Business Cycle Accounting: The propagation mechanism for the recessions in Australia[1]

(First Draft)

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March 2008

[1]I am grateful to Mark Weder and Jacob Wong for their invaluable guidance. I also thank Ellen McGrattan for her helpful suggestions. All remaining errors are mine.

Abstract

We examine the propagation mechanism that accounts for two recent economic recessions in Australia, the 1982/83 recession and the 1990/91 recession. We adopt the Business Cycle Accounting (BCA), which is developed by Chari, Kehoe and McGrattan (2007), as a tool in this study. We find that both the efficiency wedge and the labor wedge can account for the 1982/83 recession. Meanwhile, the efficiency wedge and the investment wedge are attributed to the 1990/91 recession. Over a longer horizon of 1979 - 2006, the efficiency wedge can capture the movement of the output remarkably well. Business cycle studies for Australia should emphasize the propagtion transmission through the efficiency wedge.

1 Introduction

Two most recent recessions in Australia were in 1982/1983 and 1990/1991. Figure 1 displays GDP per capita and its linear time trend at 1.8% per annum during 1960-2006. Among the two recession episodes, it is worth noting that there was a larger fall in output in the 1982/83 recession while the 1990/91 recession was more prolonged. Studies have investigated the propagation mechanism of the underlying shocks that caused the fall in output in these two recession episodes. So far, the studies have focused on four particular propagation mechanisms through which shocks can manifest themselves. The first propagation mechanism is through the Solow residual. The second propagation mechanism is through the inventory cycle and investment. The third propagation mechanism is through the international business cycle which consists of the trade balance effect and the capital account effect. The last propagation mechanism is through the price and wage stickiness. Many studies focus on a specific economic propagation mechanism and ignore other possible channels through which shocks can manifest themselves. As a result, we cannot compare the effects of different shocks across different prototype models. This leads to the question of whether we can incorporate several propagation mechanisms into a model and find out which one plays a dominant role in the recessions in Australia.

The recent paper by Nimark (2007) can explain the influence of different shocks on macro variables in the New Keynesian model successfully. His study and ours are similar on the grounds that both studies rely on the micro fundamentals. Based on the quarterly data between 1991:Q1 and 2006:Q2, he utilizes the Bayesian technique to study a standard New Keynesian small open economy model in Australia. His work focuses on how key macro variables, those include cash rate, GDP, inflation, exports, consumption imports, consumption, relative price of imports, domestic inflation and nominal depreciation, response to different shocks, namely the monetary policy shock, the export demand shock, the export income shock and the productivity shocks. He finds that output responses negatively to an unexpected increase in interest rates and an export income shock, and positively to an exogenous increase in the demand for Australian exports and a productivity shock.

This paper attempts to find the propagation mechanism that causes the business cycle fluctuations in Australia, especially in the 1982/83 recession and in the 1990/91 recession. We adopt the Business Cycle Accounting (BCA) developed by Chari, Kehoe, and McGrattan (hereafter referred to as CKM) (2007) in our study. The BCA has an advantage over previous techniques since it allows several propagation mechanisms to be studied in a prototype model. Therefore, we can find out which propagation mechanism is the most crucial that accounts for the fall in output.

We start with the Neoclassical growth model with identical households. Households maximize their utility functions subject to the budget constraint and the capital accumulation law. Firms maximize their profits with respect to the constant return to scale production function. Using the equilibrium conditions, we can obtain the four measured wedges. These wedges are the efficiency wedge, the labor wedge, the investment wedge and the government consumption wedge. The efficiency wedge represents the Solow residual in the production function. The labor wedge represents the artificial tax on labor income. In the intratemporal equilibrium, it is essentially the residual of the marginal substitution between consumption and leisure and the marginal product of labor. The investment wedge represents the artificial tax on investment. In the Euler equation, it is essentially the residual between the marginal product of capital and the intertemporal marginal rate of sustitution in consumption. The government consumption wedge represents public consumption expenditure plus net exports. By using the actual data with the equilibrium conditions, we can obtain four realized wedges. Then, we feed the realized wedges back into the model, separately and in combinations, in order to test the importance of each wedge in the model.

