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Estimating the equilibrium real exchange rate in Venezuela

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Estimating the equilibrium real exchange rate in Venezuela

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Abstract: To determine whether the real exchange rate is misaligned with respect to its long-run equilibrium is an important issue for policy makers. This paper clarifies and calculates the concept of the equilibrium real exchange rate, using a structural vector autoregression (VAR) model. By imposing long-run restrictions on a VAR model for Venezuela, four structural shocks are identified: Nominal demand, real demand, supply and oil price shocks. The identified shocks and their impulse responses are consistent with an open economy model of economic fluctuations and highlight the role of the exchange rate in the transmission mechanism of an oil-producing country.

JEL Classification Numbers: C32, E32, F31

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1. Introduction

A concern in many developing countries is to determine whether the real exchange rate is misaligned with respect to its long-run equilibrium. Economic theory typically predicts that the behaviour of the real exchange rate should be closely related to the behaviour of deviations from purchasing power parity (PPP). According to the PPP theory, nominal exchange rates adjust to offset changes in relative prices. Hence prices in different countries will eventually move towards an equilibrium in a common currency. For many developing countries that are facing large inflation differentials between domestic and foreign inflation rates, the PPP hypothesis has therefore proved particular useful, since it can be used to predict any over- and undervaluation of their currency. Any policy advice will therefore be dependent on the validity of PPP.

There is now widespread agreement, however, that there have been substantial deviations from PPP since the abandonment of the Bretton Woods fixed exchange rate system (see e.g. e.g. Froot and Rogoff 1995). In particular, real exchange rates can deviate from PPP in the short run, and can in fact be very volatile. Recently, empirical studies have also shown that real exchange rates are not only very volatile in the short run, the speed of convergence to PPP in the long run is extremely slow (see Rogoff 1995). The persistent deviation from PPP casts doubt on the Dornbusch (1976) open macroeconomic (overshooting) model, which explains short run real exchange rate volatility with sticky prices and monetary disturbances. Instead, long run deviation from PPP suggests the influence of real shocks with large permanent effects. The fact that many different empirical studies do not reject the hypothesis of a unit root in the real exchange rate (see e.g. Serletis and Zimonopoulos 1997) also supports the argument that the variations in real exchange rates are attributed to permanent shocks.

The results reported above refer mainly to developed countries. Studies of PPP in developing countries have been scarcer, but have provided results that show a consensus in favour of the PPP hypothesis for high inflation countries (see for instance McNown and Wallace (1989), Liu (1992) and Mhdavi and Zhou (1994)). However, in a recent study using new panel data techniques, Holmes (2001) rejects PPP for high inflation countries. Despite this, PPP is still often used as a base for predicting future real exchange rates (c.f. OECD 2003 among many others). Instead, the failure to find support for PPP should encourage researchers to construct exchange rate models that investigate the role of other economic fundamentals as sources of deviations from PPP.

This paper clarifies and calculates the concept of the equilibrium real exchange rate using a structural vector autoregression (VAR) model. The VAR model is particularly useful, as it can be used to decompose the variation in the real exchange rate into components attributable to different economic shocks (impulses). The different shocks will be identified through assumptions about their long-run impact on the variables in the model, and nominal and real shocks are distinguished in particular. The model is applied to Venezuela. By the end of the 1990's Venezuela was experiencing an appreciating real exchange rate. Many economic institutions and advisers therefore recommended that, based on a measure of PPP, Venezuela should devaluate its exchange rate, by as much as 25-40 % (se e.g. VenEconomy 1998). However, if PPP does not hold, these policy advices might be very misleading.

The rest of the paper is organised as follows. Section two briefly outlines the recent exchange rate experience in Venezuela and relates it to the hypothesis of PPP. In section three the structural VAR model is set out. Section four traces the impulse response and the variance decomposition of the variables in the model to the identified shocks, and thereafter calculates the long-run, equilibrium real exchange rate. Section five summaries and concludes.

