Long Run Determination of Inflation in South Africa

Dissertation presented in partial fulfilment of the requirements for the M. Com (Economics)

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Date: 15 February 2008

Word count: 6526 words

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Abstract

This paper employs multivariate estimation techniques in an expectations augmented Phillips curve framework to investigate long run determinants of inflation. By separating unit labour costs in nominal wages and labour productivity in an extension of the work by Fedderke and Schaling (2005), the labour productivity effect is shown to impact prices negatively and nominal wages positively. In addition, the implicit assumption of nominal wages and labour productivity moving in a one-for-one fashion made in using unit labour costs is a poor one. The paper makes a further contribution by comparing mark-ups of the non-agricultural sectors to the manufacturing sector and evidence of a reduced mark-up in the non-agricultural sectors is apparent.

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I. Introduction

Determining factors that affect inflation in both the long and short run can help the monetary authorities in emerging markets be more effective in their fight against inflation. As such, economists have responded by trying to ascertain the determinants of inflation in emerging markets. This paper builds on the contribution by Fedderke and Schaling (2005) by testing the links between prices, nominal wages, labour productivity and price expectations in an open economy expectations-augmented Phillips curve framework.

This paper joins the debate, furthering long run analysis of inflation determinants by splitting up unit labour costs into nominal wages and labour productivity in a cointegrating framework. Mehra (2004) points out that in using unit labour costs as a determinant of inflation, there is an implicit assumption that nominal wages move one-for-one with labour productivity; which is a limiting assumption. The sole effect of labour productivity on prices is yet to be established in this context and by separating unit labour costs, the sole effect of productivity on prices can be established. A further contribution is made by comparing firm mark-ups o f the non-agricultural sectors to the manufacturing sector.

The rest of the paper is structured as follows. Section II reviews the current literature on inflation modelling. Section III provides the theoretical framework and Section IV analyses the data and econometric methodology of the Johansen technique as relevant to the research of this paper. Section V presents the empirical results and implications. Lastly, Section VI concludes.

II. Literature Review

The estimation of the South African Phillips Curve has predominantly been undertaken within short run specifications using inflation as the dependent variable and the output gap as one of the independent variables. However, there is literature that uses a long run model to explain the inflation process instead.[1] Furthermore, previous literature has shown mixed results; with some authors either advancing the idea of a demand pull or a cost push framework. It is thus useful to group the literature into evidence advancing either the demand pull or the cost push frameworks. An additional factor that is often added is a price expectations term.

(i) Demand Pull Framework

The most common demand side variable used is some form of the output gap as a proxy for the unemployment rate. Hodge (2002) finds little evidence of a relationship between the first differences of inflation and the actual labour unemployment rate; and he finds a positive relationship between the first differences of inflation and growth when using yearly data for the period of 1983 to 1998. Fedderke and Schaling (2005) find that the output gap was statistically insignificant in explaining the first difference of prices. Using quarterly data for the period 1976Q1 to 2002Q2, Burger and Marinkov (2006) use the output gap and the growth rate of the output gap among other variables to explain the inflation gap.[2] The authors also follow a method employed by Nell (2000) in testing for non-linearities in the output gap. They use four different methods of calculating the output gap and find very little evidence supporting the notion of a trade-off between the inflation gap and output gap.

Contrary to the previous evidence showing that output has little or no effect on inflation, Nell (2006) models inflation with an ARDL approach using price expectations and both a linear and non-linear output gap and the linear and non-linear growth rate of the output gap. The two specifications are given below:

$$\rho_t = \alpha_1 + \sum_{i=1}^{k} \alpha_2 \rho_{t-i} + \sum_{i=1}^{m} \alpha_3 (y - \bar{y})_{t-i}^{upswing} + \sum_{i=1}^{j} \alpha_4 (y - \bar{y})_{t-i}^{downswing} + \mu_{1t}$$

$$\rho_t = \beta_1 + \sum_{i=1}^{k} \beta_2 \rho_{t-i} + \sum_{i=1}^{m} \beta_3 (\Delta y - \Delta\bar{y})_{t-i}^{upswing} + \sum_{i=1}^{j} \beta_4 (\Delta y - \Delta\bar{y})_{t-i}^{downswing} + \mu_{2t}$$

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[1]See Fedderke and Schaling (2005) for example. Estimating a short run relationship by first differences in a cointegrating framework leaves out the error correction terms and thus results in a loss of information and efficiency of the model. Consequently, estimating the long run structural model of the pricing process will provide further insights into the determination of long run prices and its equilibrium values.

[2] The authors use the Hodrick-Prescott filter to calculate all other gap variables in the paper. The gap variables are defined as the actual series less the Hodrick-Prescott created series.

Where ρ_t and ρ_{t-i} are inflation and lagged inflation respectively, calculated as the annualized quarterly inflation rate of the overall consumer price index. $(y-\bar{y})_{t-i}^{upswing}$ represents the output above the average trend or in other words the positive output gap. Similarly $(y-\bar{y})_{t-i}^{downswing}$ represents output below the average trend and has negative values only. Additionally $(\Delta y-\Delta\bar{y})_{t-i}^{upswing}$ represents the growth rate of output above the average trend or in other words positive deviations from the long run growth rate. Similarly $(\Delta y-\Delta\bar{y})_{t-i}^{downswing}$ represents the growth rate of output below the average trend and has negative values only. The author separates the inflation period into two: an accelerating inflation period from 1971 to 1985; and a decelerating inflation period from 1986 to 2001. His evidence supports the fact that the linear output gap is significant in explaining inflation during the inflationary period; whereas no evidence was given for the deflationary period. When analysing the growth rate of output, the upswing part of the cycle only had significant impacts in the inflationary period and the downswing part of the cycle only had statistical significance in the deflationary period. In summary, the papers reviewed show little evidence of the South African inflation process being dominated by a demand pull framework. At best there are distinct and different periods of time where the demand pull framework has been significant.

(ii) Cost Push Framework

There is much more variation in the variables used as evidence in examining the cost push framework. These variables fall into two broad categories: That of external supply side shocks which proxy for the degree of openness; and costs passed on through the labour market. The most common variable used to represent costs from the labour market is the unit labour costs variable whereas the proxies for openness vary. Akinboade *et al* (2002) show evidence that inflation is dominated by a cost push framework by extracting the error correction model from a structural VAR using the consumer price index, unit labour costs, lagged inflation, exchange rate and the money supply. Besides price expectations, they find that the unit labour cost and the exchange rate are the most significant factors for controlling inflation.