Using the quarterly data during 1965:Q3-2006:Q4, we find that the combination of the efficiency wedge and the labor wedge can account for the 1982/83 recession. Meanwhile, the efficiency wedge and the investment wedge account for the 1990/91 recession. Over a longer horizon of 1979 - 2006, the efficiency wedge can capture the movement of output remarkably well. Hence, business cycle studies for Australia should emphasize the propagation transmission through the efficiency wedge. The government wedge has a trivial role and can be ignored. It is noted that the investment wedge in our study has a depressive effect in the 1990/91 recession while that in CKM (2007) has an expansionary effect during recessions. Moreover, it is suggested that the detailed economy for Australia includes the efficiency wedge.

This paper is organized as follows. In section 2, the theoretical framework is presented. The BCA findings for Australia are unfolded in section 3. Section 4 provides the concluding remarks.

2 Theoretical Framework

2.1 The Benchmark Prototype Model

Note that all lowercase variables represent per capita values. Following CKM (2007), the economy comprises N_t identical representative households who maximize the expected utility subject to the budget constraint and the capital accumulation law. The utility function mainly depends on consumption (c_t) and leisure ($1 - l_t$) where l_t stands for labor. Time is normalized to one.

$$\max_{c_t, 1-l_t, k_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_{t,} 1 - l_t\right) N_t$$

subject to

$$c_t + (1 + \tau_{xt})x_t = (1 - \tau_{lt})w_t l_t + r_t k_t + tr_t$$

$$k_{t+1} = \frac{(1 - \delta)k_t + x_t}{(1 + \eta_t)}$$

where x_t is investment at period t

w_t is wage at period t

r_t is interest rates at period t

k_t is capital stock at period t

tr_t is lum-sum transfers at period t

β is the discount factor

δ is the depreciation rate of capital

η_t is the growth rate of population at period t

The production function is described by

$$y_t = A_t F\left(k_t, (1 + \lambda)^t l_t\right)$$

where y_t is output at period t

A_t is total factor productivity at period t

λ_t is the rate of labor-augmenting technical progress

Firms maximize their profit as follows:

$$\max_{k_t, l_t} A_t F\left(k_t, (1+\lambda)^t l_t\right) - r_t k_t - w_t l_t$$

The resource constraint is:

$$y_t = c_t + x_t + g_t$$

where g_t is government spending plus net export

According to CKM (2007), the four wedges are derived from the equilibrium equations and the resource constraint in the benchmark prototype economy. They are equivalent to the distortions that deviates an economy from a perfectly competitive equilibrium. Four wedges are:

- Efficiency wedge: A_t

$$A_t = \frac{y_t}{F\left(k_t, (1+\lambda)^t l_t\right)} \tag{1}$$

- Labor wedge: $(1 - \tau_t)$

$$1 - \tau_{lt} = -\frac{U_{lt}}{U_{ct}} \times \frac{1}{A_t(1+\lambda)^t F_{lt}} \tag{2}$$

- Investment wedge: $\frac{1}{1+\tau_{xt}}$

$$(1+\tau_{xt})U_{ct} = \beta E_t U_{ct+1} \left[A_{t+1}F_{kt+1} + (1-\delta)(1+\tau_{xt+1})\right] \tag{3}$$

- Government consumption wedge: g_t

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

3 BCA Exercise for Australia

3.1 The Accounting Procedure

Assume that the utility function is monotonically increasing and strictly concave as follows.

$$U\left(c_t, 1-l_t\right) = \frac{\left[c_t^{1-\phi}(1-l_t)^{\phi})\right]^{1-\sigma} - 1}{1-\sigma} \tag{5}$$

where $1/\sigma$ is the intertemporal elasticity of substitution

ϕ is the leisure preference

When σ is equal to 1, the utility function is reduced to

$$U\left(c_t, 1-l_t\right) = (1-\phi)\ln c_t + \phi \ln(1-l_t) \tag{6}$$

Furthermore, we assume that firms have identical production function which is characterized by a Constant Return to Scale (CRS) Cobb-Douglas function as below:

$$y_t = A_t k_t^{\alpha}\left(l_t\right)^{1-\alpha} \tag{7}$$

where α is capital share in output.

Therefore, time-varying wedges in this study are as below. Note that the variable with tilde represents the detrended actual per capita series.