2. PPP and the long run real exchange rate in Venezuela

A natural starting point for analysing the relationship between the exchange rate in Venezuela and its fundamentals is the by now well-known concept of PPP, which is usually understood as a prediction that the real exchange rate must be stationary and fluctuate around the mean in the long run.

Figure 1 graphs the (logarithm of) the real exchange rate in Venezuela relative to the US dollar, together with its mean, during the sample 1985Q1-1999Q1, the period of our analysis.[1] Figure 1 clearly emphasizes that the real exchange rate in Venezuela does not fluctuate around a fixed value in the short run. Instead the exchange rate wanders widely, and only slowly returns to its mean. In fact, from 1997 and onwards, the exchange rate has appreciated steadily from its mean, being on average 41 % below its mean in 1999Q1.

[1] During this period the exchange rate was fixed until 1989, when the central bank adopted an active managed float. However, with a continuous high inflationary pressure, the central bank switched to a system of exchange rate bands relatively to the U.S. dollar in 1996.

Figure 1. The real exchange rate (relative to US dollar) and its mean, (logarithms).

Augmented Dickey Fuller (ADF) unit-root tests confirm that one cannot reject the hypothesis that the real exchange rate is non-stationary against the stationary hypothesis (t_{ADF} =-1.43 and t_{ADF} =-1.64 using respectively a constant or both a constant and trend in the estimation). Hence, the long run deviation from PPP suggests the influence of real shocks with large permanent effects.

Below we therefore proceed by using instead an econometric VAR model, which decomposes the stochastic variation in the real exchange rate into components attributable to different economic shocks (cf. Clarida and Gali 1994). In particular, we will specify an exchange rate model that allows for both real and nominal shocks. By accumulating the contribution of the permanent (real) shocks to the real exchange rate, one will get a measure of the long run trend in the real exchange rate which can then be interpreted as the long run equilibrium real exchange rate.

There are other related model approaches in the literature that also take the departure from PPP as a starting point, but that may be less advantageous than the VAR-approach. For instance, the concept of the Fundamental Equilibrium Exchange rate (FEER), due to Williamson (1985), relies on more normative issues in its definitions, and may not necessarily be well founded in a statistical sense. Another approach is the IMF's Macroeconomic Balance Approach, (c.f. Isard and Faruqee 1998), which involves the calculation of internal and external demands at their potential levels (and, in the case of Venezuela, the oil price at its 'permanent' level). Hence, the methodology will therefore be very time-sensitive.

3. A structural vector autoregression (VAR) model

By estimating a VAR model containing the four variables; Real exchange rate relative to the US dollar (its main trading partner) (s_t), real manufacturing production relative to the US (y_t), consumer prices relative to the US (p_t) and real oil prices (op_t), four structural shocks can be identified; real demand shocks (ε_t^{RD}), nominal shocks (ε_t^{NOM}), aggregate supply shocks (ε_t^{AS}) and oil price shocks (ε_t^{OP}). The choice of variables and the restrictions imposed on the VAR model below, builds on a standard open economic model, as that presented in Bjørnland (1998).

Assume all variables are nonstationary integrated, I(1), variables, where stationarity is obtained by taking first differences.[2] Ordering the vector of stationary variables as $z_t = (\Delta op_t, \Delta y_t, \Delta s_t, \Delta p_t)'$, its moving average representation can be written as:

$$z_t = C(L)e_t \qquad (1)$$

where e_t is a vector of reduced form serially uncorrelated residuals with covariance matrix Ω. Assume that the orthogonal structural disturbances (ε_t) can be written as linear combinations of the innovations (e_t), i.e. $e_t = D_0\varepsilon_t$. A (restricted) form of the moving average containing the vector of original disturbances can then be found as:

$$z_t = D(L)\varepsilon_t \qquad (2)$$

where $C(L)D_0 = D(L)$. The ε_t 's are normalized so they all have unit variance. If D_0 is identified, one can derive the MA representation in (2). However, the D_0 matrix contains sixteen elements, so to orthogonalize the different innovations, sixteen restrictions are needed. First, from the normalization of var(ε_t) it follows that $\Omega = D_0 D_0'$. A four variable system imposes ten restrictions on the elements in D_0. Six more restrictions are then needed to identify D_0. These will come from restrictions on the