Fedderke and Schaling (2005) use the Johansen technique to model the price level under an expectations augmented Phillips curve in South Africa. The specification that they use is:

$$\rho_t = \alpha_1 + \alpha_2 (y - \bar{y})_t + \alpha_3 (w_t - q_t) + \alpha_4 z_t + \varepsilon_{1t}$$

$$(w_t - q_t) = \beta_1 + \beta_2 \rho_t^e + \beta_3 (y - \bar{y})_t + \beta_4 z_t + \varepsilon_{2t}$$

Where p_t stands for the price level, given by the GDP deflator, (w_t - q_t) denotes unit labour costs, $(y_t - \bar{y}_t)$ represents the output gap capturing demand side shocks, z_t denotes the real exchange rate as the measure for supply side shocks and p^e denotes price expectations. One concern with the construction of the real exchange rate is that it induces an endogeneity problem in the first equation.[3] This specification gives the mark-up behaviour of output prices over productivity while adjusting for labour costs and controlling for demand and supply shocks.[4] The second equation shows that unit labour costs is driven by price expectations, demand and supply shocks. All long run variables were found to be significant in explaining the price level. Burger and Marinkov (2006) also find that the unit labour cost gap is robustly significant in explaining the inflation gap.

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[3] The real exchange rate was defined as follows: $z_t = \log(\frac{\rho_t^* E_t}{\rho_t})$ where ρ_t^* is the US GDP deflator, E_t is the nominal Rand-Dollar exchange rate and ρ_t is the South African GDP deflator. Taking the first equation in the Fedderke and Schaling (2005) specification, where all variables are in logarithmic form, and substituting in the real exchange rate shows how the coefficients are biased:

$$\rho_t = \alpha_1 + \alpha_2 (y - \bar{y})_t + \alpha_3 (w_t - q_t) + \alpha_4 \frac{\rho_t^* E_t}{\rho_t} + \varepsilon_{1t}$$

$$\rho_t = \alpha_1 + \alpha_2 (y - \bar{y})_t + \alpha_3 (w_t - q_t) + \alpha_4 \rho_t^* + \alpha_4 E_t - \alpha_4 \rho_t + \varepsilon_{1t}$$

$$(1 + \alpha_4)\rho_t = \alpha_1 + \alpha_2 (y - \bar{y})_t + \alpha_3 (w_t - q_t) + \alpha_4 \rho_t^* + \alpha_4 E_t + \varepsilon_{1t}$$

$$\rho_t = \frac{\alpha_1}{(1+\alpha_4)} + \frac{\alpha_2}{(1+\alpha_4)}(y - \bar{y})_t + \frac{\alpha_3}{(1+\alpha_4)}(w_t - q_t) + \frac{\alpha_4}{(1+\alpha_4)}\rho_t^* + \frac{\alpha_4}{(1+\alpha_4)}E_t + \frac{\varepsilon_{1t}}{(1+\alpha_4)}$$

Thus it is apparent that each coefficient is misspecified by the factor of $\frac{1}{(1+\alpha_4)}$; however in principle this can be rectified by multiplying the original coefficients by the inverse of this factor.

[4] The South African manufacturing sector has been shown to have sustained and high levels of pricing power, see Fedderke, Kularatne and Mariotti (2007) for example. For further articles in the debate around pricing power in South Africa, refer to Aghion, Braun and Fedderke (2006), Aghion, Fedderke, Howitt, Kularatne and Viegi (2008) and Edwards and van de Winkel (2005).

Aron and Muellbauer (2007) point out that omitting trade liberalisation for this specification may result in biasing the estimation of the determinants of inflation. This is why previous authors have modelled openness with various variables.[5] Variables incorporated recently in the South African context are the real exchange rate used by Akinboade *et al* (2002) and Fedderke and Schaling (2005) which both find to be significant. The growth rate of the import price index used by Hodge (2002) to explain the growth rate of inflation and he finds evidence of a positive relationship; whereas Burger and Marinkov (2006) use the terms of trade gap and find very limited evidence suggesting that the supply side shocks are meaningful in the South African context. More recently, Aron and Muellbauer (2007) construct a new I(1) openness index based on the residual of the import demand function; which they extract by purging variables such as tariffs, non-tariff barriers and other economic influences on the dependent variable. The residual that remains is the openness indicator. Aron and Muellbauer (2007) find that increased openness decreases the first difference of the wholesale price index.

(iii) Expectations Framework

The use of a price expectation term has been popular in the South African context. Akinboade *et al* (2002) find that the price expectations term is the most significant factor in controlling inflation and state that current monetary policy can be effective in lowering price expectations; which can lower inflation in the long run. Hodge (2002), Fedderke and Schaling (2005), Burger and Marinkov (2006), Nell (2006) and Aron and Muellbauer (2007) all find that a price expectations term is significant in the South African context.

(iv) Univariate Characteristics of Inflation

An additional undecided issue in the literature arises from the mixed results on the univariate characteristics of inflation. Akinboade *et al* (2002) and Fedderke and Schaling (2005) find that prices are I(1) and therefore the first differences are I(0). On the other hand, Hodge (2002) and Burger and Marinkov (2006) find that inflation is I(1) and Aron and Muellbauer (2007) assume that the wholesale price index is I(2)

[5] An analysis, discussing advantages and disadvantages of open economy variables is done by Aron and Muellbauer (2007).

in light of the test statistics suggesting non-stationarity.[6] This has significant theoretical impacts on inflation determination as well as for the inflation targeting regime. An I(1) structure would suggest that inflation has a non-constant mean and/or variance. Thus inflation would not be targetable or be kept within a band in the long run such as the one that the SARB is currently aiming for. In fact the SARB would only be able to target the growth rate of inflation. This seems contrary to the international norm where most reserve banks have adopted some form of inflation targeting. In deciding on the univariate characteristics, Burger and Marinkov (2006) use the quarter on quarter annual inflation rate; which is the first difference of the price series lagged by four quarters. This method of measuring inflation could bias the stationarity tests towards the finding of an I(1) structure in inflation. This bias originates from the transformation of quarterly inflation rates to a quarter on quarter annual inflation rate which introduces an artificial inertia into the series; thereby adding bias to the underlying structure with more inertia by construction.[7] Thus

[6] Nell (2006) avoids the need to test for univariate characteristics of the data by using the ARDL approach.

[7] In particular each new quarter on quarter annual inflation rate is correlated to the previous one by construction. For example assume a quarterly price series in logarithmic form with the following data points: $(p_1, p_2, \ldots, p_n, p_{n+1})$. Let the first difference of this series be represented by $(\Delta_1, \Delta_2, \ldots, \Delta_n)$ where $\Delta_n = p_{n+1} - p_n$. Let the n[th] data point in the quarter on quarter annual inflation series be given by $\delta_n = p_n - p_{n-4}$ where p_n can be expanded into $p_n = p_1(1+\Delta_1)(1+\Delta_2)....(1+\Delta_{n-1})$.

