110	South Africa	Final consumption expenditure, constant prices	1	l	3
111	South Africa	Gross domestic product, constant prices sa	1	l	3
112	South Africa	Gross fixed capital formation, constant prices	1	l	3
113	South Africa	Changes in inventories, constant prices	1	nl	2
114	South Africa	Households' consumption expenditure, constant prices	1	l	3
115	South Africa	Government consumption expenditure, constant prices	1	l	3
116	South Africa	Share Prices	1	l	3
117	South Africa	Manufacturing - Orders inflow/Demand: tendency	0	nl	0
118	South Africa	Manufacturing - Business situation: present	0	nl	0
119	South Africa	Manufacturing - Confidence indicator	0	l	1
120	South Africa	Discount rate	0	nl	0
121	South Africa	Rate 91-day treasury bills	0	nl	0
122	South Africa	Real Effective Exchange Rate	0	l	1
123	South Africa	BOP Reserve assets	0	nl	0
124	South Africa	Terms of Trade	0	l	1
125	South Africa	GDP Growth rate (Annual)	0	nl	0
126	United Kingdom	Balance of income, value, balance of payments basis	1	nl	2
127	United Kingdom	Current account, value	1	nl	2
128	United Kingdom	Government consumption of fixed capital, value \	1	l	3
129	United Kingdom	Unit capital-labour costs	1	l	3
130	United Kingdom	Private final consumption expenditure, volume \	1	l	3
131	United Kingdom	Dependent employment \ Persons	1	l	3

Number	Country	Variable Name	Unit Root	Log	Treatment
132	United Kingdom	Dependent employment of the business sector \ Persons	1	l	3
133	United Kingdom	Government employment \ Persons	1	l	3
134	United Kingdom	Self-employed \ Persons	1	l	3
135	United Kingdom	Total employment \ Persons	1	l	3
136	United Kingdom	Employment of the business sector \ Persons	1	l	3
137	United Kingdom	Exchange rate, index of US$ per local currency \ Index	1	l	3
138	United Kingdom	Gross domestic product, volume, market prices \	1	l	3
139	United Kingdom	Private non-residential fixed capital formation, volume \	1	l	3
140	United Kingdom	Fixed investment in construction, volume \	1	l	3
141	United Kingdom	Government fixed capital formation, volume \	1	l	3
142	United Kingdom	Private residential fixed capital formation, volume \	1	l	3
143	United Kingdom	Fixed investment in machinery & equipment, volume \	1	l	3
144	United Kingdom	Private total fixed capital formation, volume \	1	l	3
145	United Kingdom	Long-term interest rate on government bonds \	1	nl	2
146	United Kingdom	Increase in stocks, volume \	1	nl	2
147	United Kingdom	Gross total fixed capital formation, volume	1	l	3
148	United Kingdom	Capital stock of the business sector, volume \	1	l	3
149	United Kingdom	Labour force \ Persons	1	l	3
150	United Kingdom	Labour force participation rate	1	nl	2
151	United Kingdom	Imports of goods&services, volume, national accounts basis	1	l	3
152	United Kingdom	Factor income paid abroad, volume,	1	l	3
153	United Kingdom	Labour productivity of the total economy \ Index 2000	1	l	3
154	United Kingdom	Labour productivity of the business economy	1	l	3
155	United Kingdom	Household saving, value \	1	l	3
156	United Kingdom	Household saving ratio \	1	nl	2
157	United Kingdom	Current transfers received by households, value \	1	l	3
158	United Kingdom	Unit labour cost of the total economy \ Index 2000	1	l	3
159	United Kingdom	Unit labour cost of the manufacturing sector \Index 2001	1	l	3
160	United Kingdom	Unemployment \ Persons	1	l	3
161	United Kingdom	Wages, value \	1	l	3
162	United Kingdom	Wage rate of the business sector \	1	l	3
163	United Kingdom	Compensation rate of government employees \	1	l	3
164	United Kingdom	Wage rate of the manufacturing sector, hourly earnings \Index 2001	1	l	3
165	United Kingdom	Compensation rate of the business sector \	1	l	3
166	United Kingdom	Compensation of employees, value \	1	l	3
167	United Kingdom	Exports of goods&services, volume, national accounts basis \	1	l	3
168	United Kingdom	Factor income from abroad	1	l	3
169	United Kingdom	Household disposable income, real \	1	l	3
170	United Kingdom	Property income received by households, value	1	l	3
171	United Kingdom	Government current disbursements, value \	1	l	3
172	United Kingdom	Current disbursements of households, value \	1	l	3
173	United Kingdom	Government current receipts, value \	1	l	3
174	United Kingdom	Current receipts of households, value \	1	l	3