- Efficiency wedge: A_t

$$A_t = \frac{\widetilde{y}_t}{\widetilde{k}_t^{\alpha}(l_t)^{1-\alpha}} \tag{8}$$

- Labor wedge: $(1-\tau_{lt})$

$$(1-\tau_{lt}) = \frac{\phi}{1-\phi} \times \frac{\widetilde{c}_t}{1-l_t} \times \frac{l_t^{\alpha}}{A_t(1+\lambda)^t(1-\alpha)\widetilde{k}_t^{\alpha}} \tag{9}$$

- Investment wedge: $\frac{1}{1+\tau_{xt}}$

$$(1+\tau_{xt})\times\frac{(1-\phi)}{\widetilde{c}_t}=\beta E_t\left\{\frac{(1-\phi)}{\widetilde{c}_{t+1}}\left[A_{t+1}\times\alpha\left(\frac{l_{t+1}}{\widetilde{k}_{t+1}}\right)^{1-\alpha}+(1-\delta)(1+\tau_{xt+1})\right]\right\} \tag{10}$$

- Government consumption wedge: g_t

$$\widetilde{g}_t=\widetilde{y}_t-\widetilde{c}_t-\widetilde{x}_t \tag{11}$$

3.2 Source of Data and Parameter Values

The data in our study cover the period between 1965:Q3 and 2006:Q4 since the data of average weekly hours worked are available from 1965:Q3 onwards. We obtain all data series from the Modellers' database of the Australian Bureau of Statistics website. The following data series are collected on the quarterly basis in chain volume measures, and they are seasonally adjusted: the household consumption, the private and the public gross fixed capital formation, changes in inventories, the government consumption excluding transfers, the exports, the imports and the GDP. Population in the model is represented by civilian non-institutional population aged 15-64. Average weekly hours worked and employed persons are on quarterly basis and seasonally adjusted.

The parameter values in our study are described on the annual basis as follows.

The share of capital income in total output (α) is 0.342. As suggested by Conesa, Kehoe and Ruhl (2007), the household net mixed income, apart from the indirect tax, should be considered when computing the labor share in income. This is because the payment to the self-employed workers and to unremunurated family workers should be excluded from the compensation of employees; otherwise, we may obtain a misleading result. Based on Conesa, Kehoe and Ruhl (2007), the labor share in income (1-α) is therefore as follows.

$$1 - \alpha = \frac{TotalCompensationOfEmployees}{GDP - NetMixedIncome - NetIndirectTaxes} \tag{12}$$

Using the data from 1960 to 2006, the labor share in income for Australia is 0.658 on average. In other words, the capital share in income is 0.342, given that the production function is constant returns to scale. Next parameter is the time allocation between leisure and consumption ($\frac{\phi}{1-\phi}$) which is 2.997. The discount factor (β) is 0.97. The depreciation rate (δ) is 5.6%. Population growth (η) is 1.67% on average during 1965-2006. The per capita labor-augmenting productivity growth (λ)is 1.81%.

3.3 Findings

The first step of BCA exercise is to obtain the measured wedges. These wedges are the efficiency wedge, the labor wedge, the investment wedge, and the government wedge from equation 14 to 17, respectively. Then, we feed the measured wedges back into the model, either one at a time or in combinations, in order to simulate the output from the model. Then, in order to assess the significance of wedges in generating the output fluctuation, we plot the actual output along with the simulated output with either one wedge at a time or in combinations, and evaluate the simulated output by both the direction of output movement and how close it can fit in with the actual output. In this study, we focus on the Australian output in two recession episodes. Figures 2 - 5 disclose the findings for the 1982/83 recession while figures 6 - 9 display the findings for the 1990/91 recession.