Thus by expanding p_n and p_{n-4} in $\delta_n = p_n - p_{n-4}$ and simplifying the expression, we obtain the expanded version of δ_n:

$$\delta_n = p_1[(1+\Delta_1)(1+\Delta_2)....(1+\Delta_{n-1})] - p_1[(1+\Delta_1)(1+\Delta_2)....(1+\Delta_{n-5})]$$

$$\delta_n = p_1[(1+\Delta_1)(1+\Delta_2)....(1+\Delta_{n-5})][(1+\Delta_{n-4})(1+\Delta_{n-3})(1+\Delta_{n-2})(1+\Delta_{n-1}) - 1]$$

$$\delta_n = p_1[\prod_{i=1}^{n-5}(1+\Delta_i)][(1+\Delta_{n-4})(1+\Delta_{n-3})(1+\Delta_{n-2})(1+\Delta_{n-1}) - 1]$$

Similarly we can do the same for δ_{n+1},

$$\delta_{n+1} = p_1[\prod_{i=1}^{n-5}(1+\Delta_i)][(1+\Delta_{n-4})][(1+\Delta_{n-3})(1+\Delta_{n-2})(1+\Delta_{n-1})(1+\Delta_n) - 1].$$

When comparing δ_n and δ_{n+1}, it can be seen that they share the common factor of $p_1\prod_{i=1}^{n-5}(1+\Delta_i)$; whilst trivially Δ_{n-1} and Δ_n have no constructed common factor. This common factor will drive an artificial correlation between the two terms by construction. Any unit root test will automatically pick up this common factor; thereby biasing the test towards non-stationarity. In the standard Dickey Fuller tests, this leads to a rejection of the null of non-stationarity more often and is due to the 4 quarter lagged series introducing an inertia bias and therefore decreasing the amount of variance around the mean when compared to the one quarter lagged series. Thus using the 4 quarter lagged series may result in the incorrect assumption that the underlying structure of the price series is I(2) as opposed to I(1). This problem will occur in all quarterly data sets that are transformed into annualised series in this manner. The problem is however more pronounced in price series due to the high level of volatility encountered; which often makes the inflation process look like it has a variant mean over time. This high level of volatility, compared to other series like GDP for example, is often at the cause of the rejection of stationarity in the first difference, 4 quarter lagged series and may bias the test statistic enough to accept non-stationarity.

authors should keep in mind this bias when using the quarter on quarter annual inflation rate and testing the univariate characteristics.

The evidence shown here illustrates that the South African economy is mainly driven by a cost push expectations framework. A number of open economy variables have been used to integrate the open economy in this framework; however no one variable dominates the literature. Furthermore there has been no investigation as to how productivity shocks effect prices outside of the unit labour cost variable.

III. Theoretical Framework

This investigation uses an extension of the Fedderke and Schaling (2005) open economy expectations-augmented Phillips curve model. In two different models it tests the links between prices, nominal wages, labour productivity, price expectations, open economy variables, and the output gap. It adds to the current literature by separating unit labour costs into nominal wages and labour productivity; thereby allowing productivity to interact with prices and nominal wages independently. Additionally the paper uses the Aron and Muellbauer (2007) openness indicator as its open economy variable.

(i) Model A

Firstly the model that was originally tested in Fedderke and Schaling (2005) will be re-tested; where the unit labour costs are not separated into nominal wages and labour productivity effects. The openness indicator is however used for the proxy of openness. The specification is shown below:

(1) $\rho_t = \alpha_1 + \alpha_2(w_t - q_t) + \alpha_3(y - \bar{y})_t + \alpha_4 z_t + \varepsilon_{1t}$

(2) $(w_t - q_t) = \beta_1 + \beta_2 \rho_t^e + \beta_3(y - \bar{y})_t + \beta_4 z_t + \varepsilon_{2t}$

Where p_t stands for the price level, given by the GDP deflator, (w_t - q_t) denotes unit labour costs, $(y_t - \bar{y}_t)$ represents the output gap capturing demand side shocks and which only enters the error correction model in the short run, z_t now denotes the

Aron and Muellbauer (2007) openness indicator as opposed to the real exchange rate and p^e denotes price expectations.[8]

(ii) Model B

The second two vector error correction model examined in this paper relaxes the assumption of nominal wages and labour productivity moving in a one-for-one fashion. The specification is outlined below:

(3) $\rho_t = \delta_1 + \delta_2 w_t + \delta_3 q_t + \delta_4 (y - \bar{y})_t + \delta_5 z_t + \varepsilon_{3t}$

(4) $w_t = \theta_1 + \theta_2 \rho_t^e + \theta_3 q_t + \theta_4 (y - \bar{y})_t + \theta_5 z_t + \varepsilon_{3t}$

Now w_t denotes nominal wages and q_t denotes labour productivity. The other variables are specified as before. Table 1 summarises the theoretical and anticipated signs of the two sets of equations.

Table 1: Theoretical Signs

Variable	*Model A*		*Model B*	
	Equation 1 (ρ_t)	*Equation 2* $(w_t - q_t)$	*Equation 3* (ρ_t)	*Equation 4* (w_t)
$w_t - q_t$	*Positive*			
w_t			*Positive*	
q_t			*Negative*	*Positive*
ρ_t^e		*Positive*		*Positive*
z_t	*Negative*	*Inconclusive*	*Negative*	*Inconclusive*
$(y - \bar{y})_t$	*Positive*	*Positive*	*Positive*	*Positive*

Equation's 1 and 3 allow for the mark-up behaviour of firms over wage costs adjusted for productivity in an open economy framework. Equation 2 shows how wage costs adjusted for productivity are formulated through price expectations, demand and supply shocks; whereas equation 4 shows how nominal wage costs are

[8] The output gap is shown to be I(0) and thus only enters the model in the short run.

formulated through price expectations and productivity gains as well as controlling for demand and supply shocks.

In equation's 1 and 3, the theoretical impact of nominal wages and unit labour costs on prices is positive such that higher wage costs are passed onto prices. Labour productivity increases serve to decrease prices in equation 3, assuming that lower unit labour costs are passed onto prices, and increase wages in equation 4 such that some productivity gains are passed onto wages through the wage bargaining process. In equation 1, Fedderke and Schaling (2005) found a mark-up over unit labour costs such that $\alpha_2 > 1$. There is no reason to expect this to have changed other than the possible lowering of the mark-up through further trade liberalisation. In a similar fashion the net effect of a one-for-one increase in productivity and wages is expected to be larger than one in equations 3 and 4, that is $(\delta_2 + \delta_3 + \delta_2\theta_3) > 1$, which is essentially the same increase provided by an increase in unit labour costs. The advantage of splitting up the unit labour costs in model B is that we can see both the net effect of an increase in productivity on prices and the relative implied effect of unit labour costs. Further inferences can be made from this specification. If labour productivity is only partially passed onto wages then an increase in labour productivity could serve to lower unit labour costs resulting in downward pressure on the inflation rate. Alternatively if labour unions are strong, resulting in productivity gains raising wages which are further marked up then this would negate the negative effect of productivity on wages. Additionally, due to imperfect information one may not necessarily expect $\theta_3 = 1$; since information asymmetries may prevent perfect adjustment by both demand and supply side participants in the labour market, thus allowing firms to capture productivity gains.

