# A VECX* model for South Africa

DRAFT[1]

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**Abstract**

We develop a structural cointegrated vector autoregressive (VAR) model with weakly exogenous foreign variables suitable for a small open economy. This type of model is known as a VECX* model. Our study applies the methodology utilised by Assenmacher-Wesche and Pesaran (2008; 2009) in their development of a VECX* model for the Swiss economy based on the Garratt, Lee, Pesaran and Shin (2003; 2006) approach. Switzerland and South Africa are both small open economies. However, since South Africa is an emerging market economy, we consult previous VECX* studies of other developing economies (Affandi, 2007; Akusuwan, 2005). We compile the foreign variables using trade-weighted three-year moving average data for 32 countries. The trade weights are time varying due to significant changes in trade shares over time. We found three significant long-run economic relations for South Africa: the augmented purchasing power parity ($PPP^A$), the uncovered interest parity (UIP) and the Fisher parity (LIR). Once these long-run relations have been imposed on the VECX* model, we will use the model to investigate the monetary transmission mechanism in South Africa and the impact of factors such as an international financial shock on the transmission process.

Journal of Economic Literature (JEL) Classification Codes: C50, E52

Keywords: South Africa, inflation targeting, monetary transmission mechanism, structural cointegrated vector autoregressive model, VECX* model

[1] This paper is work in progress. Please do not quote. Comments and suggestions are welcome.

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## 1. Introduction

South Africa adopted inflation targeting as its monetary policy approach in 2000. To date the South African Reserve Bank (SARB) remains committed to inflation targeting to ensure long-run price stability. In a letter from Finance Minister Pravin Gordhan to SARB Governor Gill Marcus, dated 16 February 2010, Minister Gordhan states that "the Bank should continue to pursue a target of 3 to 6 per cent for headline CPI inflation" (Gordhan, 2010). He highlights the importance of maintaining low inflation – that it supports sustainable growth and employment, and that it protects the living standards of people in the country.

An investigation of the monetary transmission mechanism, i.e. how changes in the official interest rate affect demand, output and finally inflation, is thus still important for policy makers in South Africa. It is not sufficient to know only the direction of change in variables following a change in monetary policy (Bain & Howells, 2003). Policy makers have to take into account the lag between a monetary policy change and the impact on aggregate output and inflation, as well as the magnitude of changes in aggregate output and inflation. Mishkin (1995) names these elements the "timing and effect" of monetary policies on the economy.

Time lags tend to differ from country to country due to differences in financial markets and structures (Casteleijn, 2001). Bain and Howells (2003) note that for industrialised countries, the lag between a change in the official interest rate and the full impact on demand and production is normally about 12 months. The lag between the interest rate change and the full impact on inflation is 24 months, thus a further 12 months. Research by the SARB, performed a decade ago, confirmed these time lags for South Africa (Smal & De Jager, 2001).

For an up-to-date investigation of the monetary transmission mechanism in the country, we build a structural vector error-correction model (VECM) with weakly exogenous (X) foreign (*) variables, i.e. a VECX* model, suitable for a small open economy such as South Africa.

The next section motivates the development of this model within the context of current literature. Section 3 provides a brief overview of the VECX* methodology. Sections 4, 5 and 6 respectively provide information on the data used, data analysis and some initial VECX* model results. We conclude with a summary and a discussion of further research we are working on.

## 2. Literature review

VECX* models are also classified as cointegrating VARX or cointegrating VARX* models (Affandi, 2007; Garratt, Lee, Pesaran &Shin, 2006). These models were introduced and further developed by Pesaran, Shin and Smith (2000), Pesaran and Shin (2002), and Garratt, Lee, Pesaran and Shin (2003), with a detailed explanation of the methodology in Garratt *et al.* (2006). Pesaran *et al.* (2000) explain that the models are particularly suitable for small open economies due to the handling of foreign variables as exogenous. Pesaran and Smith (2006) further illustrate that this type of model can be derived as the solution to an open macro economy New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model, thereby underpinning the long-run relations considered in the VECX* model.

Therefore, the first advantage of using a VECX* approach for South Africa is that the model accounts for both long-run theoretical relations and dynamic short-run properties, which are important in the analysis of the monetary transmission mechanism and the impact of shocks on the mechanism. Second, the inclusion of weakly exogenous foreign variables, which is relevant for a small open economy such as South Africa, is possible in a VECX* model. The inclusion of foreign variables also enables analysis of the impact of an international financial shock on the transmission of monetary policy in South Africa. Another advantage of developing a VECX* model for South Africa is that it can be incorporated directly into a Global VAR (GVAR) model, where all the foreign variables are determined endogenously. Pesaran, Schuermann and Weiner (2004) first suggested the GVAR framework.

Finally, the VECX* model for South Africa and its inclusion into a GVAR model could be a useful addition to the suite of econometric models of the SARB. The models currently used by the SARB include a core model (SARB, 2007), a small-scale model, VAR models, VECMs, Phillips-curve models, indicator models and structural VAR models (Casteleijn, 2001). More recently, the SARB has developed quarterly projection models (QPMs) and dynamic stochastic general equilibrium (DSGE) models, including a steady state QPM for the country (De Jager, 2007), a New Keynesian DSGE model for South Africa (Steinbach, Mathuloe & Smit, 2009) and a Small Open Economy New Keynesian DSGE-VAR (SOENKDSGE-VAR) model for South Africa (Gupta & Steinbach, 2010). The SARB draws on these models for various purposes, including forecasting and simulations. None of these models includes time-varying trade-weighted foreign variables. We show in Section 4 that the incorporation of time-varying weights in an open economy model for South Africa (as in our VECX* model) is important due to substantial changes in South Africa's main trading partners over time.

The first VECX* model was developed by Garratt *et al.* (2003) for the UK economy. Further VECX* models followed for Thailand (Akusuwan, 2005), Indonesia (Affandi, 2007) and Switzerland (Assenmacher-Wesche & Pesaran, 2008; Assenmacher-Wesche & Pesaran, 2009). The countries considered in these papers are small open economies such as South Africa. In addition, the UK and Thailand are full-fledged inflation-targeting countries like South Africa. Indonesia is categorised as an inflation-targeting "lite" country, while Switzerland follows implicit inflation targeting. Due to the similarities, all the above studies are consulted to develop a VECX* model for South Africa. However, since South Africa is an emerging market economy, we pay particular attention to the models developed for Thailand and Indonesia. Each of the previous VECX* studies effectively explores the monetary policy transmission process in the country considered, which is the objective of this paper. In addition, the models are successful in forecasting inflation.

Note that De Wet, Van Eyden and Gupta (2009) develop a VECM model for South Africa using part of the framework suggested in earlier GVAR studies. Unfortunately, this model has a different purpose (investigating portfolio risk) and it is not comparable to the VECX* models listed above since it did not utilise the Garratt *et al.* (2006) framework.