We start with the 1982/83 recession. Figure 2 compares the actual output to the models with one wedge at a time. It is apparent that the model with the efficiency wedge can replicate the movement of actual output better than other models. In other words, the efficiency wedge has strong ability to explain the movement in output. The labor wedge can also explain the output fluctuations to some extent. The government wedge has the least impact on output fluctuations. In the next step, the different combinations of two wedges are fed into the model for more simulations. The results are shown in figure 3 and figure 4. The difference between these two figures is that the models in figure 3 have included the efficiency wedge while the models in figure 4 have not. Based on the result in figure 2, the efficiency wedge seems to be the most crucial propagation mechanism. Without the efficiency wedge, the model cannot predict the movement of actual output as it can be seen in figure 4. In the same figure, the model with the investment wedge and the government wedges drive the predicted output into the wrong direction. Back to figure 3, the model with the efficiency wedge and lthe abor wedge has a better capability to capture the output fluctuations. It should be noted that the model with efficiency wedge and government wedge has produced a similar result to the model with the efficiency wedge alone in figure 2. This confirms the trivial role of government wedge. Lastly, we consider the models with a combination of three wedges. In figure 5, the model with the efficiency wedge, the labor wedge and the investment wedge can replicate the actual movement best. It is worth noting that the investment wedge has an expansionary effect in this recession episode. This only helps the prediction of the model better fits to the actual output. To sum up, our exercise suggests the significant role of the efficiency wedge and the labor wedge on the output fluctuation in the 1982/83 recession.

Next, we consider the 1990/91 recession. In figure 6, the model with the efficiency wedge and the model with the investment wedge are the best models to replicate the movement of actual output. The investment wedge has a depressive effect in this recession in contrast to the work by CKM (2007). CKM (2007) argue that the investment wedge is not a promising transmission mechanism of shocks. However, the combination of the efficiency wedge and the investment wedge does not improve the predict ability of the model. Instead, the combination of the efficiency wedge and the labor wedge gives a better result as shown in figure 7. In order to test the significance of the efficiency wedge, we exclude the efficiency wedge from the models as shown in figure 8. The predict ability of the model for output fluctuations becomes weaker. Lastly, the combination of three wedges in a model is demonstrated in figure 9. The model with the efficiency wedge, the labor wedge and the investment wedge can replicate the movement of actual output very well. In summary, we suggest the significant role of the efficiency wedge and the investment wedge in driving down the output during the 1990/91 recession episode.

The implication of the BCA exercise in this study is the significance of the efficiency wedge in both recession episodes. To find out whether the efficiency wedge is still significant besides the recession, we expand the time horizon to cover the period 1979:Q3 - 2006:Q4. In figure 10, the model with the efficiency wedge alone can explain the movement of output over the this period remarkably well. Moreover, when we estimate the standard deviations and the correlations of wedges and output components with the output over the entire sample period as suggested by CKM (2007), it supports the dominant role of the efficiency wedge in the output fluctuations. Table 1 - 4 display standard deviations and the correlations of wedges and output components with output during 1965:Q3 - 2006:Q4. Amongst four wedges in table 1, the efficiency wedge has the highest correlation with output at 0.66. However, the correlations of two wedges and output are either very small or negative as shown in table 2. In table 3, the movement of outputs due to the efficiency wedge has the highest correlation with output at 0.71. But, the standard deviation of the simulated output with efficiency wedges is also high which equals 145% of that of output. The cross correlation of the simulated output with two wedges and output in table 4 are either small or negative. To summarize, the descriptive statistics in table 1 - 4 affirms the efficiency wedge as a major propagation transmission in the longer time span. Furthermore, further research is warranted to examine why either the labor wedge or the investment wedge becomes important during the recession episodes while they play a small role beyond the episodes.

4 Concluding Remarks

The aim of this paper is to examine the propagation mechanism that causes the business cycle fluctuations in Australia, particularly the 1982/83 recession and the 1990/91 recession. We adopt the Business Cycle Accounting (BCA) developed by CKM (2007) in our study. We find that the combination of the efficiency wedge and the labor wedge is the best to account for the 1982/83 recession while either the efficiency wedge or the investment wedge are the promising mechanism transmission for the 1990/91 recession. The government wedge has a trivial role and can be ignored in both recession episodes. It is noted that the investment wedge in our study has a depressive effect in the 1990/91 recession while that in CKM (2007) has an expansionary effect during recessions.

Based on the BCA exercise in our study, it is suggested that the efficiency wedge remains in both recession episodes. Interestingly, from the 1982/83 recession to 1990/91 recession the role of the labor wedge becomes weaker while the role of the investment wedge becomes stronger.