[2] The assumptions of stationarity are discussed and verified empirically below.

long run multipliers of the D(L) matrix. Ordering the four serially uncorrelated orthogonal structural shocks: $\varepsilon_t = (\varepsilon_t^{OP}, \varepsilon_t^{AS}, \varepsilon_t^{RD}, \varepsilon_t^{NOM})'$, the long run expression of (2) can then simply be written as:

$$\begin{bmatrix} \Delta op \\ \Delta y \\ \Delta s \\ \Delta p \end{bmatrix}_t = \begin{bmatrix} D_{11}(1) & D_{12}(1) & D_{13}(1) & D_{14}(1) \\ D_{21}(1) & D_{22}(1) & D_{23}(1) & D_{24}(1) \\ D_{31}(1) & D_{32}(1) & D_{33}(1) & D_{34}(1) \\ D_{41}(1) & D_{42}(1) & D_{43}(1) & D_{44}(1) \end{bmatrix} \begin{bmatrix} \varepsilon^{OP} \\ \varepsilon^{AS} \\ \varepsilon^{RD} \\ \varepsilon^{NOM} \end{bmatrix}_t \tag{3}$$

where $D(1) = \sum_{j=0}^{\infty} D_j$ indicate the long run matrix of D(L). The restrictions on the long-run multipliers of the system that are used here to identify the structural shocks are based on a standard open economy model.

First, the nominal demand shock is separated from the other shocks, by assuming that the nominal shock can have no long run effects on the real exchange rate (cf. Clarida and Gali 1994). Hence, the real exchange rate encompasses both short term volatility and long run deviations from PPP. In particular, PPP is preserved in the long run with respect to monetary changes, so that a nominal shock will increase the price and depreciate the exchange rate proportionally. This leaves the real exchange rate unchanged in the long run, as predicted by the Dornbusch overshooting model. Thus:

$$D_{12}(1) = D_{13}(1) = D_{14}(1) = 0 \tag{4}$$

Second, the key (long run) identifying assumption that distinguishes between the demand and supply shocks, asserts that in the long run, the level of production will be determined by supply side factors (aggregate supply and real oil price shocks) only (cf. Blanchard and Quah 1989). However, in the short run, due to nominal and real rigidities, all four disturbances can influence production. Hence:

$$D_{23}(1) = D_{24}(1) = 0 \tag{5}$$

Finally, the oil price shock itself is identified as the only shock that can have a long run effect on the real oil price. However, in the short run, all shocks are allowed to influence real oil prices:

$D_{34}(1)=0$ (6)

No restrictions are placed on prices, although there are some overidentifying restrictions on prices that can be tested informally by examining the impulse response analysis. For instance, the standard aggregate demand/supply diagram suggests that whereas positive real demand and nominal shocks (that increase production only temporarily) shall increase prices permanently, following a positive aggregate supply shock (that increases production permanently), prices shall fall permanently.

With the six long run restrictions, the matrix D(1) will be lower triangular, and one can use this to recover D_0. The long run representation of expression (2) implies:

$$C(1)\Omega C(1)' = D(1)D(1)' \tag{7}$$

(7) can be computed from the estimate of Ω and C(1). As D(1) is lower triangular, expression (7) implies that D(1) will be the unique lower triangular Choleski factor of $C(1)\Omega C(1)'$.

4. Sources of real exchange rate fluctuations

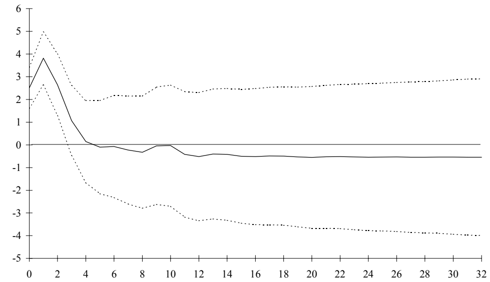
The sample uses quarterly data, 1985Q1-1999Q1. The start date reflects availability of data. All variables are taken from the IMF's IFS, except manufacturing production in Venezuela that has source Central Bank of Venezuela. Estimating a well specified VAR, figures 2-4 plot the impulse responses of the four shocks on the real exchange rate, relative prices and relative real manufacturing production, respectively.[3] The figures presented give the cumulative response in (the level of) each endogenous variable to a unit (innovation) shock, with a one standard deviation band around the point estimate.[4] All the different shocks have the effects as expected by a standard open economy model.