Regarding our aim to investigate the monetary transmission mechanism in South Africa, to our knowledge the only complete published investigation of the transmission of monetary policy in South Africa is by Smal and De Jager (2001) from the SARB. The authors analyse the monetary transmission mechanism in South Africa with a small macroeconometric model. They discuss monetary policy in the country since the 1980s, before investigating the various transmission mechanisms, or channels, through which changes in monetary policy affect the real economy and inflation in a country. The channels, as classified by Mishkin (1995), are the interest rate channel, other asset price channels (exchange rate and equity prices) and the credit channel (bank-lending channel and balance-sheet channel)[2]. Their model incorporates these channels to explore the lags involved in the transmission of monetary policy in South Africa. The authors provide no specific details of the model used, but they do clarify the two scenarios used to shock the system to determine the lags involved. These scenarios are an increase in the repo rate (providing for the

[2] See Appendix B for a more detailed discussion of the monetary transmission channels.

real exchange rate to be affected by the interest rate differential and purchasing power parity) and a change in the repo rate with a Taylor-type monetary policy reaction function added to the model (which will further allow the repo rate to adjust to local output and inflation). Smal and De Jager (2001) confirm the time lag between a change in the official interest rate and the full impact on demand and production, which is real economic activity, as approximately 12 months. The authors verify the lag between a change in monetary policy and the full impact on domestic inflation as approximately 24 months, thus a further 12 months, but they caution that the lags are dependent on the prevailing factors.

For the SARB, the core model ["a medium-sized Type II hybrid model", (2007)], the QPM model (De Jager, 2007) and the New Keynesian DSGE model (Steinbach *et al.*, 2009) all include monetary policy transmission channels. The authors note that the models' responses to shocks illustrate the correct functioning of the monetary transmission mechanism in South Africa, but they do not provide a clear indication of the time lags and magnitude of changes following a monetary policy shock.

This paper therefore adds to the literature by developing a macroeconometric model for South Africa that includes time-varying trade-weighted foreign variables to account for the considerable change in the country's key trading partners over time. In addition, due to the focus of the model on monetary policy, it will provide a more recent view of the monetary transmission mechanism in South Africa.

## 3. VECX* methodology

The VECX* approach is documented in Garratt *et al.* (2006). We provide a short summary of the methodology here.

Hendry and Richard (1983) refer to weakly exogenous explanatory variables as regressors that are uncorrelated with the stochastic error term. The definition of weakly exogenous variables in the VECX* framework is different. The sub-system VECM models (named marginal models) for the weakly exogenous foreign variables do not contain the cointegrating vectors of the overall VECX* model (Pesaran *et al.*, 2000). This assumption is necessary for modelling a small open economy, such as South Africa. A vector of endogenous and exogenous $I(1)$ variables, $\mathbf{z}_t$ ,can be written as $\mathbf{z}_t = (\mathbf{y}_t' , \mathbf{x}_t' )$, with $\mathbf{y}_t$ a vector of endogenous $I(1)$ variables and $\mathbf{x}_t$ a vector of exogenous $I(1)$ variables. Assume now that $\mathbf{x}_t$ is weakly exogenous (also know as long-run forcing for $\mathbf{y}_t$) in the long-run multiplier matrix $\mathbf{\Pi}$ of a normal VECM. This assumption corresponds to $\mathbf{\Pi}_x = 0$, where $\mathbf{\Pi}$ is separated as $\mathbf{\Pi}' = (\mathbf{\Pi}'_x, \mathbf{\Pi}'_y)$.

The VECX* model can be represented by

$$\Delta \mathbf{y}_t = -\mathbf{\Pi}_y \mathbf{z}_{t-1} + \mathbf{\Lambda} \Delta \mathbf{x}_t + \sum_{i=1}^{p-1} \mathbf{\Psi}_i \Delta \mathbf{z}_{t-i} + \mathbf{c}_0 + \mathbf{c}_1 t + \mathbf{\nu}_t ,$$

with the marginal equations for the weakly exogenous variables identified as

$$\Delta \mathbf{x}_t = \sum_{i=1}^{p-1} \mathbf{\Gamma}_{xi} \Delta \mathbf{z}_{t-i} + \mathbf{a}_{x0} + \mathbf{u}_{xt} .$$

## 4. Data

The VECX* model for South Africa incorporates quarterly domestic and time-varying trade-weighted foreign data from 1980 to 2009. Most of the data used is from the GVAR Toolbox 1.1 dataset (Smith & Galesi, 2011) that comprises data for 33 countries, thereby accounting for about 90 per cent of world output. Appendix A describes the data sources and it provides information regarding the creation of the domestic and foreign variables.

As mentioned in Section 2 it is important to use trade weights that vary over time to create the foreign variables for our model, since the trade shares of South Africa's main trading partners have changed considerably over the sample period. Figure 9 in Appendix A illustrates the evolution of the trade weights of some of South Africa's most important trading partners. South Africa's trade with China has increased from none before 1993 to a three-year moving average of 14 per cent in 2009 (based on the GVAR countries). China has been the new main trading partner of South Africa since 2009. Our trade with the UK, USA, Japan and the Euro area are generally decreasing over time. Figure 10 in Appendix A shows the combined trade share of the eight Euro countries in the GVAR with South Africa, highlighting the declining trade with these countries.

The endogenous variables included in the VECX* model are the quarterly inflation rate ($\pi$), the short-term interest rate ($r$), real M3 ($m3$), real output ($y$) and the real effective exchange rate, calculated from the nominal effective exchange rate and local prices ($ep = e - p$). The weakly exogenous variables are foreign prices ($p^*$), the foreign short-term interest rate ($r^*$), foreign real output ($y^*$) and the oil price ($p^{oil}$). Interest rates are adjusted to be comparable with the quarterly inflation rate. All the variables are used in natural logarithmic form.

## 5. Data analysis

In the remainder of this paper, we follow the modelling approach used by Assenmacher-Wesche and Pesaran (2009) in their development of a VECX* model for the Switzerland.

The long-run economic relations that we consider for South Africa are the purchasing power parity (PPP), the uncovered interest parity that relates local and foreign interest rates (UIP), the Fisher parity that links the local interest rate to local inflation (LIR), a money demand relationship (MD) and a connection between local and foreign output (GAP). These long-run relations are included in earlier VECX* literature. Table 1 provides a summary of which of these five long-run relations hold in the cases of Switzerland (Assenmacher-Wesche & Pesaran, 2009), Thailand (Akusuwan, 2005) and Indonesia (Affandi, 2007), based on the autoregressive distributed lag (ARDL) or bounds testing approach to cointegration (Pesaran & Shin, 1999; Pesaran, Shin & Smith, 2001). One of the advantages of the ARDL approach is that it is not necessary to know whether variables are $I(0)$ or $I(1)$.

**Table 1: Long-term economic relationships in previous VECX* studies**

| | Switzerland | Thailand | Indonesia |
|---|---|---|---|
| **PPP**[a] | ✓ | × | ✓ |
| **UIP**[b] | ✓ | ✓ | ✓ |
| **LIR**[c] | ✓ | ✓ | ✓ |
| **MD**[d] | ✓ | ✓ | × |
| **GAP**[e] | ✓ | × | × |

[a] PPP: Purchasing power parity ($p - p^* - e$) or PPP[A]: Augmented purchasing power parity ($e - (p - p^*) - \beta_1(y - y^*)$)
[b] UIP: Uncovered interest parity ($r - r^*$)
[c] LIR: Fisher parity ($r - \pi$) or Modified Fisher parity ($r - \beta_2\pi$)
[d] MD: Money demand relationship ($m - \beta_3 y - \beta_4 r$)
[e] GAP: Relation between domestic and foreign output ($y - y^*$)

We first investigate the potential long-term relations graphically. Theoretically, the PPP suggests that domestic and foreign prices calculated in the same currency will be in equilibrium in the long run due to global trade. Due to the large correlation between the exchange rate ($e$) and the output gap ($y-y^*$), observed in Table 2 in Appendix A, we explore both PPP ($p-p^*-e$) and PPP$^A$, augmented purchasing power parity, ($e-(p-p^*)-\beta_1(y-y^*)$). Figure 1 and Figure 2 show the movement in exchange rates against the ratio of local and foreign prices and the ratio of local and foreign output respectively, both in levels and in first differences. The exchange rate and the ratio of domestic to foreign prices have the same trend in the long run, suggesting that the PPP may hold for South Africa. The negative relationship between the exchange rate and the ratio of domestic to foreign output is only evident up to 2000. It is therefore not clear whether PPP$^A$ will be relevant for South Africa.

