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Inflation and the Role of Wages in South Africa: A Co-integration Analysis

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1. Introduction

Explaining the behaviour of inflation has received considerable attention in the literature, resulting in a variety of models of the inflation process. Amongst these models, theories of inflation that focus on cost factors such as wages (or unit labour cost) and imports costs, are widely supported in economy-wide macro-econometric models (see, for example Whitley 1994 and the Bank of England 1999) and in the recent academic literature (see, for example Ghali 1994 and Welfe 2000). Wages, in turn, are often modelled using an expectations-augmented Phillips curve (Bank of England 1999).

In South Africa, the recent change to an inflation-targeting monetary policy framework has increased the need to understand and model empirically the inflation process and, in particular, the interaction between wages and inflation. A recent paper in the respect is that of Fedderke and Schaling (1999).

The purpose of this working paper is to investigate empirically the inflation process in South Africa, both at the aggregate and sectoral levels, with a particular focus on the role of wages. The theory underlying the model specification is that of a mark-up (over costs) view of inflation determination and an expectations-augmented Phillips curve explanation of wage determination. The econometric methodology employed is that of multivariate co-integration.

The paper proceeds as follows: Section two reviews the basic theory underlying the mark-up specification of the inflation process and the expectations-augmented Phillips curve. Section three is a brief summary of previous research on the topic. Section four details the data used (which is shown graphically in the Appendix B) and section five the econometric methodology. Section six contains a summary of the results of the econometric analyses with the detailed results presented in Appendix C. Section seven concludes.

2. Inflation-wages interaction: The Basic Model

The model of inflation (and wages) used in the econometric analysis presented below consists of a cost-based mark-up view of the inflation process and an expectations-augmented Phillips curve theory of wage determination. Based on Gordon (1982), Stockton and Glassman (1987) and Welfe (2000), the model may be presented by the following set of equations:

$$p_t = \alpha_0 + \alpha_1 w_t + \alpha_2 q_t + \alpha_3 pm_t + \alpha_4 GAP_t + \varepsilon p_t \quad (1)$$

$$w_t = \beta_0 + \beta_1 p^e_t + \beta_2 q_t + \beta_3 GAP_t + \varepsilon w_t \quad (2)$$

$$p^e_t = \Sigma_i \lambda_i p_{t-i} \quad (3)$$

Where p_t denotes the price level, w_t wages, q labour productivity, pm_t import prices, GAP_t the output gap and p^e_t price expectations all at time t. Further, all the α_i, β_i, and λ_i are expected to be positive except for α_2 which should be negative.

Equation (1) represents price determination. It is based on the view that prices are determined as a mark-up over costs, where the costs are represented by wages and productivity (or unit labour cost) and import prices (see Mohr and Rogers 1991: 356-359 and Bank of England 1999: 58-59). The mark-up is influenced by the extent of excess demand in the economy, as measured by the output gap (that is the deviation of actual from potential output). The model may also be extended to provide for supply shocks (such as oil price changes or changes in the real exchange rate or in the terms of trade).

Equation (2) represents the wage determination process and is based on an expectations-augmented Phillips curve. Phillips curve models generally relate wage increases to some measure

of excess demand or real disequilibrium, conventionally measured by either an unemployment rate or output gap. The original work on the Phillips curve was undertaken by Phillips (1958), who documented the apparent inverse relationship between money wage growth and unemployment in the United Kingdom. The expectations-augmented version of the theory was proposed by Friedman (1968) and Phelps (1968). Their version provides for, in addition to excess demand as an explanation for nominal wage growth, a role for inflation expectations (see Bank of England 1999: 78-82).

Equation (2) can either be presented in the form of an equation explaining nominal wages, with productivity as a determinant, or in the form of an equation explaining unit labour costs, i.e. wage growth minus productivity growth.

Price expectations could be modelled in various ways. One approach is to model expectations as backward-looking, that is as a function of past changes in prices (also called adaptive expectations) (see Ghali, 1999: 419). Another is to assume rational expectations.

3. Previous Research

Previous research on inflation and wages in South Africa based on a Phillips curve relationship is found in Pretorius and Smal (1994), Pretorius and Janse van Rensburg (1996) and Fedderke and Schaling (1999).

The model used by Pretorius and Small (1994) consists of a price-mark-up equation on unit labour costs, import prices and administered prices; a price expectations equation based on past inflation, money supply growth and import prices and a wage equation based on price expectations, productivity, the output gap and a dummy variable to account for trade union activity. Their econometric results (for the period 1970 to 1992) suggests a mark-up on unit labour costs of 0.84 and on all costs (that is including import prices) of 0.98.

The study by Pretorius and Janse van Rensburg compares four different models, namely a Phillips curve model, a traditional monetarist model, a money demand model and a time series model. The results do not provide for an explicit calculation of the price-mark-up on unit labour costs or total costs but they found that "
than the traditional monetarist model and the money demand model over the forecasting period" (Pretorius and Janse van Rensburg, 1996: 8).

The model used by Fedderke and Schaling (1999), which is very similar to the one used in this paper (and which uses similar econometric techniques), is based on the paper of Ghali (1999) regarding inflation in the US economy. They find strong evidence for the role of wages (unit labour costs) in the inflation process in South Africa and thus for the mark-up view of price determination. Their measure of the mark-up over unit labour costs provides for a mark-up of about 30 percent, which is much higher than that found for the US and in the Pretorius and Smal (1994) study for South Africa. A more standard measure of the mark-up in an open economy would also include import costs as part of the total costs on which the mark-up is placed. If Fedderke and Schaling's (1999) measure of the impact of the real exchange rate is taken as a measure of the impact of import prices, then their mark-up increases to 54 percent, which appears to be very high.

4. Data description

As with many macroeconomic time series, the data used in this study appears to be non-stationary. This is clear even by visual inspection of the graphs (see Appendix B). Formally, a variable is integrated of order d, if taking d differences of the variable generates a stationary series (Banerjee, *et. al*. 1993: 6). The order of integration of the relevant variables are examined using the augmented Dickey-Fuller tests as is reported in Table 2 in Appendix A. The majority of the variables are evidently I(1). Co-integration in this paper will therefore refer to linear combinations of I(1) variables where the linear combination is I(0).

The analysis was conducted using quarterly data. In some cases, the official data sources provide annual frequency data only. Here quarterly data was derived by interpolation. In defining the variable names used below, an L prefix indicates the natural log of the variable and a DL the first difference of the successive log values. In defining the sectoral variables the following notation was used: A= agriculture, forestry and fishing, MI= mining and quarrying[1], M= manufacturing, E= electricity, gas and water, C= construction, catering and accommodation, T= wholesale and retail trade, TC= transport, storage and communication, F= financial intermediation, insurance, real estate and business services, G= community, social and personal services.

On prices, the GDP-deflator (GDPDEF) was used. The analysis focuses on the GDP-deflator as the primary price variable since it is the only one available on both the aggregate and sectoral levels. The comparability of price indices across sectors and at the aggregate level was the overriding consideration in this decision.

On unit labour costs, the South African Reserve Bank (SARB) data series (7080L) (ULCB) was used on the aggregate level and on the sectoral level, quarterly data derived as a linear interpolation with last period match was used (ULCW). The choice of interpolation method was based on the empirical results after experimenting with a number of methods. The sectoral data on unit labour costs was derived from the statistics on sectoral wages and productivity (derived as output divided by employment) from the Wefa database.

On import prices (MDEF), the implicit deflator for imports of goods and non-factor services was derived from the SARB data series on real (6014D) and nominal (6014L) imports of goods and non-factor services.

On exchange rates, the real effective exchange rate published by the SARB (5366M) (EFFR) was used.

On oil prices, the dollar price of Brent crude, Datastream (series code: UKI76AAZA)

On the terms of trade, a data series compiled from the implicit deflators for the exports and imports of goods and non-factor services were used (PTOT). These, in turn, were calculated using the respective real and nominal data series (6013D, 6014D, 6013L, 6014L) from the SARB.

On the output gap, data series were constructed from the actual GDP and a Hodrick-Prescott measure of trend GDP, both on the aggregate and sectoral levels (..GAP).

On price expectations, two alternative measures were used. The first assumes backward looking (static) expectations and uses the implicit deflator on personal consumption expenditure as a base (PCDEF). The second assumes rational expectations and is based on the realised (next

[1] *No data-congruent and sTable relationship could be found for prices and wages in the mining and quarrying sector.*

period) value of the Consumer Price Index[2] (SARB, 7032N). The discrepancy between using consumer prices for the process forming expectations and using a GDP deflator for the actual price series is not problematic. It is reasonable to expect that an aggregate level price series be the basis of the price expectations relevant to wage negotiations in every sector. The GDP deflator series are neither timely enough, nor broad enough to inform the price-expectations in every sector.

5. Econometric methodology

The characteristics of the data suggest that that the econometric methodology should be sensitive to the presence of non-stationary data in addition to the usual problems associated with empirical modelling in economics. There are many ways of dealing with non-stationarity in time-series econometrics, amongst which detrending and differencing of the relevant series have often been used. However, the latter loses important long-run information on the way to solving the non-stationarity problem. In the presence of I(1) series (as found above), detrending is also inadmissible as a deterministic trend is a miss-specification in the presence of unit roots (see Nelson and Plosser, 1982).

A third potential solution to the non-stationarity problem is to look for pairs or groups of variables that form a stationary linear combination. If such a combination exists we say that the relevant variables are co-integrated. Whereas detrending and differencing guarantees success in dealing with non-stationarity, co-integration is only a possibility the presence of which needs to be investigated through statistical testing. Below, the Johansen procedure is used to test the co-integration hypothesis.

A co-integrated group of variables is stationary despite it being a linear combination of individually non-stationary series. In this way the co-integrated relationship acts as an "attractor" towards which the series adjusts following a departure from the co-integrated relationship. This is why co-integrated relationships are often called "long-run equilibria" (Hendry and Juselius, 1999b: 1-2). Note that equilibrium is not used in the market clearing sense here, but in the econometric sense where a "*substantive long-run equilibrium relationship is something from which the variables involved can deviate, but not by an ever-growing amount*" (Banerjee, *et. al*., 1993: 7).

There are a number of strategies for finding co-integrated combinations but the nature of this study constrained the choice amongst these. In all the relationships of interest there are likely to be more than two variables, which excludes single equation co-integration techniques such as the Engle-Granger two-step procedure. The latter is inappropriate since it assumes that there is only one potentially co-integrating combination amongst a group of n variables, whereas there can be up to n-1 co-integrating relationships in a group of n variables (Banerjee, *et. al.,* 1993: 255-256). The Johansen procedure was used to determine the number of co-integrating vectors in each equation. Having established the number of co-integrating vectors (which was 2 in all the cases reported here) the technique of reduced rank regression was used to estimate the coefficients of the co-integrating relationships. All the associated econometrics was done using the PcGive Professional package.

The co-integration technique described above formed a part of the general-to-specific modelling strategy followed here. This is a progressive research strategy with both constructive and critical aspects. The constructive part of the strategy is the starting point, employing an unrestricted empirical specification, which is later reduced to reveal a structural model. A further constructive

[2] *See Cuthbertson, Hall, and Taylor, 1992: 161.*

aspect is the anchor in the existing literature, described above. The critical aspect of the strategy is the simplification of the general model should the latter prove to be a congruent description of the data. Subsequent reductions of the general model are testable which ensures that the final reduced model is a valid description of data insofar as the general model is valid (Hendry, 1985: 74-75).

A general unrestricted model starts by specifying the joint distribution of the data generating process (DGP). Empirically this implies a vector-autoregressive (VAR) specification with all of the relevant variables entering as jointly endogenous variables. In this study the number of variables of interest are usually greater than two, which means that there may be more than one long-run relationship between the variables. As discussed above, the Johansen procedure was consequently used to discover the number of long-run relationships and the method of reduced rank regression used to identify those relationships. As with the familiar two-variable case, the Granger representation theorem implies that there is an error correction specification (VECM) for every VAR with a positive number of co-integrated relationships (Banerjee *et. al*., 1993: 145-152).

In additional weak exogeneity tests[3] were conducted and are reported in Appendix C.

6. Empirical results

6.1 Long-run results

The above-mentioned methodology was used to investigate the relationship of wages and prices in the South African economy, both at an aggregate and a sectoral level. Table 1 summarises the long-run relationships as identified in the co-integration analysis, by sector. There are two equations in each case, the first can be read as a price-equation and the second as a wage equation. However, they are jointly endogenous so causality cannot be inferred from these results. Appendix C summarises the justification for the particular specification in each sector. The separate discussions for each equation in Appendix C contain the maximum eigenvalue and trace test on the basis of which the number of co-integrated vectors was determined.

Table 1: Long-run relationships as identified in the co-integration analysis, by sector

Long-run relationship 1							
Endogenous variables in the VAR					***Deterministic variables***		
Equation 1		***Aggregate level***					
LGDPDEF	LULCB	Lpcdef	LMDEF	LOILS	Constant		GDPgap
-1	0.93071	0	0.16124	0	0		Not in long-run relationships
0	-1	1.0054	0	0.05071	0		
Over-identifying restrictions[4]		$X^2(2) = 5.57$ [0.06]		***Number of long term relationships***			2
Estimation period:		1976:3-1999:3					

Where:

LGDPDEF:	Implicit GDP deflator
LULCB:	Unit Labour Costs
LPcdef:	Implicit deflator for private consumption expenditure
LMdef:	Implicit deflator for imports
LOILS:	Oil price in USD
GDPGAP:	Output gap

[3] *See Engle, Hendry and Richard, 1983: 282*

[4] *This statistic reports on the likelihood ratio on the over-identifying restrictions. The null hypothesis is that the over-identifying restrictions are valid.*

Long-run relationship 2						
Endogenous variables in the VAR					***Deterministic variables***	
Equation 2		***Aggregate level***				
LGDPDEF	LULCB	Lpcdef	LMDEF	LEFFR	Constant	GDPgap
-1	0.908	0	0.19018	-0.0062	0	Not in long-run relationships
0	-1	0.99233	0	0	0	
Over-identifying restrictions		$X^2(4) = 2.63$ [0.62]			***Number of long term relationships***	2
Estimation period:		1974:1-1999:3				

Where:
LEFFR: Real effective exchange rate

Long-run relationship 3					
Endogenous variables in the VAR				***Deterministic variables***	
Equation 3		***Agriculture***			
LAGDPdef	LAulcW	Lpcdef	LEFFR	Constant	AGDPgap
-1	0.83211	0	-0.02864	0	Not in long-run relationships
0	-1	1.029	0	0	
Over-identifying restrictions		$X^2(3) = 5.09$ [0.17]		***Number of long term relationships***	2
Estimation period:		1972:2-1998:4			

Where:
LAGDPdef: Implicit GDP deflator for agriculture
LAulcW: Unit labour costs in agriculture

Long-run relationship 4					
Endogenous variables in the VAR				***Deterministic variables***	
Equation 4		***Manufacturing***			
LMGDPdef	LMulcW	LCPIrat	LOILS	Constant	MGDPgap
-1	1.0824	0	0.08772	0	Not in long-run relationships
0	-1	0.99996	0	0	
Over-identifying restrictions		X^2 (3) = 4.58 [0.21]		***Number of long term relationships***	2
Estimation period:		1977:1-1998:4			

Where:
LMGDPdef: Implicit GDP deflator for manufacturing
LMulcW: Unit labour costs in manufacturing

Long-run relationship 5					
Endogenous variables in the VAR				***Deterministic variables***	
Equation 5		***Electricity, gas and water***			
LEGDPdef	LEulcW	LOILS	LPcdef	Constant	EGDPgap
-1	0.7533	0.11757	0	0	Not in long-run relationships
0	-1	0	1.304	0	
Over-identifying restrictions		X^2 (1) = 0.38 [0.54]		***Number of long term relationships***	2
Estimation period:		1975:1-1998:4			

Where:
LEGDPdef: Implicit GDP deflator for electricity
LEulcW: Unit labour costs in electricity

Long-run relationship 6						
Endogenous variables in the VAR					***Deterministic variables***	
Equation 6		***Construction***				
LCGDPdef	LCulcW	LTOT	LCPIrat		Constant	CGDPgap
-1	1.1576	-1.1128	0		0	Not in long-run relationships
0	-1	0	0.98191		0	
Over-identifying restrictions		X^2 (3) = 4.65 [0.2]			***Number of long term relationships***	2
Estimation period:		1976:3-1998:4				

Where:
LCGDPdef: Implicit GDP deflator for construction
LCPIrat: CPI price expectations assuming rational expectations
LCulcW: Unit labour costs in construction

Long-run relationship 7						
Endogenous variables in the VAR					***Deterministic variables***	
Equation 7		***Retail and wholesale trade***				
LTGDPdef	LTulcW	LCPIrat	LEFFR		Constant	TGDPgap
-1	0.92376	0	-0.55909		0	Not in long-run relationships
0	-1	1.1851	0		0	
Over-identifying restrictions		X^2 (3) = 3.35 [0.34]			***Number of long term relationships***	2
Estimation period:		1974:3-1998:4				

Where:
LTGDPdef: Implicit GDP deflator for retail and wholesale trade
LTtulcW: Unit labour cots in retail and wholesale trade

Long-run relationship 8							
Endogenous variables in the VAR						***Deterministic variables***	
Equation 8		***Transport and Communications***					
LTCGDPdef	LTCulcW	Lpcdef	LOILrand	LEFFR		Constant	TCGDPgap
-1	0.78163	0	0.5727	-1.5816		0	Not in long-run relationships
0	-1	1.0643	0	0		0	
Over-identifying restrictions		X^2 (2) = 5.8 [0.06]				***Number of long term relationships***	2
Estimation period:		1978:1-1998:4					

Where:
LTCGDPdef: Implicit GDP deflator for transport and communications
LTCulcW: Unit labour costs in transport and communications
LOILrand: Oil price in Rand

Long-run relationship 9						
Endogenous variables in the VAR					***Deterministic variables***	
Equation 9		***Financial and business services***				
LFGDPdef	LFulcW	LPcdef	LOILS		Constant	FGDPgap
-1	1.1475	0	0.10111		0	Not in long-run relationships
0	-1	0.99632	0		0	
Over-identifying restrictions		X^2 (5) = 9.56 [0.09]			***Number of long term relationships***	2
Estimation period:		1975:1-1998:4				

Where:
LFGDPdef: Implicit GDP deflator for financial and business services
LFulcW: Unit labour costs in financial and business services

Long-run relationship 10					
Endogenous variables in the VAR				***Deterministic variables***	
Equation 10		***Government services***			
LGGDPdef	LGulcW	LCPIrat	LOILS	Constant	GGDPgap
-1	1.0379	0	0.11364	0	Not in long-run relationships
0	-1	1.1855	0.17816	0	
Over-identifying restrictions		$X^2(2) = 2.42$ [0.3]		***Number of long term relationships***	2
Estimation period:		1975:1-1998:4			

Where:
LGGDPdef: Implicit GDP deflator for government services
LGulcW: Unit labour costs in government services

6.2 Short run or dynamic results

In this section we trace the effect of the shocks to the error processes of the various endogenous variables on wages and unit labour costs in each model listed above. Impulse response functions[5] allow a visual inspection of the simulated impact on wages and the unit labour cost of a shock to each of the errors processes of the endogenous (see for example, Bernanke and Mihov, 1998: 892-893). Impulse response functions are an alternative way of expressing the information contained in the model as they are moving average representations of the VECM (Vector error correction model) (Enders, 1995: 305-306). There is therefore, no need to investigate the VECM specifications explicitly here.

In this section the dynamic simulation is reported by shock. For example, the effect of a positive shock to inflationary expectations on prices and unit labour cost is traced through all the models reported above. The analysed shocks are: supply side shocks (to the real exchange rate, the terms of trade or the oil price), import prices, inflation expectation shocks (static or rational expectations), unit labour cost shocks and price shocks.

6.2.1 Supply side shocks

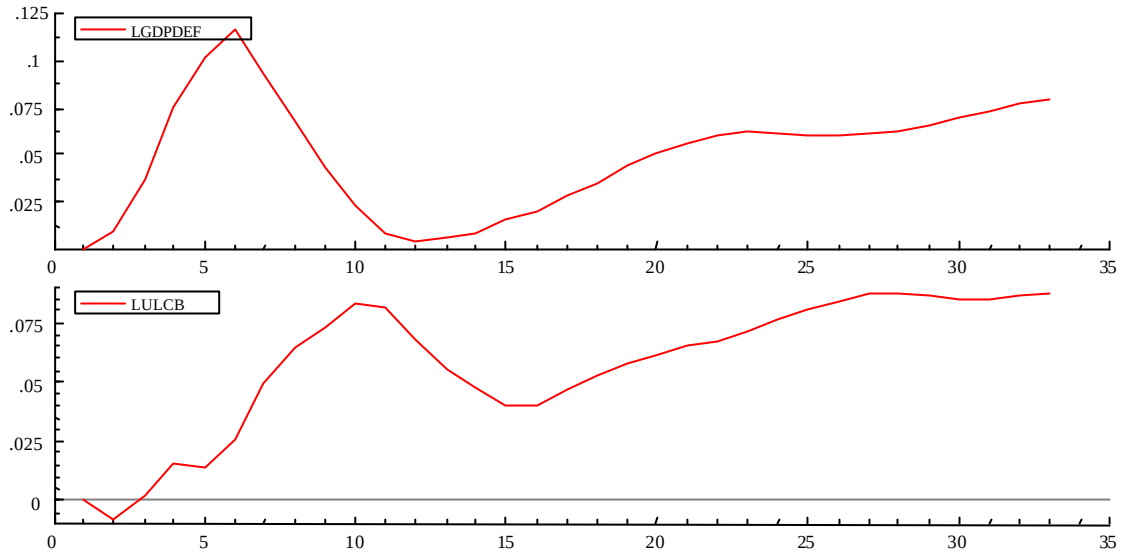
6.2.1.1 Aggregate level

Equation 1

Dynamic effect of a unit shock to the error process of the dollar oil price

[5] *The impulse response function is a dynamic simulation of the VAR's response to shocks in the error processes of the various endogenous variables (Doornik and Hendry, 1997: 150).*

Figure 1: Dynamic effect of a unit shock to the error process of the dollar oil price (eq1)

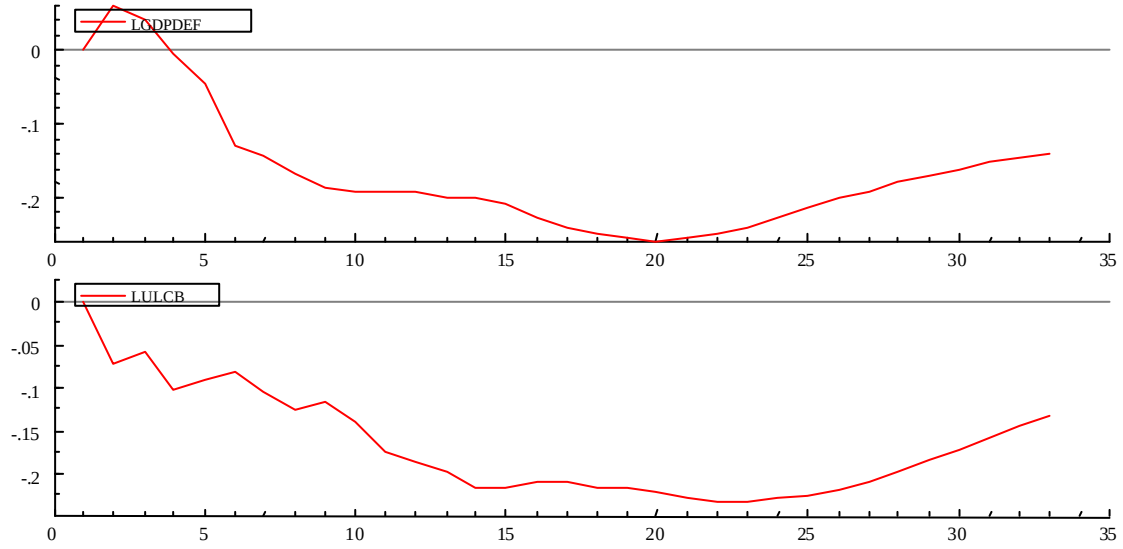


The response of the price level is faster and more pronounced than the response of unit labour cost to this supply side shock. However, the impact at an 8-year horizon is similar on both prices and unit labour cost.

Equation 2

Dynamic effect of a unit shock to the error process of the real effective exchange rate

Figure 2: Dynamic effect of a unit shock to the error process of the real effective exchange rate (eq 2)



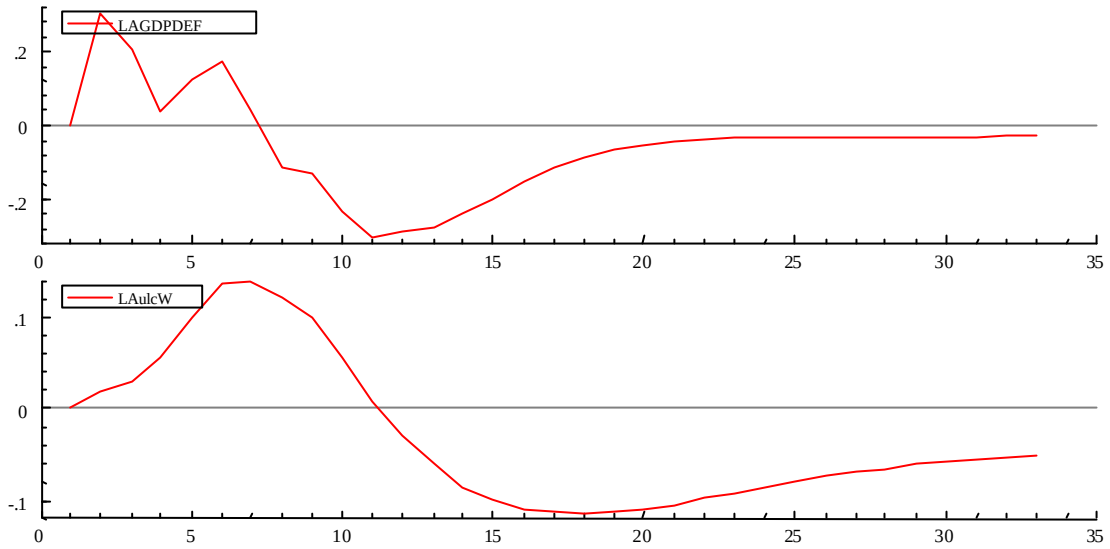
A positive unit shock to the real effective exchange rate has a more rapid depressing effect on wages at the aggregate level than on the aggregate price level. However after about 15 quarters both series register a similar response to the initial shock.

6.2.1.2 Agriculture

Equation 3

Dynamic effect of a unit shock to the real effective exchange rate

Figure 3: Dynamic effect of a unit shock to the real effective exchange rate (eq 3)



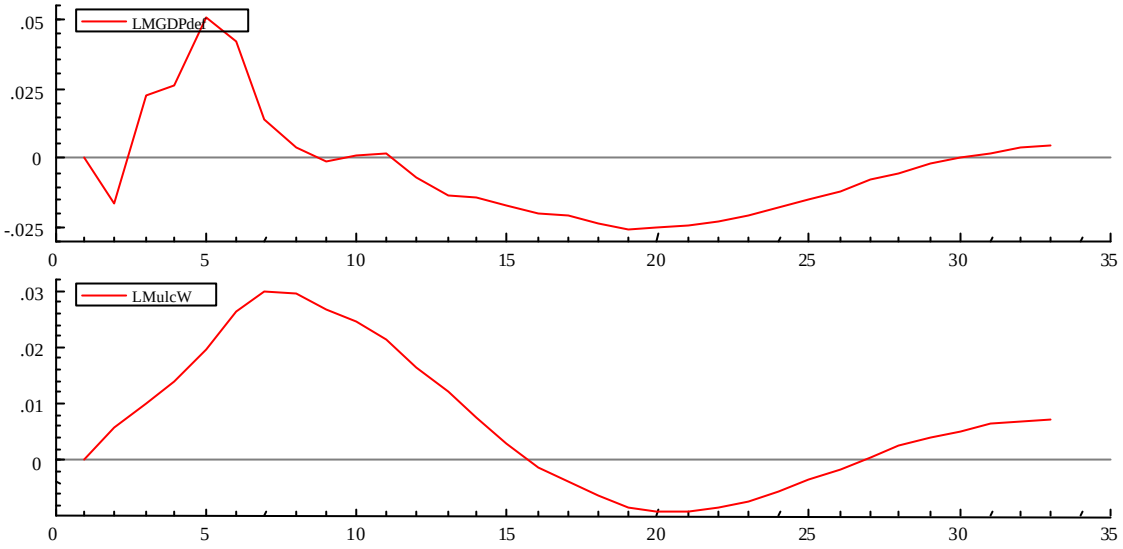
A unit shock to the real effective exchange rate has an initially perverse effect on the prices and (though slower and more damped) also on unit labour costs in agriculture. After about 7 quarters the price level starts to decline in response to the shock. Unit labour costs follow after another 4 quarters

6.2.1.3 Manufacturing

Equation 4

Dynamic effect of a unit shock to the error process of the dollar oil price

Figure 4: Dynamic effect of a unit shock to the error process of the dollar oil price (eq 4)



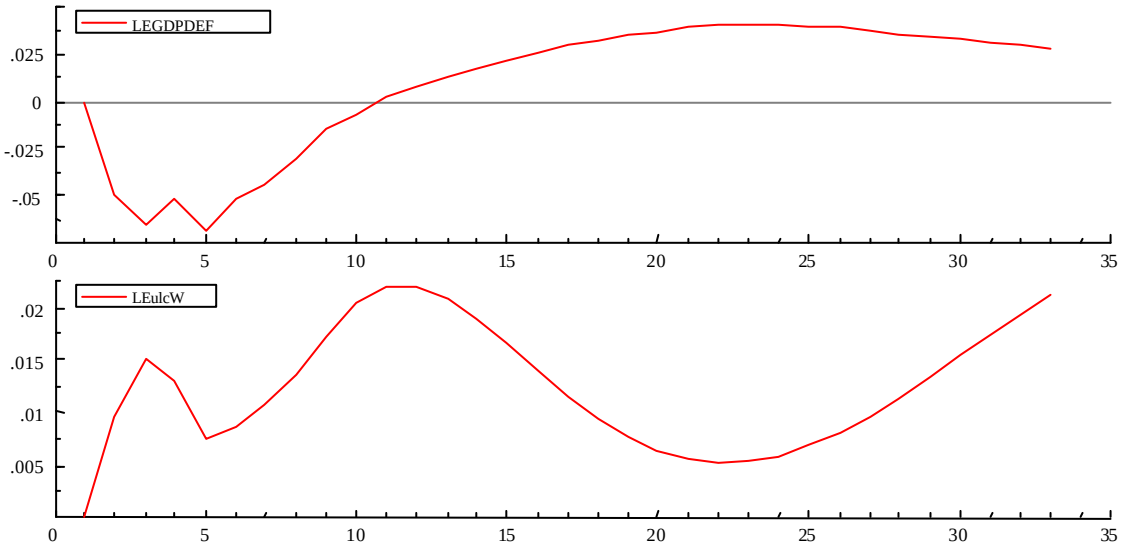
A positive unit shock to the oil price leads to a rise in manufacturing prices after 3 quarters and this effect reaches its maximum at 5 quarters. The response of unit labour costs in manufacturing is slower and more damped. Neither effect is very significant though.