References

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Table 1: Standard Deviation and Cross Correlation of Wedges with output during 1965:Q3 – 2006:Q4.

Wedges	**Standard Deviation Relative to Output**	**Cross Correlation of Wedge with Output at Lag k =**				
		-2	**-1**	**0**	**1**	**2**
Efficiency Wedge	**0.82**	**0.34**	**0.45**	**0.66**	**0.24**	**-0.02**
Labor Wedge	**1.75**	**0.06**	**0.22**	**0.42**	**0.52**	**0.53**
Investment Wedge	**1.33**	**0.30**	**0.30**	**0.14**	**0.19**	**0.16**
Government Wedge	**3.66**	**-0.06**	**-0.14**	**-0.18**	**-0.31**	**-0.30**

Table 2: Cross Correlations of the Wedges with Output during 1965:Q3 – 2006:Q4.

Wedges	**Cross Correlation of Wedge with Output at Lag k =**				
	-2	**-1**	**0**	**1**	**2**
Efficiency Wedge and Labor Wedge	**0.13**	**-0.02**	**-0.31**	**-0.29**	**-0.33**
Efficiency Wedge and Investment Wedge	**0.17**	**0.14**	**0.02**	**0.05**	**0.04**
Efficiency Wedge and Government Wedge	**-0.14**	**-0.08**	**0.09**	**0.16**	**0.22**
Labor Wedge and Investment Wedge	**-0.02**	**-0.02**	**-0.14**	**0.16**	**0.23**
Labor Wedge and Government Wedge	**-0.31**	**-0.42**	**-0.51**	**-0.46**	**-0.38**
Investment Wedge and Government Wedge	**-0.21**	**-0.30**	**-0.41**	**-0.34**	**-0.21**

Table 3: Standard Deviation and Cross Correlation of Output Components with Output during 1965:Q3 – 2006:Q4.

Output Components	Standard Deviation Relative to Output	Cross Correlation of Output Components with Output at Lag k =				
		-2	-1	0	1	2
Efficiency Wedge	**1.45**	**0.39**	**0.51**	**0.71**	**0.32**	**0.06**
Labor Wedge	**1.26**	**-0.19**	**-0.10**	**0.06**	**0.21**	**0.30**
Investment Wedge	**0.90**	**0.29**	**0.28**	**0.09**	**0.14**	**0.13**
Government Wedge	**0.42**	**-0.30**	**-0.42**	**-0.48**	**-0.47**	**-0.37**

Table 4: Cross Correlations of the Output Components with Output during 1965:Q3 – 2006:Q4.

Output Components	Cross Correlation of the Output Components with Output at Lag k=				
	-2	-1	0	1	2
Efficiency Wedge and Labor Wedge	**0.00**	**-0.18**	**-0.50**	**-0.36**	**-0.32**
Efficiency Wedge and Investment Wedge	**0.18**	**0.17**	**0.09**	**0.13**	**0.12**
Efficiency Wedge and Government Wedge	**-0.37**	**-0.43**	**-0.43**	**-0.19**	**-0.01**
Labor Wedge and Investment Wedge	**-0.19**	**-0.32**	**-0.60**	**-0.18**	**-0.02**
Labor Wedge and Government Wedge	**0.08**	**0.07**	**0.12**	**-0.11**	**-0.23**
Investment Wedge and Government Wedge	**-0.19**	**-0.30**	**-0.47**	**-0.33**	**-0.21**

Figure 1: Actual per capita annual GDP in Australia vs. its time trend at 1.8% and cyclical component during 1960-2006. (Logarithm scale)