Number	Country	Variable Name	Unit Root	Log	Treatment
175	United Kingdom	Self-employment income received by households, value	1	l	3
176	United Kingdom	Exports Prices	1	l	3
177	United Kingdom	Imports Prices	1	l	3
178	United Kingdom	Terms of Trade	1	l	3
179	United Kingdom	Overnight Interbank Min	1	nl	2
180	United Kingdom	PPI	1	l	3
181	United Kingdom	CPI: All Items	1	l	3
182	United Kingdom	FTSE 100	1	l	3
183	United Kingdom	\Cyclical Indicators\Surveys of Manufacturing Industry:\Current Industry:\Current Level of Capacity Utilization	1	l	3
184	United Kingdom	Government saving(net), value \ GBP	1	nl	0
185	United Kingdom	Unemployment rate \ PERCENT	1	nl	0
186	United Kingdom	Real Effective exchange rate, 2000 = 100, ULC-based	1	l	3
187	United Kingdom	Other Investment Assets	1	nl	2
188	United Kingdom	Other Investment Liab	1	nl	2
189	United Kingdom	Cyclical Indicators\Consumer Opinion on Economic and Financial Conditions:\Composite Consumers Confidence Indicator	1	nl	0
190	United Kingdom	Cyclical Indicators\Surveys of Manufacturing Industry:\Composite Industrial Confidence Indicator	0	nl	0
191	United Kingdom	Direct Investment Abroad	0	nl	0
192	United Kingdom	Direct Investment in Republic	0	nl	0
193	United Kingdom	Portfolio Investment Assets	0	nl	0
194	United Kingdom	Portfolio Investment Liab	0	nl	0
195	United Kingdom	Financial Account	0	nl	0
196	United States	Balance of income, value, balance of payments basis	1	nl	2
197	United States	Current account, value	1	nl	2
198	United States	Government consumption of fixed capital, value \	1	l	3
199	United States	Private final consumption expenditure, volume \	1	l	3
200	United States	Employment, country specific, variable a \	1	l	3
201	United States	Dependent employment \	1	l	3
202	United States	Dependent employment of the business sector \	1	l	3
203	United States	Government employment \	1	l	3
204	United States	Self-employed \	1	l	3
205	United States	Total employment \	1	l	3
206	United States	Employment of the business sector \	1	l	3
207	United States	Real Effective exchange rate	1	l	3
208	United States	Gross domestic product, volume, market prices \	1	l	3
209	United States	Private non-residential fixed capital formation, volume \	1	l	3
210	United States	Government fixed capital formation, volume \	1	l	3
211	United States	Industrial production \	1	l	3
212	United States	Private total fixed capital formation, volume \	1	l	3
213	United States	Long-term interest rate on government bonds \	1	nl	2
214	United States	Long-term interest rate on corporate bonds \	1	nl	2
215	United States	Short-term interest rate \	1	nl	2