6.2.1.4 Electricity, gas and water

Equation 5

Dynamic effect of a unit shock to the error process of the dollar oil price

Figure 5: Dynamic effect of a unit shock to the error process of the dollar oil price (eq 5)



A unit shock to the oil price leads to a perverse initial effect on prices in electricity, gas and water. This is reversed after 11 quarters. Unit labour cost responds positively to the shock with a

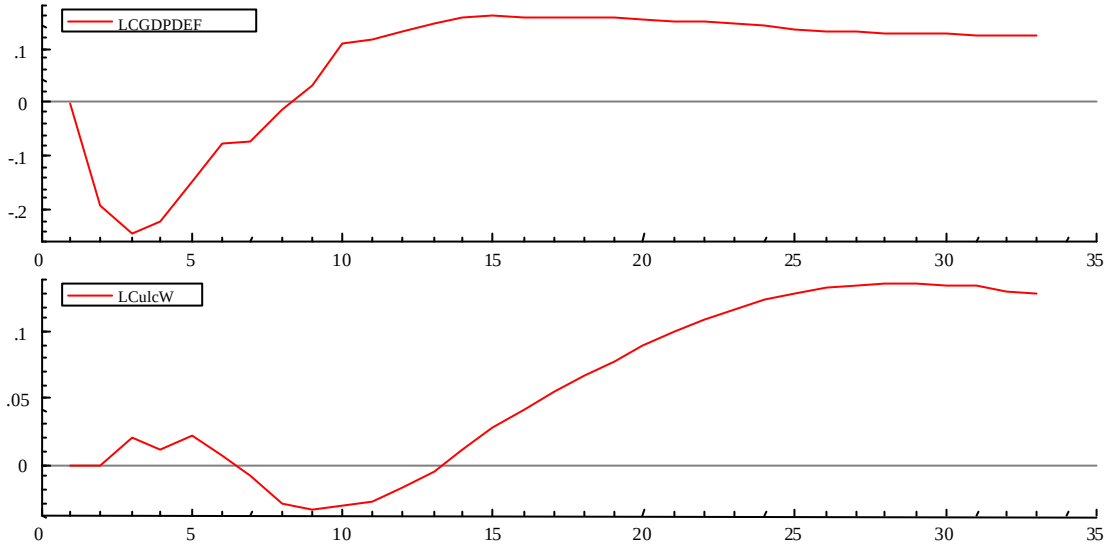
maximum effect at 12 quarters. However, both prices and unit labour cost showed a muted response to this shock over the period simulated.

6.2.1.5 Construction

Equation 6

Dynamic effect of a unit shock to the error process of the terms of trade

Figure 6: Dynamic effect of a unit shock to the error process of the terms of trade (eq 6)



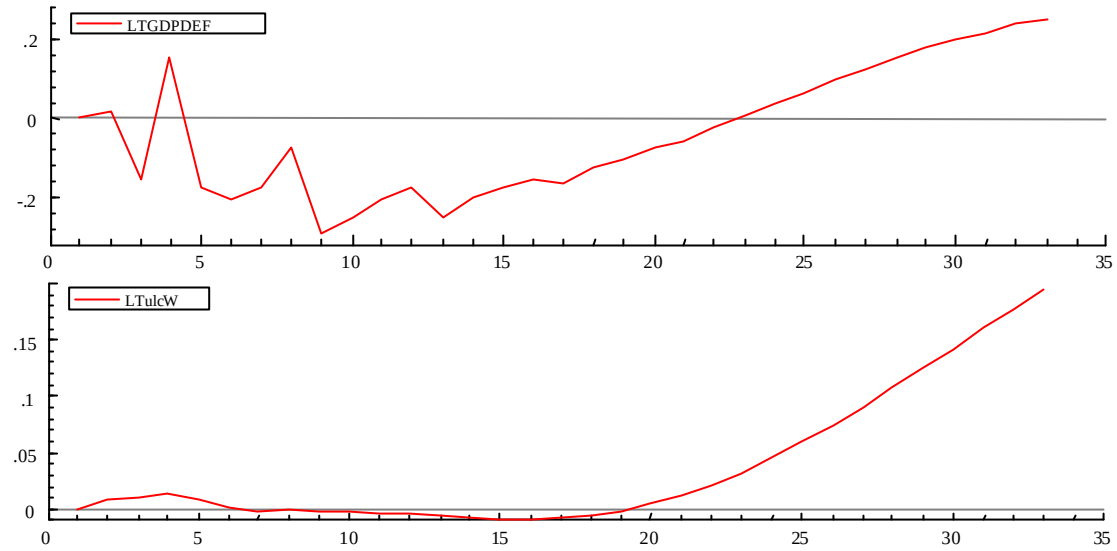
A positive unit shock to the terms of trade leads to a rapid decline in the price level in construction in this simulation, but little initial response in unit labour cost. After 8 quarters for the price level and 13 for unit labour cost both variables show a small positive response to the initial shock.

6.2.1.6 Retail and wholesale trade

Equation 7

Dynamic effect of a unit shock to the error process of the real effective exchange rate

Figure 7: Dynamic effect of a unit shock to the error process of the real effective exchange rate (eq 7)



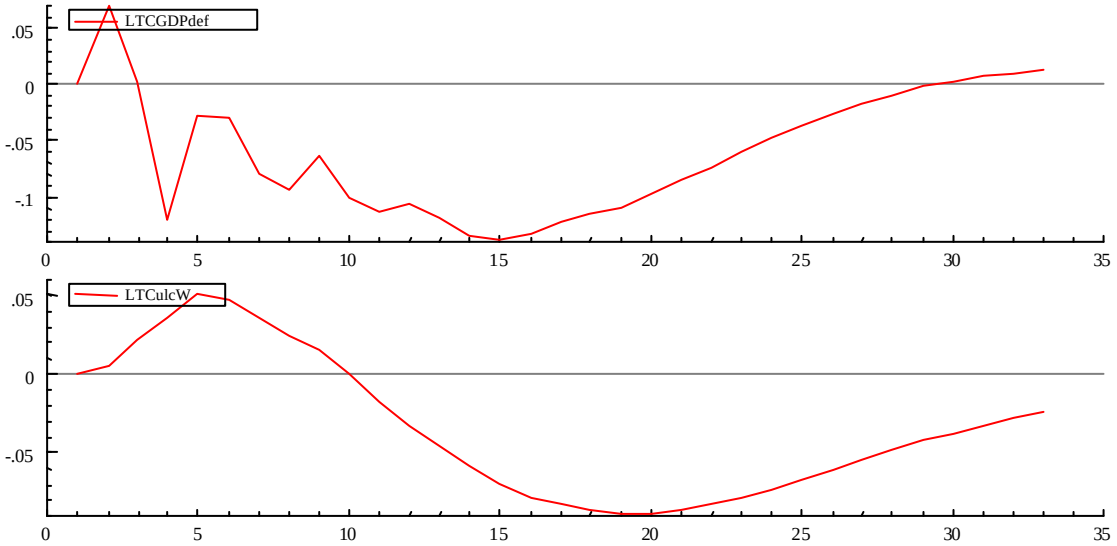
The effect of a unit shock to the real effective exchange rate on the price level in retail and wholesale trade is initially erratic, but settles into a clear negative after about 5 quarters. This effect is eventually reversed after another 13 quarters. Unit labour cost in the same sector does not seem to show any sensitivity to this shock until a perverse response appears at around 20 quarters.

6.2.1.7 Transport and Communications

Equation 8

Dynamic effect of a unit shock to the error process of the real effective exchange rate

Figure 8: Dynamic effect of a unit shock to the error process of the real effective exchange rate (eq 8)

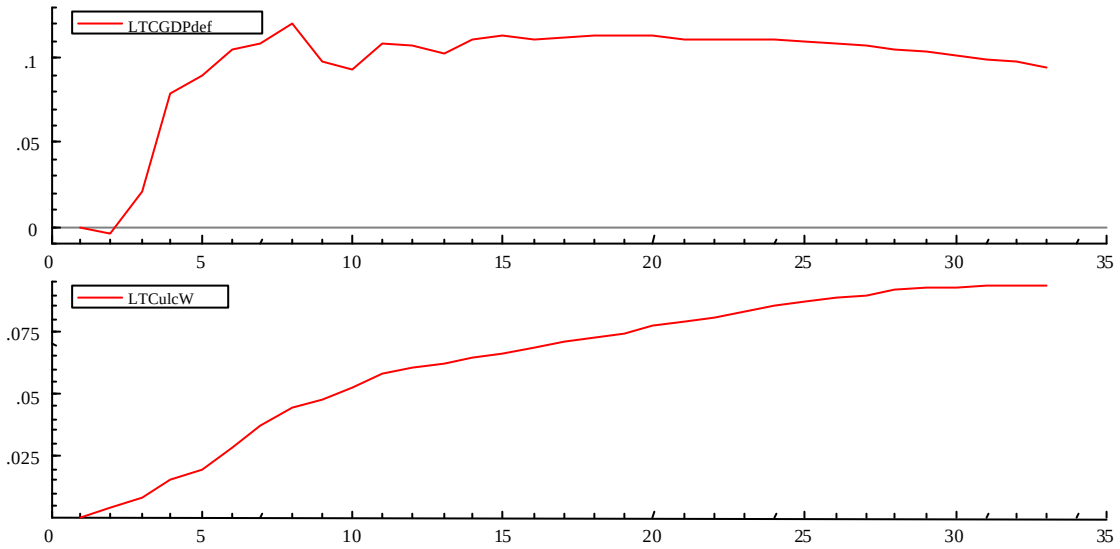


The price level in transport and communications shows an expected negative response to a positive unit shock to the real effective exchange rate, but this effect dissipates after 29 quarters. Unit labour cost responds perversely at first, but then declines from 11 quarters onwards in response to the same shock.

Equation 8

Dynamic effect of a unit shock to the error process of the Rand oil price

Figure 9: Dynamic effect of a unit shock to the error process of the Rand oil price (eq 8)



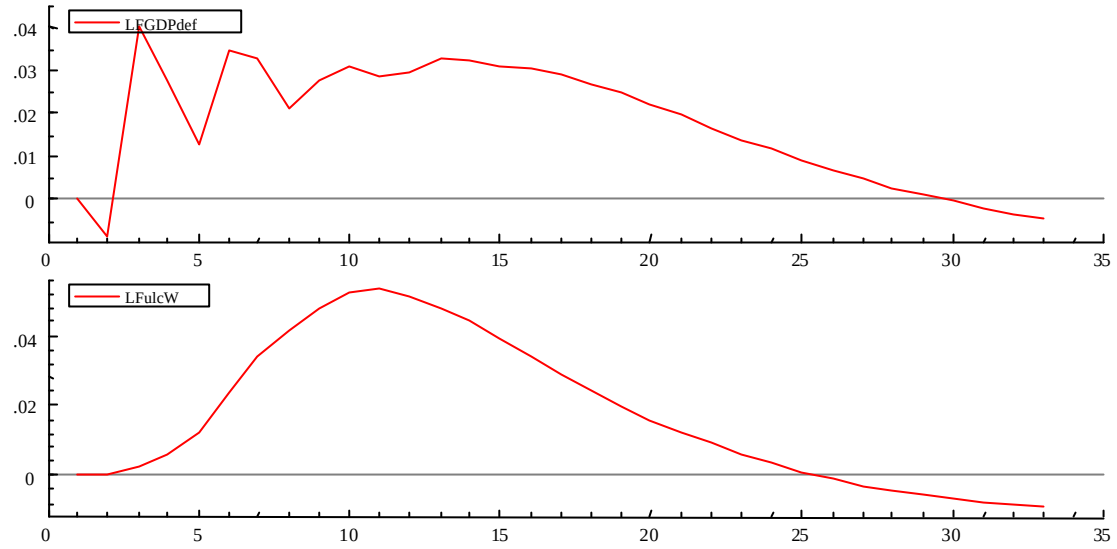
The effect of a unit shock to the Rand oil price on the price level in transport and communications is rapid and persists for a few years. In contrast the effect on wages is more gradual, but also positive.

6.2.1.8 Financial and business services

Equation 9

Dynamic effect of a unit shock to the error process of the dollar oil price

Figure 10: Dynamic effect of a unit shock to the error process of the dollar oil price (eq 9)



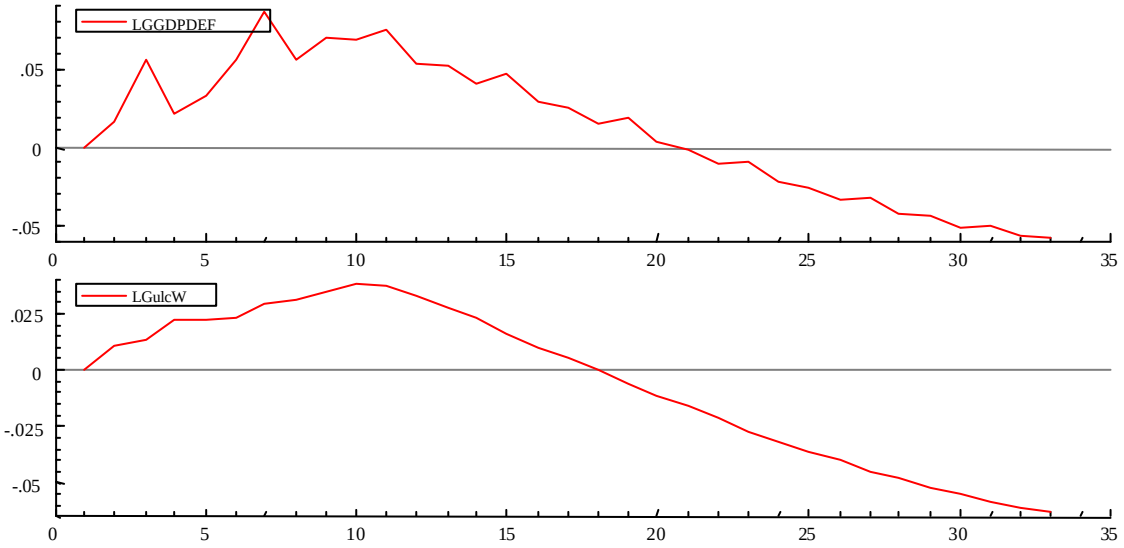
The price level and unit labour cost in financial and business services responds positively to a unit shock in the oil price, but this effect seems transitory in both series. The price level responds more rapidly and erratically than the gradual response of unit labour cost.

6.2.1.9 Government services

Equation 10

Dynamic effect of a unit shock to the dollar oil price

Figure 11: Dynamic effect of a unit shock to the dollar oil price (eq 10)



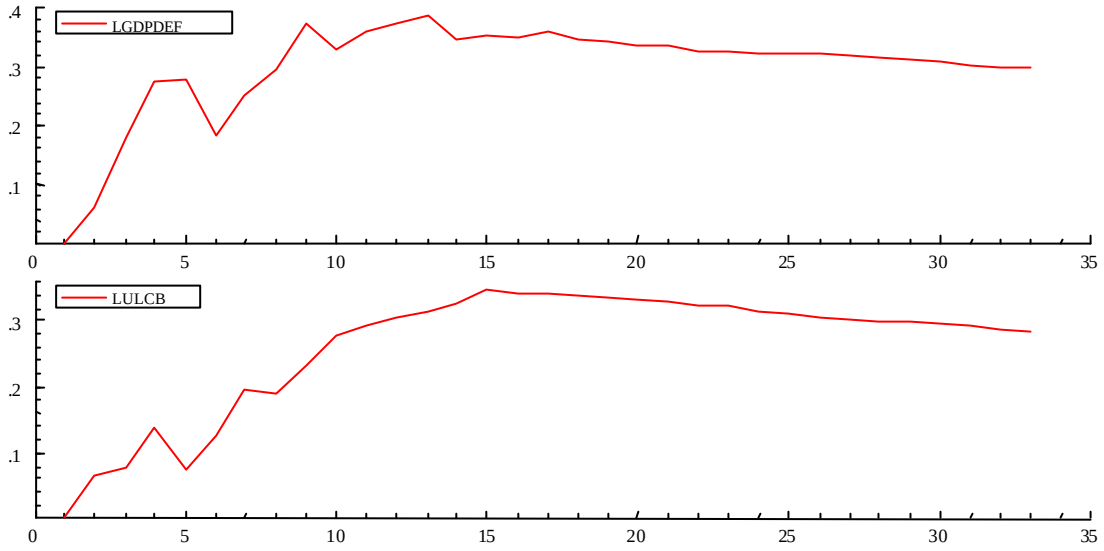
The effect of a unit shock to the oil price is more rapid and pronounced on the price level of government services than on unit labour cost in government services. However, the effect of this shock is eventually eroded in both series.

6.2.2 Import price shocks

Equation 1

Dynamic effect of a unit shock to the error process of the import price deflator

Figure 12: Dynamic effect of a unit shock to the error process of the import price deflator (eq 1)

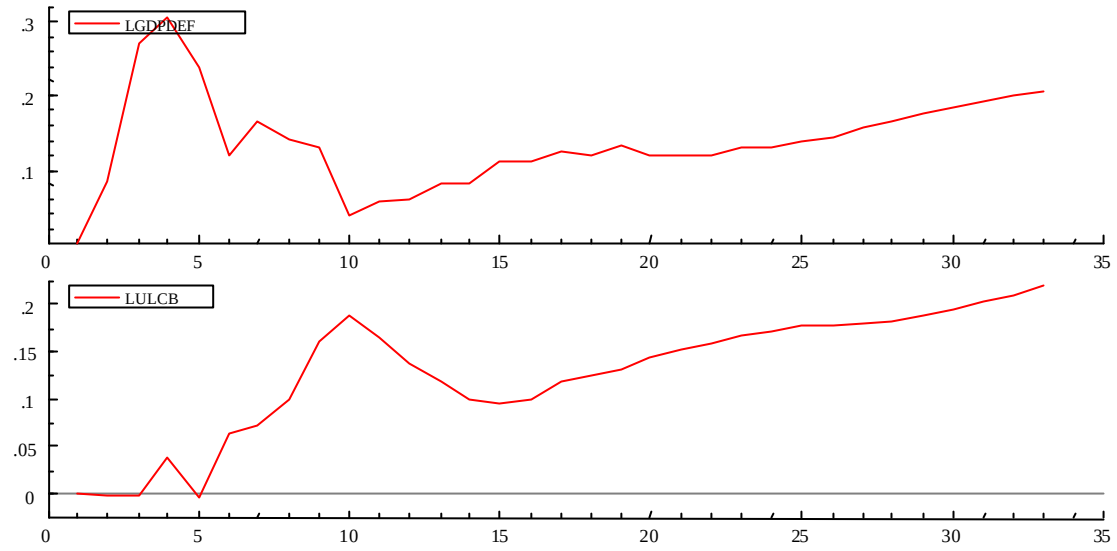


In equation 1 the aggregate price level responds rapidly and strongly to a unit shock in the import price deflator. Aggregate unit labour cost responds more slowly, but attains a comparably strong impact after about 16 quarters.

Equation 2

Dynamic effect of a unit shock to the error process of the import price deflator

Figure 13: Dynamic effect of a unit shock to the error process of the import price deflator (eq 2)



In equation 2 the effect of a unit impulse on the aggregate price level is more rapid, but less persistent over time. Similarly, the unit labour cost response is slower, and more muted in its eventual impact over the simulated period.

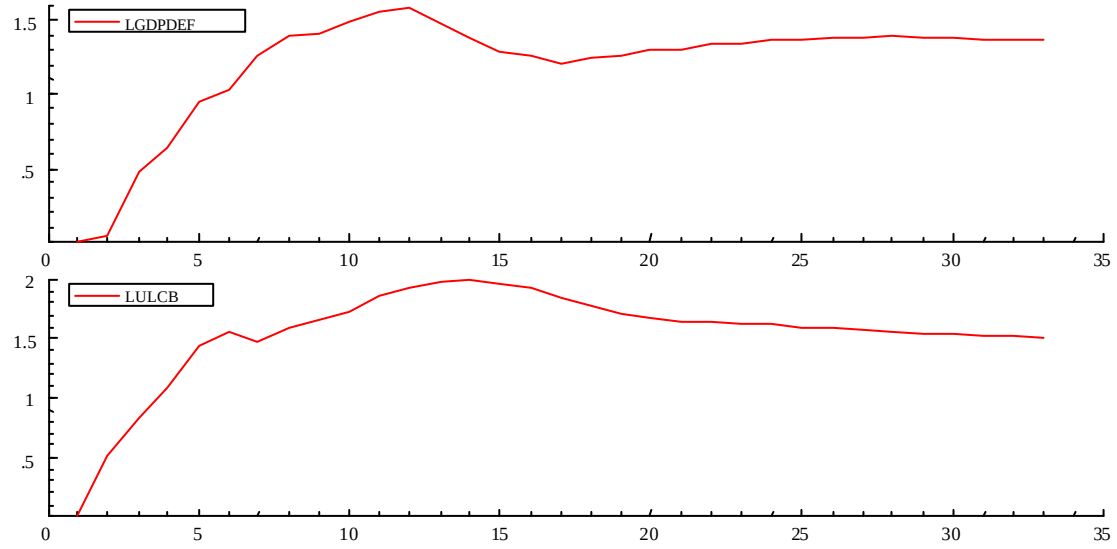
6.2.3 Price expectations shocks

6.2.3.1 Aggregate level

Equation 1

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 14: Dynamic effect of a unit shock to the error process of the static price expectations (eq 1)

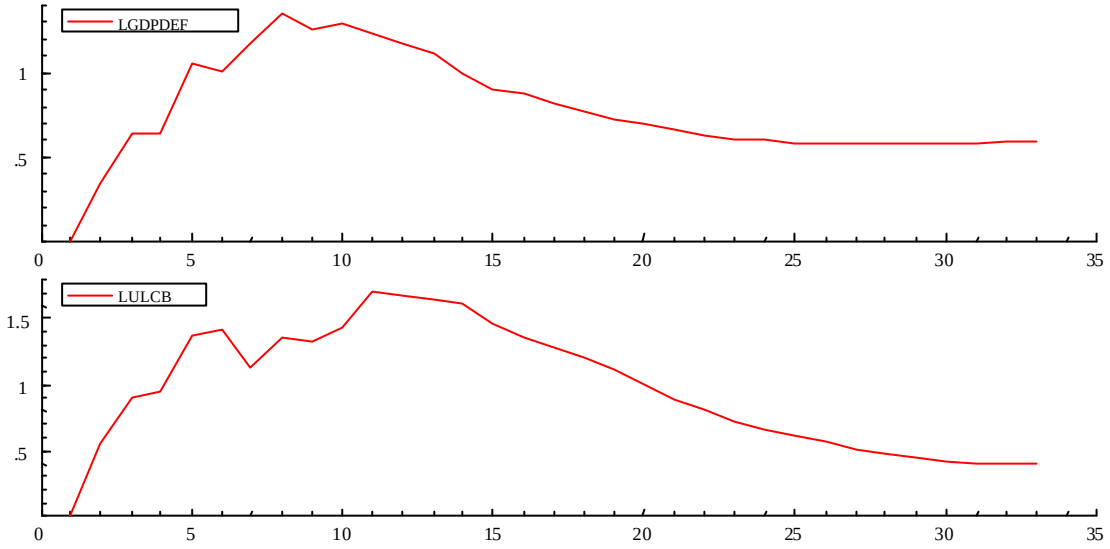


A unit shock to the static price expectations in equation 1 has a rapid impact on unit labour cost which reaches a peak after 13 quarters. The initial response of the aggregate price level is 1 quarter slower, but then accelerates to reach its peak after 12 quarters.

Equation 2

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 15: Dynamic effect of a unit shock to the error process of the static price expectations (eq 2)



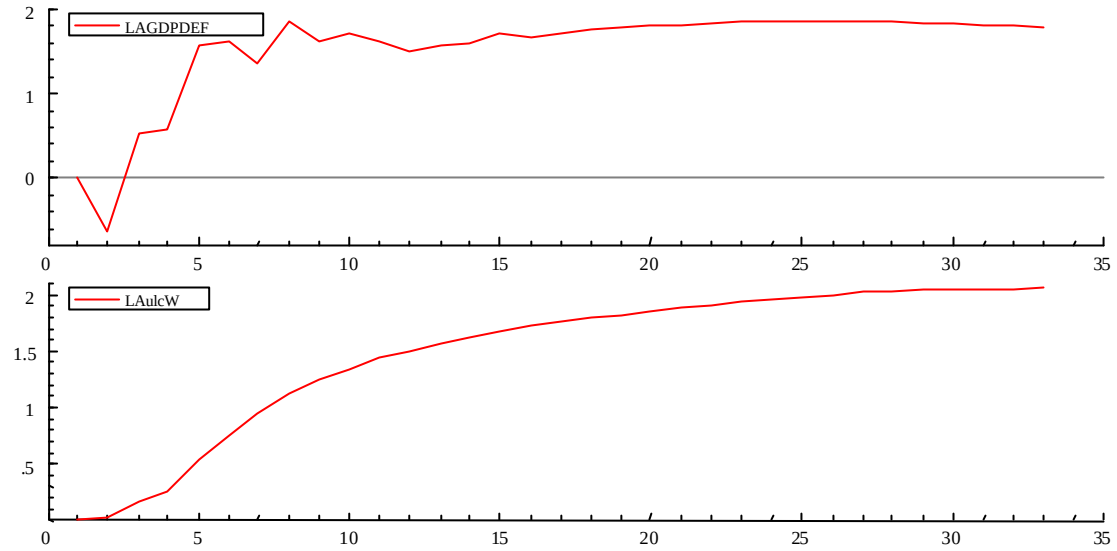
The effect of a unit shock to the static price expectation shows a similar pattern in the simulation of equation 2, though here the response by both unit labour cost and the aggregate price level is less persistent over the simulated period.

6.2.3.2 Agriculture

Equation 3

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 16: Dynamic effect of a unit shock to the error process of the static price expectations (eq 3)



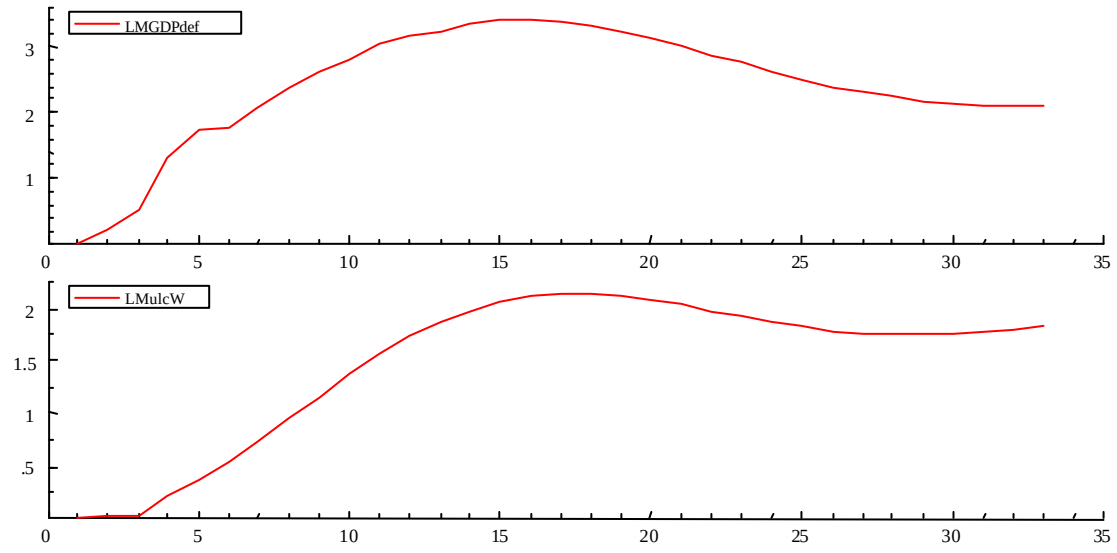
A unit shock to static price expectation leads to a rapid and more than proportional response in agricultural prices and unit labour cost. The price series responds more rapidly, but eventually the response unit labour reaches a comparable magnitude.

6.2.3.3 Manufacturing

Equation 4

Dynamic effect of a unit shock to the error process of the rational price expectations

Figure 17: Dynamic effect of a unit shock to the error process of the rational price expectations (eq 4)



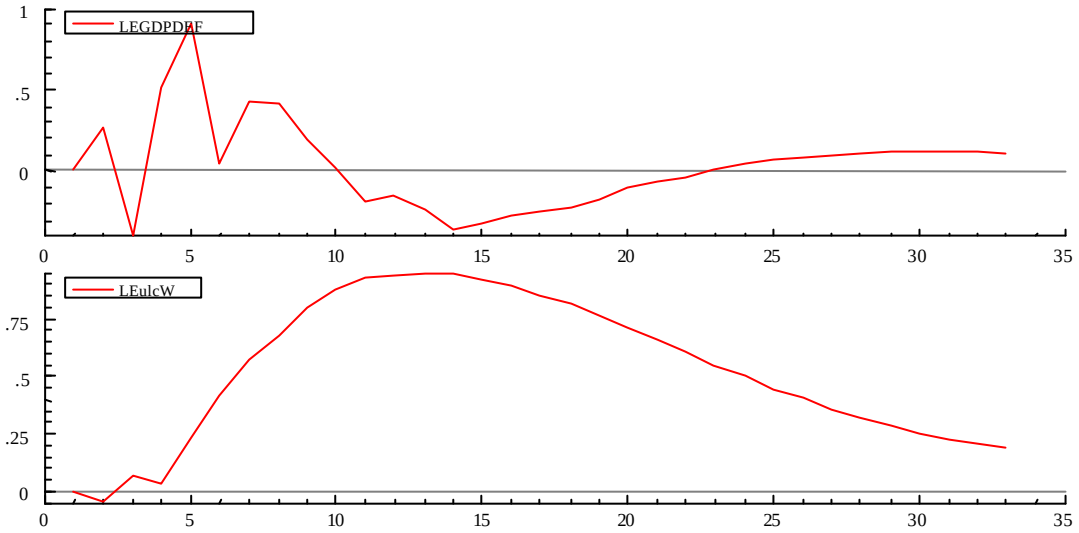
Unit labour costs in manufacturing responds slowly to a unit shock in the rational price expectations. However, from a bout 10 quarters onwards this response is more than proportional. Prices respond more rapidly and more strongly than unit labour cost to a price expectations shock in this sector.

