Business Cycle Accounting for South Africa

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Abstract

Quantitative DSGE Models are an increasingly important tool for policy analysis and evaluation in South Africa. The basic framework of these models is a monetary real business cycle model with market imperfections (monopolistic competition, price and wage rigidities and credit market imperfections) introduced to mimic the time series properties of the data. This paper evaluates the importance of each imperfection in explaining the business cycle in South Africa. To do so we apply the business cycle accounting methodology proposed by Chari, Kehoe and McGrattan. The analysis starts showing that many models are equivalent to a prototype growth model with time varying wedges looking like productivity, labour taxes, investment taxes and government expenditure. We then identify these wedges for the period 1970-2010 and we describe the contribution of each wedges in explaining the 2000-2007 boom and the 2008-2010 downturn. In particular we show that the labour wedge seems particularly important in explaining the severity of labour market response experienced in the period. The results is robust to different parameterization of the model and different treatments of the data. We conclude by suggesting a possible modelling framework which would help explaining the preponderance of the labour wedge in the South African business cycle.

Keywords: Business Cycle Accounting, South Africa, Labour Market, Credit Market
J.E.L. Classification: E32; E37; O47.

1 Introduction

In their seminal article on business cycle accounting Chari, Kehoe and McGrattan (2002, 2007) (CKM) develop a way to identify sources of business cycle fluctuations from a generic real business cycle model with wedges. The appeal of this approach is that it provides a guide of identify where imperfections matter thus giving some guidance in the modelling framework search. This approach is particularly appealing in an economy like South Africa where there is a significant increase in the use of modern quantitative models of economic fluctuations but there is little agreement on the relevant economic characteristics of the country. This debate is generally short-circuited by evaluating models prevalent in the international literature on the basis of their ability to fit the data. This approach has proven to be very successful in providing efficient forecasting instruments (Liu et all, 2009, Liu and Gupta. Steinbach et al, 2009, Alpanda et al, 2010). A different issue is the use of these model for policy analysis and policy simulations. For example, the canonical New Keynesian model place a lot of emphasis on the importance of rigidities in the price mechanism, but it is not well suited in analysisng labour market imperfections generating unemployment as the one experience in South Africa. Also, the role of the financial market in the transmission of shocks is generally absent, while it could be an important factor in explaining South Africa macroeconomic fluctuations, given the importance of this sector in the economy. These limitations of the canonical New Keynesian model are well known in the literature and there are many attempt to include both financial frictions (see Gertler and Kyiotaki 2009) and a well specified labour market (Blanchard and Gali 2007) in the model.

The contribution of this paper is to give some guidance of which avenue of research would be more in line with the characteristics of the South African economy. Because the models present in the literature are not nested and mutually exclusive, the decision of the research direction should be guided by some understanding of the main drivers of economic fluctuations .

The paper is organized as follows. In the next section we present the main characteristics of the methodology. In section 3 we present the data and discuss its limitations, especially in respect to labour market data. section 4 presents the result of the decomposition. The final session discuss and concludes.

2 Business Cycle Accounting

The business cycle accounting methodology of Chari et al. (2007) considers a standard neoclassical growth model with time varying wedges. The wedges are a labour wedge, an investment wedge, an efficiency wedge and a government wedge, that captures government spending and net export. The economy is populated by an infinitely lived consumer and a representative producer. They are both price takers in all markets. The representative consumer optimizes a lifetime utility function in consumption and labour.

$$\max_{\{c_t,l_t,x_t\}} E\sum_{t=0}^{\infty}\beta^i U\left(c_t,l_t\right)N_t \tag{1}$$

subject the usual budget constraint and dynamic capital equation

$$\left(1+\tau_{xt}\right)x_t+c_t=\left(1-\tau_{lt}\right)w_t l_t+r_t k_t+T_t \tag{2}$$

$$\frac{N_{t+1}}{N_t}k_{t+1}=\left(1-\delta\right)k_t+x_t$$

where $U()$ is the instantaneous utility function, c denotes consumption, l hours worked, x denotes investment, k_t.the per capita capital stock, w_t is the wage rate and r_t is the rental rate of capital. and N_t is the population, with growth rate $\frac{N_{t+1}}{N_t}=(1+\gamma)$, δ is the depreciation rate and T_t is the per capita lump-sum transfers. The difference between the formulation above and the canonical form is the inclusion of two wedges affecting consumers optimization: τ_{xt} is the investment wedge, which affect investment return and τ_{lt}, the labour wedge, which operates like a labour tax.