Theoretically, an increase in openness is associated with a reduction in prices given by equations 1 and 3. There are two relevant theoretical mechanisms that increased openness can serve to lower prices. First, increased competition from imports can act to lower mark-ups.[9] Secondly increased openness could allow for technology

[9] Evidence is provided in Aghion, Fedderke, Howitt, Kularatne and Viegi (2008) and Fedderke, Kularatne and Mariotti (2007).

transfer and therefore serve to increase productivity.[10] The effect of increased openness on wages is more complex as South Africa is a middle income country that competes with both developing and developed nations. It may be the case that as South Africa opens up, some of our industries may be unable to compete with other more efficient developing countries, leading to the less efficient industries being shed and the more productive industries remaining.[11] One would expect labour to be more productive in these remaining industries and therefore be paid more; thus under this scenario, openness would lead to increased wages.[12] Alternatively increased competition may lead to downward pressure on wages. Thus the outcome is inconclusive.

The price expectations term is modelled using the Hodrick-Prescott filter and positive coefficients in equations 2 and 4 show that labour adjust their wage according to price expectations positively.[13] Lastly, the effect of the output gap in all equations should be positive showing the standard Phillips Curve argument of excess demand or that an increase in the output relative to its long run level has inflationary impacts.

IV. Data and Economic Methodology

(i) Data

All data series were obtained and formulated over the period of 1973Q1 to 2005Q4. This gives a sample of 132 observations. For both models the price variable is defined as the natural logarithm of the GDP deflator, denoted LNP, and is constructed from the quarterly SARB series of nominal and real GDP.[14] Figure 1 illustrates the series. In model A, unit labour costs for the manufacturing sector are used to measure the mark-up over wages adjusted for productivity. It is denoted

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[10] Fedderke and Romm (2006) discuss the impacts of Foreign Direct Investment on efficiency and growth in the South African context. For further analysis see Ramirez (2000), Barrel and Pain (1997), Balasubramanyam *et al* (1996), Blomstrõm (1983) and Blomstrõm and Wolf (1994).

[11] See Aghion and Howitt (1992) for the original creative destruction model.

[12] If the shed labour is not absorbed in the economy, then under this scenario a decrease in employment would be expected.

[13] Fedderke and Schaling (2005) and Burger and Marinkov (2006) use the HP Filter in the South African context. For further explanation on the HP filter in this context, see Ball and Mankiw (2002) pages 122-123.

[14] The SARB published real GDP data series is at constant 2000 prices.

LNULC and is illustrated in figure 2.[15] Figure 3 shows the quarter on quarter inflation of the GDP deflator, denoted DLNP and the smoothed filter DLNPEX. The output gap, denoted YGAP and illustrated by figure 4, was calculated as the difference between the log of the real GDP series and the output series calculated from the Hodrick-Prescott filter of the real GDP series.

Model B splits the unit labour costs into nominal wages and labour productivity. As nominal remuneration per worker in the manufacturing sector could not be obtained, nominal remuneration per worker for the whole economy was used bar partial agricultural sectors.[16] The series is denoted LNW and is shown in figure 5. The logarithm of labour productivity, denoted LNQ and illustrated in figure 6, had to be constructed by dividing the real gross value added for all non-agricultural sectors by an employment series for the same sectors that was originally constructed by Stats SA but obtained from the SARB.[17] [18]

Lastly, the openness indicator denoted OPEN is illustrated in figure 7 and was obtained from Aron and Muelbauer (2007).[19] The unit of this series is meaningless except for the fact that an increase in the series represents an increase in openness of South Africa. Thus the coefficient signs are meaningful; whilst magnitudes are difficult to interpret. The variable was preferred over other openness variables as it

[15] Unit: Index 2000=100, seasonally adjusted.
[16] Unit: Rand, seasonally adjusted. This was obtained by adding the two series of nominal wages in the private and non-agricultural public sectors together. The SARB publishes wage indices as opposed to raw data and so both these series were obtained directly from the SARB.
[17] Unit: Rand at constant 2000 prices. Two issues were encountered and dealt with in the employment figures. There are two structural breaks in periods 2002Q3 and 2004Q4 representing singular positive shocks of 40% and 7% respectively. In both cases a bridging estimate was made by projecting a two period average growth rate on the quarter before the structural break, to obtain a figure of employment for each quarter of 2002Q3 and 2004Q4. The rest of the series was then spliced to obtain comparable figures. Whilst this operation is far from perfect it can be justified for two reasons. First, we are interested in the trend structure of the series, not the absolute level of employment and on the whole this method captures the growth rates of employment in this sector. Secondly, there is little other data available in South Africa; which leaves no other option.
[18] One will note that there is a small unavoidable error in measurement between nominal wages and labour productivity. The productivity series is for all non-agricultural sectors whereas the nominal wage series is for private sectors including agriculture and non-agricultural public sectors. This is unavoidable due to not having a wage series for non-agricultural private sectors. However, this error is small as the agricultural sector only makes up less than 4% of GDP at the beginning of the sample space and declines to 3% at the end of the sample space. Thus productivity is only slightly biased upwards.
[19] The data series is available on the following website http://www.cepr.org. through the Aron and Muelbauer (2007) paper.

gave much more robust results across the two models as well as a better fit in both models.[20]