6.2.3.4 Electricity, gas and water

Equation 5

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 18: Dynamic effect of a unit shock to the error process of the static price expectations (eq 5)



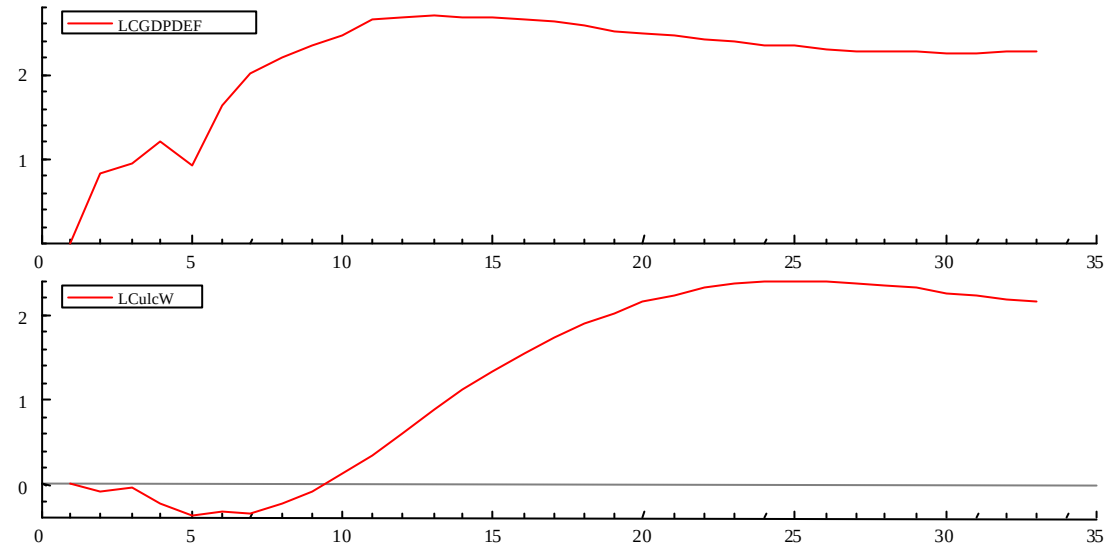
The simulated response of electricity, gas and water prices to a unit shock in static expectations is erratic, though positive in the first two years. Subsequently, the effect dissipates. Unit labour cost shows a slower, but more persistently positive response. The maximum effect of this shock is less than proportionate on unit labour cost.

6.2.3.5 Construction

Equation 6

Dynamic effect of a unit shock to the error process of the rational price expectations

Figure 19: Dynamic effect of a unit shock to the error process of the rational price expectations (eq 6)



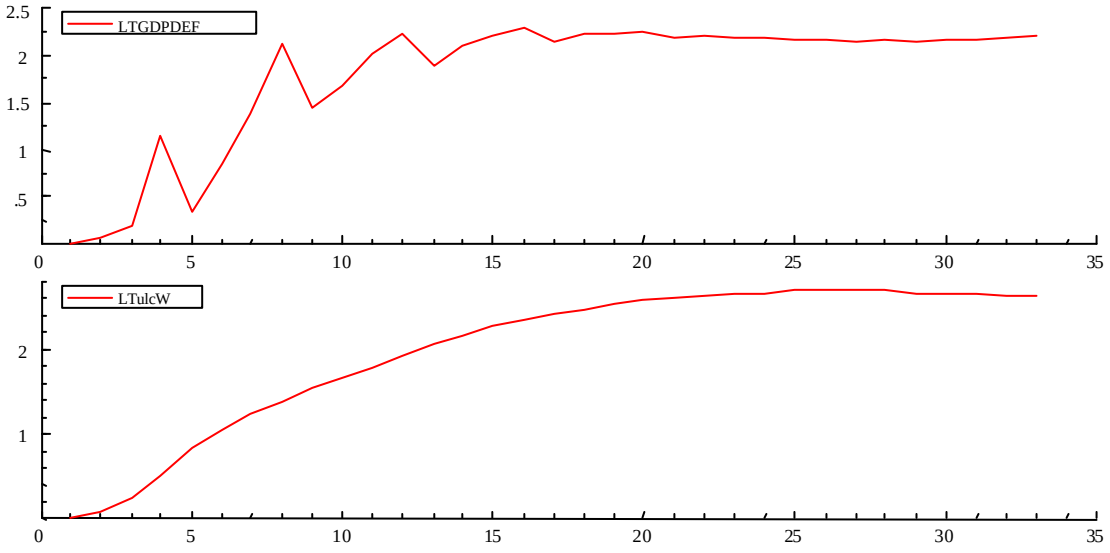
A shock to the rational price expectations in construction leads to a raid and fairly persistent response in prices. This effect is more than proportional to the shock. Unit labour cost in construction responds significantly slower in this simulation, but eventually its response reaches a similar magnitude.

6.2.3.6 Retail and wholesale trade

Equation 7

Dynamic effect of a unit shock to the error process of the rational price expectations

Figure 20: Dynamic effect of a unit shock to the error process of the rational price expectations (eq 7)



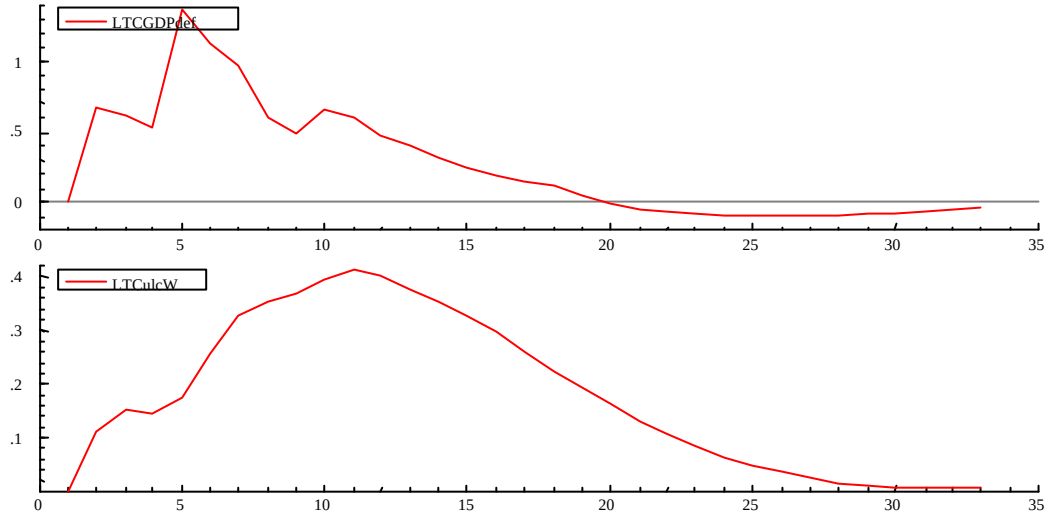
The price level for retail and wholesale trade responded positively and more than proportionally to a unit shock in the rational expectation price series. As in construction, unit labour cost responds more slowly and here the eventual impact on unit labour cost is more muted than on price. Nevertheless, the impact on unit labour cost is more than proportionate to the shock.

6.2.3.7 Transport and Communications

Equation 8

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 21: Dynamic effect of a unit shock to the error process of the static price expectations (eq 8)



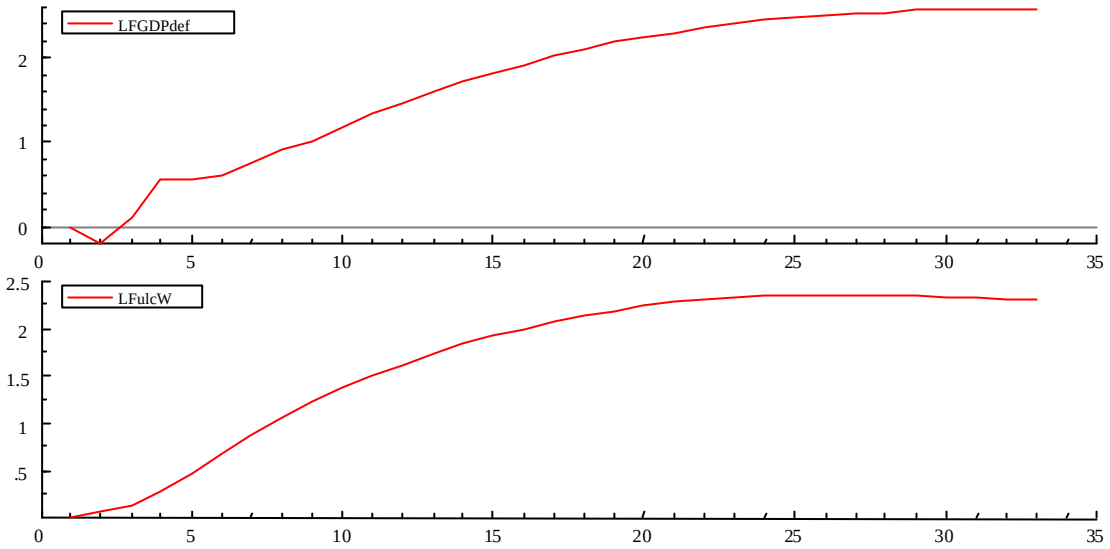
A unit shock to the static price expectations in transport and communications has a rapid and more than proportionate effect on the price level in that sector. In contrast the effect on unit labour cost is slower and less than proportionate.

6.2.3.8 Financial and Business services

Equation 9

Dynamic effect of a unit shock to the error process of the static price expectations

Figure 22: Dynamic effect of a unit shock to the error process of the static price expectations (eq 9)



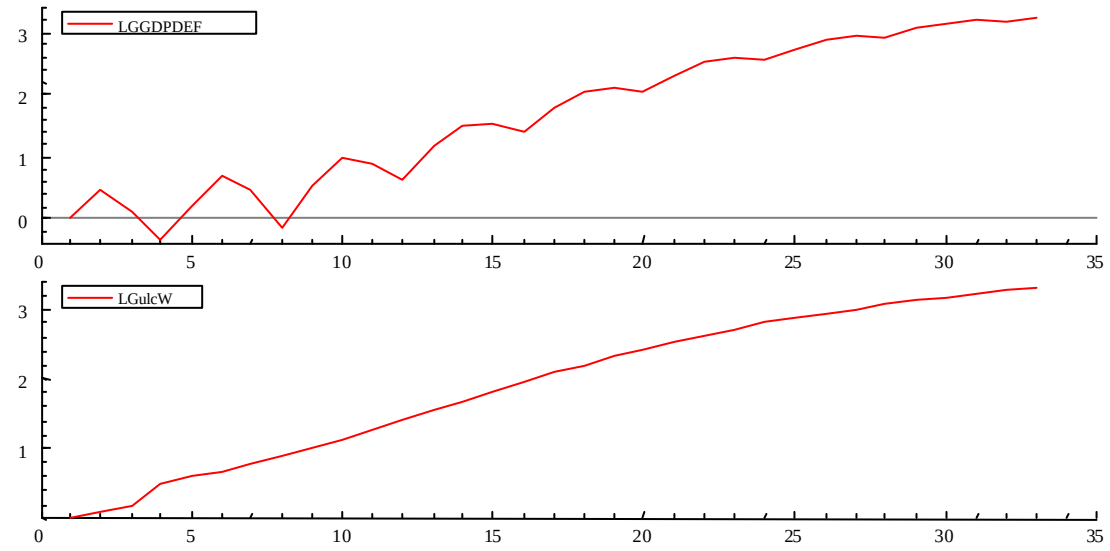
Both unit labour cost and the price level of financial and business services respond slowly to static price expectations in this simulation. However, the eventual impact is more than proportionate to the shock in both variables.

6.2.3.9 Government services

Equation 10

Dynamic effect of a unit shock to the error process of the rational price expectations

Figure 23: Dynamic effect of a unit shock to the error process of the rational price expectations (eq 10)



The effect of a shock price expectations shock is slow, but eventually more than proportionate both where the price level and the unit labour cost in the government services sector is concerned.

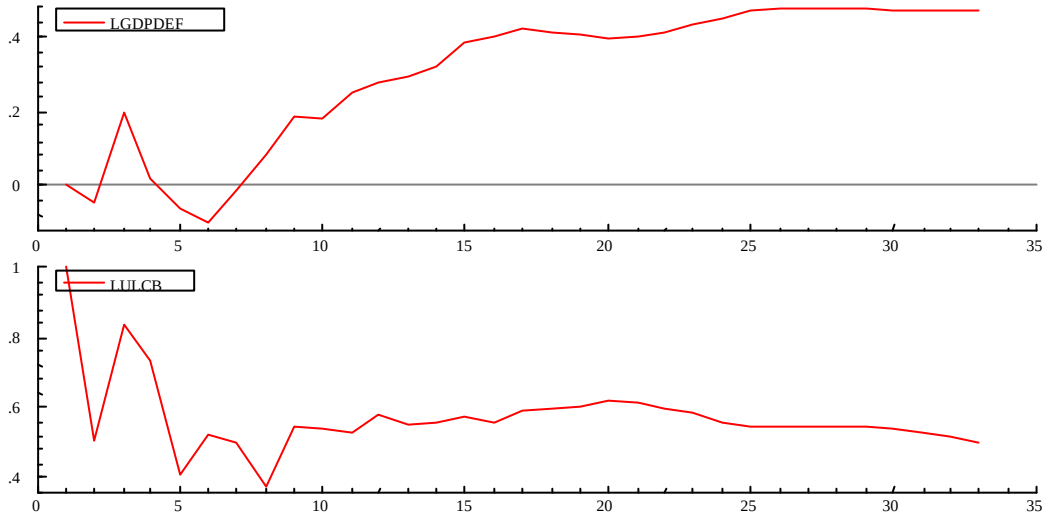
6.2.4 Unit labour cost shocks

6.2.4.1 Aggregate level

Equation 1

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 24: Dynamic effect of a unit shock to the error process of unit labour cost (eq 1)

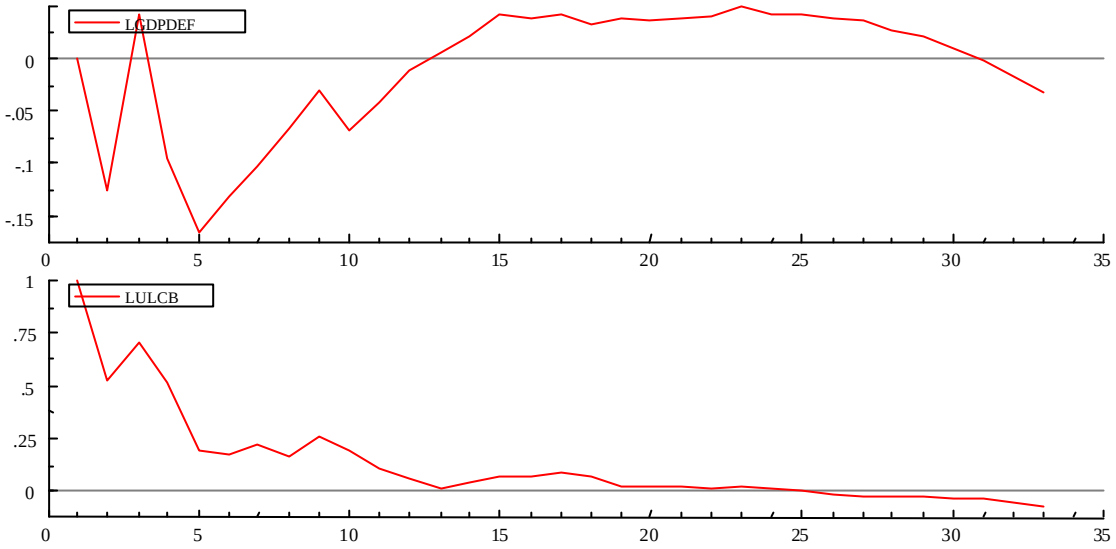


In equation 1 a shock to unit labour cost decays over the first 8 quarters. Meanwhile the simulated response of the aggregate price level is slow and eventually less than proportionate to the shock.

Equation 2

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 25: Dynamic effect of a unit shock to the error process of unit labour cost (eq 2)



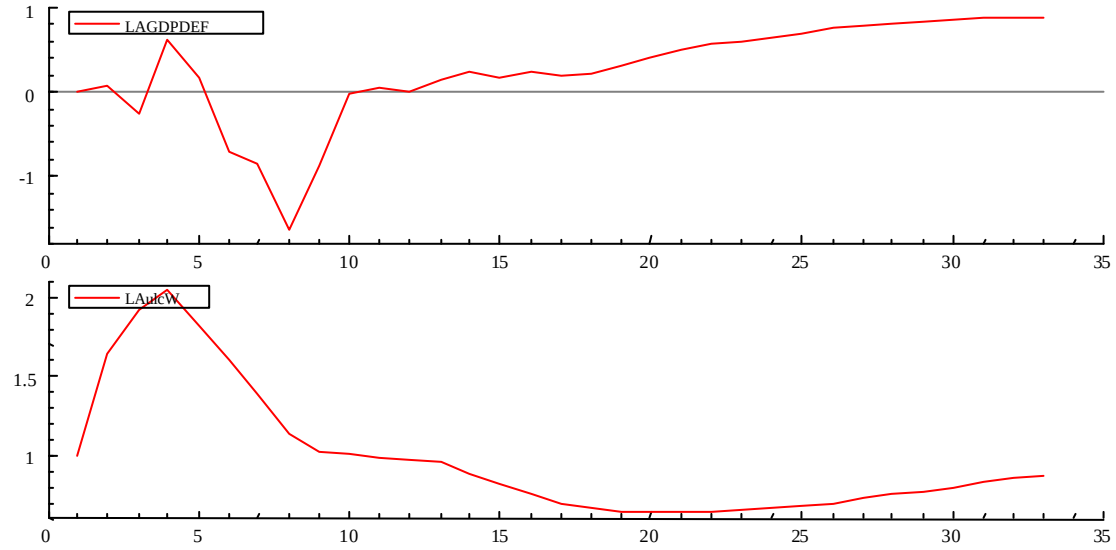
A unit shock to unit labour cost decays more fully in equation 2 than in equation 1 and the impact on the aggregate price level is perverse in this simulation.

6.2.4.2 Agriculture

Equation 3

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 26: Dynamic effect of a unit shock to the error process of unit labour cost (eq 3)



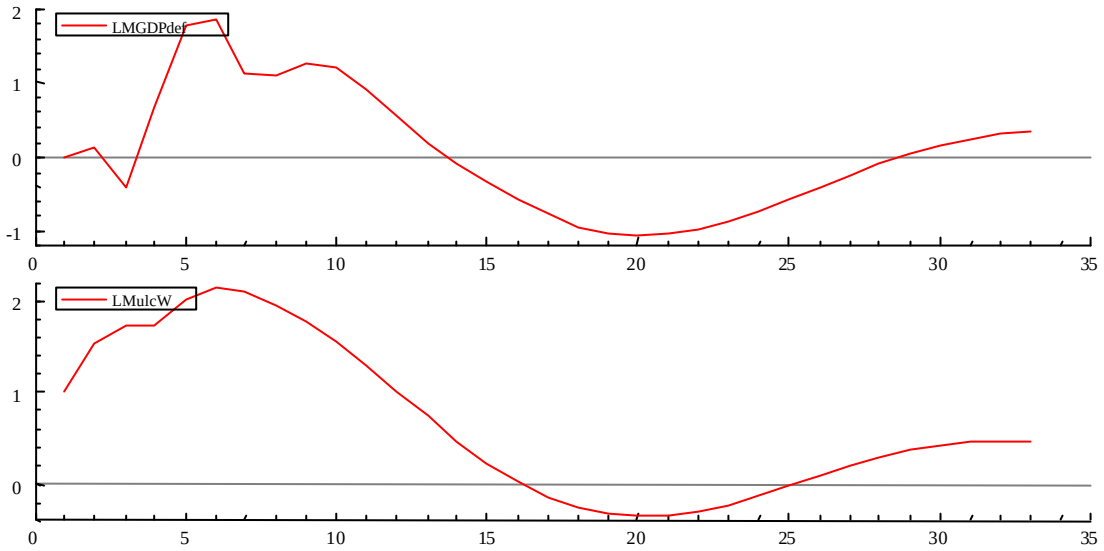
Agricultural prices respond slowly to a unit shock to unit labour cost in this simulation and the eventual impact is less than proportional to the shock. Meanwhile the shock to unit labour cost seems to decay slowly in this simulation.

6.2.4.3 Manufacturing

Equation 4

Dynamic effect of a unit shock to the error process of the unit labour cost

Figure 27: Dynamic effect of a unit shock to the error process of the unit labour cost (eq 4)



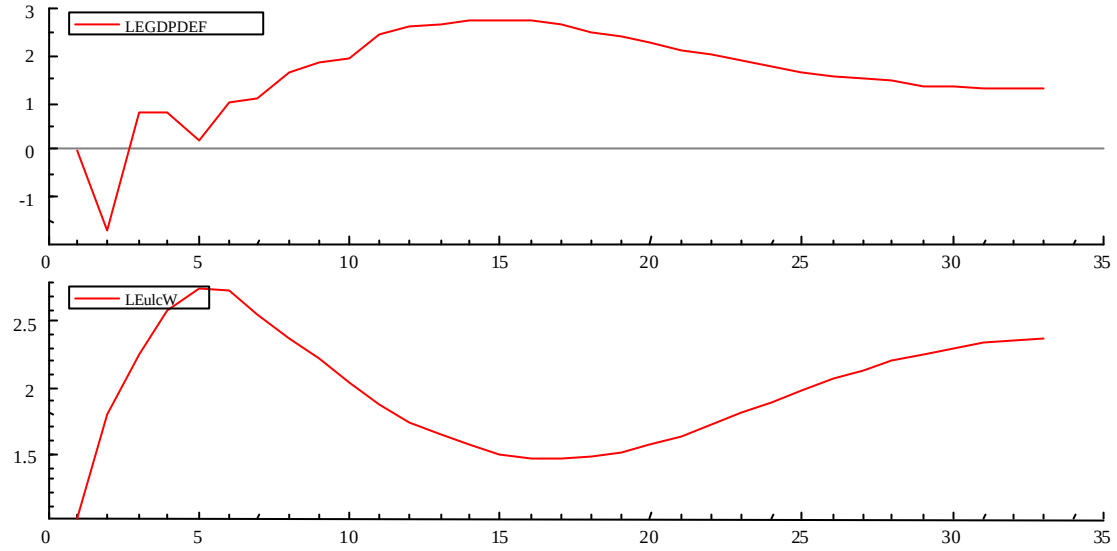
A unit shock to unit labour cost decays slowly in manufacturing. After about 3 quarters manufacturing prices responds positively and more than proportionally to the unit labour cost shock. This latter effect dissipates after another 11 quarters.

6.2.4.4 Electricity, gas and water

Equation 5

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 28: Dynamic effect of a unit shock to the error process of unit labour cost (eq 5)



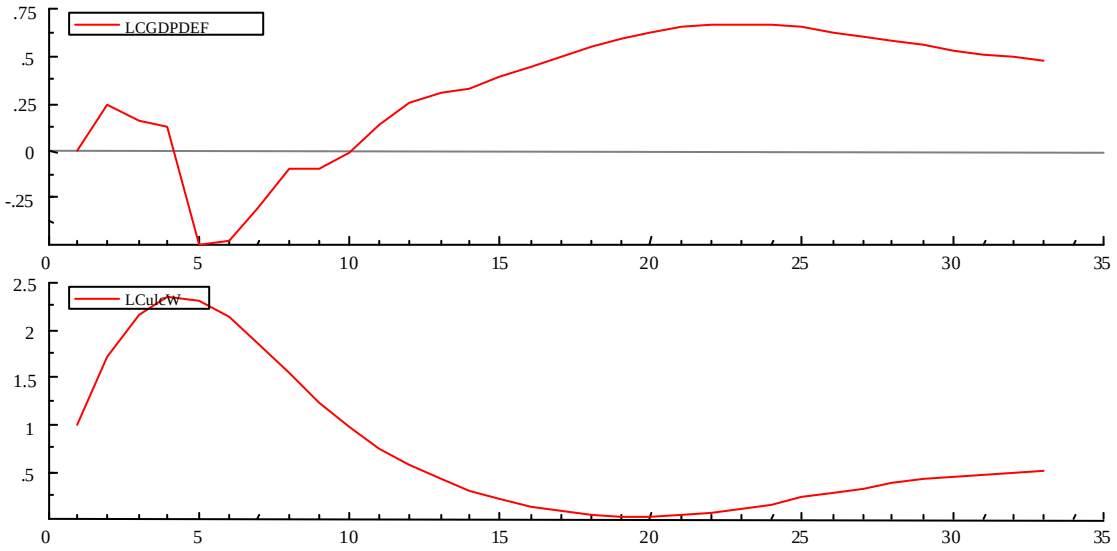
A shock to unit labour cost in electricity, gas and water dissipates only very slowly. The price level in the same sector responds positively to this shock after 3 quarters and this response is ultimately more than proportional to the shock.

6.2.4.5 Construction

Equation 6

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 29: Dynamic effect of a unit shock to the error process of unit labour cost (eq 6)



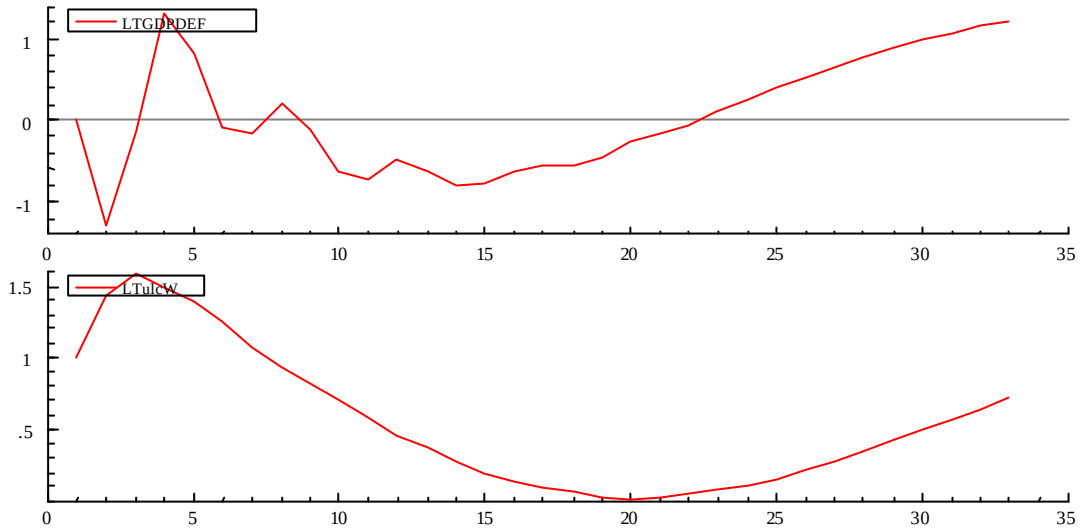
The simulated response of construction prices to a unit labour cost shock is modest and rapid at first, but then decays only to return more forcefully after 11 quarters. The maximum effect remains less than proportionate to the shock in this simulation though.

6.2.4.6 Retail and wholesale trade

Equation 7

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 30: Dynamic effect of a unit shock to the error process of unit labour cost (eq 7)



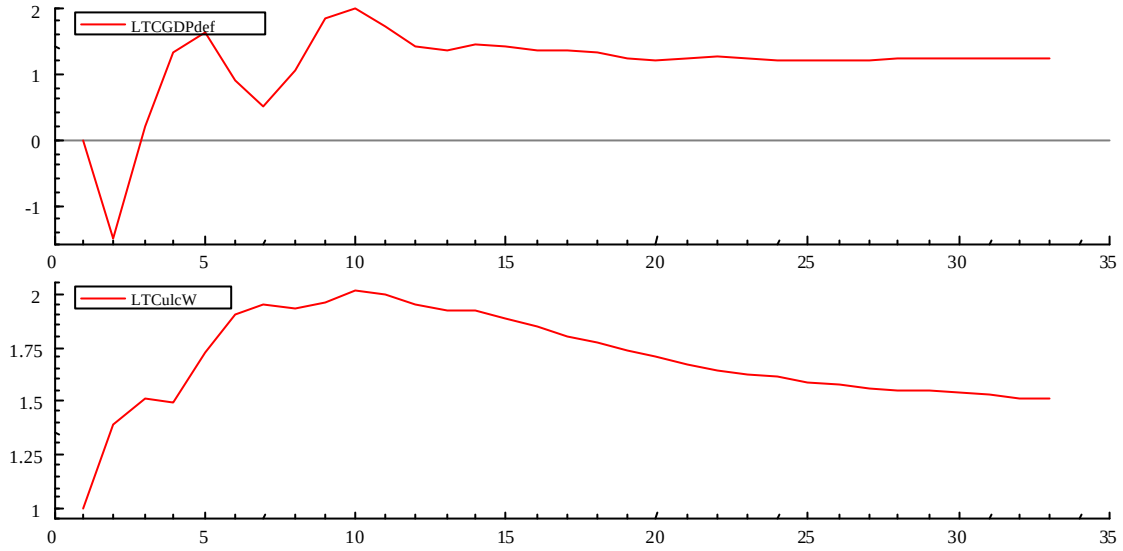
After a sharp positive initial response to e unit labour cost shock the simulated effect on retail and wholesale prices decays and only returns after 23 quarters. This initial response was approximately proportional to the unit labour cost hock.

6.2.4.7 Transport and Communications

Equation 8

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 31: Dynamic effect of a unit shock to the error process of unit labour cost (eq 8)



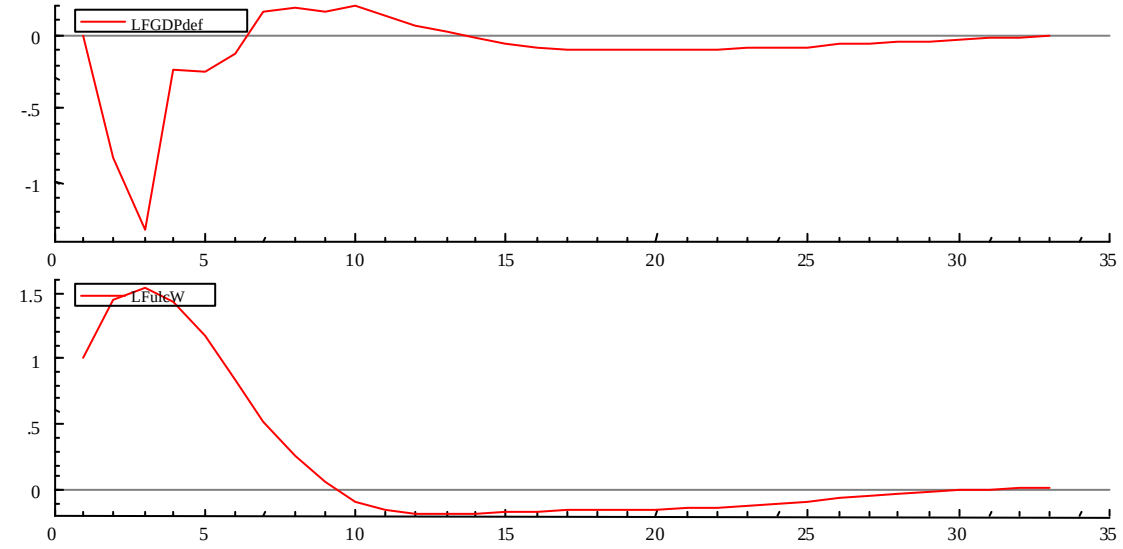
The slowly decaying shock to unit labour cost in transport and communications leads to a fairly persistent and more than proportional response in the sectoral price level within about 4 quarters.