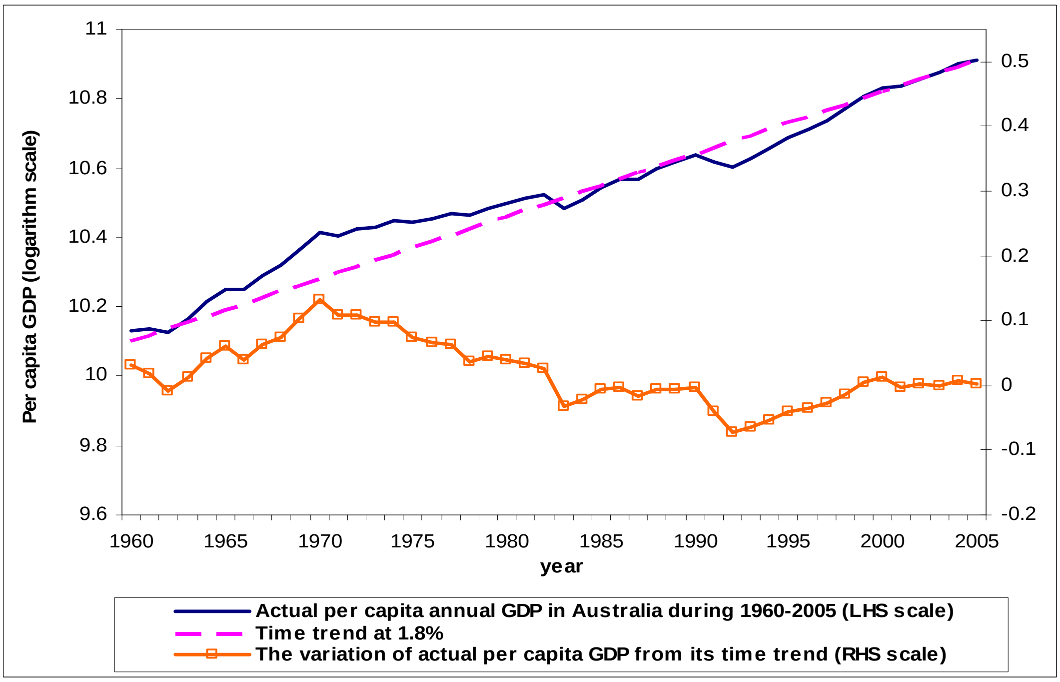

Figure 2: Detrended Actual Output vs. Models with One Wedge at a Time in Australia, 1979:Q3 – 1985:Q3, Normalized to equal 1 in 1979:Q3.

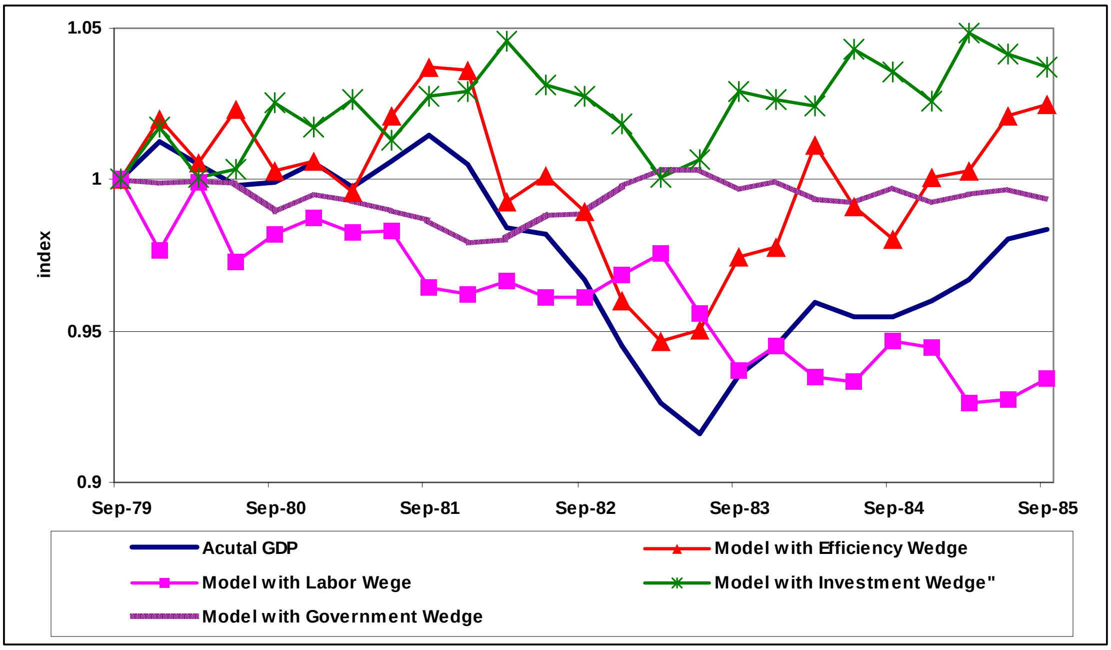

Figure 3: Detrended Actual Output vs. Models with A Combination of Efficiency Wedge and Another Wedge in Australia, 1979:Q3 – 1985:Q3, Normalized to equal 1 in 1979:Q3.