**Figure 1: Exchange rate and ratio of local to foreign prices**

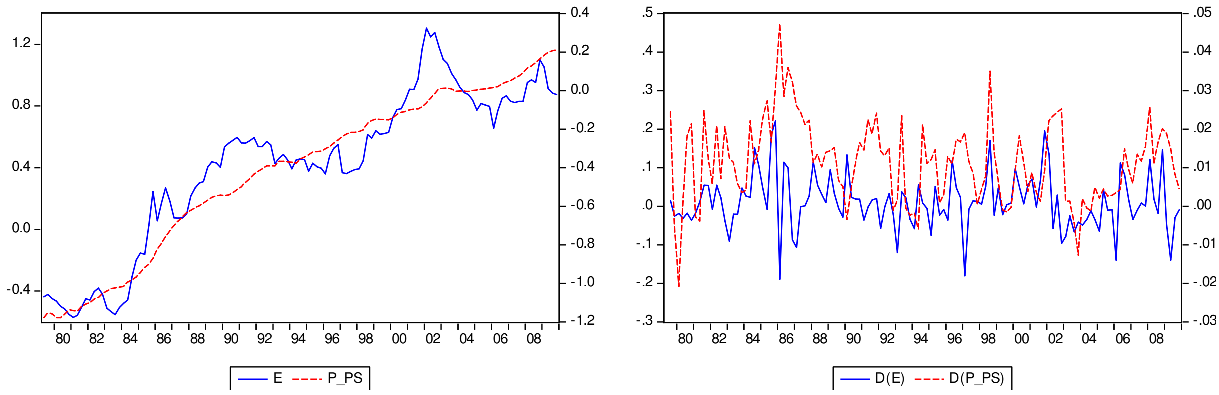
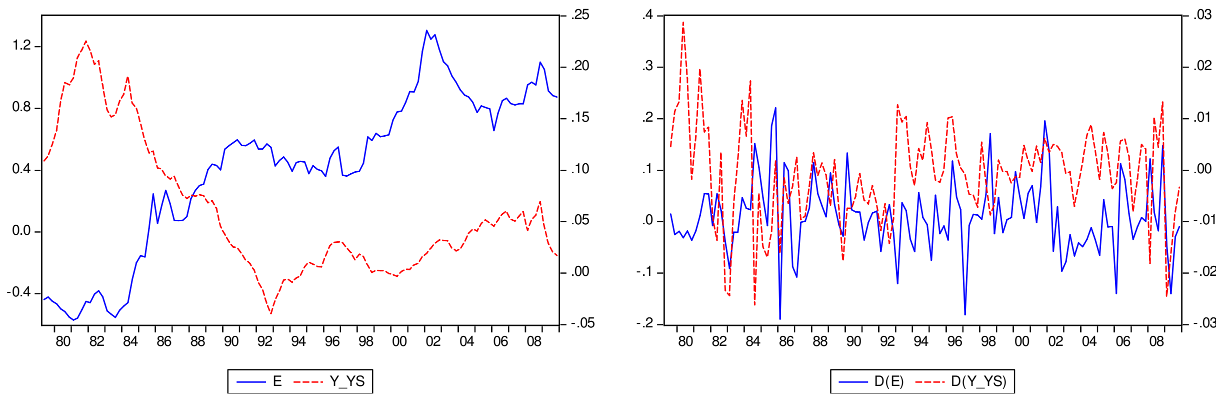


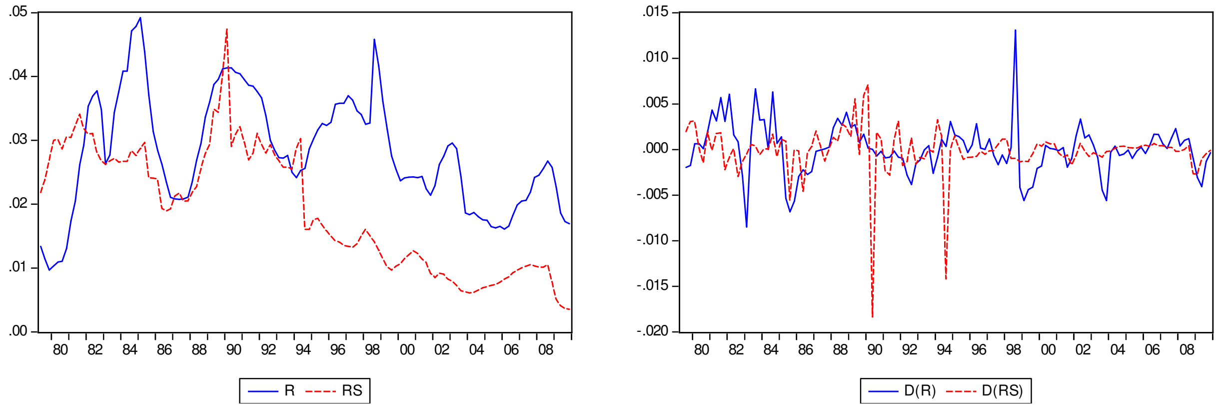

**Figure 2: Exchange rate and ratio of local to foreign output**




The UIP implies that the arbitrage process between domestic and foreign bonds will ensure that domestic and foreign interest rates will be in equilibrium in the long run. Figure 3 illustrates local and foreign short-term interest rates, first in levels and then in first differences. The short-term interest rates seem to have similar patterns over time, indicating that the UIP may hold for South

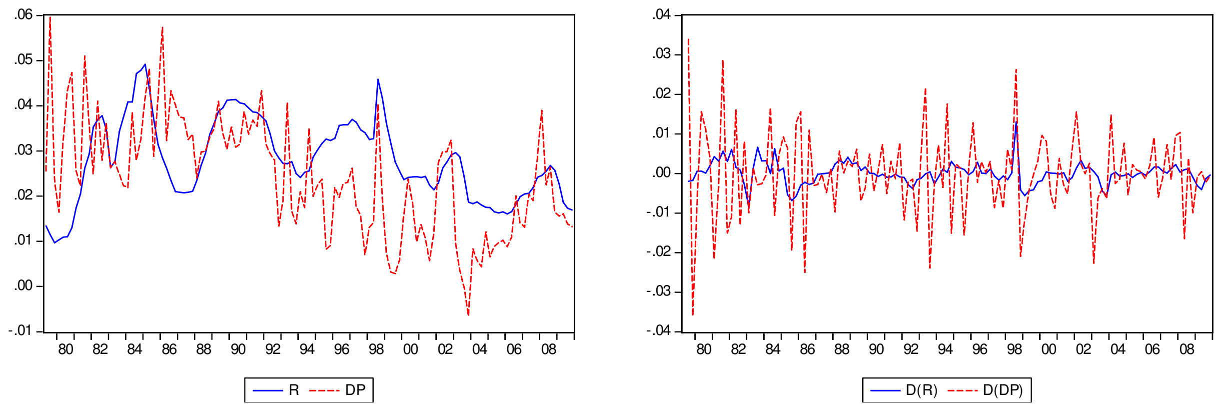
Africa. The large gap between local and foreign rates is in line with expectations, since South Africa is a developing country and the higher interest rate rewards investor for the risk faced.