Figure 1 LNP: The logarithm of the GDP Deflator

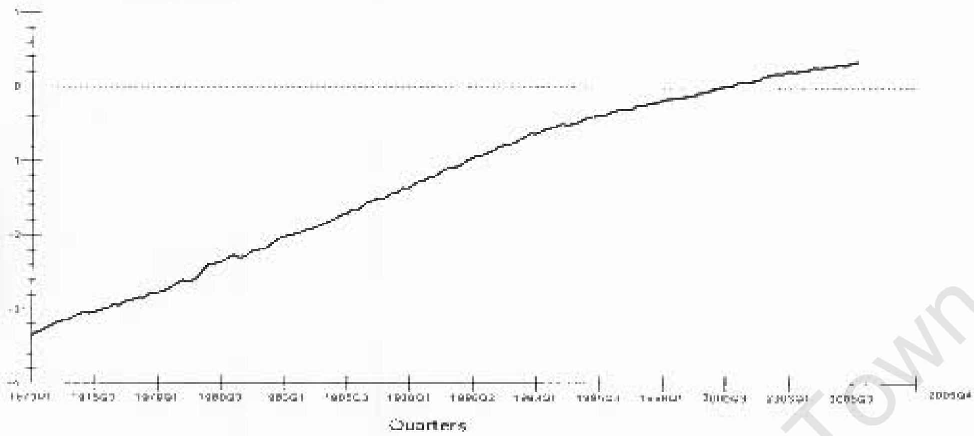


Figure 2 LNULC: The logarithm of Unit Labour Costs

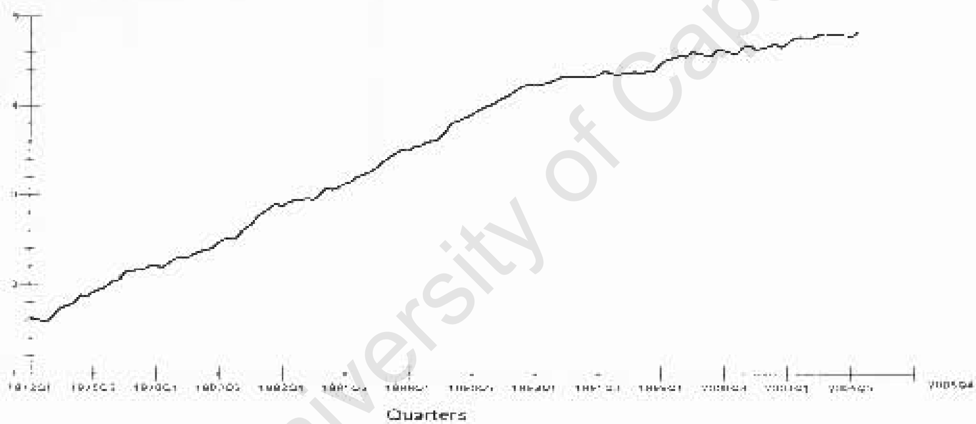
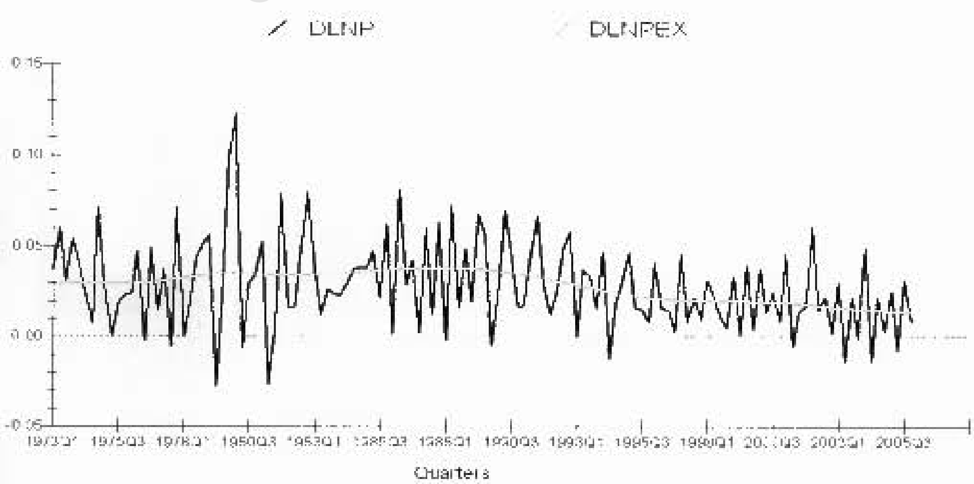


Figure 3 DLNP and DLNPEX: The first difference of Price Expectations



[20] Other variables tested were the real and nominal exchange rate, import prices, the oil price, the gold price and the terms of trade variable.

Figure 4 YGAP: The Output Gap

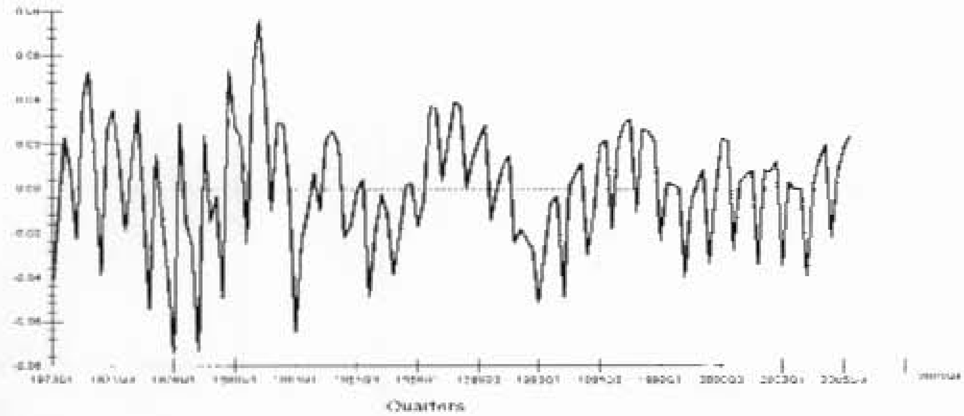


Figure 5 LNW: The logarithm of Nominal Wages

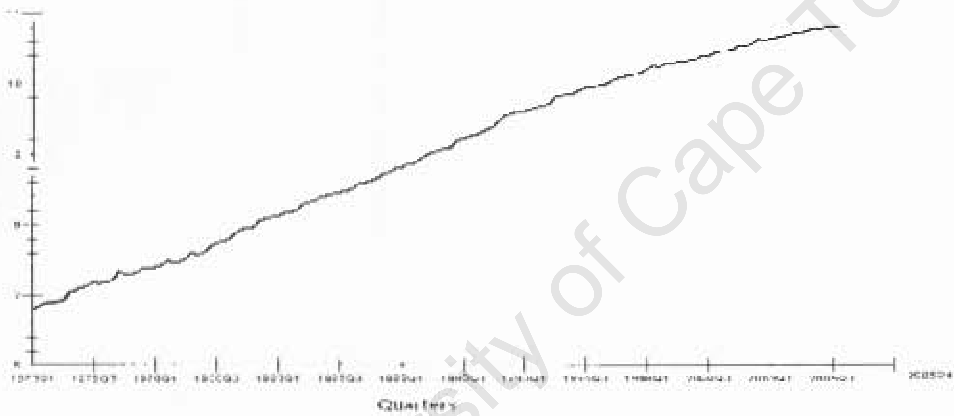


Figure 6 LNQ: The logarithm of Labour Productivity

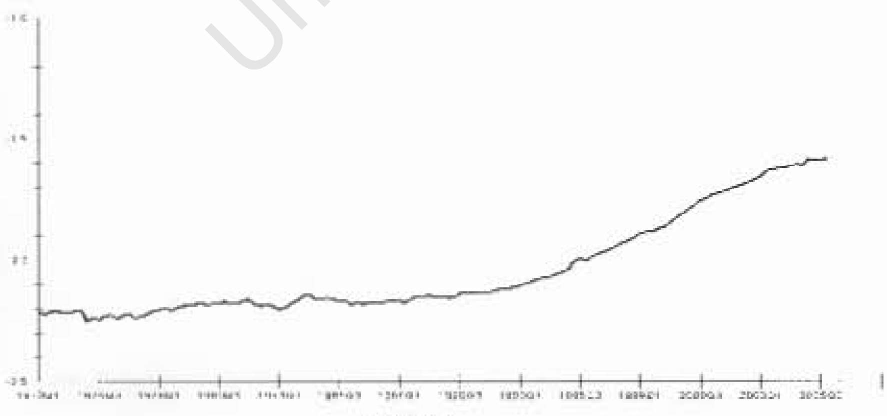
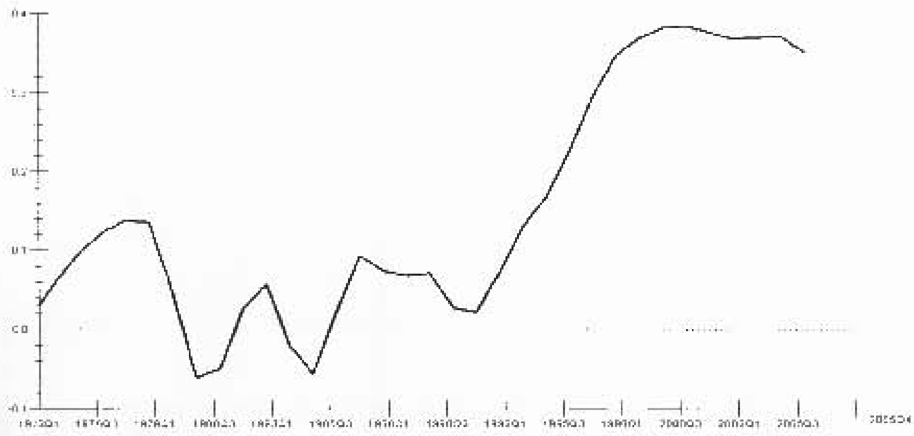