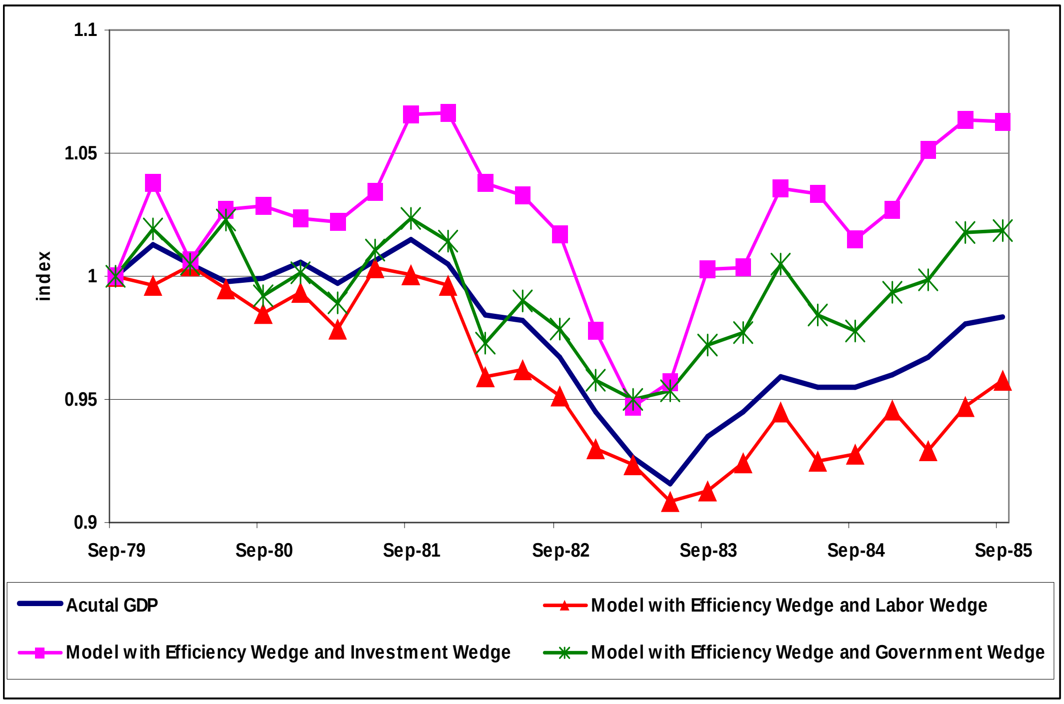

Figure 4: Detrended Actual Output vs. Models with A Combination of Two Wedges (No Efficiency Wedge) in Australia, 1979:Q3 – 1985:Q3, Normalized to equal 1 in 1979:Q3.