**Figure 3: Local and foreign short-term interest rates**




For the connection between the local interest rate and local inflation (LIR), we consider the modified Fisher parity ($r - \beta_2 \pi$) in addition to the usual Fisher parity ($r - \pi$). Figure 4 shows this link, again in both levels and first differences. Interest rates and inflation seem to have the same long-term trends.

**Figure 4: Short-term interest rates and inflation**




For the money demand (MD) connection defined in Table 1, $m$ - $\beta_3 y$ - $\beta_4 r$, $\beta_3$ (the income elasticity) is expected to be positive and $\beta_4$ (the interest rate elasticity) is expected to be negative. Figure 5 and Figure 6 confirm the anticipated relationships of money with output and interest rates respectively. The negative link between money and interest rates is, however, only valid from late 1998 onwards.

**Figure 5: Broad money (M3) and output**

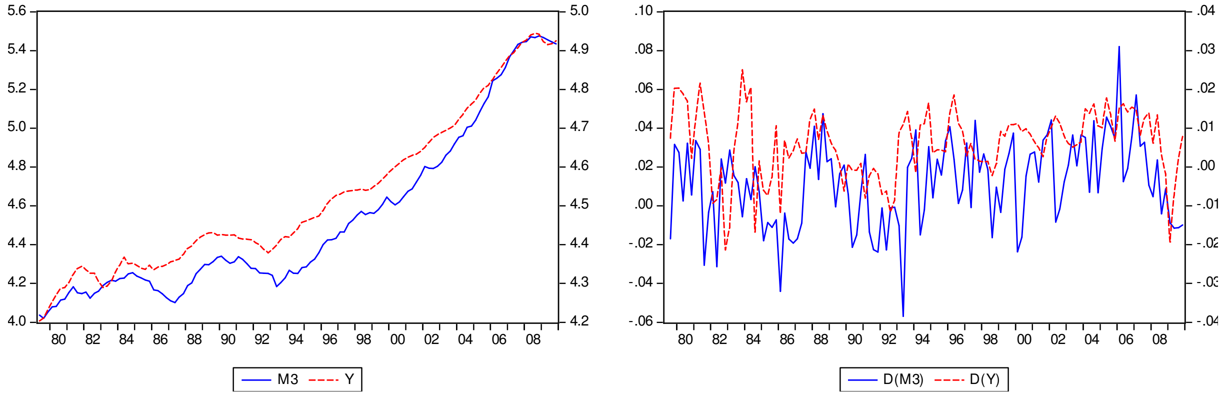
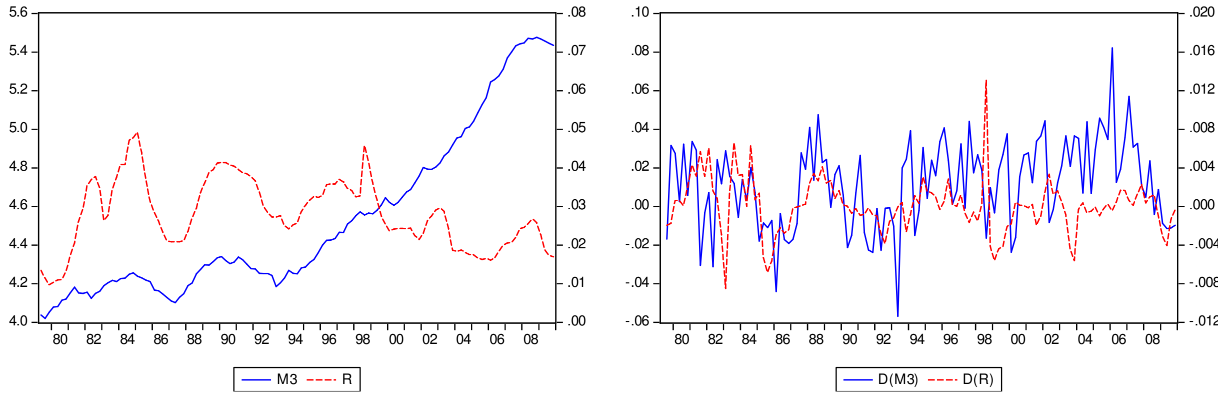
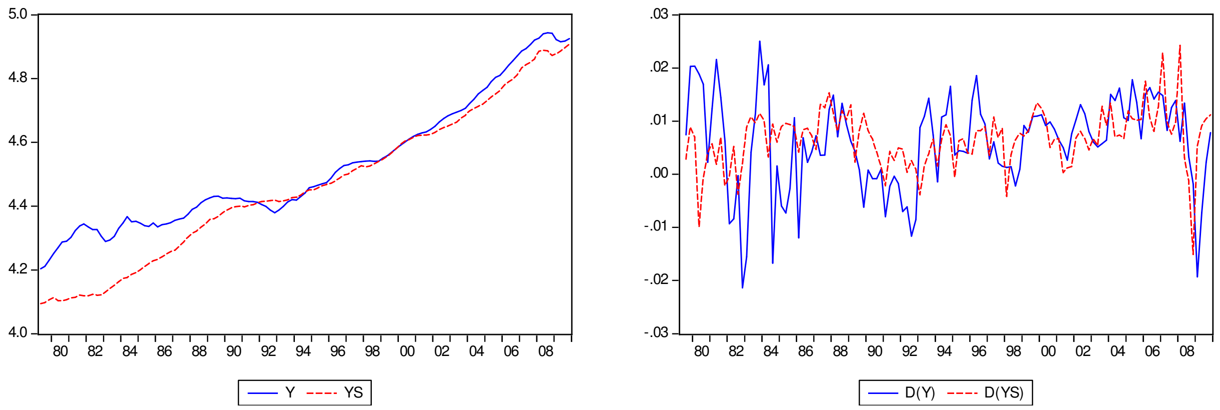



**Figure 6: M3 and short-term interest rates**




According to output convergence (GAP in Table 1), domestic and foreign output should converge in the long run. Figure 7, which includes the levels and first differences of domestic and foreign output, suggests that this relation hold in the long run.

**Figure 7: Local and foreign output**




We used the ARDL cointegration approach (Pesaran & Shin, 1999; Pesaran *et al.*, 2001) to determine whether the above long-run relations are valid. Table 2 summarises the formal test results. The PPP[A], UIP and LIR long-run relations exist for South Africa. The MD and GAP relations do not hold. Comparing South Africa's results to those from earlier VECX* studies (Table 1), the same long-run relations that hold for Indonesia are valid for South Africa.