6.2.4.8 Financial and business services

Equation 9

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 32: Dynamic effect of a unit shock to the error process of unit labour cost (eq 9)



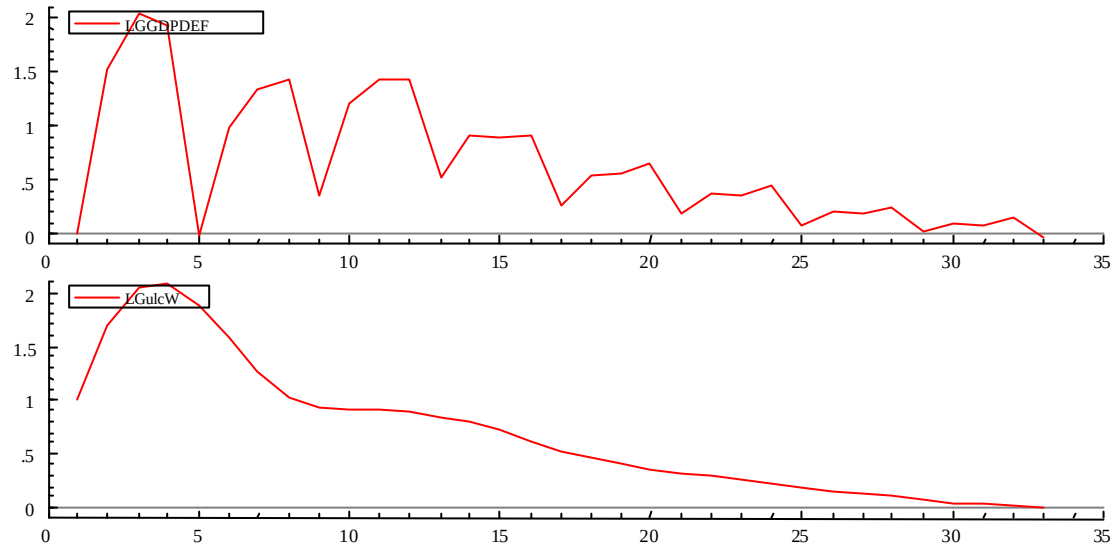
The sectoral price level for financial and business services shows a sharp and perverse initial response to a unit labour shock, but after this has decayed there is no persistent price level effect in this simulation.

6.2.4.9 Government services

Equation 10

Dynamic effect of a unit shock to the error process of unit labour cost

Figure 33: Dynamic effect of a unit shock to the error process of unit labour cost (eq 10)



The smoothly decaying shock to unit labour cost in this simulation is associated with an erratic price response in the government services sector. The sectoral price level responds more than proportionally to the shock for the first three years of the simulation, but the impact of the shock wears off thereafter.

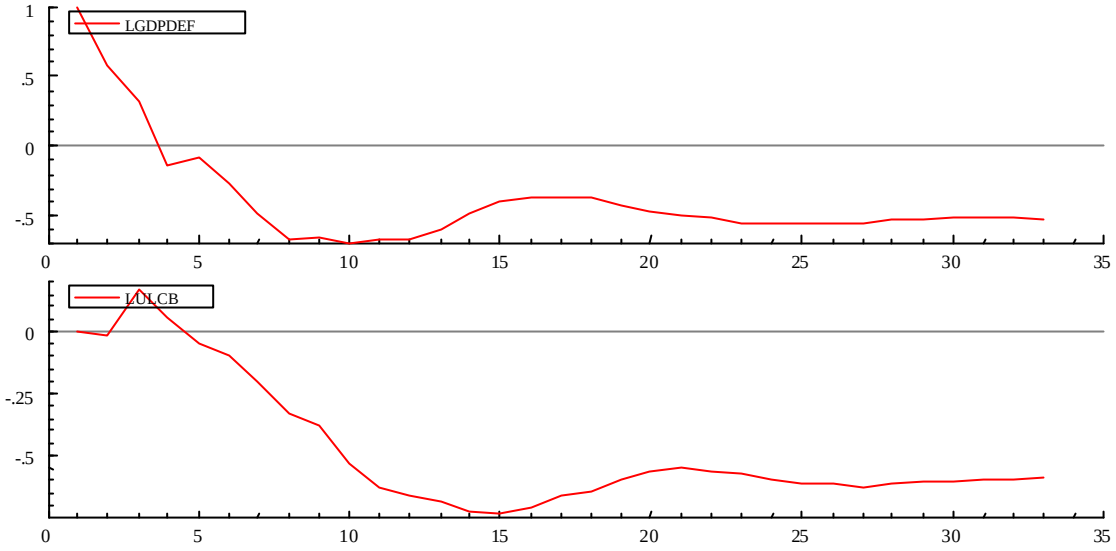
6.2.5 Price shocks

6.2.5.1 Aggregate level

Equation 1

Dynamic effect of a unit shock to the error process of the GDP deflator

Figure 34: Dynamic effect of a unit shock to the error process of the GDP deflator (eq 1)

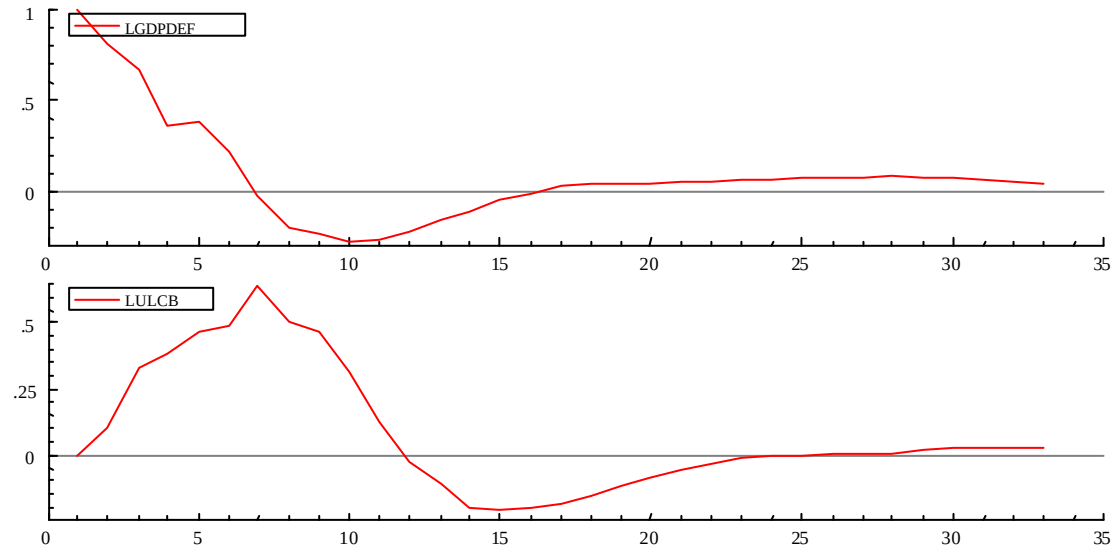


The simulated response of unit labour cost to an aggregate price level shock in equation 1 seems perverse.

Equation 2

Dynamic effect of a unit shock to the error process of the GDP deflator

Figure 35: Dynamic effect of a unit shock to the error process of the GDP deflator (eq 2)



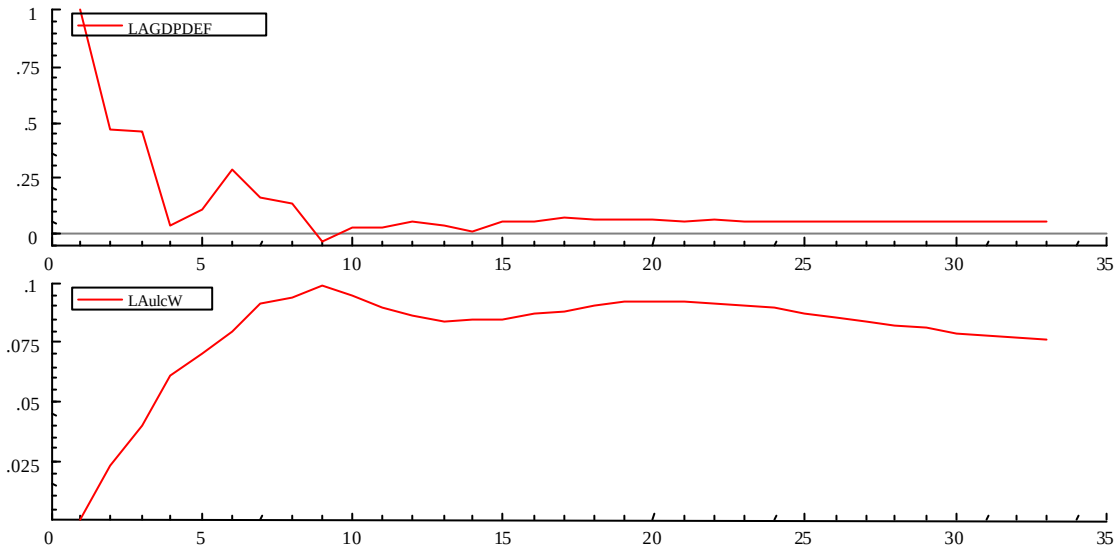
In contrast to the simulation for equation 1 a unit shock to the aggregate price level results in a positive, though less than proportionate, response in aggregate unit labour cost. This effect has decayed after 12 quarters in this simulation.

6.2.5.2 Agriculture

Equation 3

Dynamic effect of a unit shock to the error process of the sectoral GDP deflator

Figure 36: Dynamic effect of a unit shock to the error process of the sectoral GDP deflator (eq 3)



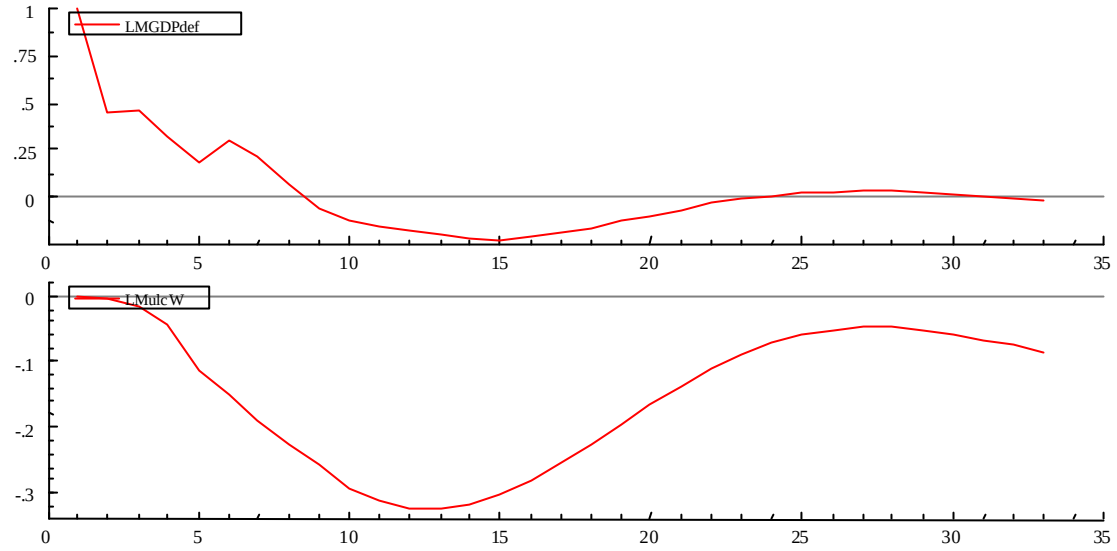
A unit shock to agricultural prices is associated with a positive response in sectoral unit labour cost which peaks at 9 quarters. At the maximum the response is slightly less than proportionate to the shock.

6.2.5.3 Manufacturing

Equation 4

Dynamic effect of a unit shock to the error process of the sectoral GDP deflator

Figure 37: Dynamic effect of a unit shock to the error process of the sectoral GDP deflator (eq 4)



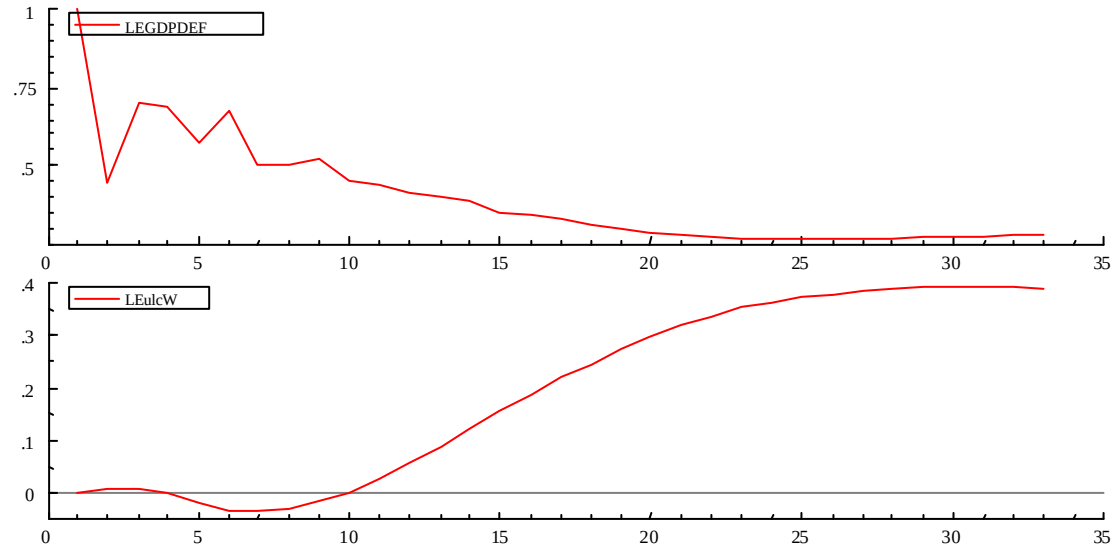
Unit labour cost in manufacturing responded perversely to a shock to the sectoral price level in this simulation.

6.2.5.4 Electricity, gas and water

Equation 5

Dynamic effect of a unit shock to the error process of the sectoral GDP deflator

Figure 38: Dynamic effect of a unit shock to the error process of the sectoral GDP deflator (eq 5)



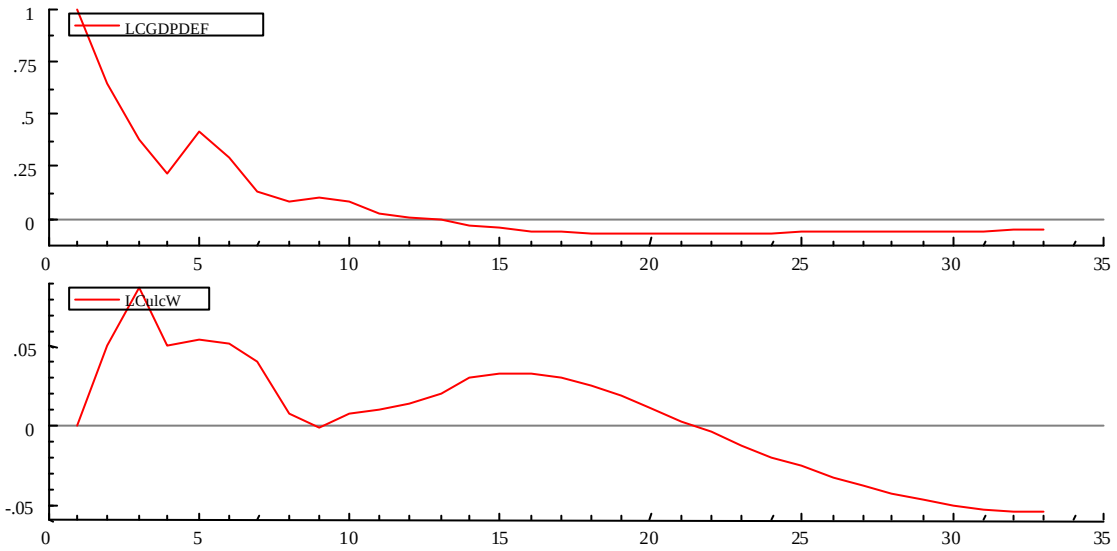
A unit shock to electricity gas and water prices has little impact on the sectoral unit labour cost for the first 10 quarters in this simulation. Thereafter unit labour cost responds positively, but peaks at a less than proportionate response.

6.2.5.5 Construction

Equation 6

Dynamic effect of a unit shock to the error process of the sectoral GDP deflator

Figure 39: Dynamic effect of a unit shock to the error process of the sectoral GDP deflator (eq 6)



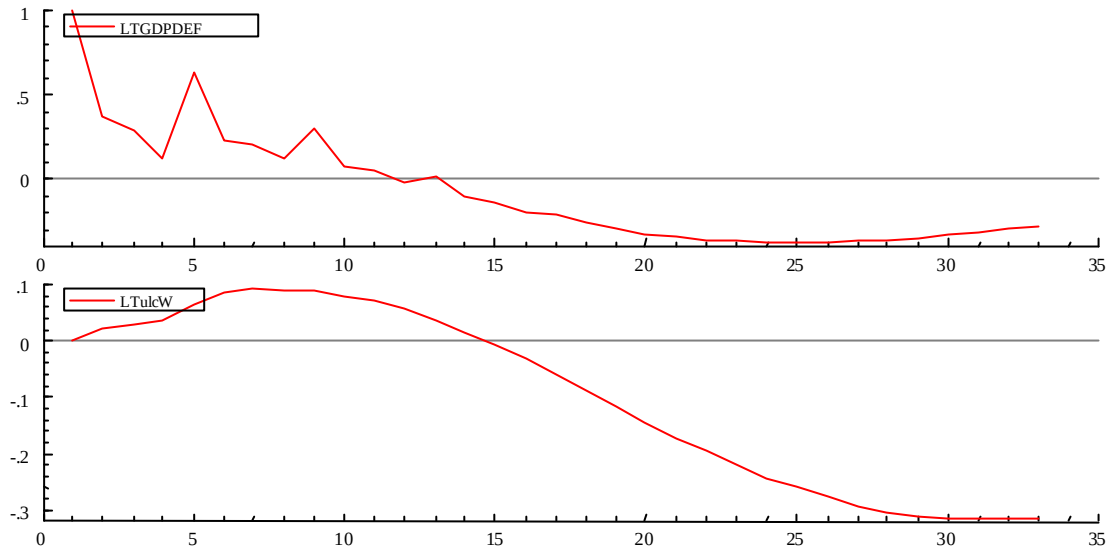
The effect of a unit shock to construction prices on the sectoral unit labour cost is positive, but very muted.

6.2.5.6 Retail and wholesale trade

Equation 7

Dynamic effect of a unit shock to the sectoral GDP deflator

Figure 40: Dynamic effect of a unit shock to the sectoral GDP deflator (eq 7)



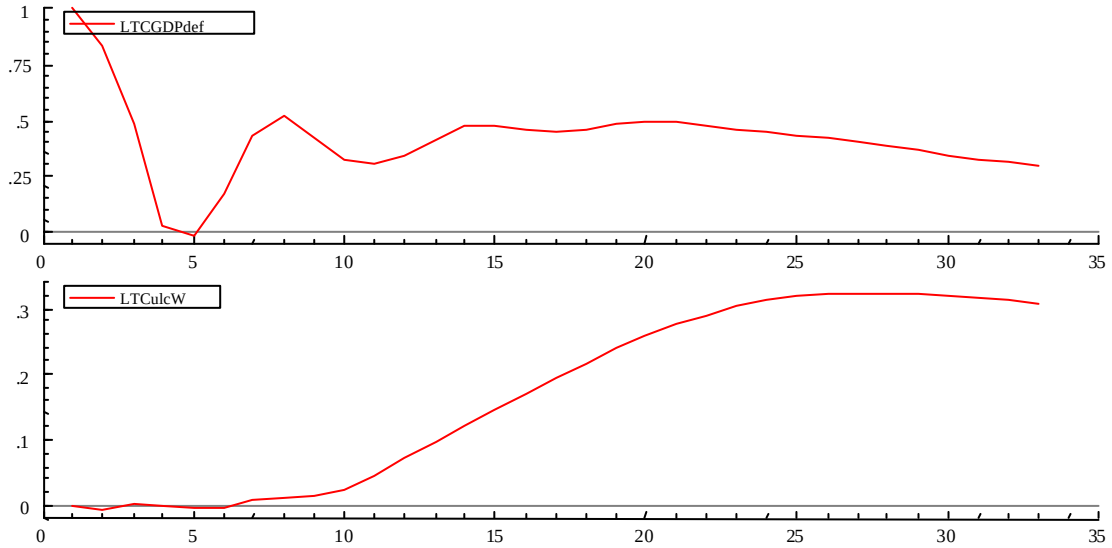
The initial response of a unit labour cost in retail and wholesale trade to a sectoral price level shock is positive, though muted. After 15 quarters the simulated response becomes perverse.

6.2.5.7 Transport and communications

Equation 8

Dynamic effect of a unit shock to the error process of the sectoral GDP deflator

Figure 41: Dynamic effect of a unit shock to the error process of the sectoral GDP deflator (eq 8)



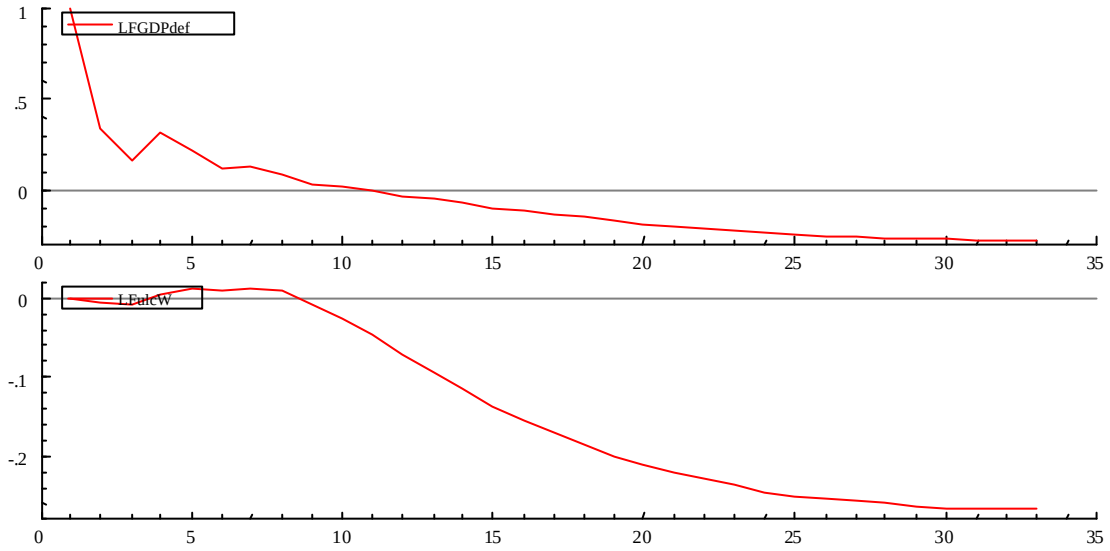
A unit shock to the sectoral price level is associated with a delayed impact on the unit labour cost in the transport and communications sector. The maximum effect of this delayed impact is less than proportionate to the shock.

6.2.5.8 Financial and business services

Equation 9

Dynamic effect of a unit shock to the sectoral GDP deflator

Figure 42: Dynamic effect of a unit shock to the sectoral GDP deflator (eq 9)



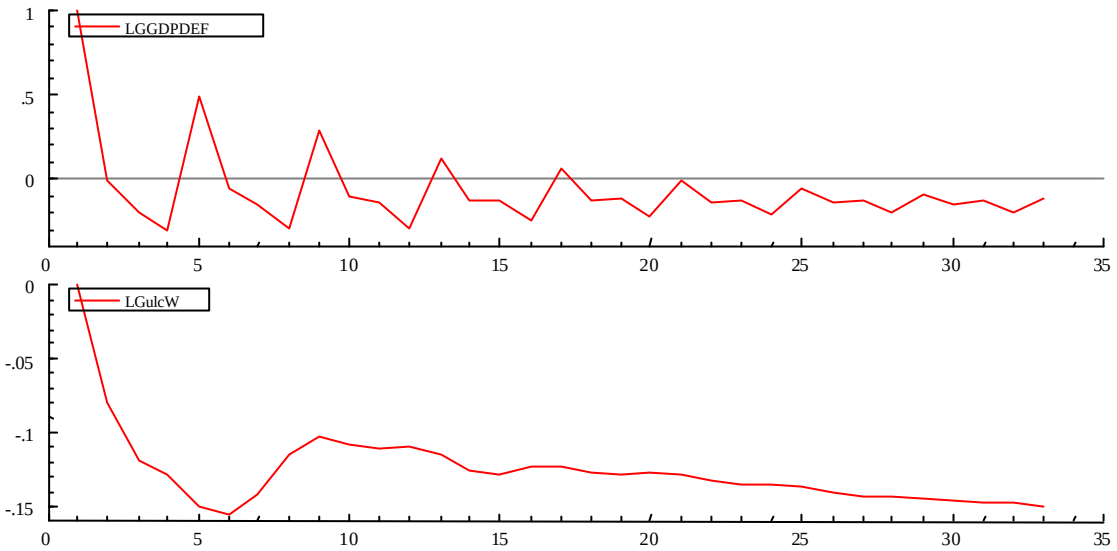
A price shock to the financial and business services sector decays rapidly in this simulation. This shock does not seem to have an impact on the sectoral unit labour cost, until a perverse, though damped, effect emerges after 9 quarters.

6.2.5.9 Government services

Equation 10

Dynamic effect of a unit shock to the sectoral GDP deflator

Figure 43: Dynamic effect of a unit shock to the sectoral GDP deflator (eq 10)



Unit labour cost in the government services sector also seems to responds perversely to a unit shock in the sectoral price level.

7. Conclusion

The analysis of price and wage determination in the South African economy conducted above suggests the following conclusions with respect to the long-term equilibrium relationships of these variables:

1. South African prices as measured by the GDP deflator can be modelled as a function of unit labour costs.

2. The long-run impact of unit labour cost on the price level is smaller than 1 at the aggregate level, but the combined effect of unit labour cost and import prices exceed 1, implying a positive mark-up on the aggregate level. These results on the mark-up on unit labour costs (or more appropriately, on unit labour costs and imports prices) are broadly in line with the previous results of Pretorius and Small (1994) for South Africa and that Ghali (1999) for the US. It is however, substantially lower than that of Fedderke and Schaling (1999) for South Africa. This calls into question their conclusions on the implications of the size of the mark-up for the degree of competition in the South African labour and product markets and the attendant policy implications.

3. In 4 of the 8 sectoral equations the long-run effect of unit labour cost exceeds 1, falling short of 1 in the remainder. Consequently, it seems as if conclusions about the ability to pass cost pressure onto customers would have to be sector specific.

4. The long-run contribution of price expectations is just above or below unity in all of the wage equations, except for the following sectors where price expectations seem to have an amplified long-run effect on wages: Electricity, gas and water; Retail and wholesale trade; Transport and communications; Government services. In the case of the aggregate level expectations appear to be backward looking. On the sectoral level prices expectations appear to be backward looking in the case of agriculture, electricity, gas and water, transport and communications, and financial and business services and rational in the case of manufacturing, construction, retail and wholesale trade and government services.

5. Various supply-side effects, in the form of international energy prices (proxied by the oil price), variations in the Rand's real effective exchange rate, and variations in the terms of trade have a long-run impact on prices (and wages in some sectors).

The impulse-response analysis conducted on the basis of the estimated relationships for prices and unit labour costs generally provided responses that were in line with prior expectations. In some cases, however, perverse results were obtained.

In the case of an **oil price shock**, the price effect was generally more rapid than that on unit labour cost and both peaked within 5 to 10 quarters. The maximum response to an **exchange rate shock** followed with a substantially longer log, generally in the order of 15 to 20 quarters.

A shock to **import prices** had a similar effect to that observed for an oil price shock, only with a somewhat longer lag. Both prices and unit labour costs appear to respond more than proportionally to a price expectation shock at their maximum, which is reached after 5 to 15 quarters.

A shock to unit labour cost was associated with a rapid (peaking after 5 years) price response in the cases of manufacturing and government services. In most of the other cases the response was substantially longer (15 quarters plus).

The effects of a shock to **prices** was generally less than proportional and fairly rapid (less than 10 quarters except in the cases of electricity, gas and water and transport and communication).

The results of the analysis suggest the following **policy implications** of the interaction between prices and wages (unit labour cost) in South Africa:

1. The important role of unit labour costs (wages) in price formation implies that the monetary authorities will have to pay close attention to developments in the labour market in pursuing their inflation targets

2. The (generally) long and varied lags between changes in unit labour cost and prices, however, highlight the complexity of a policy of inflation targeting in South Africa.

3. The important role of price expectations in the wage formation process underscores the importance of credibility of monetary policy in South Africa.

4. The significant role played by supply shocks in domestic price and wage formation suggest an important qualification (caveat) to targeting inflation using demand-side instruments only – provision must be made for escape clauses in the case of supply-side shocks such as these modelled above.