[3] For neither of the variables, can one reject the hypothesis of I(1) in favour of the (trend) stationary alternative but one can reject the hypothesis that all variables are I(2) (see table A1 in the appendix). Lag reduction tests suggest a lag order of four. Estimating a VAR-model with four lags and seasonal dummies, one can reject the hypothesis of serial correlation, heteroscedasticity and non-normality in each equation at the 1 % level (see table A2). Testing for cointegration, one can conclude that none of the variables in the VAR models are cointegrated (see table A.3).

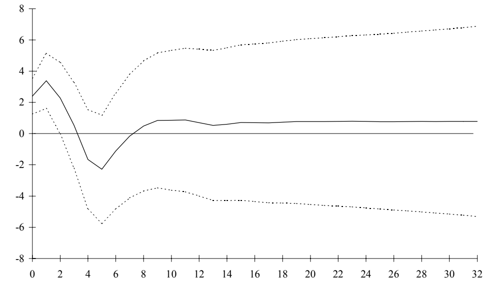
[4] The standard errors reported are calculated using Mount Carlo simulation based on normal random drawings from the distribution of the reduced form VAR. The draws are made directly from the posterior distribution of the VAR coefficients. The standard errors that correspond to the distributions in the D(L) matrix are then calculated using the estimate of D_0.

Figure 2. Impulse responses for the real exchange rate with one standard error band

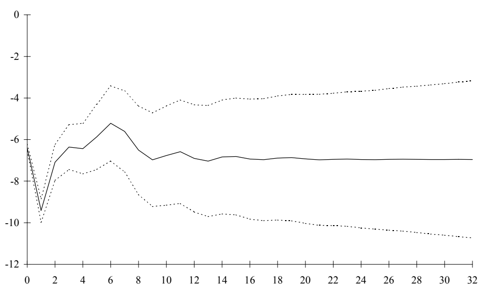
A) Oil price shock



B) Aggregate supply shock



C) Real demand shock



D) Nominal shock

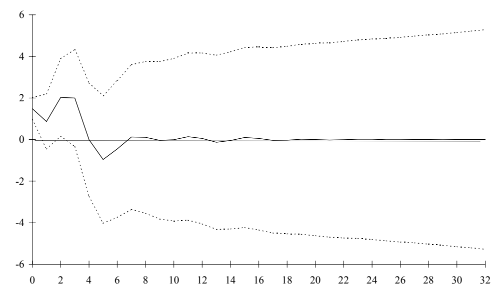
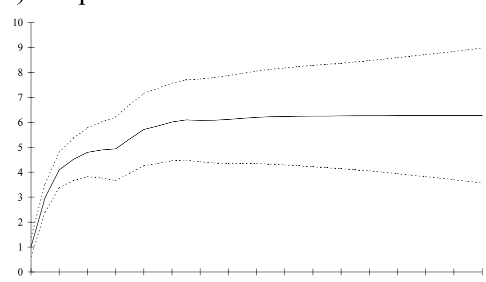
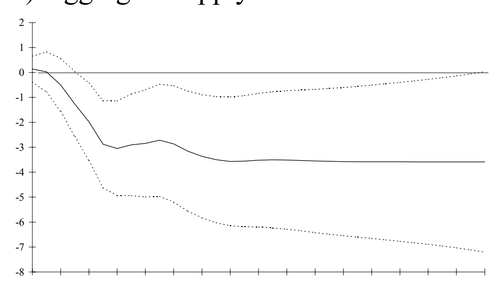