Firm maximizes profits subject to a neoclassical production function. Thus the firm's problem is:

$$\max_{K_t,L_t} A_t F\left(k_t,\left(1+g_z\right)l_t\right)-w_t l_t-r_t k_t \tag{3}$$

where $(1+g_z)$ is the labour augmenting technological progress, while A_t is an efficiency wedge. The equilibrium of this benchmark model is identified by a vector of price functions $\{w_t,r_t\}_{t=0}^{\infty}$ and a vector of allocation functions $\{c_t,l_t,x_t,y_t\}_{t=0}^{\infty}$ satisfying the following conditions every period:

$$c_t+x_t+g_t=y_t \tag{4}$$

$$y_t=A_t F\left(k_t,\left(1+g_z\right)l_t\right) \tag{5}$$

$$\frac{U_{l,t}}{U_{c,t}}=\left(1-\tau_{lt}\right)A_t F_{l,t}\left(k_t,\left(1+g_z\right)l_t\right) \tag{6}$$

$$U_{c,t}\left(1+\tau_{xt}\right)=E_t\beta U_{c,t+1}\left[\left(1-\delta\right)\left(1+\tau_{xt+1}\right)+A_{t+1}F_{k,t+1}\left(k_{t+1},\left(1+g_z\right)l_{t+1}\right)\right] \tag{7}$$

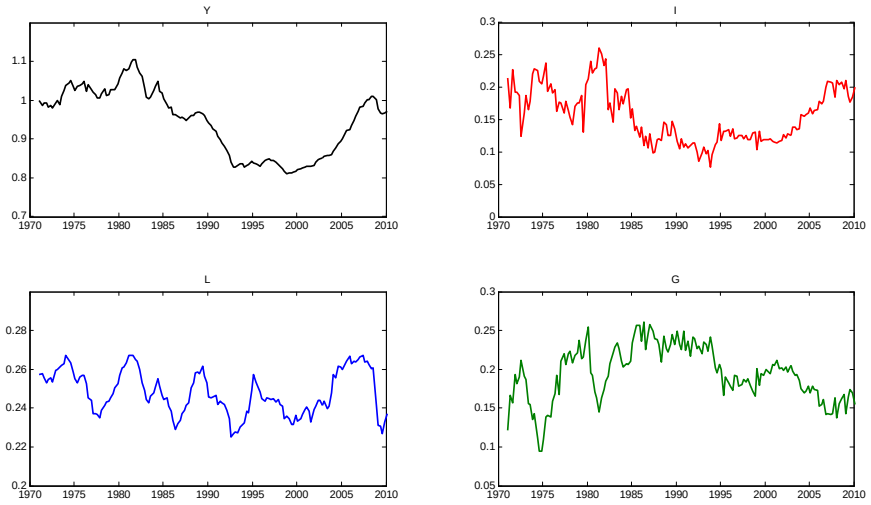
where $U_{c,t}$, $U_{l,t}$ $F_{l,t}$ and $F_{k,t}$ denote the derivative of the of the utility function and the production function with respect to their arguments. Equation (4) represents the resource constraint, where g_t is the sum of government consumption and net exports per capita and .y_t is per capita income Equation (5) shows the output every period is constraint by the production technology, where A_t, the efficiency wedge, looks like a technological parameter. Equation (6) equates the marginal rate of substitution between consumption and labour with the "wedge-adjusted" marginal productivity of labour, which equated to the equilibrium wage rate. Equation (7) is the standard inter-temporal Euler equation equating the intertemporal marginal

rate of substitution and marginal product of capital. Notice that these equilibrium conditions are distorted by the presence of the four wedges, g_t, A_t, τ_{lt}, τ_{xt} (if time varying). Chari et al (2007) show that various quantitative business cycle models are equivalent to the above model with wedges: in particular they show that a model with input-financing frictions is equivalent to the prototype growth model with efficiency wedges; model with nominal wage rigidities, as in a sticky wage model like Erceg et al () is equivalent to the prototype economy with labour wedges; while an economy with financial frictions as in Calstrom and Fuerst (1997) is equivalent to the prototype economy with an investment wedge.