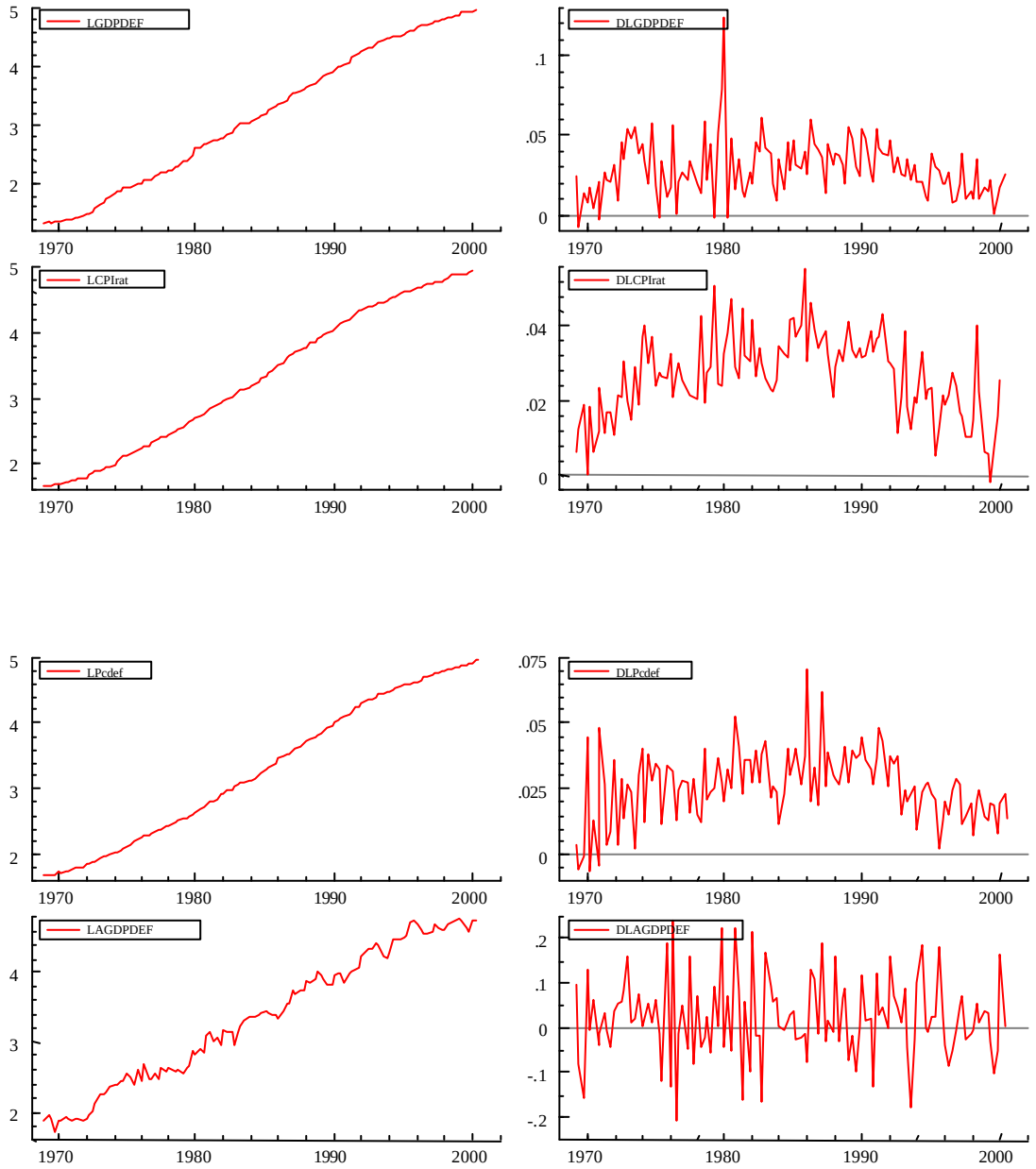
Appendix A

Table 2: Unit root tests of the data series

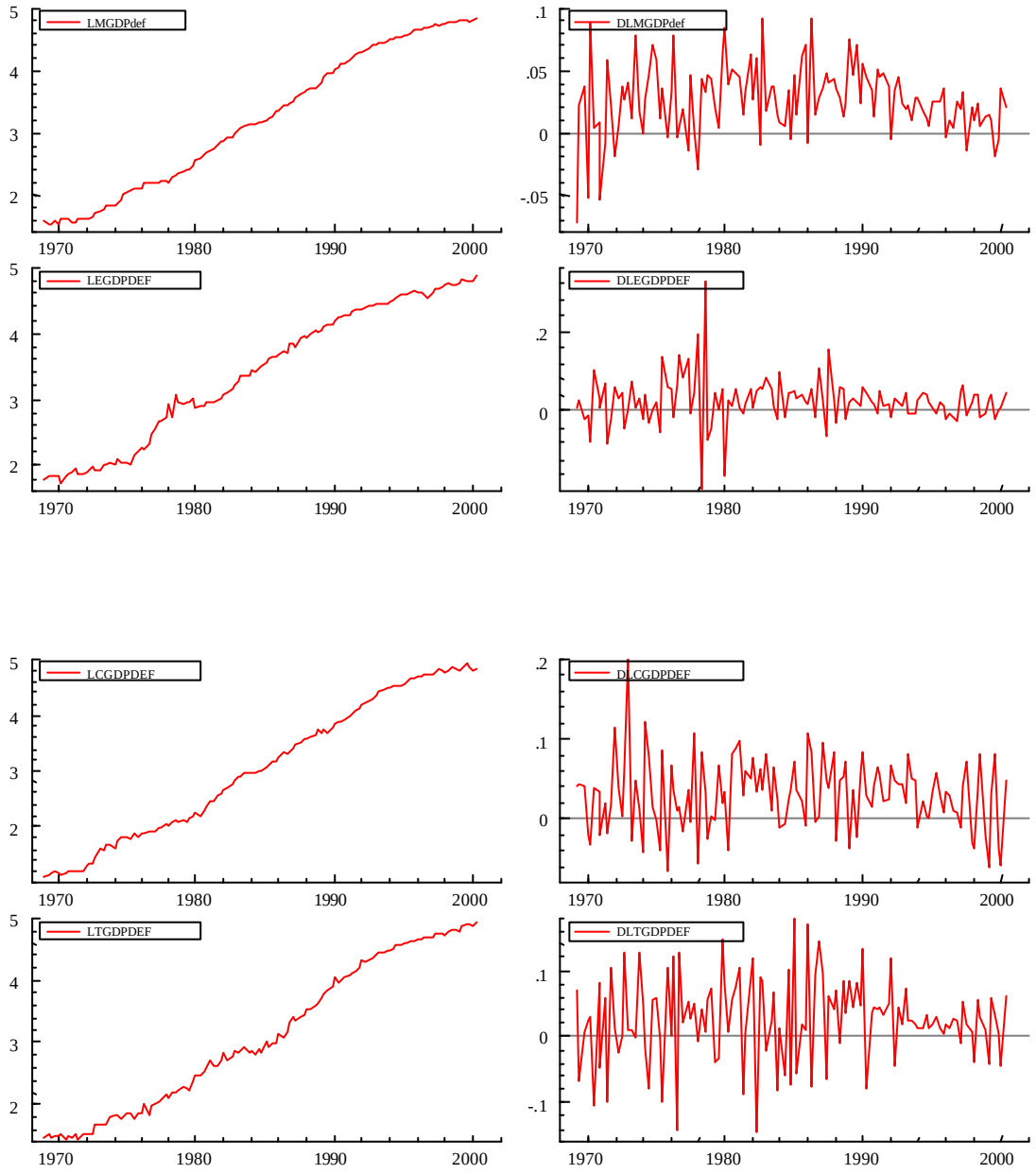
Variable	Period	Lags	Deterministic Components			Level of Integration
			Trend and constant	Constant	None	
LGDPDEF	1969:1-1998:4	5	-0.8784	-1.259	1.541	I(1)
DLGDPP	1970:1-1998:4	5	-3.666*	-3.509**	-0.9382	I(0)
LCPIrat	1969:1-2000:2	2	-0.824	-0.7448	2.348	I(1)
DLCPIrat	1969:2-2000:1	2	-3.027	-2.994*	-0.8355	I(0)
LPCDEF	1969:1-2000:3	2	-0.7908	-0.4548	3.551	I(1)
DLPCDEF	1969:2-2000:3	2	-4.634**	-4.685**	-1.094	I(0)
LAGDPDEF	1969:1-2000:2	5	-3.298	-0.9418	2.881	I(1)
DLAGDPDEF	1969:2-2000:2	5	-5.306**	-5.265**	-3.515**	I(0)
LMGDPDEF	1969:1-2000:2	2	-0.7145	-0.6669	4.603	I(1)
DLMGDPDEF	1970:1-2000:2	2	-5.124**	-5.121**	-2.415*	I(0)
LEGDPDEF	1969:1-2000:2	5	-1.657	-1.445	2.194	I(1)
DLEGDPDEF	1970:1-2000:2	5	-3.597*	-3.472*	-1.955*	I(0)
LCGDPDEF	1969:1-2000:2	5	-1.397	-1.125	1.809	I(1)
DLCGDPDEF	1970:1-2000:2	5	-3.247	-3.164*	-1.432	I(0)
LTGDPDEF	1969:1-2000:2	5	-2.232	-0.2793	2.345	I(1)
DLTGDPDEF	1970:1-2000:2	5	-3.402	-3.5**	-1.584	I(0)
LTCGDPDEF	1969:1-2000:2	5	-1.424	-0.3207	4.235	I(1)
DLTCGDPDEF	1970:1-2000:2	5	-4.896**	-4.913**	-2.054*	I(0)
LFGDPDEF	1969:1-2000:2	5	-1.824	0.2929	2.323	I(1)
DLFGDPDEF	1970:1-2000:2	5	-3.269	-3.348*	-1.056	I(0)
LGGDPDEF	1969:1-2000:2	5	-1.284	-0.5606	1.956	I(1)
DLGGDPDEF	1970:1-2000:2	5	-1.284	-4.626**	-1.449	I(0)
LMiGDPDEF	1969:1-2000:2	5	-1.599	-2.219	2.243	I(1)
DLMiGDPDEF	1970:1-2000:2	5	-4.553**	-4.135**	-2.82**	I(0)
LulcW	1970:4-1998:4	5	-2.283	-0.9937	-2.188*	I(1)
DLulcW	1971:1-1998:4	5	-3.162	-3.135*	-0.4583	I(0)
LulcB	1971:2-2000:2	4	0.2814	-1.624	2.045	I(1)
DLulcB	1971:2-2000:2	4	-4.034*	-3.735**	-1.534	I(0)
LAulcW	1970:4-1998:4	5	-2.117	-1.457	-3.658**	I(1)
DLAulcW	1971:1-1998:4	5	-3.98*	-3.687**	-0.8275	I(0)
LMulcW	1970:4-1998:4	5	-2.502	-2.461	-2.96**	I(1)
DLMulcW	1971:1-1998:4	5	-3.665*	-3.579**	-0.7273	I(0)
LEulcW	1970:4-1998:4	5	-2.122	-0.04553	-2.496*	I(1)

DLEulc	1971:1-1998:4	5	-2.888	-3.003*	-0.5743	I(0)
LCulcW	1970:4-1998:4	5	-4.156**	0.5881	-2.901**	I(1)
DLCulcW	1971:1-1998:4	5	-4.418**	-4.383**	-1.322	I(0)
LTulcW	1970:4-1998:4	5	-1.512	-1.184	-1.184	I(2)
DLTulcW	1971:1-1998:4	5	-1.533	-1.695	-0.8029	I(1)
LTCulcW	1970:4-1998:4	5	-1.825	-1.825	-2.536*	I(1)
DLTCulcW	1971:1-1998:4	5	-3.016	-2.994*	-0.4645	I(0)
LFulcW	1970:4-1998:4	5	-2.433	0.1627	-2.583*	I(1)
DLFulcW	1971:1-1998:4	5	-3.178	-3.227*	-0.6909	I(0)
LGulcW	1970:4-1998:4	2	-2.611	0.5095	-2.608**	I(1)
DLGulcW	1971:1-1998:4	2	-3.743*	-3.659**	-1.34	I(0)
LMiulcW	1970:4-1998:4	5	-2.832	-0.5073	-2.75**	I(1)
DLMiulcW	1971:1-1998:4	5	-3.225	-3.277*	-0.5125	I(0)
LEFFR	1970:1-2000:2	5	-2.569	-2.526	-0.3984	I(1)
DLEFFR	1970:2-2000:2	5	-5.393**	-5.362**	-5.369**	I(0)
LOILS	1970:1-2000:2	5	-2.195	-2.733	0.5089	I(1)
DLOILS	1970:2-2000:2	5	-4.918**	-4.581**	-4.454**	I(0)
LOILRAND	1970:1-2000:2	5	-1.998	-2.22	1.339	I(1)
DLOILRAND	1970:2-2000:2	5	-5.304**	-5.057**	-4.488**	I(0)
LTOT[6]	1969:1-2000:3	5	-4.452**	-4.627**	0.3851	I(1)
DLTOT	1970:2-2000:2	5	-4.684**	-4.456**	-4.432**	I(0)
GDPgap	1969:1-2000:2	5	-4.23**	-4.249**	-4.267**	I(0)
AGDPgap	1969:1-2000:2	5	-5.789**	-5.815**	-5.778**	I(0)
MGDPgap	1969:1-2000:2	5	-1.763	-3.966**	-3.982**	I(0)
EGDPgap	1969:1-2000:2	5	-4.838**	-4.84**	-4.861**	I(0)
CGDPgap	1969:1-2000:2	5	-3.929*	-3.945**	-3.961**	I(0)
TGDPgap	1969:1-2000:2	5	-3.938*	-3.946**	-3.92**	I(0)
TCGDPgap	1969:1-2000:2	5	-4.138**	-4.158**	-4.171**	I(0)
FGDPgap	1969:1-2000:2	5	-3.347	-3.361*	-3.373**	I(0)
GGDPgap	1969:1-2000:2	5	-5.094**	-5.097**	-5.113**	I(0)
MiGDPgap	1969:1-2000:2	5	-4.149**	-4.169**	-4.187**	I(0)
	* Reject H_0 at 5% level			** Reject H_0 at 1% level		

Appendix B



[6] *The Dickey-Fuller tests suggest that LTOT is a stationary series. However, inspection of the spectral representation of LTOT revealed the typical spectrum of a macroeconomic time containing at least one unit root Granger (1969).*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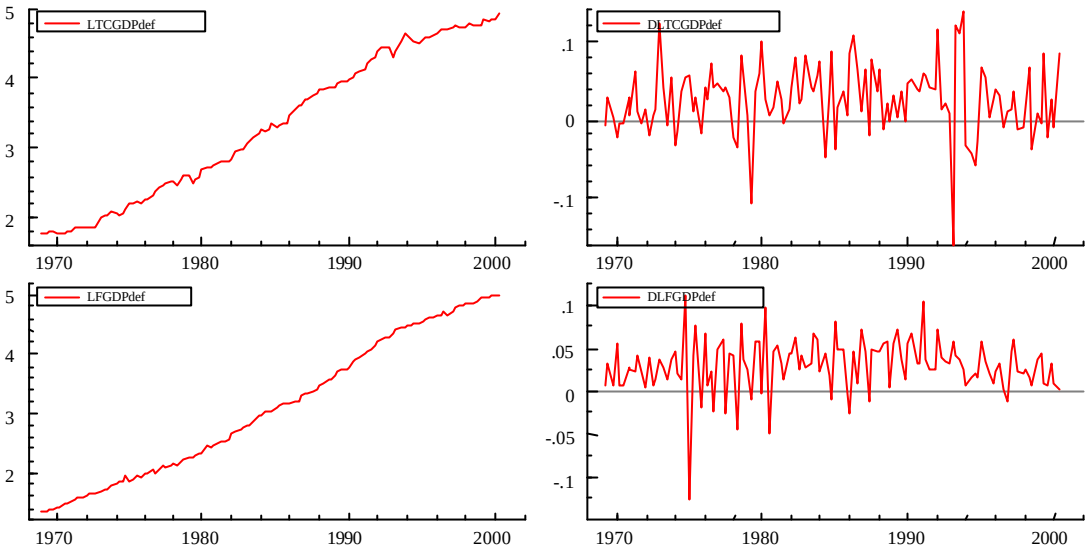
1980
1990
2000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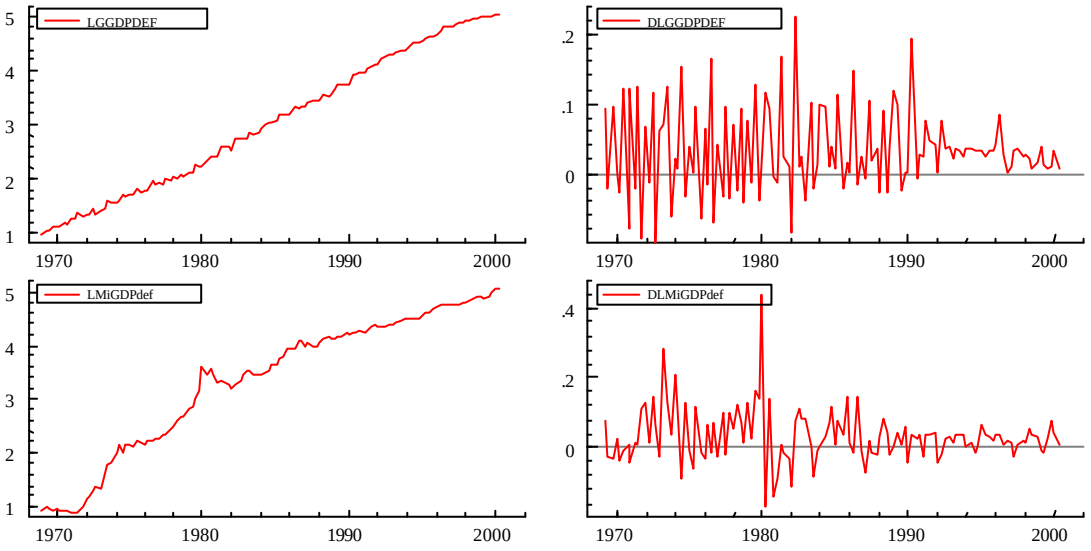
1990
2000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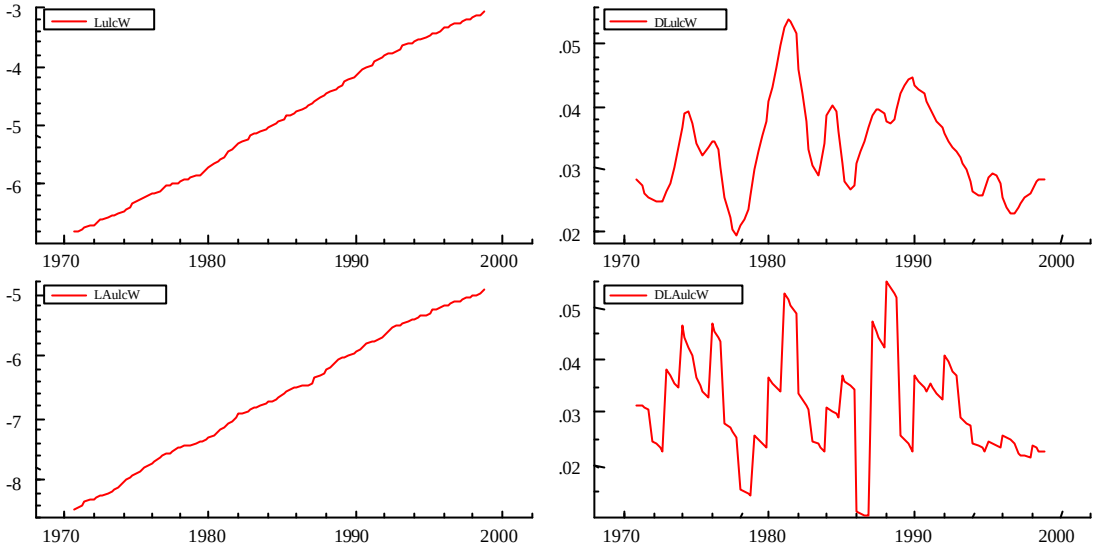
1990
2000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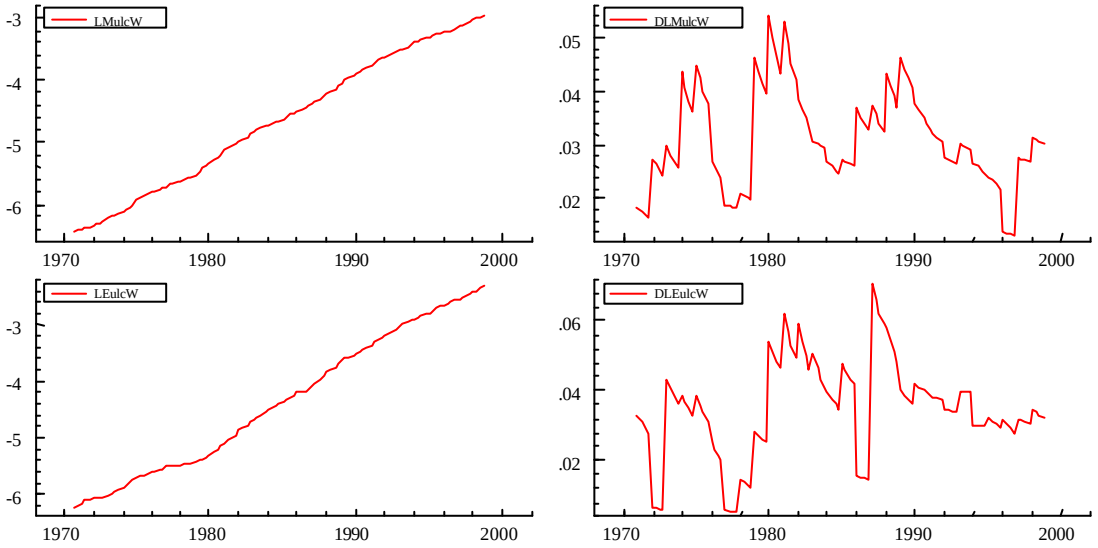
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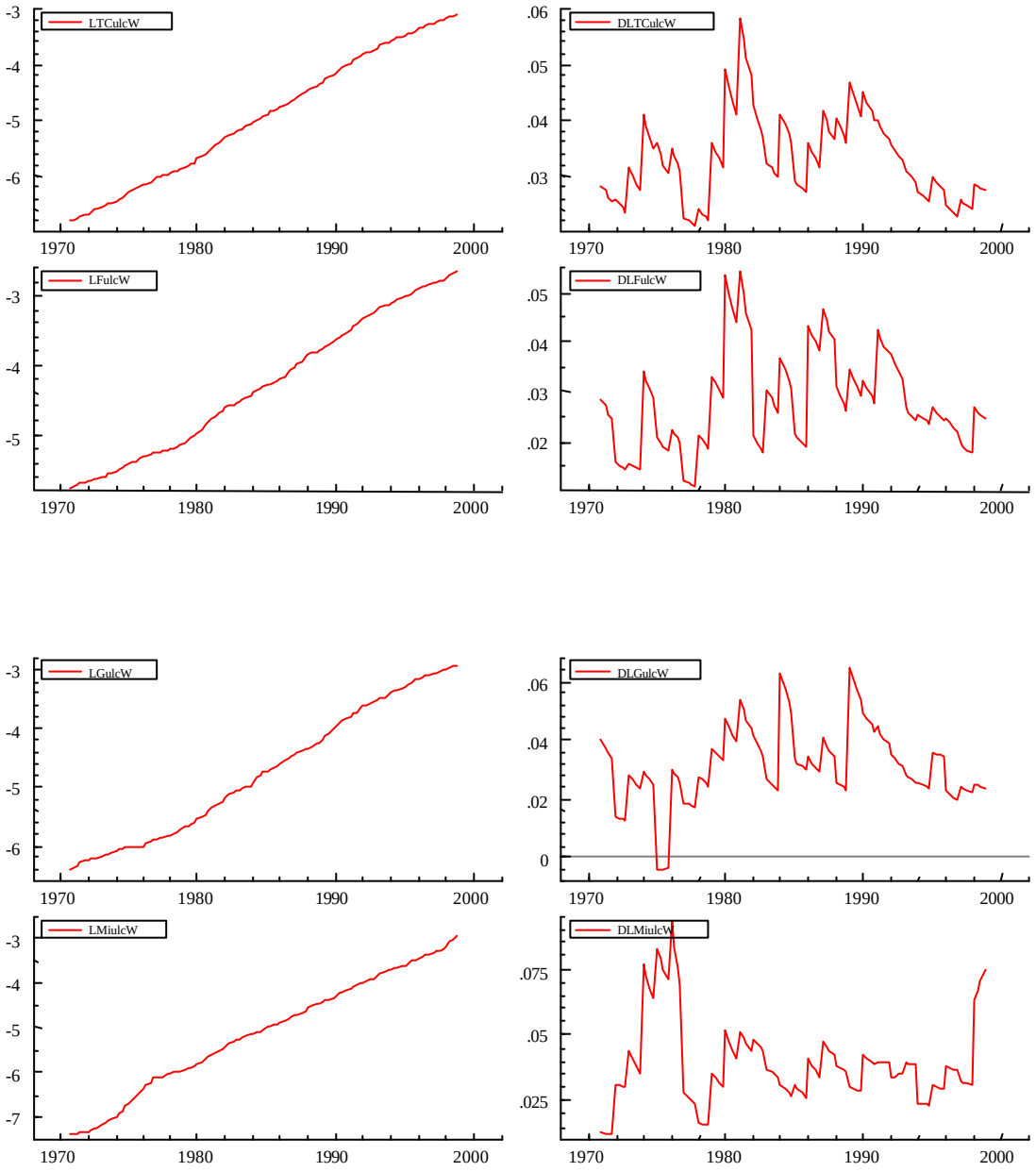
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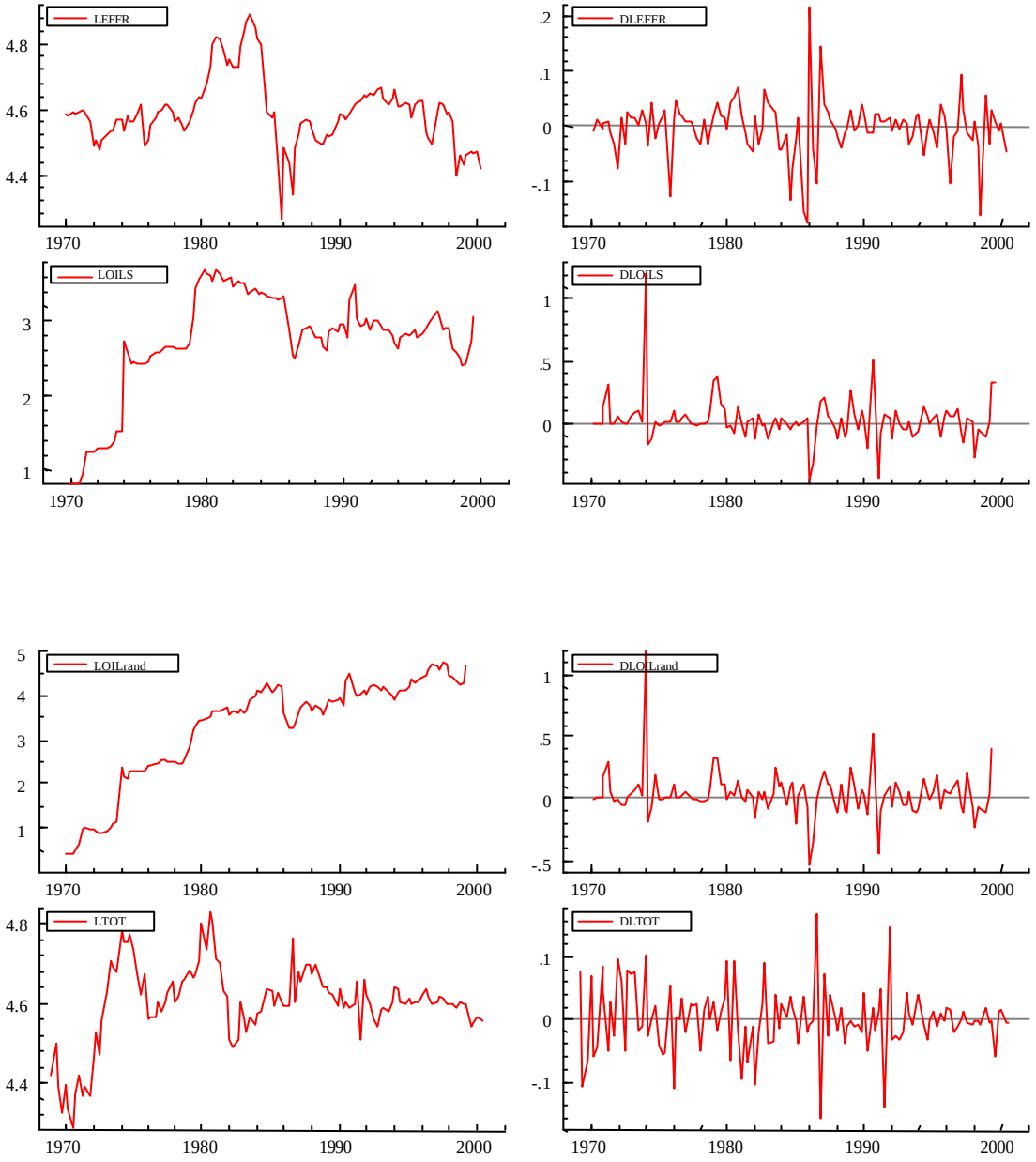
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2000
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0
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2
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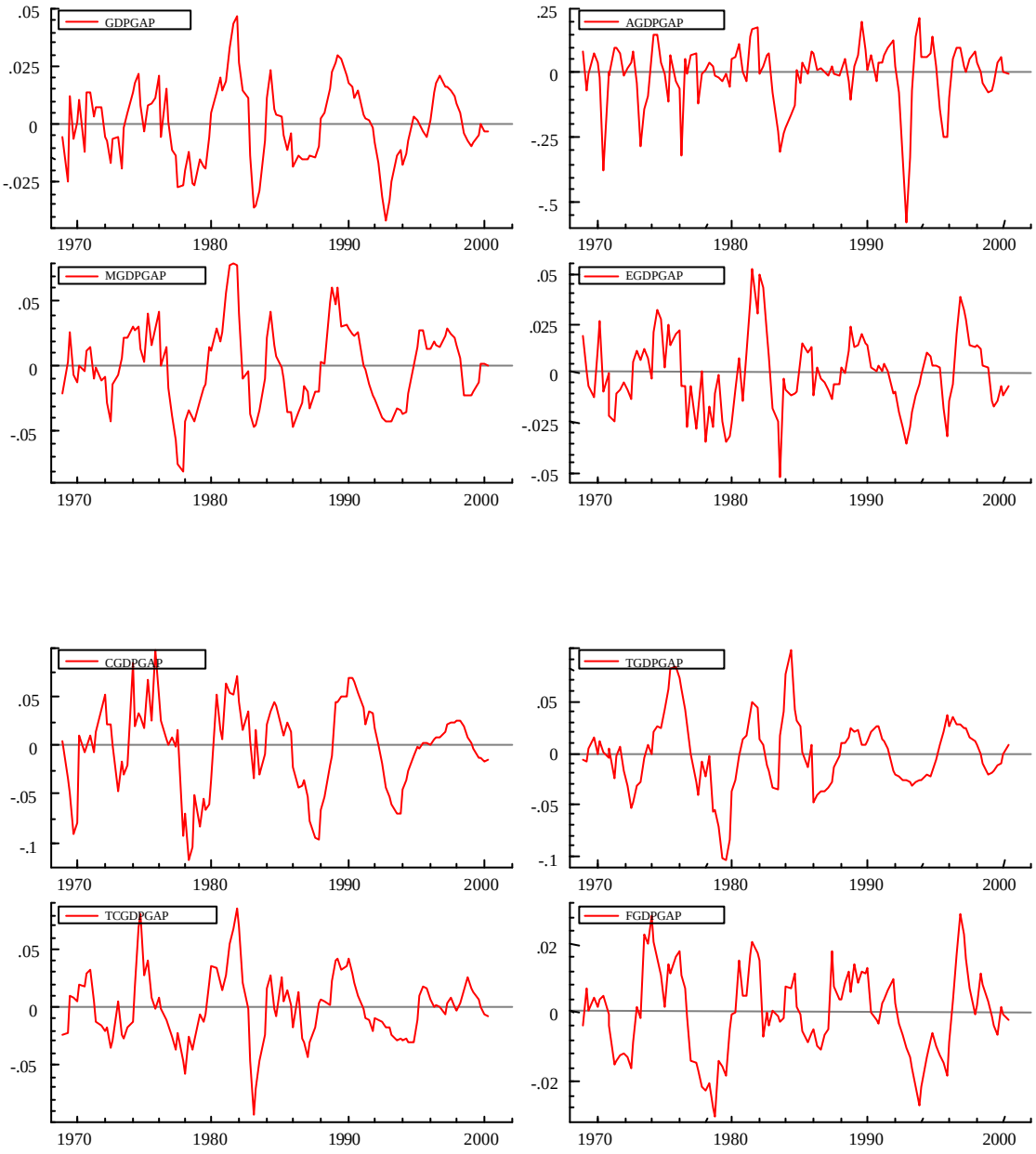
DLOILrand
-.5
LTOT
DLTOT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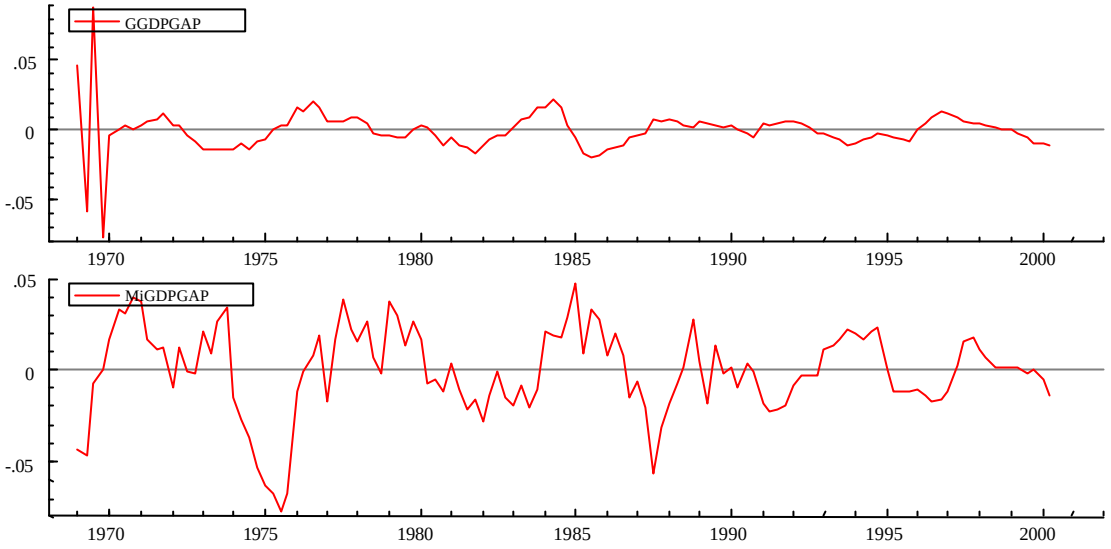
1990
2000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0
-.05
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1975
1980
1985
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1995
2000
MiGDPGAP
.05
0
-.05
1970
1975
1980
1985
1990
1995
2000

Appendix C

The results reported in Table 2 (see Appendix A) are the long-run relationships that were derived using a general to specific modelling strategy. In this appendix each of the models are considered in turn, showing how the results of Table 2 were derived. For the first two models the reduction process was followed to reach parsimonious dynamic models. That exercise could be extended to the other models too.