Figure 7 OPEN: The Openness Indicator



(ii) Econometric Methodology

With the expectations of two interrelated long term relationships in model's A and B, we employ the standard Johansen technique for multivariate cointegration.[21] A vector error correction (VECM) framework is used with k variables and a possibility of up to r cointegrating vectors; where $0 \leq r \leq k-1$.

In each case, a k-dimensional VAR is given:

$$z_t = a_1 + \ldots + a_m z_{t-m} + \mu + \delta_t \qquad (5)$$

Where m is the lag length, μ is the deterministic trend and δ_t is the Gaussian error term. Reparametrization of equation 5 gives the standard VECM specification:

$$\Delta z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + \Pi z_{t-k+1} + \mu + \delta_t \qquad (6)$$

Thus the $\Pi = \alpha\beta'$ matrix should have a reduced rank of r and this would then give r cointegrating vectors. By expanding the $\Pi = \alpha\beta'$ matrix below for each model, one will be able to see the over-identifying restrictions more clearly.[22]

[21] See Johansen (1988) and Johansen and Juselius (1990, 1992)

[22] See Wickens (1996), Johansen and Juselius (1990, 1992), Pesaran and Shin (1995a, 1995b), and Pesaran, Shin and Smith (1996).

Model A:

$$\Pi z_{t-k+1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \end{bmatrix} \begin{bmatrix} 1 & \beta_{12} & 0 & \beta_{14} \\ 0 & 1 & \beta_{23} & \beta_{24} \end{bmatrix} \begin{bmatrix} p_t \\ w_t \\ p_t^e \\ z_t \end{bmatrix}_{t-k+1}$$

Model B:

$$\Pi z_{t-k+1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \end{bmatrix} \begin{bmatrix} 1 & \beta_{12} & \beta_{13} & 0 & \beta_{15} \\ 0 & 1 & \beta_{23} & \beta_{24} & \beta_{25} \end{bmatrix} \begin{bmatrix} p_t \\ w_t \\ q_t \\ p_t^e \\ z_t \end{bmatrix}_{t-k+1}$$

The point of the estimation will be to establish the nature of the unrestricted coefficients in the β' matrix and to see if they correspond with the theoretical priors specified in the previous section.

V. Empirical Results and Assessment

(i) Univariate Time Series Characteristics of the Data

The Perron test sequence is used to determine univariate time series characteristics. The AIC and SBC test statistics were used to determine the appropriate Augmented Dickey-Fuller lag lengths in each model. Table 2 reports the relevant test statistic for the first difference of each variable bar the output gap which is in its levels form.

The first difference of the price series is I(0) using the standard augmented Dicky-Fullers test statistics. However, it is important to note that the price series is subject to a structural break in 1991Q4. This structural break was originally modelled in Fedderke and Schaling (2005) and represents the end of international isolation as well as severe SARB action against inflation. Consequently, the price expectations term will also be subject to this structural break. Given this structural break, we tested for a Perron additive outlier test. The test statistic is given in the last column of table 2 and since -5.18 < -5.08 the critical value, the series is stationary.[23]

Table 2: Perron test Sequence Statistics

Variable	*Level*		*First – Difference*	
	T_T	*Outlier – Test*	T_T	*Outlier – Test*
$\ln p_t$	0.96		-3.68 *	-5.18 *
$\ln p_t^e$	−1.43		-0.55	-2.67
$\ln(w_t - q_t)$	−2.20		-3.77 *	
z_t	−2.92		-3.30 *	
$(\ln y_t - \ln \bar{y}_t)$	-5.63 *			
$\ln w_t$	0.87		-4.83 *	
$\ln q_t$	−0.53		-3.61 *	

**denotes rejection of the null of non-stationarity at the 5% significance level.*

The first difference of the price expectation term is not stationary under the Perron test sequence even when including the structural break. However, if it is not I(1), then assuming an I(2) structure suggests that inflation expectations has a non-constant mean and/or variance and thus cannot be targeted or kept within a band such as the one that the SARB is currently aiming for. Figure 3 illustrates that it is difficult to argue that this series has a non-constant mean and/or variance. Moreover, an I(2) series seems further counter intuitive when considering that the actual price series is I(1) and we used it to extract the expectations series. Thus it is assumed that this series is I(1).[24] All other variables are I(1) except for the output gap which is I(0); thus excluding itself from the long run estimation and included in the error correction model only.

[23] The critical value of -5.08 is obtained from Perron (1997), originally in Perron (1994).

[24] One should query the practice of even testing series calculated from the Hodrick-Prescott filter. By construction, the filter smoothes out all variation around the long run trend as well as creating significant inertia in the series. Both these factors add to the confusion of the standard Dickey-Fuller tests. In the end, it was decided that theory must override the standard tests here.

(ii) Empirical Results

The cointegration tests for models A and B are presented in Tables 3 and 4 respectively.[25] A further dummy denoted DTB, was introduced in both models to correct for a spike in inflation in the period 1980Q1.[26] Both the Eigenvalue and Trace statistic show that two cointegrating relationships exist in Model A. The Eigenvalue test statistic in Model B suggests that there are three cointegrating relationships but only marginally so; whereas the Trace test statistic shows two cointegrating relationships. However the Trace test statistic has superior power characteristics in small samples and consequently it was decided to proceed with two cointegrating relationships.

Table 3: Cointegration for Model A

Null	**Alternative**	**Eigenvalue Statistic**	**95% Critical Value**	**Trace Statistic**	**95% Critical Value**
r = 0	r ≥ 1	534.67*	27.42	578.80*	48.88
r = 1	r ≥ 2	29.60*	21.12	44.13*	31.54
r = 2	r ≥ 3	12.57	14.88	14.54	17.86
r = 3	r ≥ 4	1.97	8.07	1.97	8.07

**denotes statistical significance. List of variables included in cointegrating vector: LNP, LNULC, LNPEX, OPEN; list of I(0) variables included in VAR: YGAP, DU and DTB.*

Table 4: Cointegration for Model B

Null	**Alternative**	**Eigenvalue Statistic**	**95% Critical Value**	**Trace Statistic**	**95% Critical Value**
r = 0	r ≥ 1	574.02*	33.64	635.96*	70.49
r = 1	r ≥ 2	30.49*	27.42	61.94*	48.88
r = 2	r ≥ 3	21.16*	21.12	31.44	31.54
r = 3	r ≥ 4	8.81	14.88	10.28	17.86
r = 4	r ≥ 5	1.48	8.07	1.48	8.07

**denotes statistical significance. List of variables included in cointegrating vector: LNP, LNW, LNQ, LNPEX, OPEN; list of I(0) variables included in VAR: YGAP, DU and DTB.*

[25] All tests were done for the period 1973Q1-2005Q4; which gives a sample of 132 observations. For each test the order of the VAR is 4.