**Table 2: Long-term economic relationships: ARDL cointegration test results**

| | EC[a] | *t*-stat[b] | CV bounds[c] | | *F*-stat[b] | CV bounds[c] | | ARDL(*p*,*q*,*s*)[e] |
|---|---|---|---|---|---|---|---|---|
| **PPP[A]** | -0.16 | -3.42* | -2.57 | -3.21 | 3.98* | 2.89[d] | 3.86[d] | ARDL(4,0,1) |
| **UIP** | -0.12 | -4.26* | -2.57 | -2.91 | 8.56* | 4.04 | 4.78 | ARDL(2,0) |
| **LIR** | -0.10 | -3.96* | -2.57 | -2.91 | 5.76* | 4.04 | 4.78 | ARDL(2,0) |
| **MD** | -0.08 | -2.88 | -2.57 | -3.21 | 3.53 | 3.17 | 4.14 | ARDL(2,4,0) |
| **GAP** | -0.02 | -1.59 | -2.57 | -2.91 | 1.37 | 4.04 | 4.78 | ARDL(2,2) |

[a] Error-correction term.
[b] Significant $t$-stat or $F$-stat indicated by *.
[c] Lower and upper 90% critical value bounds (Pesaran, Shin & Smith, 2001).
[d] Lower and upper 90% critical value bounds from Microfit 5.0 (Pesaran & Pesaran, 2009a).
These critical values are simulated stochastically and are valid in the presence of a dummy variable.
[e] Lag lengths selected by the Akaike information criterion (AIC), with maximum four lags.
The models include an intercept, except for PPP that includes a dummy from 1992 onwards.

The long-term equations for the valid relations are included below, with the $p$-values for the coefficients shown in brackets. $D92$ is a dummy variable that is zero up to 1991 and one from 1992 onwards.

PPP[A]: $ep_t = -0.74\, p_t^* - 1.88(y_t - y_t^*) - 3.68(D92_t)$

(0.00) (0.03) (0.01)

UIP: $r_t = 0.62\, r_t^* + 0.02$

(0.00) (0.00)

LIR: $r_t = 0.50\, \pi_t + 0.02$

(0.01) (0.00)

Hypothesis testing show that in the augmented PPP the coefficient of $p^*$ is significantly different from one, but the coefficient of $y - y^*$ is not significantly different from one. In the UIP the coefficient of $r^*$ is not significantly different from one, but in the LIR the coefficient of $\pi$ is significantly different from one, suggesting that the modified Fisher parity may be more relevant. However, it should be taken into account that all the models tested are single-equation models and further interactions will need to be considered in the VECX* model.

To summarise, the results from the ARDL approach indicate three potential long-term relations between the variables that we consider in our VECX* model. The next section shows that the VECX* cointegration test results do suggest three cointegrating relations.

## 6. VECX* model results

The VECX* model for South Africa was developed in Microfit 5.0 (Pesaran & Pesaran, 2009a; 2009b). The AIC signifies an optimal lag length of two for the VARX model, both for the endogenous and exogenous variables. Table 3 contains the cointegration test results for the model with an unrestricted intercept, a restricted trend, a restricted dummy variable (D92) and an unrestricted differenced dummy variable (DD92).

**Table 3: Cointegration test results**

| **Maximum Eigenvalue** | | | | | | |
|---|---|---|---|---|---|---|
| | | | 95% CV | 95% CV | 90% CV | 90% CV |
| Null | Alternative | **Statistic** | 4 Exogenous | 3 Exogenous | 4 Exogenous | 3 Exogenous |
| r = 0 | r = 1 | **86.49** | 63.41 | 58.14 | 59.33 | 54.58 |
| r ≤ 1 | r = 2 | **71.23** | 54.22 | 49.99 | 50.87 | 46.98 |
| r ≤ 2 | **r = 3** | **39.52** | 46.31 | 42.58 | 43.01 | 39.32 |
| r ≤ 3 | r = 4 | **27.94** | 37.57 | 34.18 | 34.69 | 31.04 |
| r ≤ 4 | r = 5 | **14.40** | 28.73 | 26.15 | 25.97 | 23.07 |
| **Trace** | | | | | | |
| | | | 95% CV | 95% CV | 90% CV | 90% CV |
| Null | Alternative | **Statistic** | 4 Exogenous | 3 Exogenous | 4 Exogenous | 3 Exogenous |
| r = 0 | r ≥ 1 | **239.6** | 170.13 | 153.63 | 163.43 | 147.11 |
| r ≤ 1 | r ≥ 2 | **153.1** | 125.52 | 113.17 | 119.91 | 107.40 |
| r ≤ 2 | **r ≥ 3** | **81.9** | 87.97 | 79.31 | 83.70 | 75.11 |
| r ≤ 3 | r ≥ 4 | **42.3** | 55.75 | 50.24 | 51.96 | 46.01 |
| r ≤ 4 | **r = 5** | **14.4** | 28.73 | 26.15 | 25.97 | 23.07 |

The critical values (CVs) are simulated using 3000 replications. The CVs for three exogenous variables are considered, since there is one cointegrating relationship between the four exogenous variables.

The marginal models for the weakly exogenous foreign variables each include one lag for the differenced endogenous variables, one lag for the differenced exogenous variables and an intercept. Since there is one cointegrating relationship between the four exogenous variables, we use the simulated critical values (CVs) for three exogenous variables rather than those for four exogenous variables. Both the maximum eigenvalue statistics and the trace statistics in Table 3 indicate three cointegrating relationships in the model. We will therefore impose the three long-run relations found in Section 5 on the VECX* model.

We impose all these overidentifying restrictions on the model, but the Likelihood Ratio (LR) test rejects the combination of restrictions. However, since the LR test often over-rejects the null hypothesis that the restrictions are valid (Pesaran & Pesaran, 2009b), we decide to use the model with the overidentifying restrictions given the strong theoretical foundations of the three long-run relations. Before finalising the model, we want to consider the possibility of identifying the model using only two long-run relations, e.g. PPP and UIP. In addition, we have to update the model for easier incorporation into the GVAR model. This includes the addition of equity prices, replacing M3 with a long-run interest rate and investigating the availability of the monetary policy rate for all the countries included in the current GVAR model.

## 7. Conclusion and future research

We developed a new type of model for South Africa to investigate the monetary transmission mechanism. This is the first VECX* model built for South Africa. Foreign variables were calculated using time-varying trade-weighted data for 32 trading partners of South Africa. This is also a first for the country, since either previous models use the US as a proxy for the rest of the world or they use trade-weighted data for a fixed period to represent the rest of the world. Three significant long-run economic relations for South Africa are $PPP^{A}$, UIP and LIR. We will use the final VECX* model to investigate the monetary transmission mechanism in South Africa.

Bain and Howells (2003) mention that the time lags involved in the monetary transmission mechanism are only averages. Many factors influence the lags, including "the state of business and consumer confidence, how this confidence is influenced by monetary policy changes, events in the world economy and expectations about future inflation". We are especially interested in whether and how global financial shocks affect the transmission of monetary policy in South Africa. If it does have an effect on the local monetary transmission mechanism, then policy makers would need to consider this in the aftermath of financial crises. Due to the inclusion of the foreign trade-weighted variables in the VECX* model for South Africa, we are able to use the model to analyse the influence of a global financial shock on the monetary transmission mechanism in South Africa.