Model 1: GDP deflator and wages

The first model under consideration is one where the price series is taken to be the GDP deflator. The unit labour cost is measured at the aggregate level. Supply-side shocks in form of the dollar oil price and import prices enter the model. Price expectations are static. Finally, an aggregate demand effect is included with an output gap variable.

The output gap is not included in the long-run relationships but as a part of the dynamic adjustment to that long-run. The VAR for the first model therefore contains the following jointly endogenous variables: LGDPDEF, LulcB, LPcdef, LMdef, LOILS.

The Johansen procedure is used to determine the number of cointegrating vectors in the VAR system. First, however, the data congruency of the VAR has to be established. The diagnostic evaluation of the VAR is shown visually in Figures 44 and 45.

Figures 44 and 45 demonstrate the close fit between the model and the data on levels as well as the correlogram of residuals.

Figure 44: Confirmation of data congruency

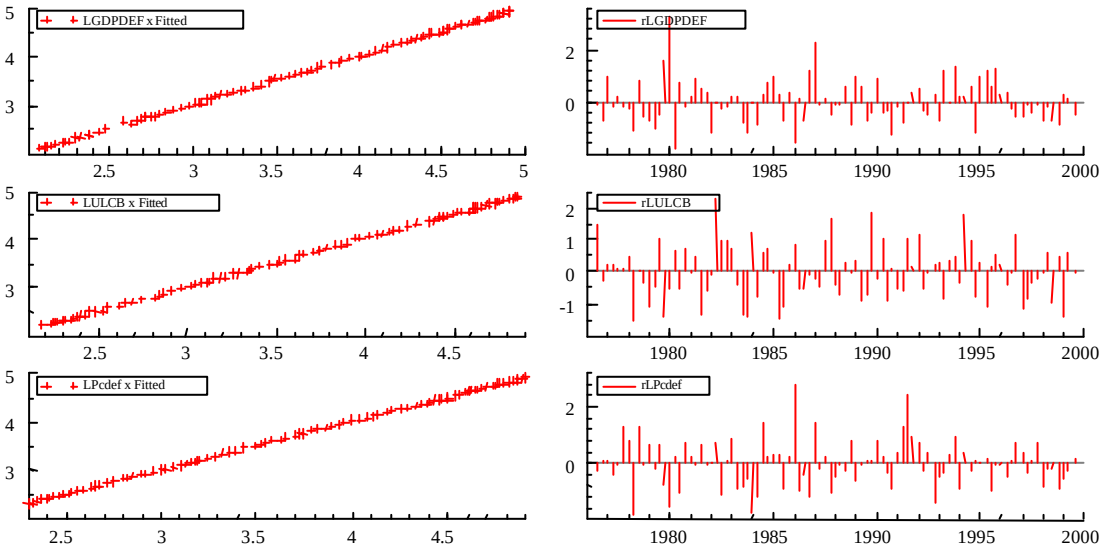
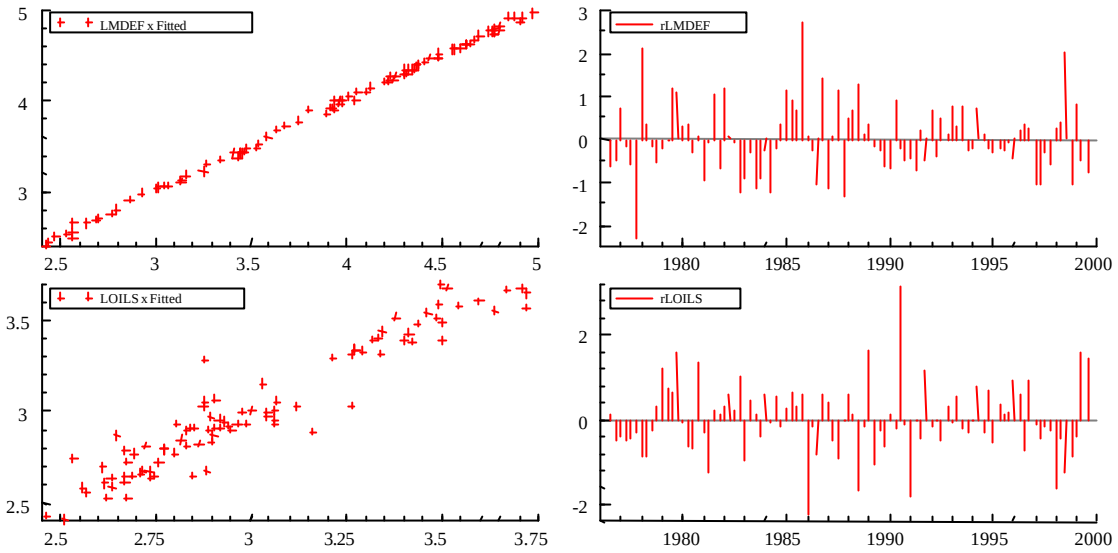


Figure 45: Confirmation of data congruency



Figures 46 and 47 examine the characteristics of the residuals more closely by plotting the correlograms, spectral densities and histogram (against the normal distribution).

Figure 46: Residual analysis

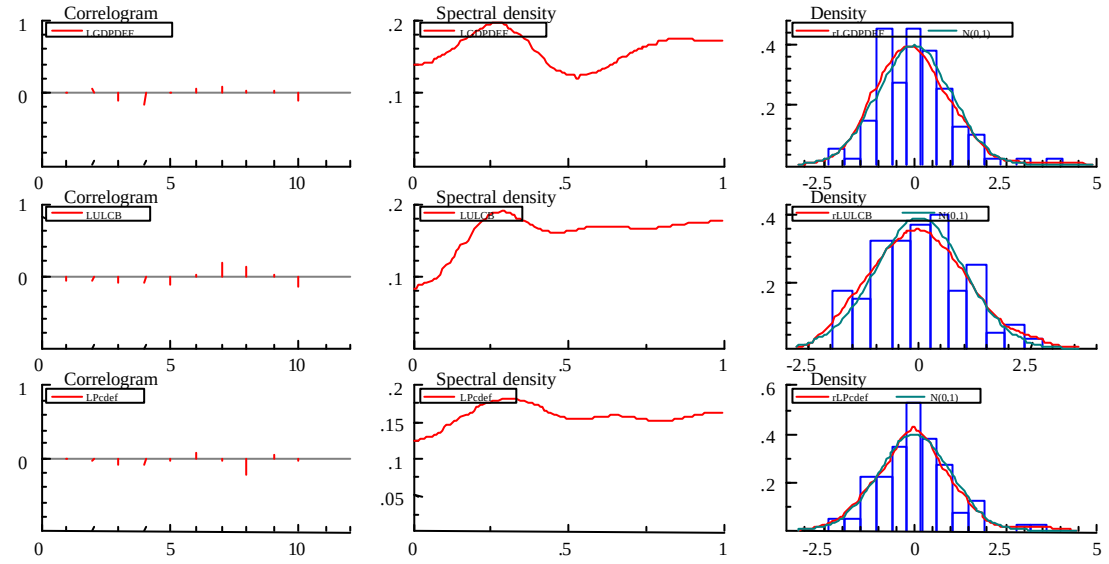
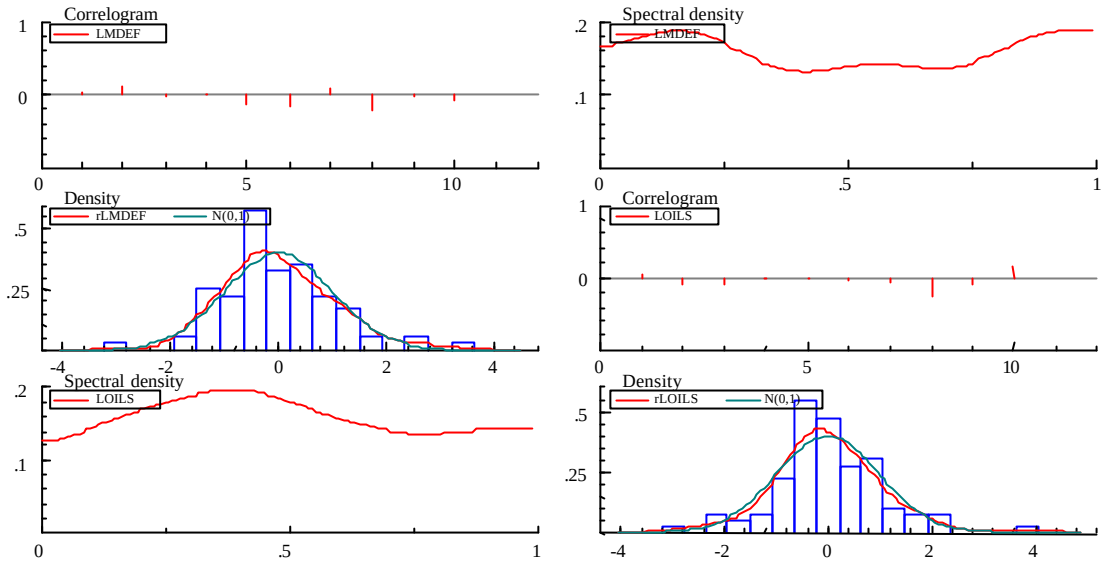


Figure 47: Residual analysis



The residual plots against the normal distribution reveals the only shortcoming of the model. However data congruency is not greatly compromised by this single shortcoming. The vector diagnostics are summarised in Table 3.

Table 3: Vector diagnostics

Endogenous variables	LGDPDEF, Lpcdef, Lmdef, LOILS
Unrestricted variable in short run dynamics	GDPgap
Data frequency	Quarterly
Period	1976:3-1999:3
Vector AR 1-1 F(125, 162)	1.0934 [0.2955]
Vector normality $Chi^2(10)$	36.963 [0.0001] **

The VAR appears to be congruent with the data. Table 4 reports on the results of the co-integration tests using the maximum Eigenvalue (λ) and trace tests.

Table 4: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	54.89**	37.18*	33.5	103.2**	69.94*	68.5
r <= 1	28.88*	19.56	27.1	48.35*	32.75	47.2
r <= 2	11.98	8.117	21	19.47	13.19	29.7
r <= 3	6.541	4.431	14.1	7.487	5.072	15.4
r <= 4	0.9465	0.6411	3.8	0.9465	0.6411	3.8

Period	1976:3-1999:3	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	GDPgap

From the tests and inspection of the possible long-run relationships, the conclusion is drawn that there are probably two long-run relationships in this VAR. The identification of the long-run relationships requires the use of economic theory in combination with the conclusion that the co-integration space is two-dimensional.

None of the jointly endogenous variables could be marginalised using weak exogeneity criteria. The long-run relationships can now be identified and are reported in Table 5.

Table 5: Co-integrating relationships

Variable	LGDPDEF	LULCB	LPcdef	LMDEF	LOILS
Coefficient	-1	0.93071	0	0.16124	0
Coefficient	0	-1	1.0054	0	0.05071

A dynamic simulation was performed to investigate the implicit wage-price dynamics and is reported above.

Model 2: GDP deflator and wages

In the second model the price series is once more the GDP deflator. The unit labour cost is measured at the aggregate level, but here the real exchange rate enters as a supply shock. Import prices also enter the price equation via the import price deflator. Price expectations are static as in equation 1. Finally, an aggregate demand effect is included with an output gap variable.

The output gap is not included in the long-run relationships but as a part of the dynamic adjustment to that long-run. The VAR for the first model therefore contains the following jointly endogenous variables: LGDPDEF, lULCB, LPCDEF, LMDEF, LEFFR.

The Johansen procedure is used to determine the number of cointegrating vectors in the VAR system. First, however, the data congruency of the VAR has to be established. The diagnostic evaluation of the VAR is shown in Figures 48 and 49.

Figures 48 and 49 demonstrate the close fit between the model and the data on levels as well as the correlogram of residuals.

Figure 48: Confirmation of data congruency

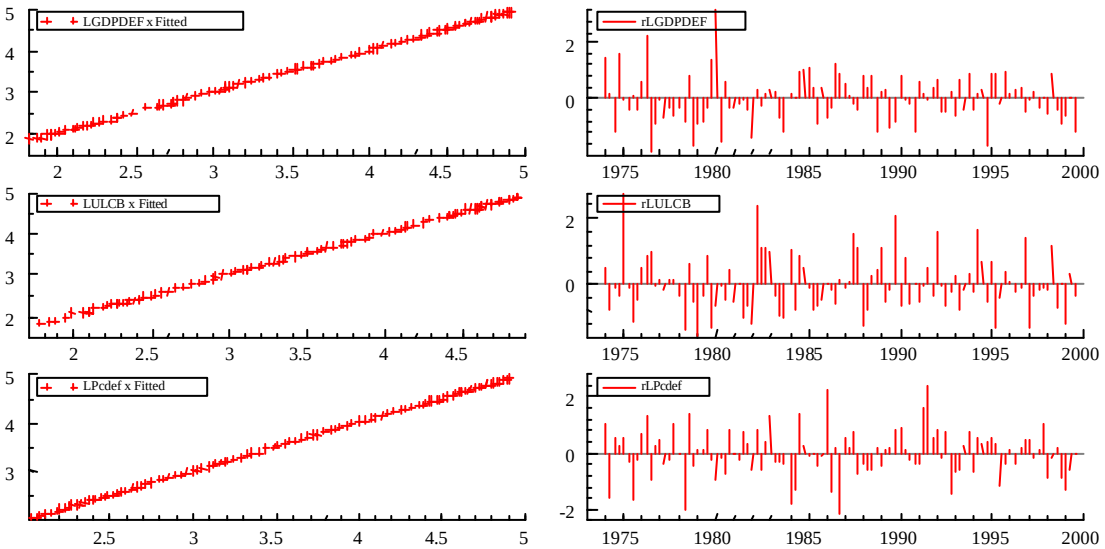
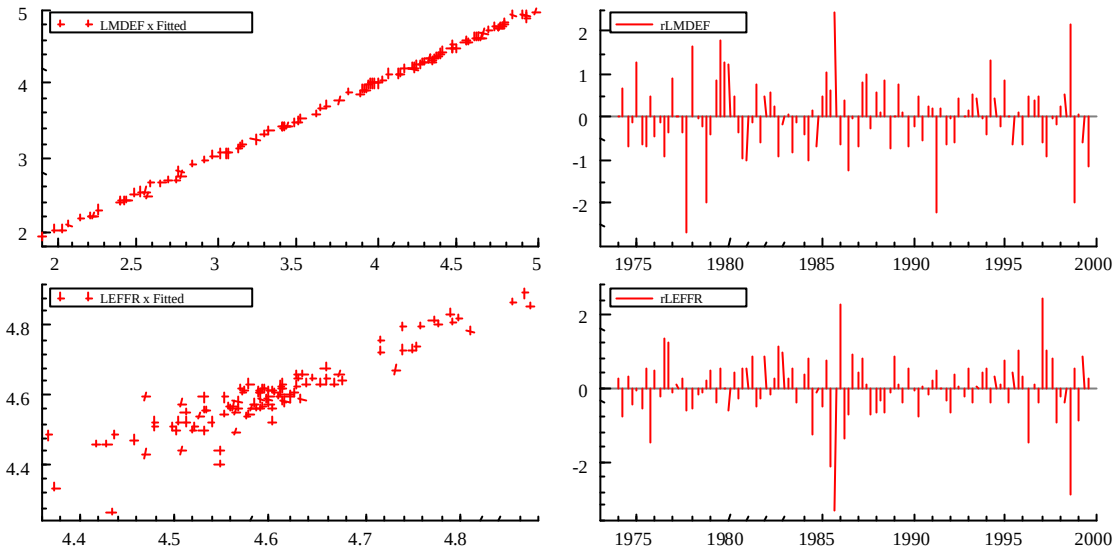


Figure 49: Confirmation of data congruency



Figures 50 and 51 examine the characteristics of the residuals more closely by plotting the correlograms, spectral densities and histogram (against the normal distribution).

Figure 50: Residual analysis

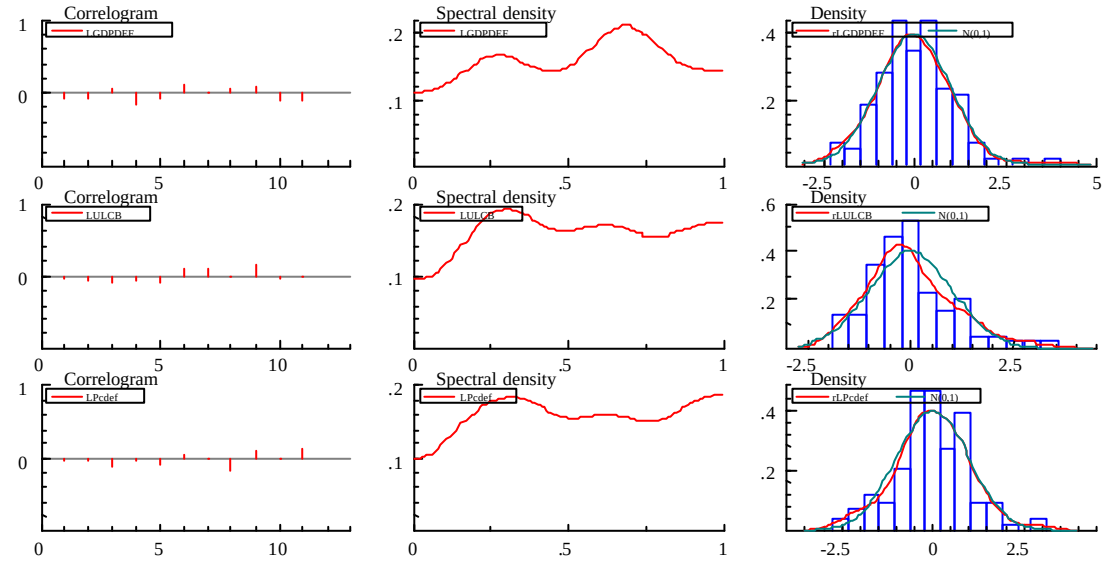
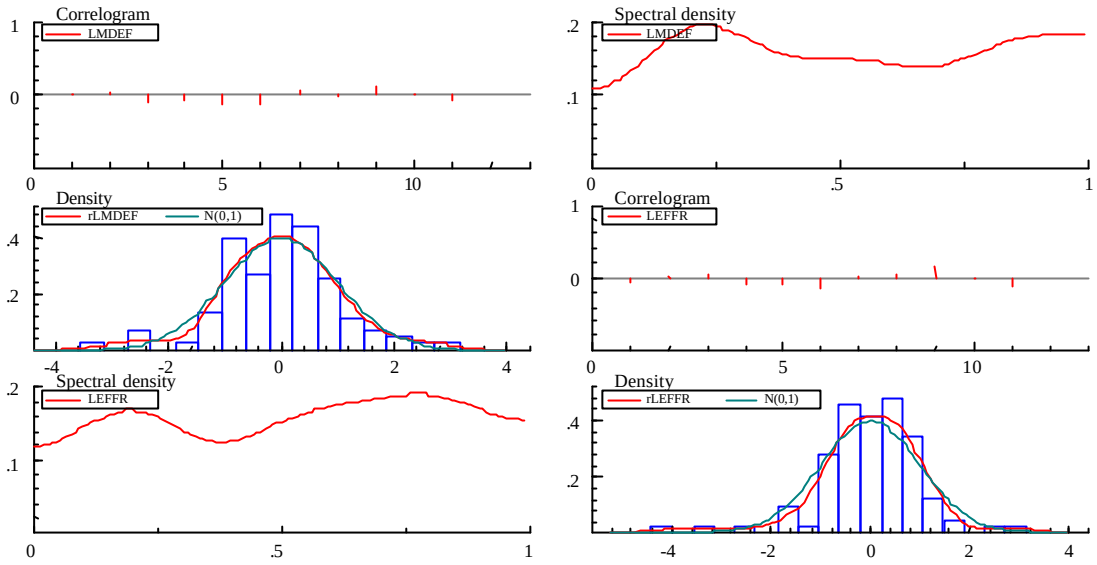


Figure 51: Residual analysis



The residual plots against the normal distribution reveals the only diagnostic problem with the model. However data congruency is not greatly compromised by this single shortcoming. The vector diagnostics are summarised in Table 6.

Table 6:Vector Diagnostics

Endogenous variables	LGDPDEF, LULCB, LPCDEF, LMDEF, LEFFR
Unrestricted variable in short run dynamics	GDPgap
Data frequency	Quarterly
Period	1974:1-1999:3
Vector AR 1-1 F(125, 211)	1.1234 [0.2282]
Vector normality $Chi^2(10)$	49.207 [0.0000] **

The VAR appears to be congruent with the data. Table 7 reports on the results of the co-integration tests using the maximum Eigenvalue (λ) and trace tests.

Table 7: Co-integration Analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	47.61**	33.74*	33.5	103.3**	73.21*	68.5
r <= 1	27.8*	19.7	27.1	55.68**	39.47	47.2
r <= 2	15.76	11.17	21	27.89	19.76	29.7
r <= 3	9.511	6.741	14.1	12.13	8.594	15.4
r <= 4	2.615	185%	3.8	2.615	1.854	3.8

Period	1974:1-1999:3	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	GDPgap

From the tests and inspection of the possible long-run relationships, the conclusion is drawn that there are probably two long-run relationships in this VAR. The identification of the long-run relationships requires the use of economic theory in combination with the conclusion that the co-integration space is two-dimensional.

However, before reporting on the identification of the long-run relationships, the results of weak exogeneity tests for the jointly endogenous variables are reported in Table 8. LEFFR could be treated as weakly exogenous.

Table 8: Weak exogeneity tests

LEFFR	Chi2(4) = 2.6276 [0.6220]

The long-run relationships can now be identified and are reported in Table 9

Table 9: Co-integrating relationships

Variable	LGDPDEF	LULCB	LPcdef	LMDEF	LEFFR
Coefficient	-1	0.908	0	0.19018	-0.0062
Coefficient	0	-1	0.99233	0	0

A dynamic simulation was performed to investigate the implicit wage-price dynamics and is reported above.

Model 3: GDP deflator and wages for the Agricultural sector

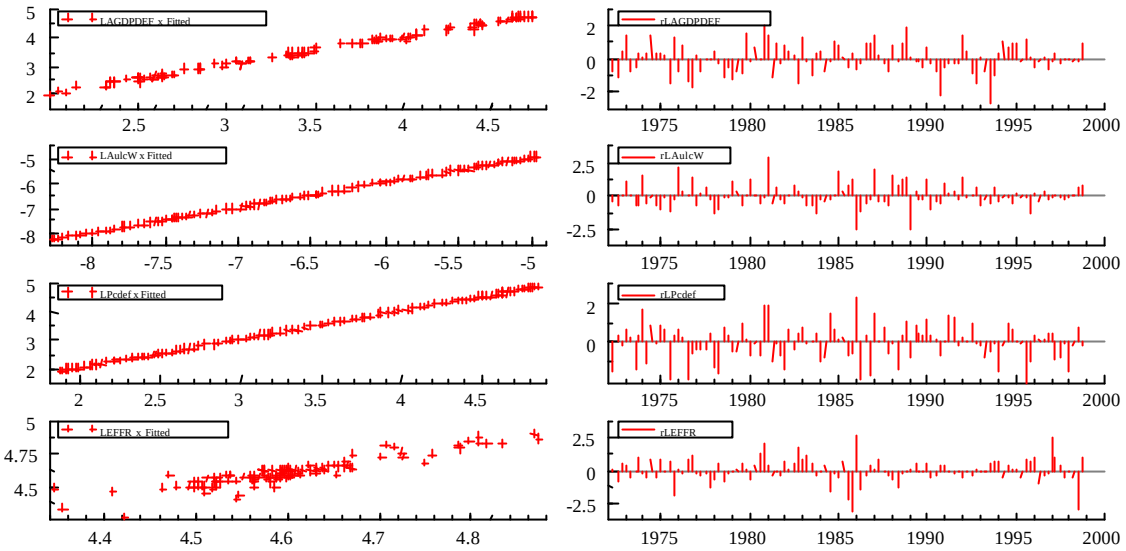
The third model concerns the agricultural sector. The price series is the GDP deflator for the agricultural sector. Labour costs are incorporated through a sector specific unit labour cost variable. The price expectations are formed according to a static expectations scheme and the real exchange rate represents a supply shock. A demand effect is included with a sector specific output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the third model therefore contains the following jointly endogenous variables: LAGDPDEF, LAULCW, LPCDEF, LEFFR[7]. A constant is also included in the long-run space.

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 52.

[7] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 52: Confirmation of data congruency



The residuals are analysed in Figures 53 and 54 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 53: Residual analysis

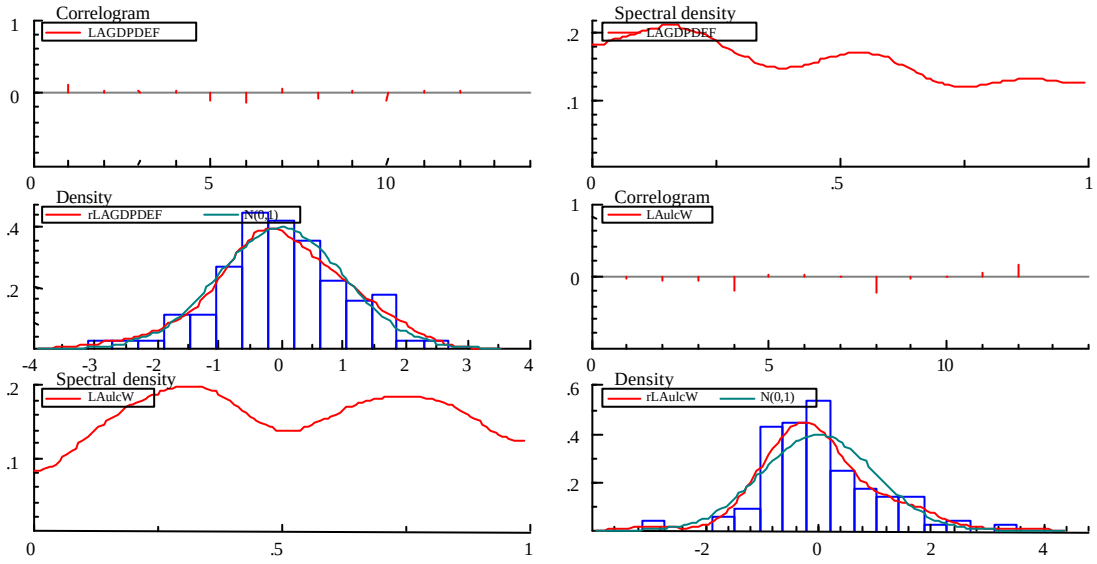
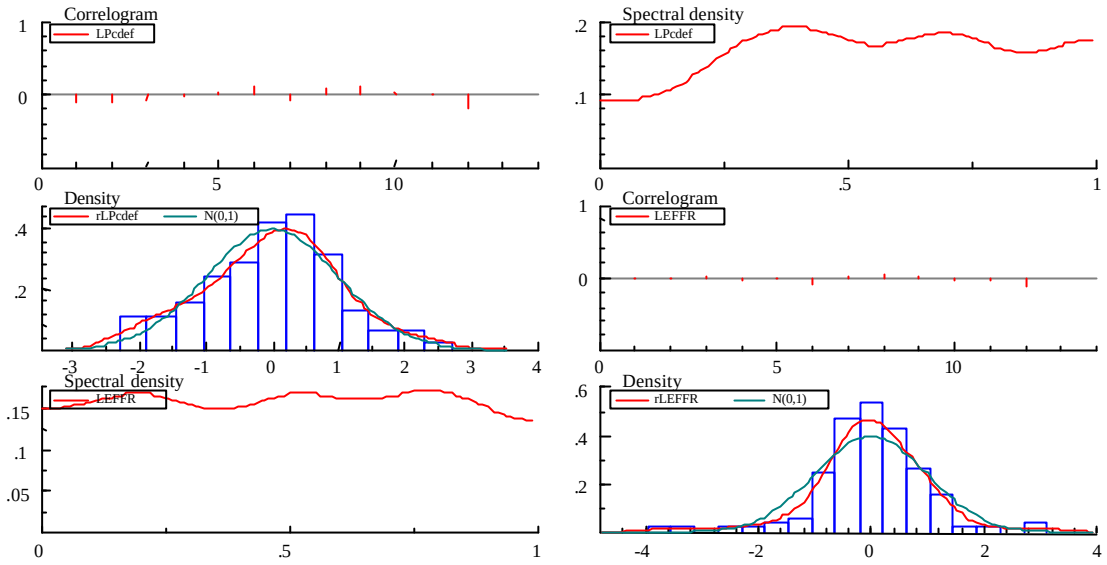


Figure 54: Residual analysis



A battery of diagnostic tests did not uncover any concerns regarding this model excepting a deviation from normality for the residuals. Though unfortunate this does not compromise the modelling fatally. The vector diagnostics are summarised in Table 10.

Table 10: Vector diagnostics

Endogenous variables	LAGDPDEF , LAULCW, LPCDEFf, LEFFR
Unrestricted variable in short run dynamics	AGDPgap
Data frequency	Quarterly
Period	1972:2-1998:4
Vector AR 1-1 F(80, 231)	1.0041 [0.4792]
Vector normality $Chi^2(8)$	29.346 [0.0003] **

The VAR is congruent with the data. Table 11 reports on the results of the co-integration tests.

Table 11: Co-integration Analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	26.56	20.6	27.1	56.71**	43.99	47.2
r <= 1	20.72	16.07	21	30.15*	23.39	29.7
r <= 2	7.415	5.752	14.1	9.432	7.316	15.4
r <= 3	2.017	1.565	3.8	2.017	1.565	3.8

Period	1972:2 - 1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	AGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. In Table 12 the weak exogeneity tests are once more reported on. The real effective exchange could be treated as weakly exogenous in the system.

Table 12: Weak exogeneity tests

LEFFR	$Chi2^{(4)} = 5.0942$ [0.1650]

The long-run relationships can now be identified and are reported in Table 13.