[26] This period reflects the gold boom of the early 1980's.

Estimates for the β matrix are given in table 5 for each of the models.[27] The brackets under each coefficient show the chi-squared test statistics based on over-identifying restrictions. Firstly, all signs are correct and the openness coefficient is consistently positive in equations 2 and 4. Moreover, all variables are significant bar the price expectations term due to perfect statistically collinearity between the two CVs when testing for significance.[28]

Table 5: Estimates of the Restricted Cointegrated Relations.

Variable	*Model A*		*Model B*	
	Equation 1 (ρ_t)	*Equation* 2 ($w_t - q_t$)	*Equation* 3 (ρ_t)	*Equation* 4 (w_t)
$w_t - q_t$	1.202* (426.28)**			
w_t			1.041* (540.56)	
q_t			-0.511* (572.57)	0.524* (565.22)
ρ_t^e		0.832 (N/A)**		0.955 (N/A)**
z_t	-1.036* (415.28)	0.864* (507.93)**	-0.312* (25.78)	0.309* (25.69)**

**denotes significance at the 5% level and ** denotes the fact the model did not converge when testing for the over-identifying restrictions. Instead the non-convergence results are given.*

In model A the manufacturing mark-up over unit labour costs is 1.202; which is consistent with, though lower than the result of 1.31 obtained in Fedderke and Schaling (2005) using the manufacturing sector data. This smaller mark-up may be due to the further trade liberalisation post 1999. Model B shows a considerable drop in the mark-up from 1.202 to 1.076.[29] This lower mark-up can be explained due to

[27] All estimation results were obtained using the program Microfit.

[28] Specifying a zero coefficient on the price expectation term resulted in the CVs being collinear. An alternative test is to set the coefficient to -0.01 as well as 0.01 in separate tests. If the both tests are significant then it is more than likely the zero restriction will be rejected as well. In both models the chi-squared coefficient of such a test was consistently above 540 and therefore significant at the 5% level.

[29] This is the net effect of a joint 1% increase in nominal wages and labour productivity; which is the equivalent increase in model A, that is $(\delta_2 + \delta_3 + \delta_2\theta_3)$. The net effect can be broken down into a direct and indirect

the change from the use of manufacturing sector data in model A to the more comprehensive economy wide data in model B which may have lower mark-ups.[30] Fedderke, Kularatne and Mariotti (2007) found that a larger mark-up in the range of 1.6 and 1.8 exists in the manufacturing sector of South Africa. Including other industries in estimation appears to suggest that non-manufacturing firms have lower pricing power in South Africa.

Model B shows how labour productivity interacts with nominal wages and prices independently. Taking into account both the direct and indirect effects, the net effect of a 1% increase in labour productivity on prices is an increase of 0.035%.[31] This net effect is small and although firms do pass on productivity increases to customers by lowering prices in equation 3, the firms mark-up on wages over productivity is marginally greater than this direct effect in equation 3. Thus the net effect is positive. Moreover we see that the productivity coefficient in equation 4 is not unity; which suggests that the implicit assumption of nominal wages and labour productivity moving in a one-for-one fashion is a poor assumption.

The price expectations terms of 0.832 and 0.955 are similar to the figure of 0.86 in Fedderke and Schaling (2005). Although these coefficients are very close to unity, they are statistically significantly different from unity.[32] This suggests that price expectations are not completely passed on to wages. In both models, however, there is a mark-up on wages over the sum of price expectations and productivity; that is workers receive wage increases above inflation expectations.

In equations 1 and 3, the coefficient on the openness indicator is negative, illustrating the theoretical expectation that an increase in openness decreases

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effect on prices. The direct effect is the impact of a 1% increase in nominal wages and labour productivity on prices through equation 3, that is $(\delta_3 + \delta_2)$. More specifically, 1.041% less 0.511% is equal to a 0.53% increase in prices. The indirect effect, of $(\delta_2\theta_3)$, occurs because part of the labour productivity gains are passed onto higher nominal wages in equation 4; which in turn increases prices in equation 3. For example, 1.041% multiplied by 0.524% is equals to a 0.546% increase in prices. Thus adding the direct and indirect effects gives a 1.076% increase.

30 This change of the mark-up could also be, in part, due to the change in the specification of unit labour costs.

31 The net effect is $(\delta_3 + \delta_2\theta_3)$, specifically (1.041*0.524) - 0.511= 0.035.

32 At the 5% level, the Chi-squared test rejects the null of valid restrictions for both model's A and B, with test statistics of 24.99 and 13.14 respectively.

prices.[33] The positive coefficient on equations 2 and 4 suggests that as South Africa opens up, wages increase. Theoretically this is in line with the destruction of inefficient industries in South Africa and that remaining labour is more productive in the industries that survive.[34]

Table 6 illustrates the dynamics of the error correction model for model's A and B. The coefficients on the output gap in the dynamics of price equations are negative and significant across both models. This is contrary to the standard Phillips curve argument. On the other hand, the theory holds in the dynamics of equation 4 with a significant positive sign. The stability of either model to a system wide shock is illustrated in diagram's 8 and 9 in the appendix for model's A and B respectively. Both diagrams show a small upward spike after 4 quarters showing the second round effects of shocks to the system. Model A has a severe case of persistence in the 20th quarter. The nature of this persistence to the shock is unrealistic due to the magnitude; however model B has an oscillation in the same time period. This suggests persistence in both models.

There are a number of implications to be drawn from this model. In model B, non-agricultural sectors are used and in combination with splitting up unit labour costs, a smaller mark-up is obtained than the one in model A. This evidence provides a comparison of the mark-up between the manufacturing sector and non-agricultural sectors and is in line with the fact that the manufacturing industries have high mark-ups in South Africa.[35] Secondly, increased openness lowers prices, consistent with the Aron and Muelbauer (2007) results for South Africa. Additionally, this paper adds to the evidence that increased openness increases the average wage and is due to inefficient firms with lower labour productivity being eliminated. Finally, evidence in favour of a cost-push pricing process is found in South Africa. Other significant factors are the open economy and price expectations.

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[33] This is due to one or both of the mechanisms previously mentioned. First, increased competition from imports can act to lower mark-ups and second increased openness could allow for technology transfer and therefore serve to increase productivity.