As a further step, we will to incorporate the South African VECX* model in a GVAR model, which determines all the foreign variables endogenously. We plan to customise the GVAR model for South Africa, by including its 36 main trading partners (excluding Zimbabwe) who together account for 88 per cent of total South African trade between 2006 and 2010. Annual trade data from 1980 to 2010 will be used to determine the trade weights, but all the variables included in the model will be quarterly data between 1980 and 2010. We intend to use the theoretical framework introduced and expanded by Pesaran *et al.* (2004), Garratt *et al.* (2006), Dees, Di Mauro, Pesaran and Smith (2007), Pesaran, Schuermann and Smith (2009a) and Pesaran, Schuermann and Smith (2009b).

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## Appendix A: Data

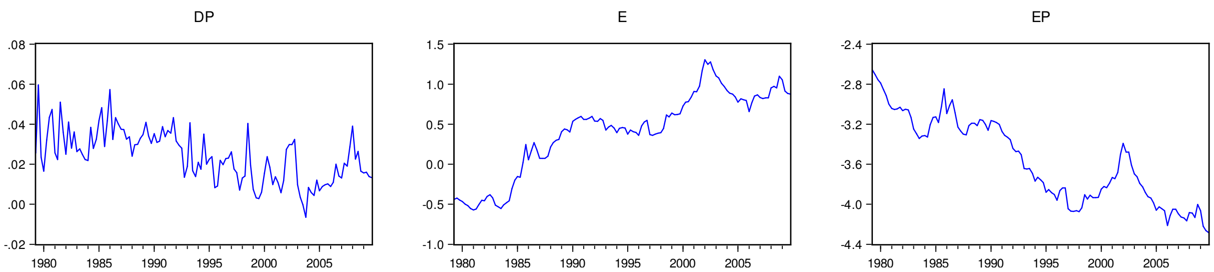
Except for broad money supply (M3) for South Africa, the data used are from the GVAR Toolbox 1.1 dataset (Smith & Galesi, 2011), which includes data for 33 countries accounting for around 90 per cent of world output. Comprehensive information about the data sources and the methods of calculation for the GVAR Toolbox 1.1 database is included in Technical Appendix B of the User Guide compiled by Smith and Galesi (2011). M3 for South Africa was collected from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Table 4 lists the variables. Variables without an assigned type are not in the final VECX* model, but they are used for calculations and for analysis. Unit root tests indicate that the variables in the model are $I(1)$.

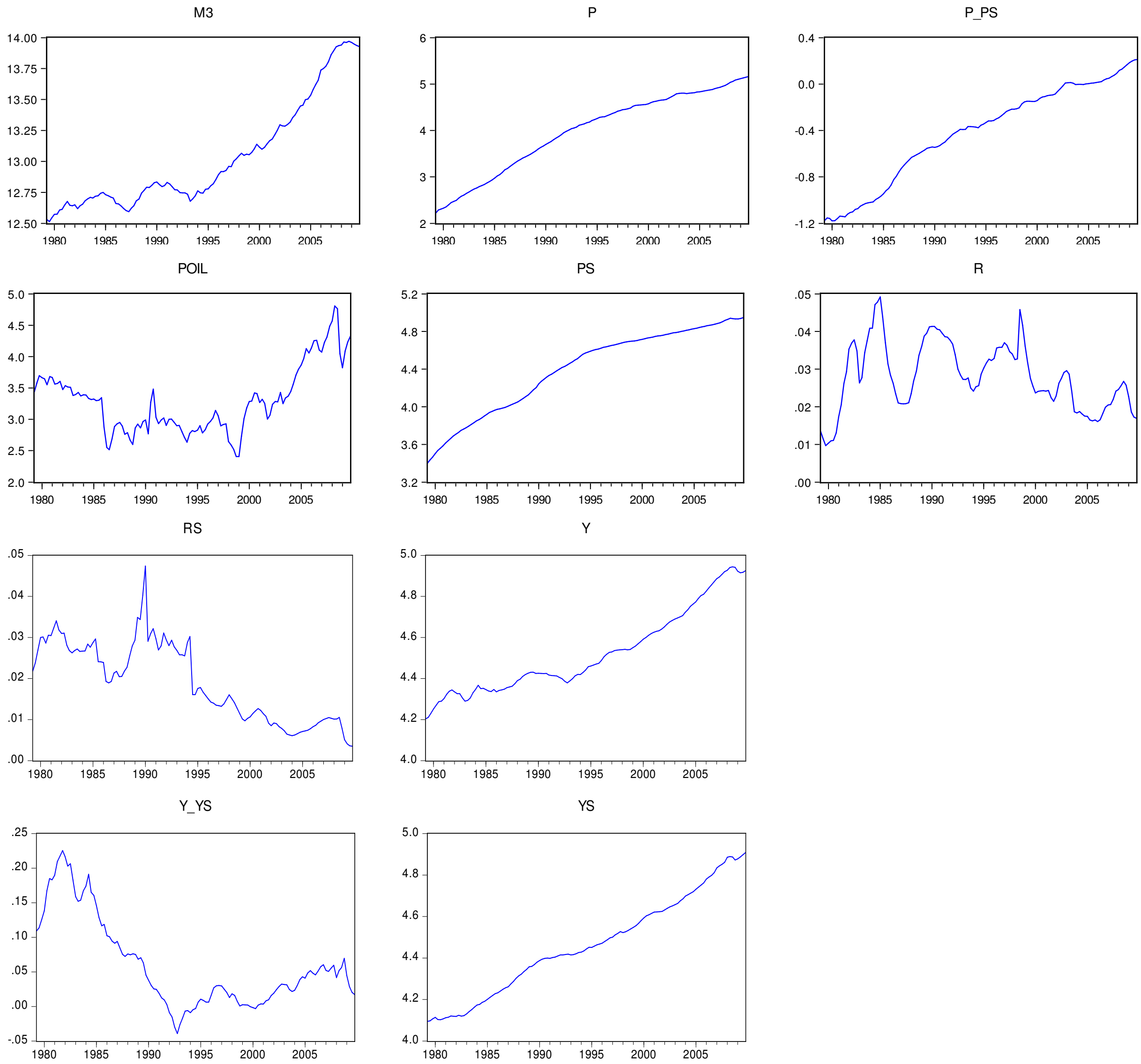
**Table 4: Variables**

| Variable | Name | Description | Type |
|---|---|---|---|
| $e$ | e | ln nominal effective exchange rate | |
| $ep$ | ep | ln real effective exchange rate = e - p | Endogenous $I(1)$ |
| $r$ | r | 0.25*ln(1+short-term interest rate/100) | Endogenous $I(1)$ |
| $\pi$ | Dp | Quarterly inflation rate: first difference of ln CPI | Endogenous $I(1)$ |
| $p$ | p | ln CPI | |
| $m3$ | m3 | ln real M3 | Endogenous $I(1)$ |
| $y$ | y | ln real GDP | Endogenous $I(1)$ |
| $r^*$ | rs | 0.25*ln(1+foreign short-term interest rate/100)) | Exogenous $I(1)$ |
| $p^*$ | ps | ln foreign CPI | Exogenous $I(1)$ |
| $p - p^*$ | p_ps | Ratio of ln CPI to ln foreign CPI | |
| $y^*$ | ys | ln foreign real GDP | Exogenous $I(1)$ |
| $y - y^*$ | y_ys | Ratio of ln real GDP to ln foreign real GDP | |
| $p^{oil}$ | poil | ln oil price | Exogenous $I(1)$ |

Figure 8 presents graphs of all the variables, while Table 5 contains the simple correlation coefficients between the variables.