Table 13: Co-integrating relationships

Variable	LAGDPDEF	LAulcW	LPcdef	LEFFR
Coefficient	-1	0.83211	0	-0.02864
Coefficient	0	-1	1.029	0

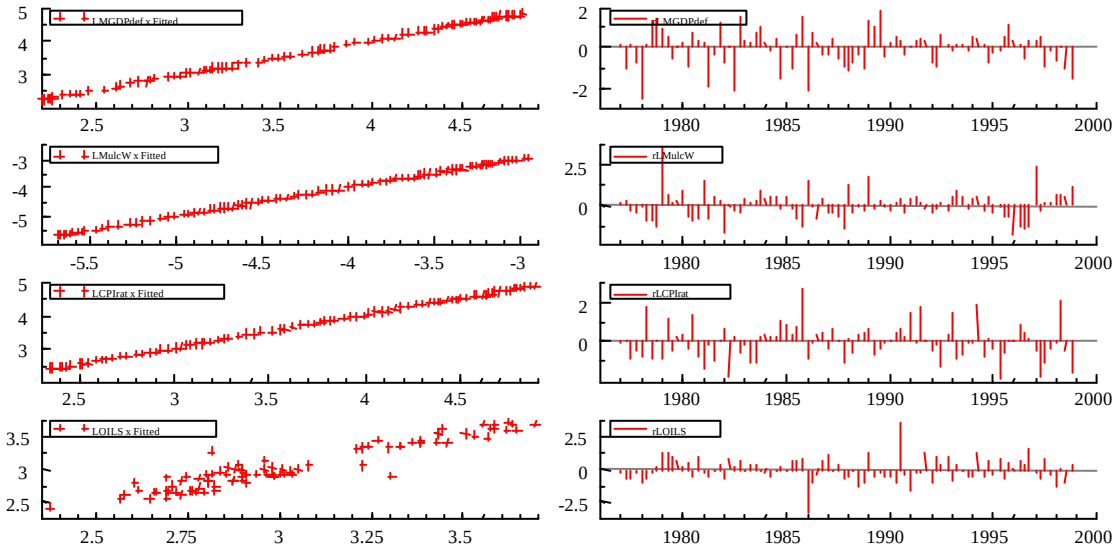
Model 4: GDP deflator and unit labour costs for the manufacturing sector

The fourth model is specified at the level of the manufacturing sector. The price series is the GDP deflator for the manufacturing sector. Similarly, unit labour cost is measured at sectoral level. The price expectations are rational forward looking and the dollar oil price represents an aggregate supply shock. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the second model therefore contains the following jointly endogenous variables: LMGDPDEF, LMULCW, LCPIRAT, LOILS[8].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 55. Figure 55 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

Figure 55: Confirmation of data congruency



The residuals are analysed in Figures 56 and 57 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

[8] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 56: Residual analysis

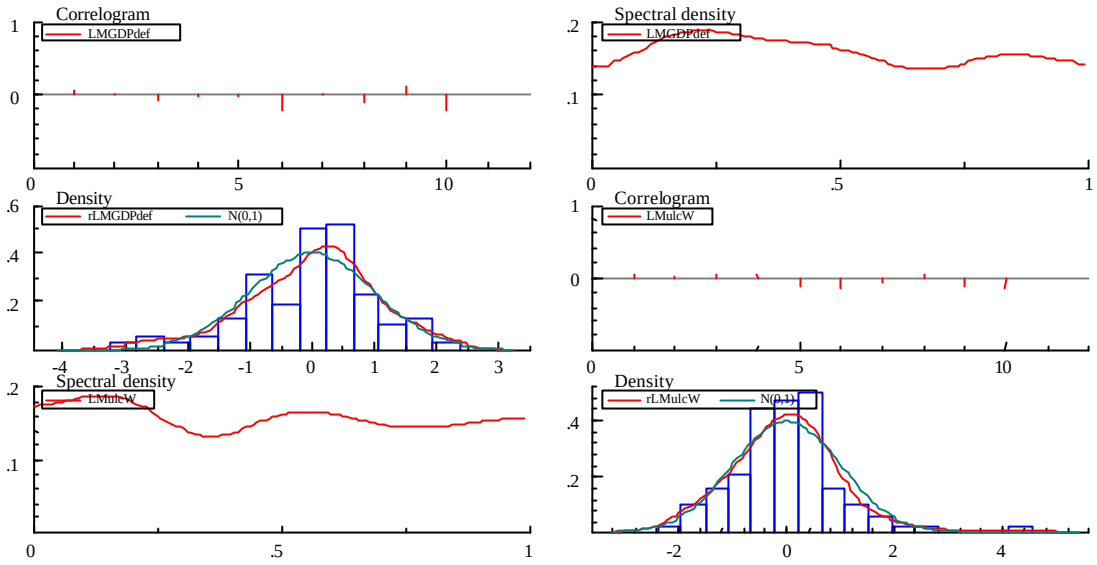
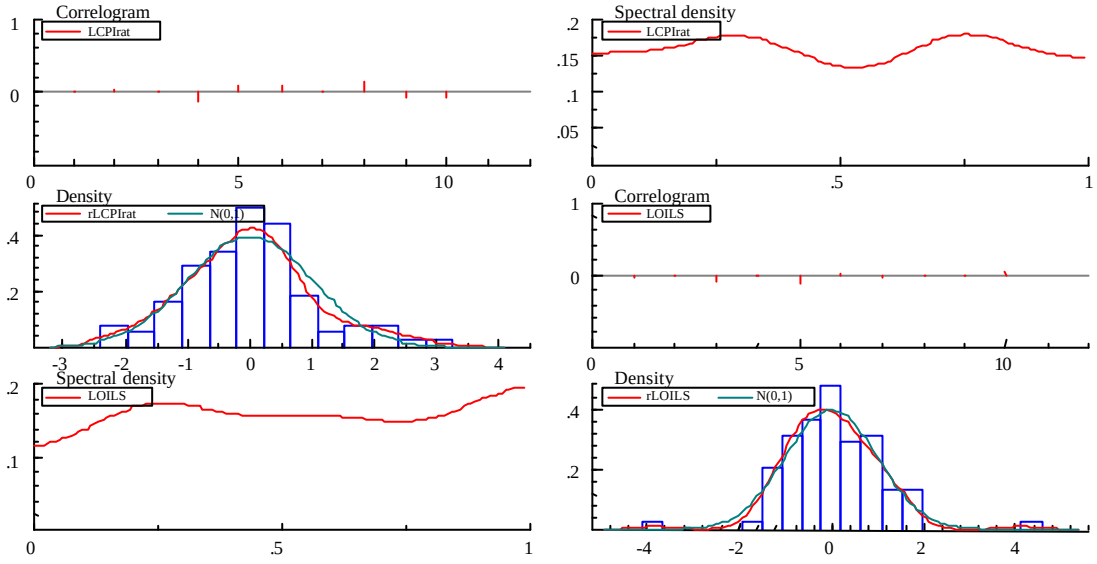


Figure 57: Residual analysis



There is a slight departure from normality in the residuals of this system in the LOILS and LMULCW processes. The vector diagnostics are summarised in Table 14.

Table 14: Vector diagnostics

Endogenous variables	LMGDPdef, LMULCW, LCPIRAT, LOILS
Unrestricted variable in short run dynamics	MGDPgap
Data frequency	Quarterly
Period	1977:1-1998:4
Vector AR 1-1 F(80,172)	0.837 [0.8143]
Vector normality Chi^2(8)	50.242 [0.0000] **

The system appears to be congruent with the data. Table 15 reports on the results of the co-integration tests.

Table 15: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	40.13**	31.01*	27.1	68.67**	53.06*	47.2
r <= 1	21.68*	16.75	21	28.54	22.06	29.7
r <= 2	5.836	4.51	14.1	6.863	5.303	15.4
r <= 3	1.026	0.7931	3.8	1.026	0.7931	3.8

Period	1977:1-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	MGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. In Table 16 the weak exogeneity tests are once more reported on. Only the LCPIrat could be treated as weakly exogenous. However, this was not done as we were interested in the dynamic process underlying this variable.

Table 16: Weak exogeneity tests

LCPIrat	Chi2(3) = 4.5801 [0.2053]

The long-run relationships can now be identified and are reported in Table 17.

Table 17: Co-integrating relationships

Variable	LMGDPdef	LMulcW	LCPIrat	LOILS
Coefficient	-1	1.0824	0	0.08772
Coefficient	0	-1	0.99996	0

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

Model 5: GDP deflator and wages for the Electricity, Gas and Water sector

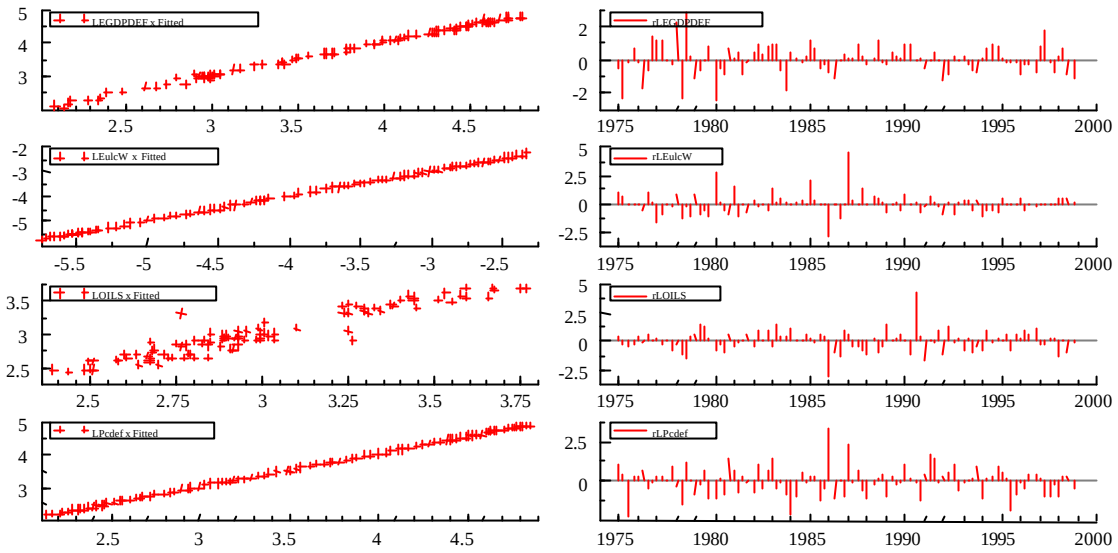
The fifth model has the same specification as the model for the manufacturing sector, with the GDP deflator for the electricity gas and water sector as price variable. A sector specific unit labour cost enters the model, as does static price expectations and a supply shocks in the form of the dollar oil price. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the second model therefore contains the following jointly endogenous variables: LEGDPDEF, LEULCW, LPDDEF, LOILS[9].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 58. Figure 58 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

[9] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 58: Confirmation of data congruency



The residuals are analysed in Figures 59 and 60 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 59: Residual analysis

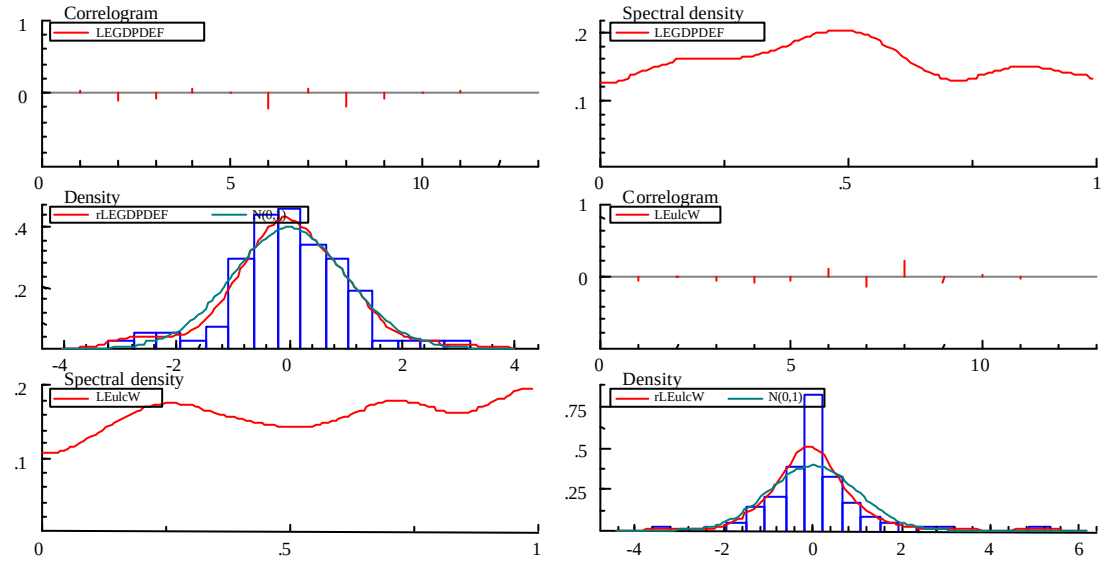
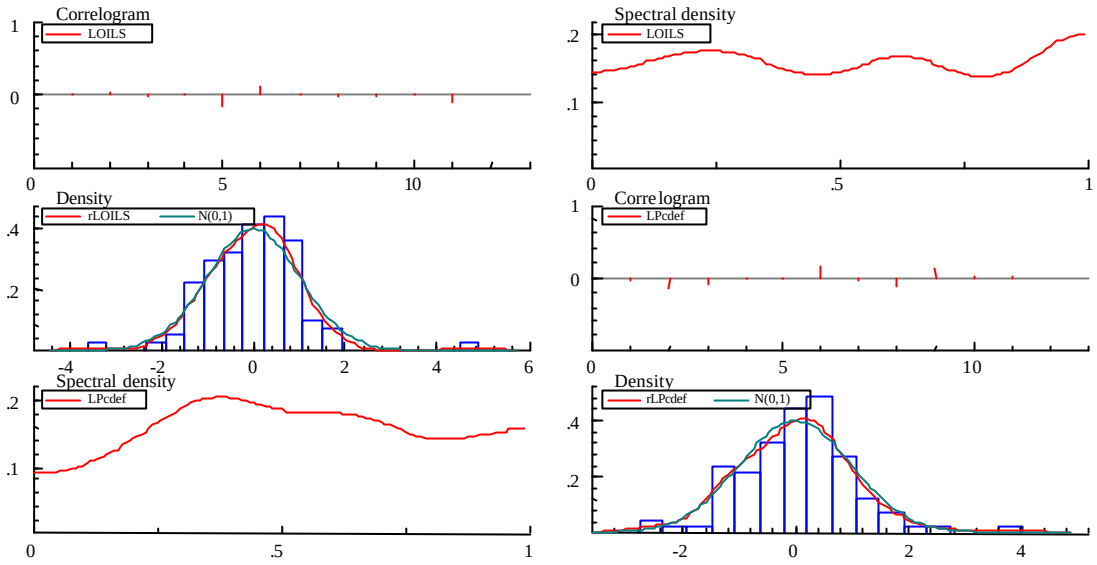


Figure 60: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 18.

Table 18: Vector diagnostics

Endogenous variables	LEGDPdef, LEULCW, LPSDEF, LOILS
Unrestricted variable in short run dynamics	EGDPgap
Data frequency	Quarterly
Period	1975:1-1998:4
Vector AR 1-1 F(80,203)	1.2716 [0.0913]
Vector normality Chi^2(8)	92.322 [0.0000] **

The system appears to be congruent with the data. Table 19 reports on the results of the co-integration tests.

Table 19: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	23.71	18.77	27.1	55.81**	44.18	47.2
r <= 1	19.89	15.75	21	32.1*	25.42	29.7
r <= 2	8.859	7.013	14.1	12.21	9.666	15.4
r <= 3	3.351	2.653	3.8	3.351	2.653	3.8

Period	1975:1-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	EGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. Though the marginal process for LOILS could probably be treated as weakly exogenous on the basis of the following

test this was rejected on the basis of an unacceptable coefficient in the long-run coefficient which obtained under that restriction.

Table 20: Weak exogeneity tests

LCPIrat	Chi2(3) = 4.3453 [0.2265]

The long-run relationships can now be identified and are reported in Table 21.

Table 21: Co-integrating relationships

Variable	LEGDPDEF	LEulcW	LOILS	LPcdef
Coefficient	-1	0.7533	0.11757	0
Coefficient	0	-1	0	1.304

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

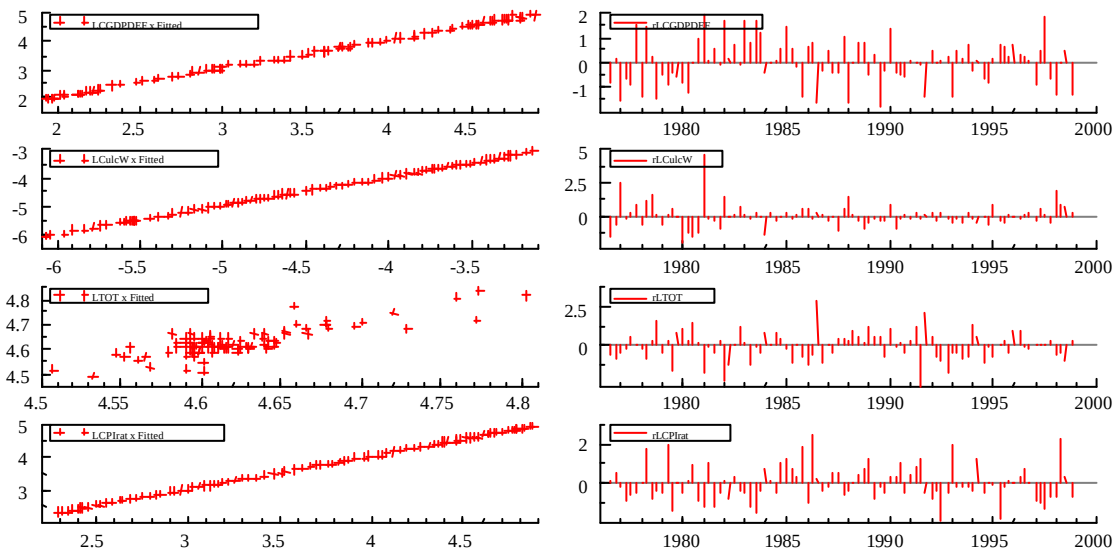
Model 6: GDP deflator and wages for the Construction sector

The sixth model has the same specification as the model for the manufacturing sector, with the GDP deflator for the construction as price variable. A sector specific unit labour cost enters the model, as does rational price expectations and a supply shock in the form of the terms of trade (LTOT). A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the sixth model therefore contains the following jointly endogenous variables: LCGDPDEF, LCULCW, LCPIRAT, LTOT[10].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 61. Figure 61 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

Figure 61: Confirmation of data congruency



[10] *An import-price effect could again not be included in a data-congruent VAR.*

The residuals are analysed in Figures 62 and 63 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 62: Residual analysis

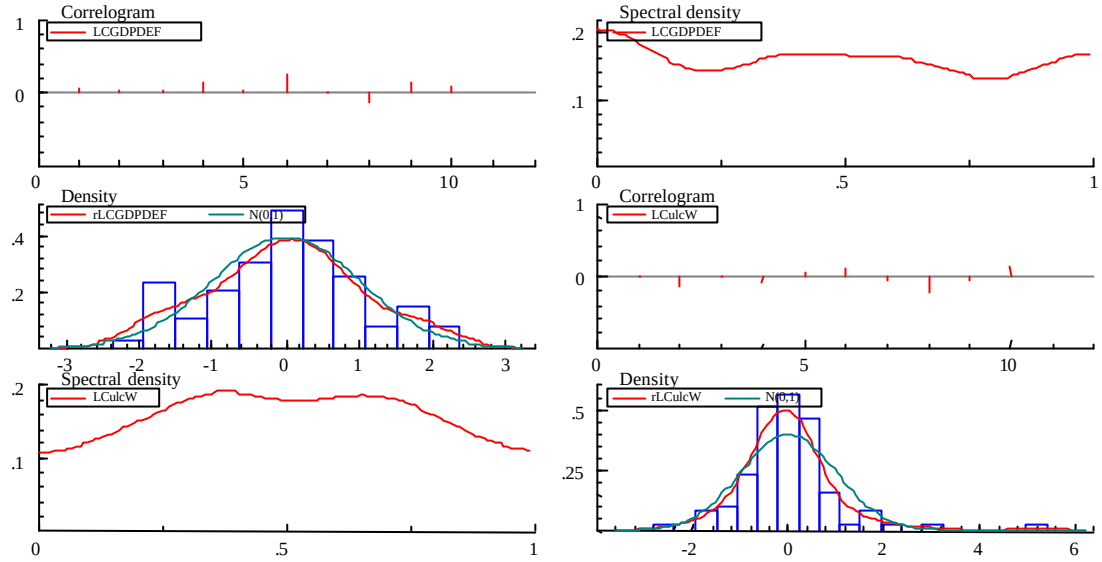
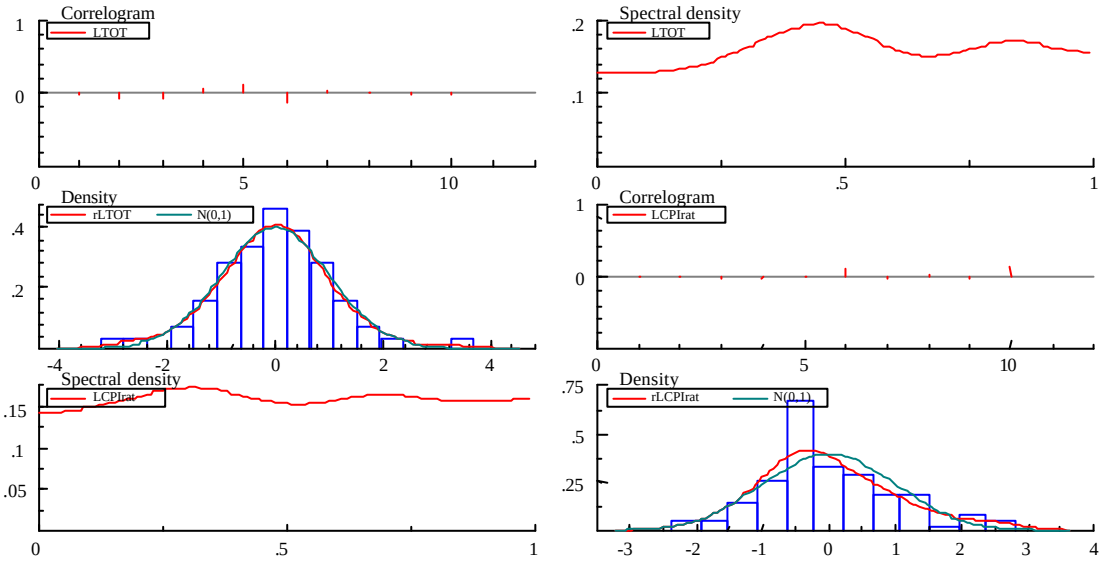


Figure 63: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 22.

Table 22: Vector diagnostics

Endogenous variables	LCGDPdef, LCULCW, LCPIRAT, LTOT
Unrestricted variable in short run dynamics	CGDPgap
Data frequency	Quarterly
Period	1976:3-1998:4
Vector AR 1-1 F(80,178)	1.1894 [0.1726]
Vector normality Chi^2(8)	38.962 [0.0000] **

The system appears to be congruent with the data. Table 23 reports on the results of the co-integration tests.

Table 23: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	38.61**	30.03*	27.1	69.3**	53.9**	47.2
r <= 1	15.6	12.13	21	30.69*	23.87	29.7
r <= 2	9.522	7.406	14.1	15.09	11.74	15.4
r <= 3	5.566*	4.329*	3.8	5.566*	4.329*	3.8

Period	1976:3-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	CGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. Though the marginal process for LOILS could probably be treated as weakly exogenous on the basis of the following test this was rejected on the basis of an unacceptable coefficient in the long-run coefficient which obtained under that restriction.

Table 24: Weak exogeneity tests

LOILS	Chi2(3) = 4.6548 [0.1989]

The long-run relationships can now be identified and are reported in Table 25.

Table 25: Co-integrating relationships

Variable	LCGDPDEF	LCulcW	LTOT	LCPIrat
Coefficient	-1	1.1576	-1.1128	0
Coefficient	0	-1	0	0.98191

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

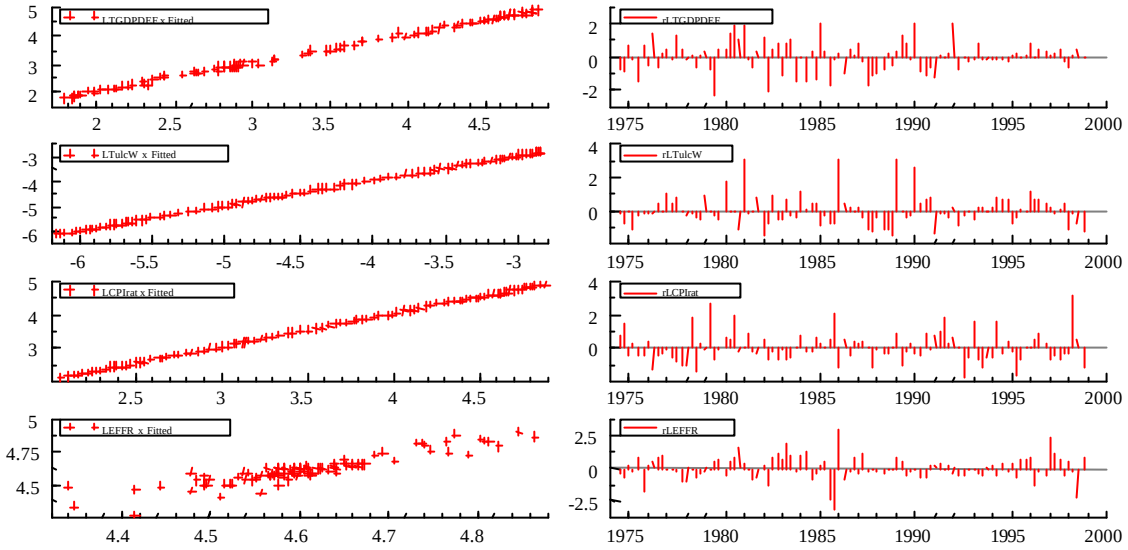
Model 7: GDP deflator and wages for the Retail and wholesale trade sector

The seventh model has the same specification as the model for the manufacturing sector, with the GDP deflator for retail and wholesale trade as price variable. A sector specific unit labour cost enters the model, as does rational price expectations and a supply shock in the form of the real exchange rate. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the seventh model therefore contains the following jointly endogenous variables: LTGDPDEF, LTULCW, LTPIRAT, LEFFR[11].

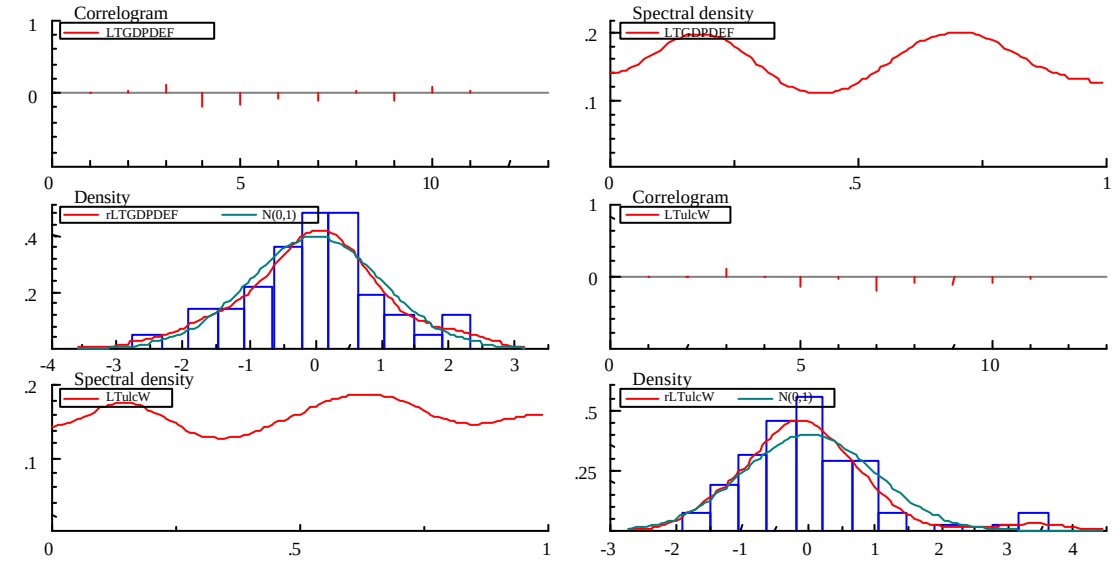
The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 64. Figure 64 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

Figure 64: Confirmation of data congruency



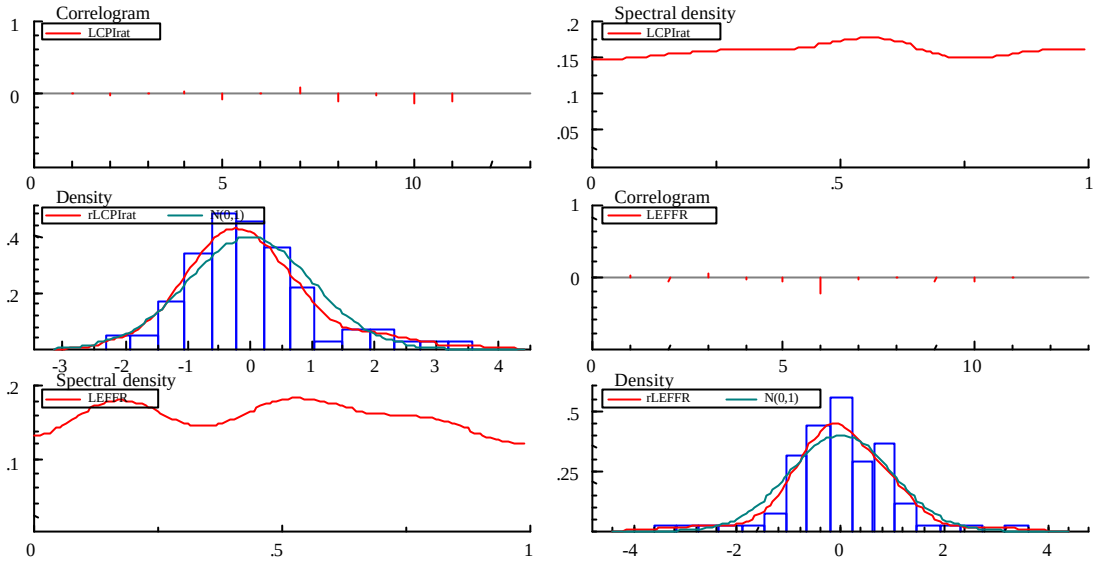
The residuals are analysed in Figures 65 and 66 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 65: Residual analysis



[11] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 66: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 26.

Table 26: Vector diagnostics

Endogenous variables	LTGDPdef, LTULCW, LCPIRAT, LEFFR
Unrestricted variable in short run dynamics	TGDPgap
Data frequency	Quarterly
Period	1974:3-1998:4
Vector AR 1-1 F(80,211)	1.3203 [0.0604]
Vector normality Chi²(8)	40.771 [0.0000] **

The system appears to be congruent with the data. Table 27 reports on the results of the co-integration tests.