Figure 3. Impulse responses for price with one standard error band

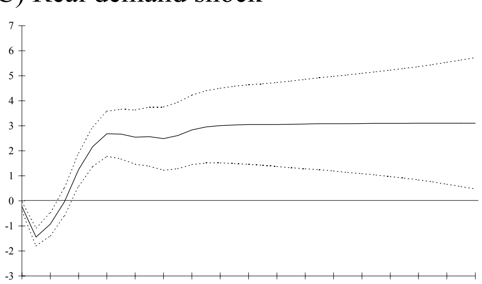
A) Oil price shock



B) Aggregate supply shock



C) Real demand shock



D) Nominal shock

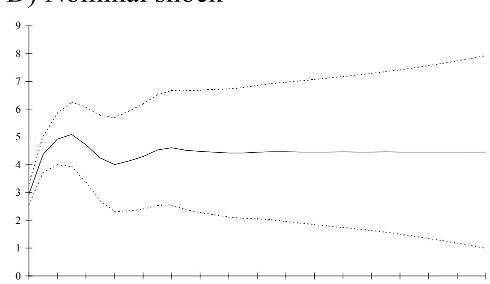
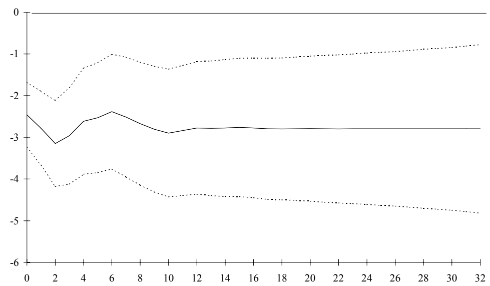
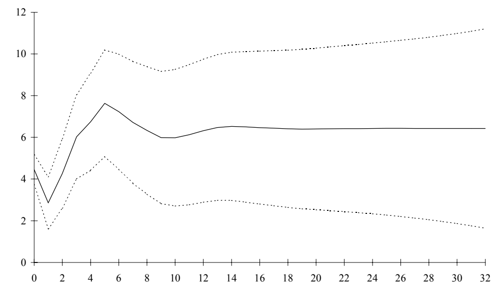


Figure 4. Impulse responses for manufacturing production with one standard error band

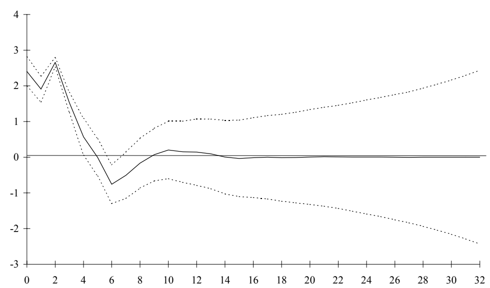
A) Oil price shock



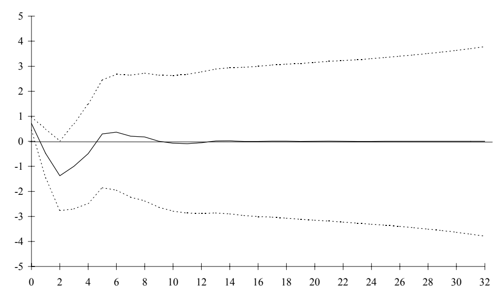
B) Aggregate supply shock



C) Real demand shock



D) Nominal shock



For a large oil producing country like Venezuela, a positive oil price shock appreciates the real exchange rate and increases relative prices in the long run. However, the long run effect on the real exchange rate is very small and insignificant, and the first two quarters, the real exchange rate actually depreciates, before it gradually appreciates towards its new long run equilibrium level. Manufacturing production falls in response to the oil price shock, and the effect is significant in the long run (eight years).

A supply shock depreciates the real exchange rate, reduces prices and increases real production permanently, which is consistent with a flexible price exchange rate model. However, the effect on the real exchange rate is not significantly different from zero in the long run.

A positive real demand shock appreciates the real exchange rate and increases prices gradually. Real manufacturing production also increases temporarily. Manufacturing production thereafter declines gradually as the long run restriction bites, and after two years, the standard error bands include zero.