**Figure 8: Graphs of variables**






### Table 5: Simple correlation coefficients

| | Dp | e | ep | m3 | p | p_ps | poil | ps | r | rs | y | y_ys | ys |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dp** | 1 | | | | | | | | | | | | |
| **e** | -0.49* | 1 | | | | | | | | | | | |
| **ep** | 0.67* | -0.70* | 1 | | | | | | | | | | |
| **m3** | -0.52* | 0.73* | -0.78* | 1 | | | | | | | | | |
| **p** | -0.62* | 0.94* | -0.91* | 0.82* | 1 | | | | | | | | |
| **p_ps** | -0.61* | 0.95* | -0.89* | 0.83* | 0.99* | 1 | | | | | | | |
| **poil** | -0.15* | 0.14 | -0.29* | 0.69* | 0.23* | 0.25* | 1 | | | | | | |
| **ps** | -0.63* | 0.92* | -0.92* | 0.80* | 0.99* | 0.99* | 0.21* | 1 | | | | | |
| **r** | 0.28* | -0.12 | 0.14 | -0.34* | -0.14 | -0.18* | -0.46* | -0.10 | 1 | | | | |
| **rs** | 0.64* | -0.70* | 0.78* | -0.78* | -0.79* | -0.80* | -0.35* | -0.78* | 0.42* | 1 | | | |
| **y** | -0.55* | 0.80* | -0.83* | 0.99* | 0.88* | 0.90* | 0.61* | 0.87* | -0.31* | -0.82* | 1 | | |
| **y_ys** | 0.45* | -0.80* | 0.63* | -0.35* | -0.78* | -0.78* | 0.26* | -0.79* | -0.00 | 0.45* | -0.44* | 1 | |
| **ys** | -0.59* | 0.90* | -0.88* | 0.93* | 0.97* | 0.97* | 0.45* | 0.95* | -0.27* | -0.82* | 0.97* | -0.65* | 1 |

* Indicates significance at a 10% significance level.

For the creation of the foreign variables, the three-year moving average trade weights of South Africa with each of the other 32 counties in the GVAR dataset were calculated from the annual trade data (average of exports and imports, c.i.f.[3]) between 1980 and 2009. We used the time-varying trade shares to weigh each variable for all the countries. The summation of the weighted country data provided the specific foreign variable. The 32 countries in the GVAR are responsible for 77 per cent of South Africa's average trade from 2006 to 2010 with the rest of the world, according to more recent data from the Direction of Trade Statistics (DOTS) of the IMF (2011). Table 6 shows the individual and total trade shares based on this data.

**Table 6: Average trade shares of countries included in the model (2006 - 2010)**

| Country | Average trade share |
|---|---|
| China | 10.58% |
| Germany | 9.78% |
| USA | 8.82% |
| Japan | 7.45% |
| UK | 5.52% |
| Saudi Arabia | 3.20% |
| Netherlands | 2.90% |
| India | 2.74% |
| Spain | 2.55% |
| Italy | 2.50% |
| France | 2.48% |
| Belgium | 1.91% |
| Korea | 1.89% |
| Australia | 1.82% |
| Switzerland | 1.64% |
| Brazil | 1.43% |
| Thailand | 1.39% |
| Malaysia | 1.09% |
| Sweden | 1.08% |
| Singapore | 0.97% |
| Argentina | 0.91% |
| Canada | 0.81% |
| Turkey | 0.68% |
| Indonesia | 0.67% |
| Austria | 0.57% |
| Finland | 0.50% |
| Mexico | 0.36% |
| Norway | 0.24% |
| New Zealand | 0.17% |
| Philippines | 0.13% |
| Chile | 0.12% |
| Peru | 0.05% |
| **Total** | **76.95%** |
| Euro countries | 23.20% |

Source: Calculated from DOTS of the IMF(2011).

[3] Cost, insurance and freight.

Figure 9 illustrates the movements in trade shares of South Africa's 15 most important trading partners using the GVAR dataset.

**Figure 9: Three-year moving average trade weights for 15 main trading partners (1980 - 2009)**

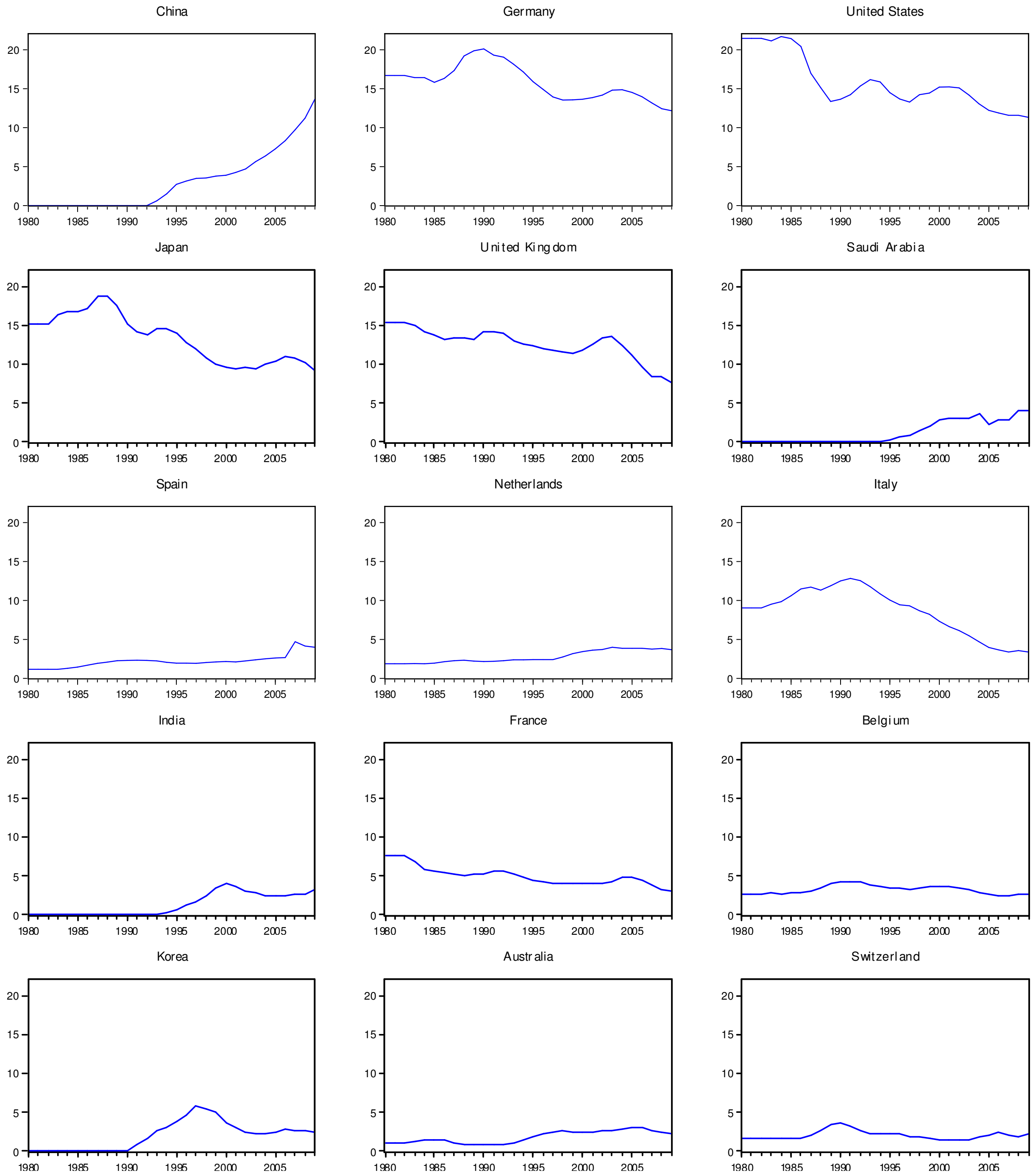
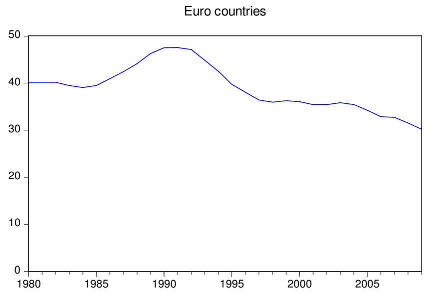