Table 27: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	27.31*	21.74	27.1	71.53**	56.93**	47.2
r <= 1	25.35*	20.18	21	44.22**	35.19*	29.7
r <= 2	9.734	7.747	14.1	18.87*	15.02	15.4
r <= 3	9.137**	7.272**	3.8	9.137**	7.272**	3.8

Period	1974:3-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	TGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. The real effective exchange rate is treated as weakly exogenous on the evidence presented in Table 28.

Table 28: Weak exogeneity tests

LEFFR	3.3503 [0.3407]

The long-run relationships can now be identified and are reported in Table 29.

Table 29: Co-integrating relationships

Variable	LTGDPDEF	LTulcW	LCPIrat	LEFFR
Coefficient	-1	0.92376	0	-0.55909
Coefficient	0	-1	1.1851	0

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

Model 8: GDP deflator and wages for the Transport and communications sector

The eighth model has the same specification as the model for the manufacturing sector, with the GDP deflator for transport and communications as price variable. A sector specific unit labour cost enters the model, as does static price expectations and two supply shocks in the form of the real exchange rate and the Rand oil price. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the eight model therefore contains the following jointly endogenous variables: LTCGDPDEF, LTCULCW, LPCDEF, LEFFR and LOILRAND[12].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 67. Figure 67 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

[12] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 67: Confirmation of data congruency

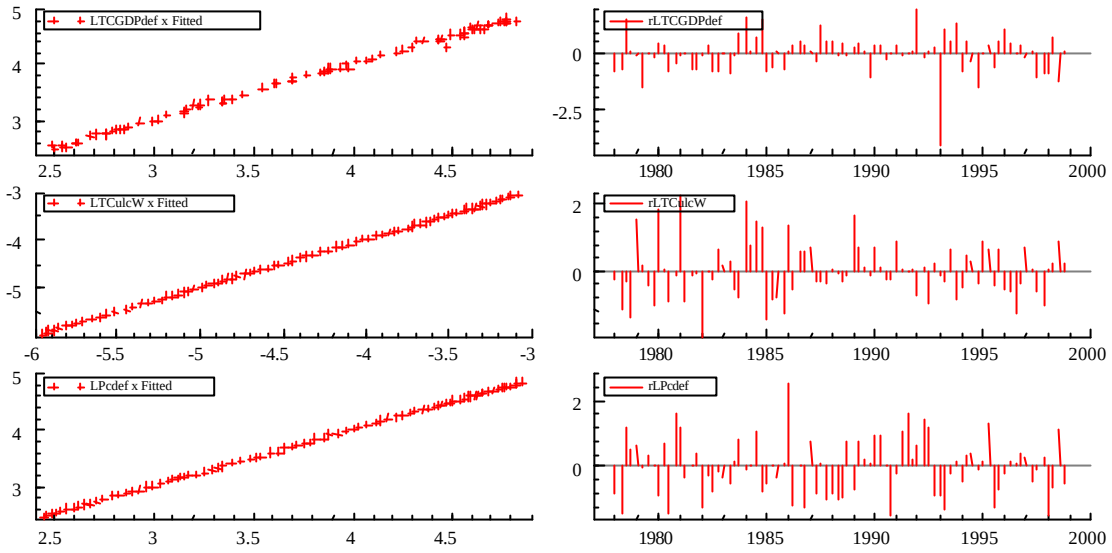
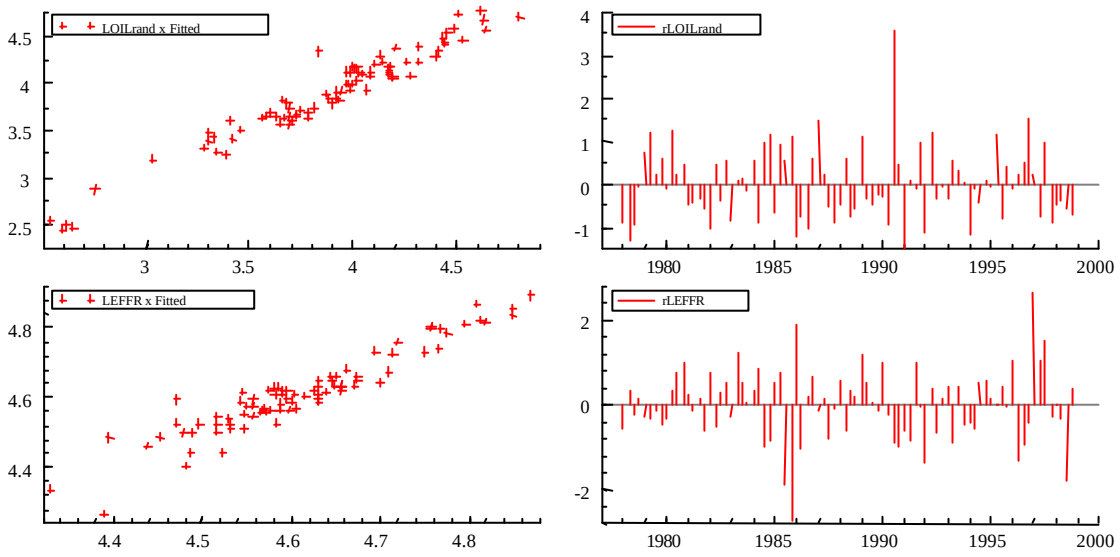


Figure 68: Confirmation of data congruency



The residuals are analysed in Figures 69 and 70 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 69: Residual analysis

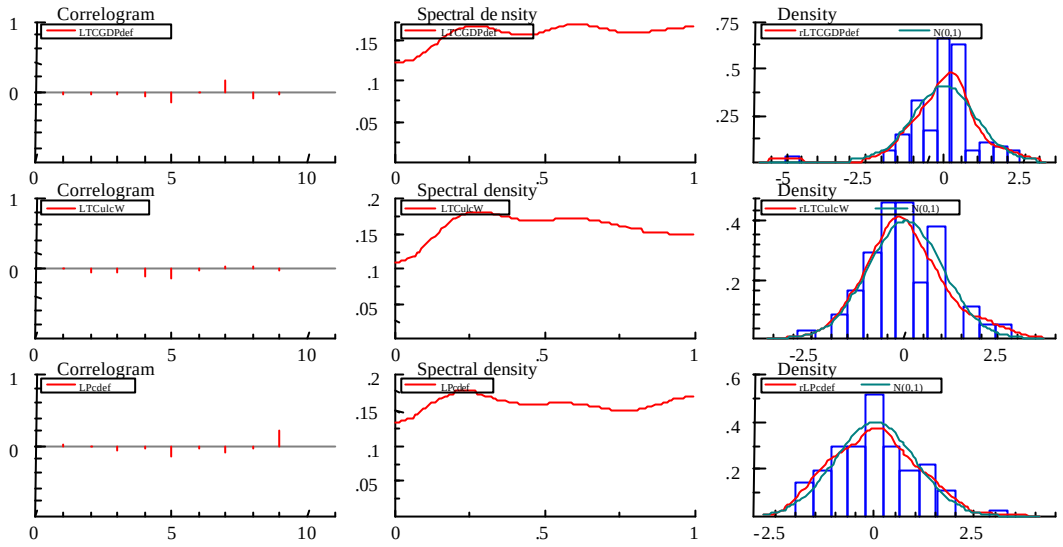
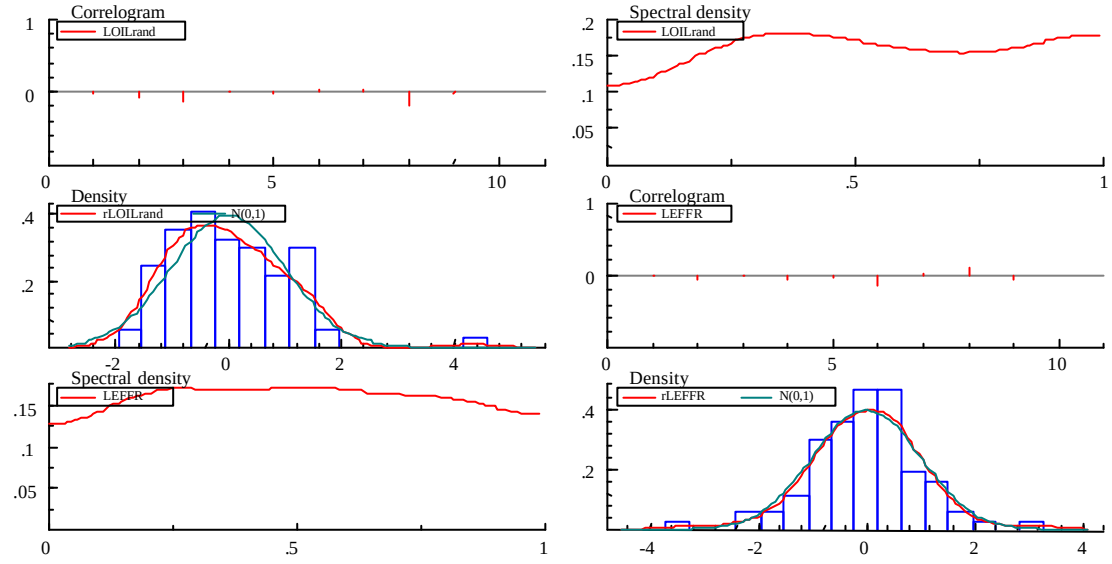


Figure 70: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 30.

Table 30: Vector diagnostics

Endogenous variables	LTCGDPdef, LTCULCW, LPCDEF, LEFFR, LOILRAND
Unrestricted variable in short run dynamics	TCGDPgap
Data frequency	Quarterly
Period	1978:1-1998:4
Vector AR 1-1 F(125,142)	1.1294 [0.2405]
Vector normality Chi^2(8)	58.749 [0.0000] **

The system appears to be congruent with the data. Table 31 reports on the results of the co-integration tests.

Table 31: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	40.27**	28.29	33.5	93.03**	65.34	68.5
r <= 1	24.01	16.87	27.1	52.75*	37.05	47.2
r <= 2	15.04	10.57	21	28.74	20.19	29.7
r <= 3	11.27	7.915	14.1	13.7	9.621	15.4
r <= 4	2.429	1.706	3.8	2.429	1.706	3.8

Period	1978:1-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	TCGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. None of the endogenous variables appear to be weakly exogenous.

The long-run relationships can now be identified and are reported in Table 32.

Table 32: Co-integrating relationships

Variable	LTCGDPdef	LTCulcW	LPcdef	LOILrand	LEFFR
Coefficient	-1	0.78163	0	0.5727	-1.5816
Coefficient	0	-1	1.0643	0	0

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

Model 9: GDP deflator and wages for the finance and business services sector

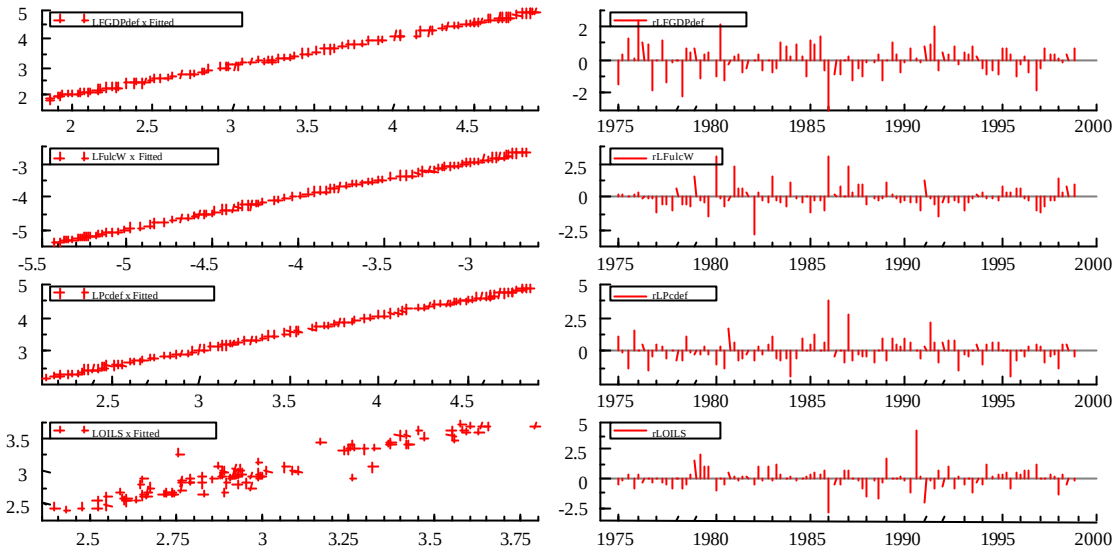
The ninth model has the same specification as the model for the manufacturing sector, with the GDP deflator for finance and business services as a price variable. A sector specific unit labour cost enters the model, as does static price expectations and a supply shock in the form of the dollar oil price. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the ninth model therefore contains the following jointly endogenous variables: LFGDPDEF, LFULCW, LPCDEF, LOILS[13].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 71. Figure 71 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

[13] *An import-price effect could again not be included in a data-congruent VAR.*

Figure 71: Confirmation of data congruency



The residuals are analysed in Figures 72 and 73 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 72: Residual analysis

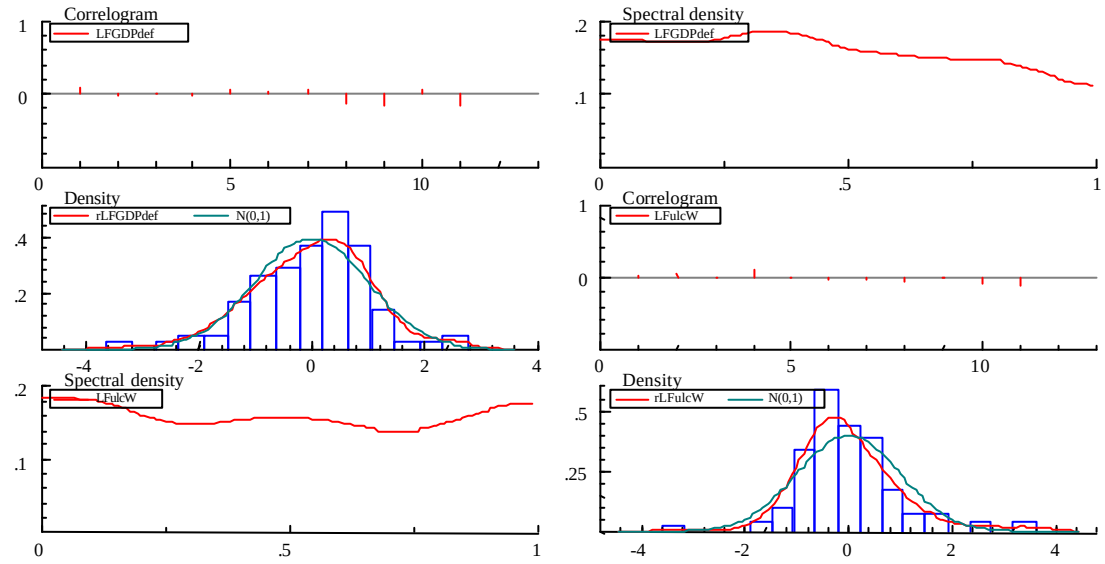
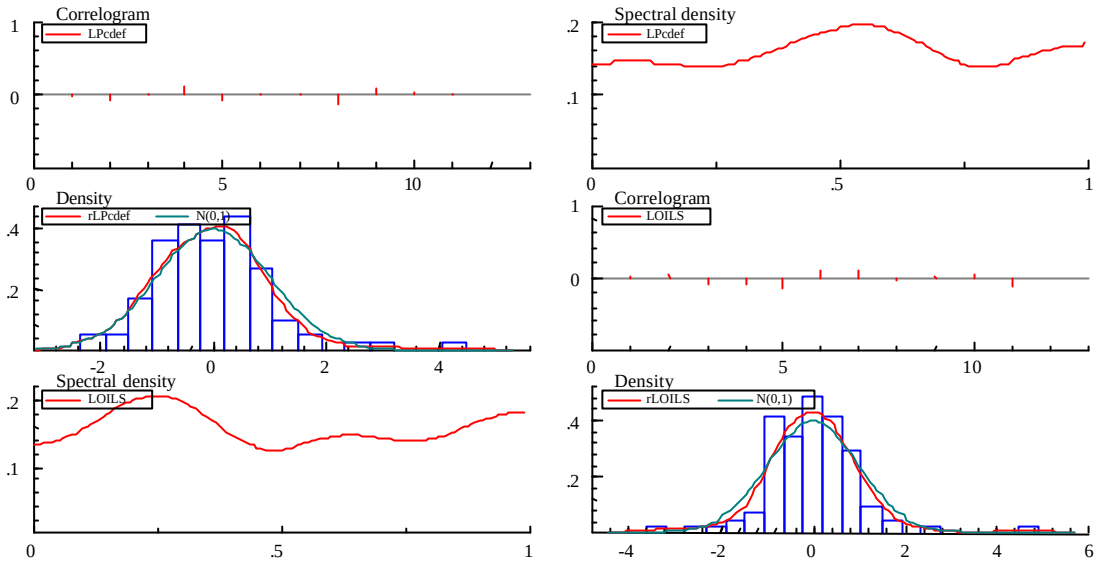


Figure 73: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 33.

Table 33: Vector diagnostics

Endogenous variables	LFGDPdef, LFULCW, LPCDEF, LOILS
Unrestricted variable in short run dynamics	FGDPgap
Data frequency	Quarterly
Period	1975:1-1998:4
Vector AR 1-1 F(80,219)	1.2123 [0.1392]
Vector normality $Chi^2(8)$	58.967 [0.0000] **

The system appears to be congruent with the data. Table 34 reports on the results of the co-integration tests.

Table 34: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	47.7**	39.75**	27.1	85.53**	71.28**	47.2
r <= 1	20.23	16.86	21	37.83**	31.52*	29.7
r <= 2	14.21*	11.85	14.1	17.59*	14.66	15.4
r <= 3	3.379	2.816	3.8	3.379	2.816	3.8

Period	1975:1-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	FGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. The static expectations and the dollar oil price is treated as weakly exogenous on the basis of the following evidence.

Table 35: Weak exogeneity tests

LPCDEF, LOILS	9.5642 [0.0886]

The long-run relationships can now be identified and are reported in Table 36.

Table 36: Co-integrating relationships

Variable	LFGDPdef	LFulcW	LPcdef	LOILS
Coefficient	-1	1.1475	0	0.10111
Coefficient	0	-1	0.99632	0

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

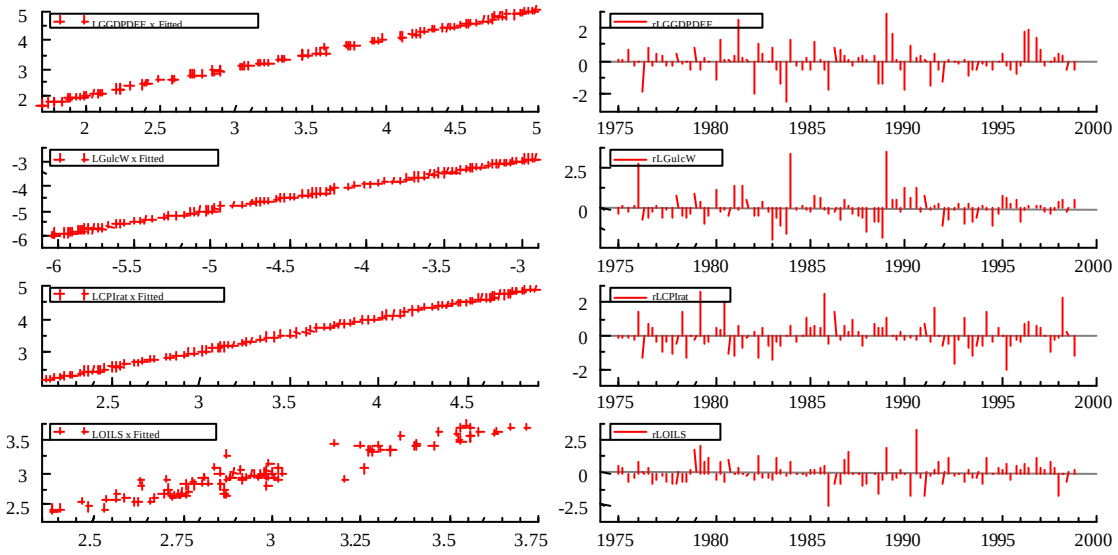
Model 10: GDP deflator and wages for the government services sector

The ninth model has the same specification as the model for the manufacturing sector, with the GDP deflator for government services as price variable. A sector specific unit labour cost enters the model, as does rational price expectations and a supply shock in the form of the dollar oil price. A demand effect is included with an output gap variable.

As before, the output gap is not included in the long-run relationships but constrained to be part of the dynamic adjustment to that long-run. The VAR for the tenth model therefore contains the following jointly endogenous variables: LGGDPDEF, LGULCW, LCPIRAT, LOILS[14].

The general-to-specific strategy starts with the establishment of the data congruency of the VAR and that is confirmed visually in Figure 74. Figure 74 demonstrates the close fit between the model and the data on levels as well as the pattern of residuals.

Figure 74: Confirmation of data congruency



[14] *An import-price effect could again not be included in a data-congruent VAR.*

The residuals are analysed in Figures 75 and 76 where the correlograms, spectral densities and histogram (with the normal distribution) are plotted.

Figure 75: Residual analysis

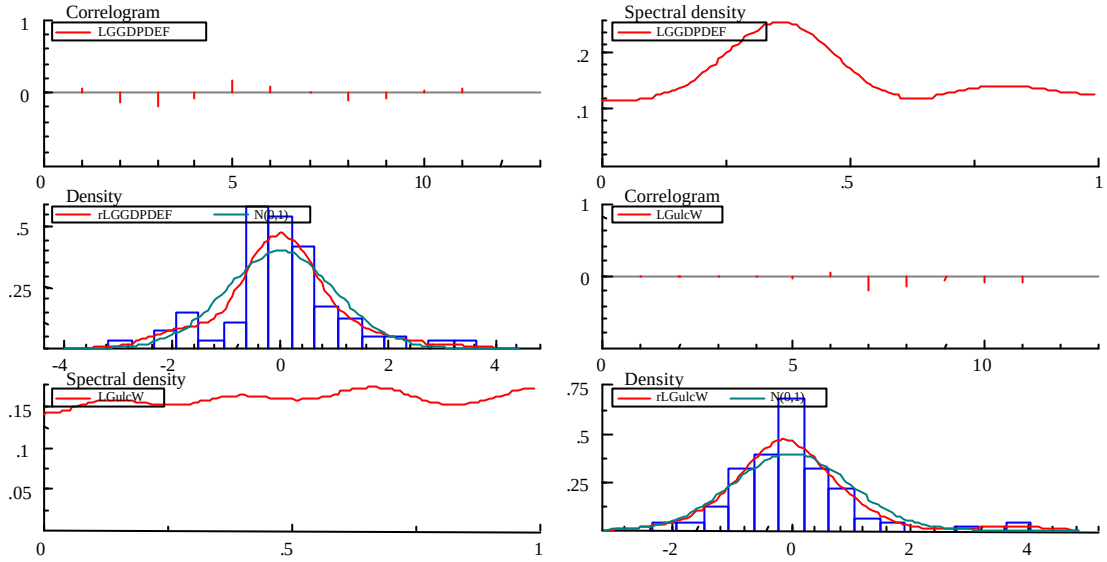
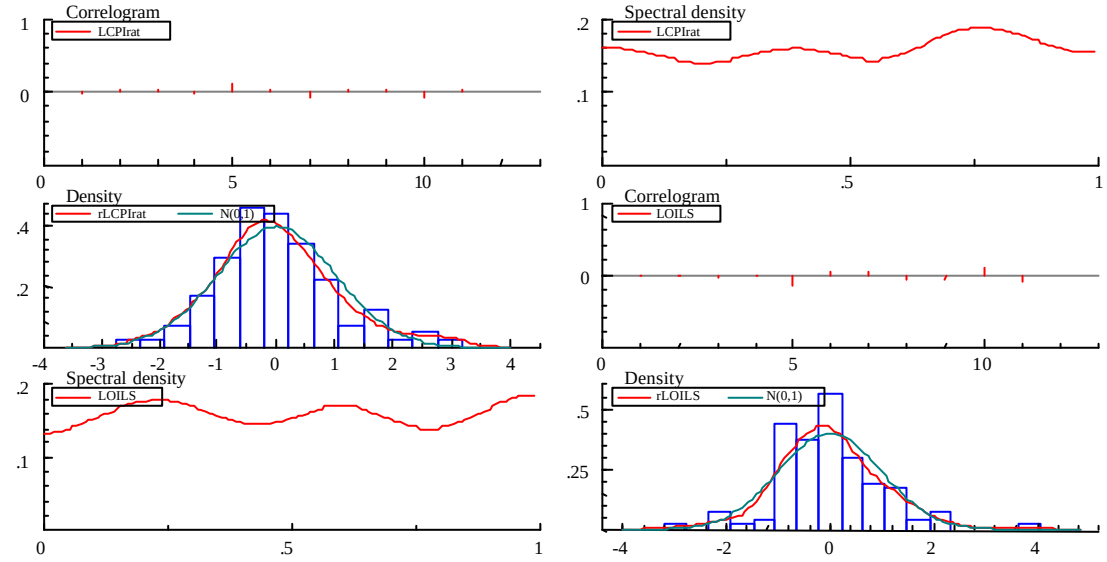


Figure 76: Residual analysis



There is a slight departure from normality in the residuals of this system. The vector diagnostics are summarised in Table 37.

Table 37: Vector diagnostics

Endogenous variables	LGGDPdef, LGULCW, LCPIRAT, LOILS
Unrestricted variable in short run dynamics	GGDPgap
Data frequency	Quarterly
Period	1975:1-1998:4
Vector AR 1-1 F(80,203)	1.1252 [0.2537]
Vector normality Chi²(8)	38.538 [0.0000] **

The system appears to be congruent with the data. Table 38 reports on the results of the co-integration tests.

Table 38: Co-integration analysis

H_0:rank=r	λ-max	Adj.λ-max	95%	Trace	Adj. Trace	95%
r = 0	44.28**	35.06**	27.1	90.83**	71.9**	47.2
r <= 1	28.72**	22.74*	21	46.54**	36.85**	29.7
r <= 2	14.36*	11.37	14.1	17.83*	14.11	15.4
r <= 3	3.468	2.745	3.8	3.468	2.745	3.8

Period	1975:1-1998:4	***Reject H_0 at 5% level***	*
Lags	2	***Reject H_0 at 1% level***	**
Restricted variable	Constant	***Unrestricted variable***	GGDPgap

The test output and a visual inspection of the possible long-run relationships lead to the conclusion that there are probably two long-run relationships in this VAR. On the basis of the evidence presented below the rational expectations variable is treated as weakly exogenous.

Table 39: Weak exogeneity tests

LCPIRAT	CHI^2 (2) = 2.4235 [0.2977]

The long-run relationships can now be identified and are reported in Table 40.

Table 40: Co-integrating relationships

Variable	LGGDPDEF	LGulcW	LCPIrat	LOILS
Coefficient	-1	1.0379	0	0.11364
Coefficient	0	-1	1.1855	0.17816

Impulse response functions have been calculated to simulate the dynamic effects implicit in this model. These are reported in the main content.

Bibliography

Banerjee, A,. *et. al*. 1993. *Co-integration, Error correction, and the Econometric Analysis of Non-stationary Data*. Oxford: Oxford University Press.

Bank of England, 1999. *Economic Models at the Bank of England*. London: Bank of England.

Bernanke, B.S., and Mihov, I., 1998. Measuring Monetary Policy, *Quarterly Journal of Economics*, (vol. 113), pp. 869-902

Curthbertson, K., Hall, S.G., and Taylor, M.P., 1992. *Applied Econometric Techniques*. London: Harvester/Wheatsheaf.

Doornik, J.A., and Hendry, D.F., 1997. *Modelling Dynamic Systems Using PcFiml 9.0 for Windows*. London: International Thomson Business Press

Enders, W., 1995. *Applied econometric time series*. New York: John Wiley & Sons, Inc.

Engle, R.F., Hendry, D.F., and Richard, J.-F., 1983. Exogeneity, *Econometrica*, (vol. 51, no. 2), pp. 277-304.

Fedderke, J., and Schaling, E., 1999. Modelling Inflation in South Africa: *A Multivariate Cointegration Analysis*. Working Paper.

Friedman, M., 1968. The Role of Monetary Policy, *American Economic Review*, (vol. 58), pp. 1-17.

Ghali, K.H., 1994. Wage Growth and the Inflation Process: a Multivariate Co-integration Analysis. *Journal of Money Credit and Banking*, (vol. 31, no. 3), pp. 417-431

Gordon, R.J., 1982. Price Inertia and Policy Ineffectiveness in the US, 1890-1980, *Journal of Political Economy,* (vol. 90), pp. 1087-1117

Granger, C.W., 1969. Investigating causal relations by econometric models and cross spectral methods, *Econometrica* (vol. 37), pp. 424-438

Harris, R., 1995. *Using Co-integration Analysis in Econometric Modelling*. London: Prentice Hall.

Hendry, D.F., and Juselius, K., 1999a. *Explaining Co-integration Analysis: Part I*. Unpublished

Hendry, D.F., and Juselius, K., 1999b. *Explaining Co-integration Analysis: Part II*. Unpublished

Hendry, D.F., 1995. *Dynamic Econometrics*. Oxford: Oxford University Press.

Hendry, D.F., 1986. Using Pc-Give in Econometrics Teaching, *Oxford Bulletin of Economics and Statistics*, (vol. 48, no. 1), pp. 87-98.

Hendry, D.F., 1985. Monetary Economic Myth and Econometric Reality, *Oxford Review of Economic Policy*, (vol. 1, no. 1), pp. 72-84.

Johansen, S., 1988. Statistical Analysis of Co-integrating Vectors, *Journal of Economic Dynamics and Control,* (vol. 12), pp. 231-254.

Jonsson, G., 1999. Inflation, Money Demand and Purchasing Power Parity in South Africa, *IMF working paper,* WP/99/122, African Department.

Mohr, P., and Rogers, C., 1991. *Makro-Ekonomie (2e uitgawe).* Johannesburg: Lexicon

Nelson, C.R., and Plosser, C.I., 1982. Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications, *Journal of Monetary Economics* (vol. 10), pp. 139-62

Phelps, E., S., 1968. Money-wage Dynamics and Labour Market Equilibrium, *Journal of Political Economy,* (vol. 76), pp. 678-711.

Phillips, A.W., 1958. The Relation Between Unemployment and the Rate of Change in Money Wages in the United Kingdom, 1861-1957, *Economica*, (vol. 25), pp. 283-299.

Pretorius, C.J., and Janse van Rensburg, T.N., 1996. The Forecast Performance of Alternative Models of Inflation, *SARB Occasional Paper, no. 10*. Pretoria: South African Reserve Bank.

Pretorius, C.J., and Smal, M.M., 1994. A Macro-economic Examination of the Price- formation Process in the South African Economy, *SARB Quarterly Bulletin*, (March), pp. 25-36.

Stockton, D.J., and Glassman, J.E., 1987. An Evaluation of the Performance Alternative Models of Inflation, *The Review of Economics and Statistics*, (vol. 69), pp. 108-117.

Welfe, A., 2000. *Modelling Inflation in Poland, Economic Modelling*, (vol. 17), pp. 375-385

Whitley, J., 1994. *A Course in Macroeconomic Modelling and Forecasting*. London: Harvester Wheatsheaf.