The actual wedges are derived directly from the model and the data. The government consumption wedge g_t it taken directly from the data on government expenditure and net exports. The efficiency wedge A_t is calculated from the production function (5). The labour wedge $(1 - \tau_{lt})$ is calculated from the consumption-leisure condition (6) while the investment wedge $(1 + \tau_{xt})$ is calculated from the intertemporal Euler equation (7). The investment wedge is the only one that need to be estimated and in doing so we follow chari et al. (2007) and assume that expectations follows an AR(1) process, in which next period wedges can be fully determined by current period data and wedges[1]. An alternative specification would be to follow Chari et al (2002) or Kobayashi and Inaba (2006) and assume perfect foresight, with very little effect on final results.

3 The Data and Estimation Procedure

To perform the decomposition we use data on income, investment, labour, government and net export, collected from the South African Reserve Bank dataset. The data are expressed in real per capita terms, relative to real the per capita income level of 1971Q1. The data are shown in figure (1).



Raw Data

[1] For the estimation we modify the original MatLab code generously provided by Ellen McGrattan.

The main objective of this decomposition is to evaluate what was the main source of fluctuations in the period after 1994.

The series that requires particular attention is the series on hours worked. Because there is not complete hours worked series available for the South African economy, we need to use a production function method to extract hours from the series of capacity utilization in the manufacturing sector, available for the whole sample[2] from StatSA. The idea is to link capacity utilization to hours worked, considering that at business cycle frequency the only variable input is labour. Thus, assuming a Cobb-Douglas production function we can write:

$$\frac{Y_t}{Y_{t,\max}} = \frac{A_t K_t^{\alpha} L_t^{1-\alpha}}{A_t K_t^{\alpha} L_{t,\max}^{1-\alpha}} \tag{8}$$

On the left end side we have the definition of capacity utilization while on the right hand side we have capacity utilization expressed in term of production function. The amount of hours used each period can be calculated from (8) as:

$$\frac{L_t}{L_{t,\max}} = \left(\frac{Y_t}{Y_{t,\max}}\right)^{\frac{1}{1-\alpha}} \tag{9}$$

Given a maximum working hours of 1/3 of the day, the labour hours defined by (9) is shown in figure (3). The level of cyclical variation is significant and in all probability overestimated. In the estimation we experiment with different smoothing technique, to reduce the cyclical variation, but the results were not affected significantly.

Finally, in the following table we report the values of the parameters calibrated on the South African economy as far as the population growth and productivity growth is concerned. Relative to the parametrization in Chari et al (2007) we have assumed a slightly higher depreciation rate, which in anyway does not affect the results significantly.

Parameter	Value	Notes
β	$(0.9722)^{1/4}$	Calibration
δ	$1-(1-.0464)^{1/4}$	Calibration
ψ	2.24	Calibration (to have 0.3 L/Y ration in steady state
θ	0.35	Calibration
g_z	$(1.016)^{1/4}-1$	match 1.6% annual TFP Growth (Du Plessis)
g_n	$(1.01)^{1/4}-1$	1% population growth

Table 1: Parameterization

[2] The few available data are coming from the annual October Household Survey collected untill 1999 and the following Labour Force Survey, biannual at the introduction and collected quarterly from 2008. These data are too eterogeneous and sparse to be useful in identify labour utilization at business cycle frequency.

4 Results for the whole sample

We first analyses the contribution of each wedge to the business cycle for the whole sample period 1971-2010. We calculate standard deviations of the wedges relative to output and correlations of the wedges with each other and with output at different lags and leads, using HP filtered data. The summary statistics illustrate that the government wedge is highly volatile, while the efficiency wedge is the least volatile, all relative to output. in addition, labour and efficiency wedge are positive correlated with income at different lags and leads, while the government wedge is negatively correlated with output. The investment wedge instead seems to have a very insignificant correlation with output at any lead and lag. The cross correlations in panel B show negative correlation between efficiency and labour wedge and negative correlation between investment and efficiency wedges.

PROPERTIES OF THE WEDGES, 1971:1-2010:2

A. SUMMARY STATISTICS

	Standard Deviation	Cross-Correlation with Y(t-k), k=				
Variable	Rel. to Y	-2	-1	0	1	2
Efficiency	0.63	-0.09	0.06	0.27	0.25	0.29
Labor	2.93	0.65	0.74	0.74	0.66	0.48
Investment	1.63	0.07	0.05	-0.00	-0.04	-0.03
Govt. Cons.	6.32	-0.47	-0.53	-0.54	-0.53	-0.43