In line with Dornbusch's overshooting model, a nominal shock depreciates the real exchange rate temporarily, before it appreciates (overshoots) back to long run equilibrium. Prices increase quickly to a new permanent higher level. Due to the quick adjustment in prices, the effect on real manufacturing production is essentially zero.

Variance decompositions confirm the picture from above (and can be obtained from the author on request). For a resource rich country, stochastic shocks to the goods market (IS shocks) may induce excessive exchange rate volatility. This view is supported for Venezuela, as real demand shocks explain over 70 % of the variation in the real exchange rate the first year, increasing to 80 % after two years.[5] The other three shocks explain each approximately 10 % of the real exchange rate variation the first year, declining thereafter gradually to zero.

Finally, figure 5 plots the time path of the real exchange rate that is due to the permanent effect of the real demand shocks, adding the drift term, together with the log of the actual real exchange rate.[6] If one takes the contribution of the permanent shocks to the real exchange rate as a measure of the long run trend in the real exchange rate, then this is a measure of the long run equilibrium real exchange rate. Any deviation of the real exchange rate above (below) the trend signifies an undervaluation (overvaluation).

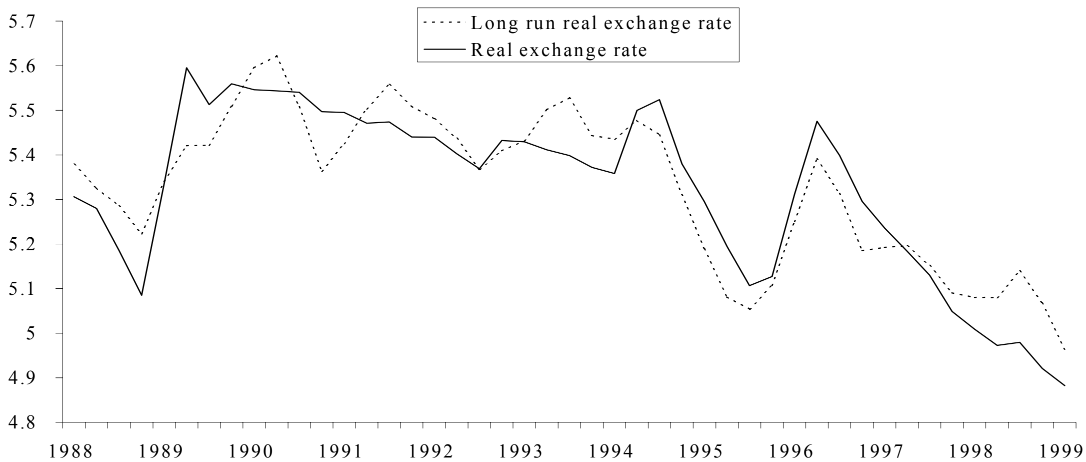
Figure 5 suggests that although the trend (accumulated real demand shocks) follows the real exchange rate closely, in many periods, real demand shocks fail to explain the full move in the real exchange rate. In particular, the real exchange has been overvalued and subsequently undervalued in the late 1980s, it has fluctuated around trend in the early 1990s, it has been undervalued from 1994-1996 and finally overvalued from 1997. The overvaluation of the real exchange rate from its trend from 1997 and onwards, is the most severe in this sample, being on average 12 % below trend in 1998, falling to 8 % in 1999Q1. However, the degree of overvaluation is much smaller in the VAR model compared

[5] This may be consistent with the fact that the high oil revenues in the beginning of the 1980's allowed Venezuela to pursue an ambitious fiscal spending program throughout the 1980's, which eventually led to debt and currency crisis, as the oil price fell in 1986.

[6] The long term effects of aggregate supply and real oil price shocks on the real exchange rate are ignored, as neither of the shocks have significant long run effects.

to the static PPP-measure as we now are able to explain more of the long term movements in the real exchange rate within the model.