Figure 10 shows the evolution in the combined Euro area trade weight for the eight Euro countries included in the GVAR (Austria, Belgium, Finland, France, Germany, Italy, Netherlands and Spain).

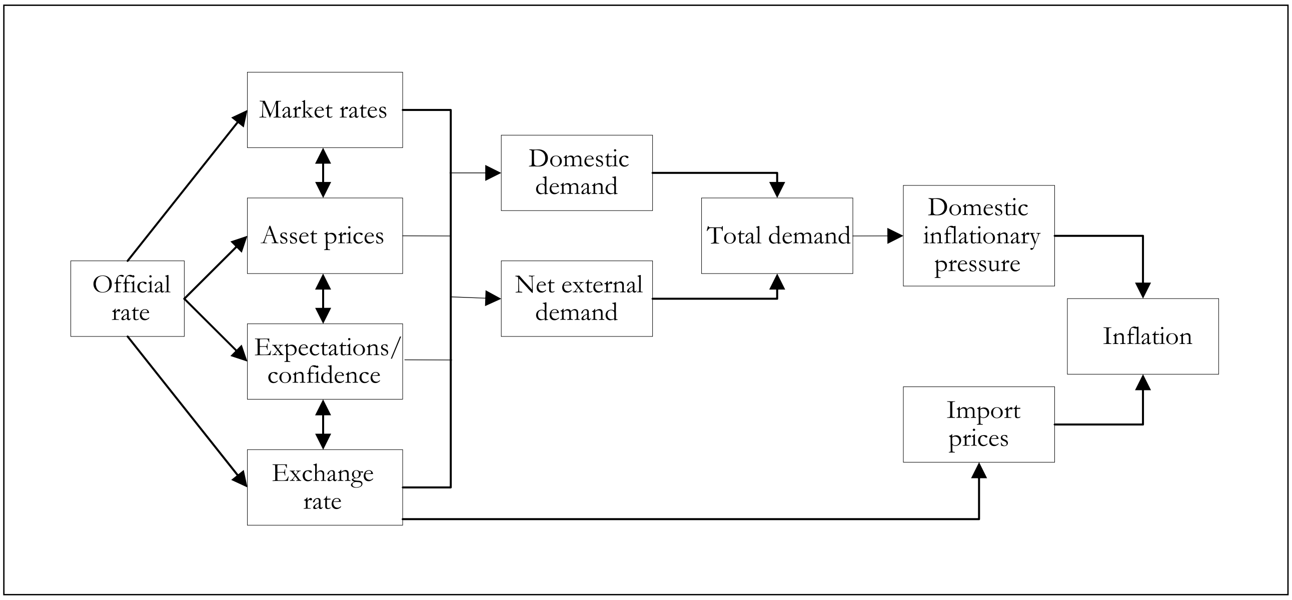
**Figure 10: Three-year moving average trade weight for Euro area (1980 - 2009)**



## Appendix B: The monetary transmission mechanism

Bain and Howells (2003) defined the transmission mechanism of monetary policy as the "series of links between the monetary policy change and the changes in output, employment and inflation". This study considers a monetary policy change as a change in the official short-term interest rate at which the central bank lends money to the banking sector. This transmission process is summarised in Figure 11.

**Figure 11: The transmission mechanism of monetary policy**




Source: Adapted from Bank of England (1999).

Figure 11 illustrates the various transmission mechanisms, or channels, through which changes in monetary policy affect the real economy and inflation in a country. Mishkin (1995:4) used the following categories to describe the transmission mechanisms: the interest rate channel, the exchange rate channel, other asset price channels and the credit channel. These channels are discussed below, for the most part using the categories chosen by Mishkin (1995:4) and the notation utilised by Smal and De Jager (2001:6-9).

Schematically the *interest rate channel* can be represented as follows:

$\downarrow$official rate $\rightarrow$ $\downarrow$other interest rates $\rightarrow$ ($\uparrow$I, $\uparrow$C) $\rightarrow$ $\uparrow$Y, where ↓official rate shows an expansionary monetary policy through a decrease in the official short-term interest rate at which the central bank lends money to the banking sector. This causes other interest rates in the economy to decrease, which in turn increase fixed capital formation (I) and consumption spending (C), resulting in an increase in real economic output (Y).

Changes in monetary policy also affect the real economy through the effect of exchange rate (ER) changes on net exports (NX). Lower domestic interest rates in comparison to interest rates in foreign countries depreciate the domestic currency, leading to an increase in net exports and thus in real economic activity. The *exchange rate channel* can be presented as follows:

↓official rate → ↓other interest rates → ↓ER → ↑NX → ↑Y

Mishkin (1995:5-7) furthermore showed how the monetary transmission mechanism works through other relative asset prices and real wealth. Schematic illustrations of the two *other asset price channels* are:

↓official rate → ↑equity prices → ↑I → ↑Y
↓official rate → ↑prices of equity, property and land → ↑wealth → ↑C → ↑Y

The first of the above channels illustrates the transmission mechanism through other relative asset prices, where lower interest rates would increase equity prices and the attractiveness of investment spending according to Tobin's *q* theory of investment (in Mishkin, 1995:6). The second channel shows the transmission mechanism through wealth effects on consumption, where the prices of previously acquired assets would increase due to lower interest rates, thereby increasing the wealth and consumption spending of the asset-holders.

The final channel is the *credit channel*. Mishkin (1995:7) separated the credit channel, which incorporates problems with asymmetric information and the expensive enforcement of contracts, into the bank-lending channel and balance-sheet channel. The *bank-lending channel* illustrates how a change in the official rate would change bank deposits, and hence bank loans to households and small firms as well as aggregate economic activity, in the opposite direction. This can be illustrated as follows:

↓official rate → ↑bank deposits → ↑bank loans → (↑I, ↑C) → ↑Y

The *balance-sheet channel* specifically deals with the net worth of households and firms. As shown with the other asset price channels, an expansionary monetary policy causes an increase in equity prices, thereby increasing the net worth of households and firms. In addition, lower interest rates improve the cash flow position of households and businesses, as a result further increasing their net worth. Adverse selection and moral hazard problems are lower and lending increases, allowing higher consumption and investment spending. The schematic representation of the balance-sheet channel is:

↓official rate → ↑equity prices, ↑cash flow → ↓adverse selection, ↓moral hazard → ↑lending → (↑I, ↑C) → ↑Y