B. Cross Correlations

	Cross-Correlation X(t), Z(t-k), k=				
Variable X,Z	-2	-1	0	1	2
Efficiency , Labor	-0.24	-0.20	-0.23	-0.06	0.04
Efficiency , Investment	-0.14	-0.21	-0.22	-0.13	-0.03
Efficiency , Govt. Cons.	0.09	-0.01	-0.06	-0.11	-0.12
Labor , Investment	0.13	-0.00	-0.36	0.02	0.16
Labor , Govt. Cons.	-0.43	-0.58	-0.67	-0.51	-0.36
Investment , Govt. Cons.	-0.02	0.20	0.30	0.18	0.00

Note: Statistics based on logged and HP-filtered series

Table 2

Table (3) below compare the simulated movements in output due to a particular wedge to those of actual output for the whole sample 1971-2010, using HP filtered data. The first row in part A shows that movements in output due to movement of the efficiency wedge and investment wedge have a standard deviation close to unity, relative to output fluctuation in the data. These wedges than seems to capture the right magnitude in the output fluctuation in the data. On the other hand the correlation of the simulated series with the actual output is quite low. The labour wedge instead overestimate output volatility but it is strongly correlated with actual output at any lead or lag. Finally, in part B of the table output due to efficiency wedge is negatively correlated with output due to investment and labour wedge.

PROPERTIES OF THE OUTPUT COMPONENTS, 1971:1-2010:2

A. Summary Statistics

Variable	Standard Deviation Rel. to Y	Cross-Correlation with Y(t-k), k= -2	-1	0	1	2
Efficiency	1.12	-0.31	-0.23	-0.06	-0.04	0.06
Labor	2.04	0.60	0.68	0.69	0.62	0.44
Investment	0.99	0.13	0.11	0.05	0.02	0.01
Govt. Cons.	0.64	-0.50	-0.57	-0.58	-0.57	-0.44

B. Cross Correlations

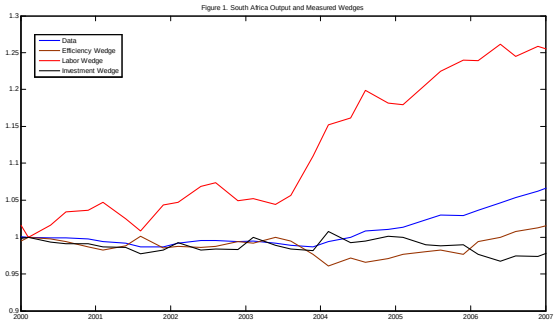
Variable X,Z	Cross-Correlation X(t), Z(t-k), k= -2	-1	0	1	2
Efficiency , Labor	-0.32	-0.32	-0.33	-0.21	-0.12
Efficiency , Investment	-0.14	-0.26	-0.36	-0.23	-0.07
Efficiency , Govt. Cons.	0.20	0.11	0.01	0.01	0.00
Labor , Investment	0.16	0.02	-0.43	0.04	0.18
Labor , Govt. Cons.	-0.44	-0.63	-0.76	-0.56	-0.36
Investment , Govt. Cons.	-0.12	0.09	0.23	0.07	-0.10

Note: Statistics based on logged and HP-filtered series

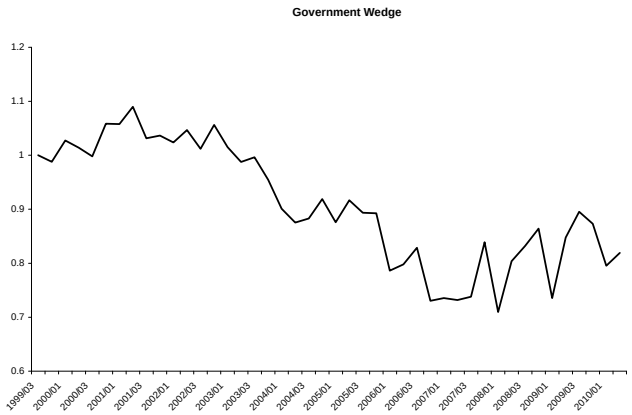
Table 3

5 Expansion 2000-2007

The first period we analyse is the expansionary phase in the period 200-2007. This was the longest period of expansion of the South African economy in a generation. Using the calibrated model and the aggregate variable, we first compute the four wedges described in equations (4)-(7). Figure (2) below plot these wedges, together with the actual output data