Number	Country	Variable Name	Unit Root	Log	Treatment
216	United States	Gross total fixed capital formation, volume \	1	l	3
217	United States	Capital stock of the business sector, volume \	1	l	3
218	United States	Capital stock, housing, volume \	1	l	3
219	United States	Labour force \	1	l	3
220	United States	Labour force participation rate \	1	nl	2
221	United States	Imports of goods&services, volume, national accounts basis \	1	l	3
222	United States	Money supply, narrow definition: base money, M1 or M2 \	1	l	3
223	United States	Money supply, broad definition: M2 or M3 \	1	l	3
224	United States	Factor income paid abroad, volume,	1	l	3
225	United States	Labour productivity of the total economy \	1	l	3
226	United States	Labour productivity of the business economy \	1	l	3
227	United States	Household saving ratio \	1	nl	2
228	United States	Current transfers received by households, value \	1	l	3
229	United States	Unit labour cost of the total economy \	1	l	3
230	United States	Unit labour costs in the business sector \	1	l	3
231	United States	Unit labour cost of the manufacturing sector \	1	l	3
232	United States	Velocity of money \	1	l	3
233	United States	Wages, value \	1	l	3
234	United States	Wages of the government sector, value \	1	l	3
235	United States	Wage rate of the business sector \	1	l	3
236	United States	Compensation rate of government employees \	1	l	3
237	United States	Wage rate of the manufacturing sector, hourly earnings \	1	l	3
238	United States	Compensation rate of the business sector \	1	l	3
239	United States	Compensation of employees, value \	1	l	3
240	United States	Exports of goods & services, volume,	1	l	3
241	United States	Factor income from abroad, volume,	1	l	3
242	United States	Household disposable income, real \	1	l	3
243	United States	Property income received by households, value \	1	l	3
244	United States	Government current disbursements, value \	1	l	3
245	United States	Current disbursements of households, value \	1	l	3
246	United States	Government current receipts, value \	1	l	3
247	United States	Current receipts of households, value \	1	l	3
248	United States	Self-employment income received by households\	1	l	3
249	United States	Direct Investment Abroad	1	nl	2
250	United States	Direct Investment in Republic	1	nl	2
251	United States	Portfolio Investment Assets	1	nl	2
252	United States	Portfolio Investment Liab	1	nl	2
253	United States	Financial Account	1	nl	2
254	United States	Exports Prices	1	l	3
255	United States	Imports Prices	1	l	3
256	United States	Terms of Trade	1	l	3
257	United States	PPI /	1	l	3
258	United States	CPI	1	l	3
259	United States	Share Prices	1	l	3

Number	Country	Variable Name	Unit Root	Log	Treatment
260	United States	Consumer Confidence	0	nl	0
261	United States	USA PMI Business confidence	0	nl	0
262	United States	Fixed investment in non-residential construction \	0	l	1
263	United States	Private residential fixed capital formation, volume \	0	l	1
264	United States	Fixed investment in machinery & equipment, volume \	0	l	1
265	United States	Increase in stocks, volume \	0	nl	0
266	United States	Government saving(net), value \	0	nl	0
267	United States	Household saving, value \	0	l	1
268	United States	Unemployment \	0	l	1
269	United States	Unemployment rate \	0	nl	0
270	United States	Production/Rate of capacity utilisat	0	nl	0
271	United States	Other Investment Assets	0	nl	0
272	United States	Other Investment Liab	0	nl	0
273	World	Commodity Food and Beverage Price Index	1	l	3
274	World	Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh, US$ per barrel	1	l	3
275	World	Commodity Metals Price Index, 1995 = 100, includes Copper, Aluminum, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices	1	l	3
276	World	Commodity Non-Fuel Price Index, 1995 = 100, includes Food and Beverages and Industrial Inputs Price Indices	1	l	3
277	World	Commodity Industrial Inputs Price Index, 1995 = 100, includes Agricultural Raw Materials and Metals Price Indices	0	l	1

Note: Interger of order 0 = 0, 1 = 1, 2 = 2; natural log variables = l, no transformation =nl
Treatment 0 = no transformattion; 1 = logarithm; 2 = first difference; 3 = first difference of logarithm