[34] Alternatively as South Africa opens up, our firms increase their capital labour ratios thereby increasing labour productivity; which raises wages. This has a damaging effect on employment.

[35] See Fedderke, Kularatne and Mariotti (2007).

Table 6: Error Correction Representation of Model's A and B.

Variable	Model A		Model B_1	
	ΔLNP	ΔLNULC	ΔLNP	ΔLNW
ΔLNP(-1)	-0.43 (0.00)	-0.07 (0.43)	-0.35 (0.01)	-0.07 (0.72)
ΔLNP(-2)	-0.32 (0.01)	0.17 (0.37)	-0.25 (0.04)	0.09 (0.61)
ΔLNP(-3)	-0.34 (0.00)	0.07 (0.63)	-0.32 (0.00)	0.10 (0.47)
ΔLNULC(-1)	-0.04 (0.48)	-0.07 (0.43)	_	_
ΔLNULC(-2)	-0.07 (0.19)	-0.15 (0.08)	_	_
ΔLNULC(-3)	0.02 (0.77)	-0.10 (0.27)	_	_
ΔLNW(-1)	_	_	0.08 (0.25)	-0.37 (0.00)
ΔLNW(-2)	_	_	0.10 (0.12)	-0.21 (0.04)
ΔLNW(-3)	_	_	0.02 (0.73)	-0.31 (0.00)
ΔLNQ(-1)	_	_	-0.10 (0.79)	-0.41 (0.11)
ΔLNQ(-2)	_	_	-0.14 (0.42)	0.01 (0.95)
ΔLNQ(-3)	_	_	-0.10 (0.54)	0.31 (0.20)
ΔLNPEX(-1)	193.72 (0.00)	98.91 (0.17)	-213.25 (0.00)	123.31 (0.11)
ΔLNPEX(-2)	376.02 (0.00)	-252.93 (0.10)	419.65 (0.00)	-264.70 (0.09)
ΔLNPEX(-3)	-181.51 (0.00)	159.60 (0.05)	-205.87 (0.00)	144.85 (0.07)
ΔOPEN(-1)	0.46 (0.09)	-0.17 (0.69)	0.32 (0.23)	0.57 (0.15)
ΔOPEN (-2)	-0.10 (0.79)	0.78 (0.17)	-0.12 (0.73)	-0.72 (0.16)
ΔOPEN(-3)	0.10 (0.70)	-0.39 (0.38)	0.13 (0.61)	0.32 (0.42)
DU	-0.02 (0.05)	-0.00 (0.96)	-0.02 (0.05)	0.04 (0.03)
DTB	0.08 (0.00)	-0.01 (0.84)	0.08 (0.00)	0.00 (0.88)
YGAP	-0.17 (0.01)	-0.09 (0.35)	-0.16 (0.01)	0.23 (0.01)
Constant	-0.02 (0.90)	0.86 (0.00)	-1.25 (0.11)	3.89 (0.00)
ECM1(-1)	-0.29 (0.03)	-0.31 (0.14)	-0.32 (0.01)	0.12 (0.52)
ECM2(-1)	-0.33 (0.06)	-0.60 (0.03)	-0.22 (0.18)	-0.22 (0.36)
R^2	0.62	0.32	0.66	0.52
F-Statistic	F(17,114)= 10.86(0.00)	F(17,114)= 3.13(0.00)	F(20,111)= 10.76(0.00)	F(20,111)= 6.07(0.10)
DW	1.95	1.89	2.07	1.98
Serial Correlation	2.43 (0.66)	6.91 (0.14)	4.02 (0.40)	4.58 (0.33)
Ramsey Reset Test	2.79 (0.10)	1.34 (0.27)	6.04 (0.01)	3.29 (0.07)
Normality	1.42 (0.49)	2.03 (0.36)	1.17 (0.56)	4.63 (0.10)
Heteroskedascity	0.86 (0.35)	0.10 (0.76)	1.57 (0.21)	12.76 (0.00)

Probability is denoted in the round brackets and ECM denotes the error correction term.

VI. Conclusion

This paper uses two different variations of the price and wage setting relationship to model the pricing process. It builds on previous papers by separating unit labour costs into nominal wages and labour productivity allowing for independent movement. The model has shown that the implicit assumption of nominal wages and labour productivity moving in a one-for-one fashion is a poor one. We also see that workers receive wage increases above unity when they bargain with price expectations and productivity gains in mind. Both models show that a mark-up over wages adjusted for productivity is evident in South Africa. The mark-up is diminished to 1.076 when using the economy wide definition of nominal wages as opposed to a mark-up of 1.20 in the manufacturing sectors. This provides some comparative evidence between the two different sets of sectors. Additionally, the recent openness indicator created by Aron and Muelbauer (2007) is found to impact prices negatively and therefore shown to be robust as an openness indicator.

Finally, the paper adds to the evidence that the South African pricing process is determined by cost-push factors in an open economy context and demonstrates how significant price expectations are in South Africa. Thus the monetary authorities should use the inflation targeting regime to lower inflation expectations. Additionally, opening up the economy serves to improve efficiency and lower prices which is beneficial for all consumers.

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VIII. Appendix A: Impulse Response Functions

Figure 8 Model A's Persistence Profile of Cointegrating Vectors to System Wide Shocks

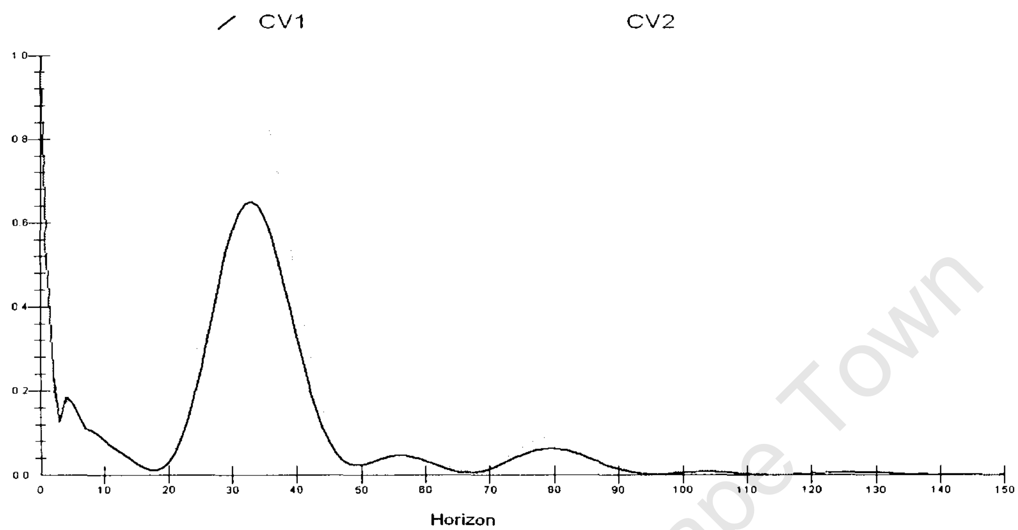

Figure 9: Model B's Persistence Profile of Cointegrating Vectors to System Wide Shocks