The labour wedge $(1-\tau_{lt})$ in the period shown a very large increase, consistent with an improved employment situation, especially from 2004. However a more detailed model focusing on labour market imperfections would be required, especially to explain the large difference in variability between the labour wedge and the actual output. In fact, the period is also market by very little variation in the efficiency and investment wedge. This lack of dynamic in the investment and efficiency wedge might indicate that model of credit market imperfections might not capture any significant dynamic of the South African economy. The government wedge in the following figure shows instead a significant deterioration during the period,

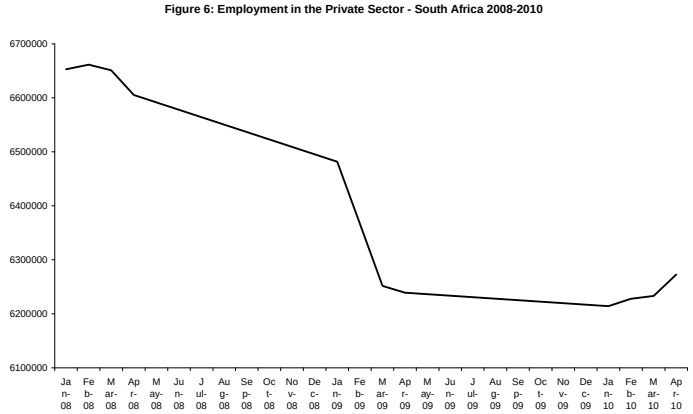


consistent with a persistent current account deficit during the period.

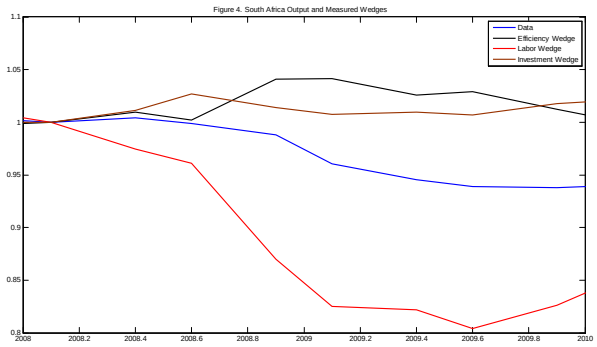
The result are in line with general picture on the previous part. The business cycle in South Africa seems to be driven mainly by labour market and external (or government) sector, with very limited role for credit or efficiency explanation of the cycle

6 The 2008-2010 Financial Crisis

Another interesting episodes that we want to analyse using this methodology is the economic contraction of the period 2008-2010, following the global financial crisis started in US the year before. The peculiarity of this crisis has been that although the output effect was not particularly dramatic, compared to countries at the epicenter of the crisis, the employment reduction has been dramatic, as we can see in the employment dynamic

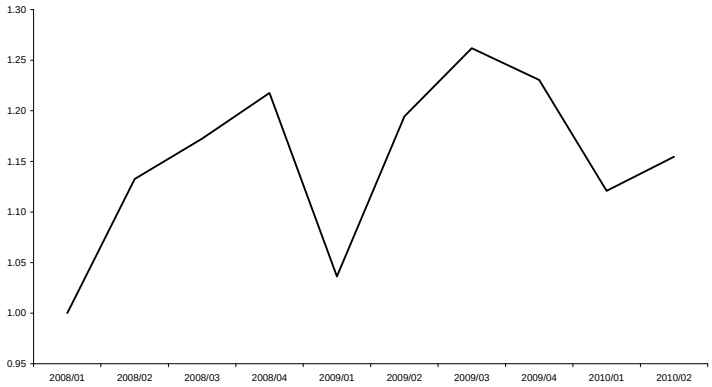


The decomposition allow us to interpret this episodes as a combination of worsening of labour market conditions, represented by a reduction in the labour market wedge, matched by an improvement in the efficiency and intertemporal investment conditions. This is shown in figure (4) below.



Also the economic downturn was partly mitigated by an improvement of the Government wedge, as we can see in figure 6

Figure 6: Government Wedge 2008-2010



The analysis also shows that the labour wedge predict correctly the direction of the business cycle, but it tend to overestimate the magnitude of the fluctuation.

7 Conclusions

This preliminary analysis of business cycle accounting for South Africa confirm the importance of the labour market in the business cycle of the country. Although business cycle accounting does not allow a structural interpretation of the wedges, it gives an indication that the most fruitful line of research to interpret the economic dynamic of the country might be models with real wage rigidities like Blanchard and Gali (2007), with an important role played by the external conditions. An extension of this exercise would require the separate identification of the effects of commodity prices and international investment.

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