Figure 5. Long run real exchange rate (Accumulated real demand shocks)



6. Conclusions and summary

This paper clarifies and calculates the concept of the equilibrium real exchange rate in an oil producing developing country like Venezuela. In particular, the relative ability of demand and supply shocks in explaining real exchange rate fluctuations is examined. To do so, a structural VAR model is specified in real exchange rates, relative real manufacturing production, relative prices and the real oil price, that is identified through long run restrictions on the dynamic multipliers in the model. The way the model is specified, four structural shocks are identified; Nominal demand, real demand, aggregate supply and oil price shocks.

There seems to be overwhelming evidence that the behaviour of the real exchange rate in Venezuela is not related to PPP. The hypothesis of PPP can therefore not be used to predict any over- and undervaluation of the exchange rate. Instead, if one takes the contribution of the permanent real demand shocks to the real exchange rate as a measure of the long run trend in the real exchange rate, then this is a measure of the long run equilibrium real exchange rate. The model implies that the real exchange rate is overvalued by the late 1990s. However, the overvaluation is relative small compared to that implied by the PPP, hence, any policy advice based on PPP would therefore exaggerate the misalignment of the real exchange rate in Venezuela.

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APPENDIX Model specification

Table A.1. Augmented Dickey-Fuller unit-root tests, 1986Q4-1999Q1[a]

Series	ADF(lags)	t_{ADF}	Series	ADF(lags)	t_{ADF}
y	ADF(4)	-2.54	Δy	ADF(5)	-3.42*
p	ADF(2)	-2.11	Δp	ADF(2)	-3.50*
s	ADF(6)	-1.85	Δs	ADF(5)	-4.26**
op	ADF(3)	-2.73	Δop	ADF(3)	-4.44**

[a] Critical values were taken from Fuller (1976). A constant and a time trend are included in the regression using levels, whereas only a constant is included in the regression using first differences. The number of lags is determined by selecting the highest lag with a significant *t* value on the last lag, as suggested by Doornik and Hendry (1997).
* Rejection of the unit root hypothesis at the 5 percent level, ** Rejection of the unit root hypothesis at the 1 percent level

Table A.2. Misspecification tests, 1986Q2-1999Q1[a]

Test	Statistic	Δy	Δp	Δs	Δop
AR 1-4[b]	F^2 *(4, 28)*	0.84	0.93	0.55	0.83
		(0.51)	(0.46)	(0.70)	(0.52)
ARCH 4[c]	F^2 *(4, 24)*	0.74	0.31	0.28	0.93
		(0.57)	(0.87)	(0.89)	(0.47)
Normality[d]	X^2 (2)	2.64	5.17	2.49	3.42
		(0.27)	(0.08)	(0.29)	(0.18)

[a] The number in brackets are the p-values of the test statistics. All statistics have been calculated using PcFiml 9.0 (see Doornik and Hendry 1997). [b] LM test for residual autocorrelation of order 5. [c] LM test for 4th order ARCH in the residuals
[d] Test of normality, see Doornik and Hendry (1997) for references and descriptions.

Table A.3. Johansen cointegration tests; Cointegrating vector (y_t, p_t, s_t, op_t), 1986Q2-1999Q1[a]

H_0	H_1	Critical value 5 %	Critical value 5 %		*df-adj*[b]		*df-adj*[b]
		λ_{max}	λ_{trace}	λ_{max}	λ_{max}	λ_{trace}	λ_{trace}
r=0	r≥1	27.07	47.21	18.16	11.18	38.46	23.67
r≤1	r≥2	20.97	29.68	11.51	7.09	20.29	12.49
r≤2	r≥3	14.07	15.41	8.52	5.24	8.78	5.40
r≤3	r≥4	3.76	3.76	0.26	0.16	0.26	0.16

[a] All test-statistics are calculated using PcFiml 9.0 (see Doornik and Hendry 1997). Critical values are taken from Table 1 in Osterwald-Lenum (1992), corresponding to the case where the constant is unrestricted.
[b] df-adj refers to the eigenvalue adjusted for degrees of freedom (see Reimers 1992).