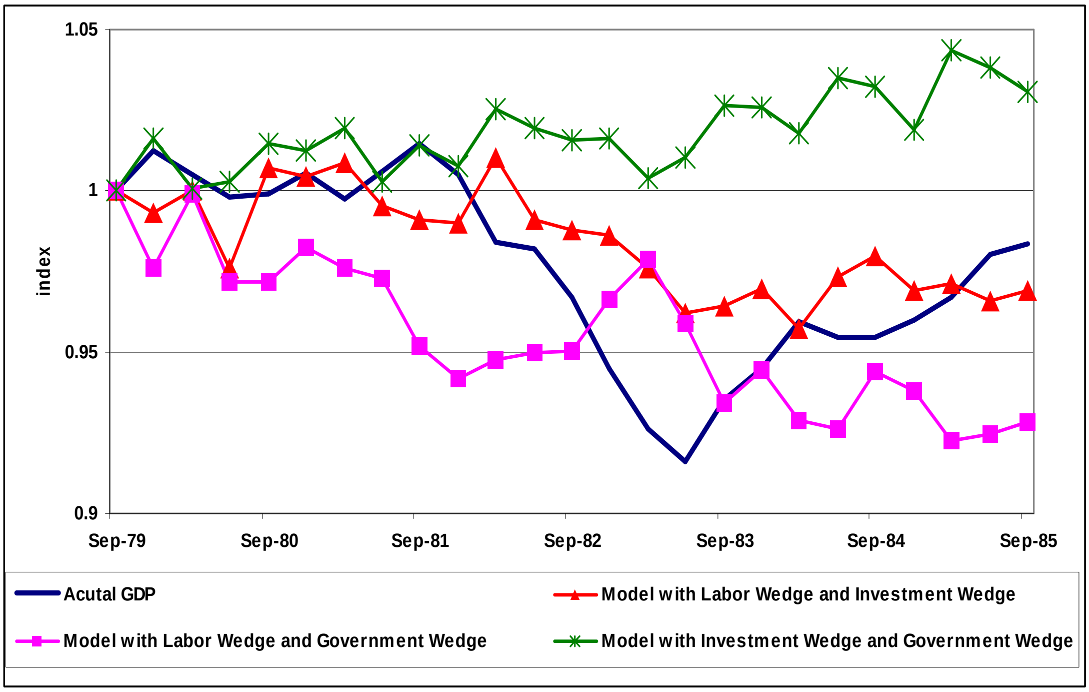

Figure 5: Detrended Actual Output vs. Model with a Combination of Three Wedges in Australia, 1979:Q3 -1985:Q3, Normalized to equal 1 in 1979:Q3.

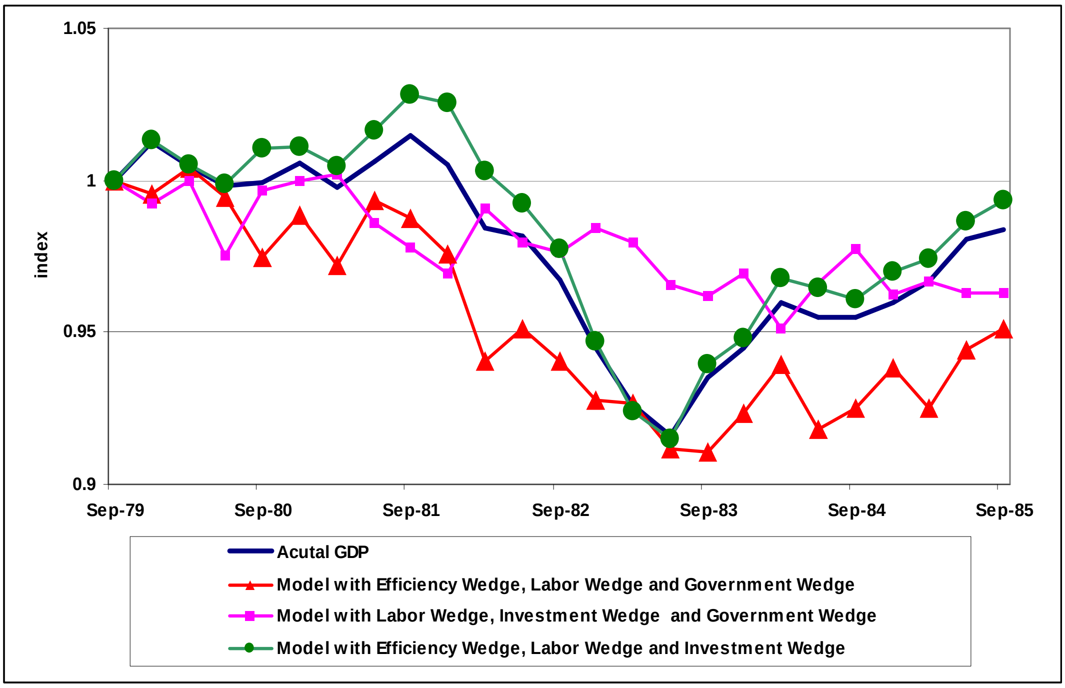

Figure 6: Detrended Actual Output vs. Models with One Wedge at a Time in Australia, 1989:Q3 – 1997:Q3, Normalized to equal 1 in 1989:Q3.

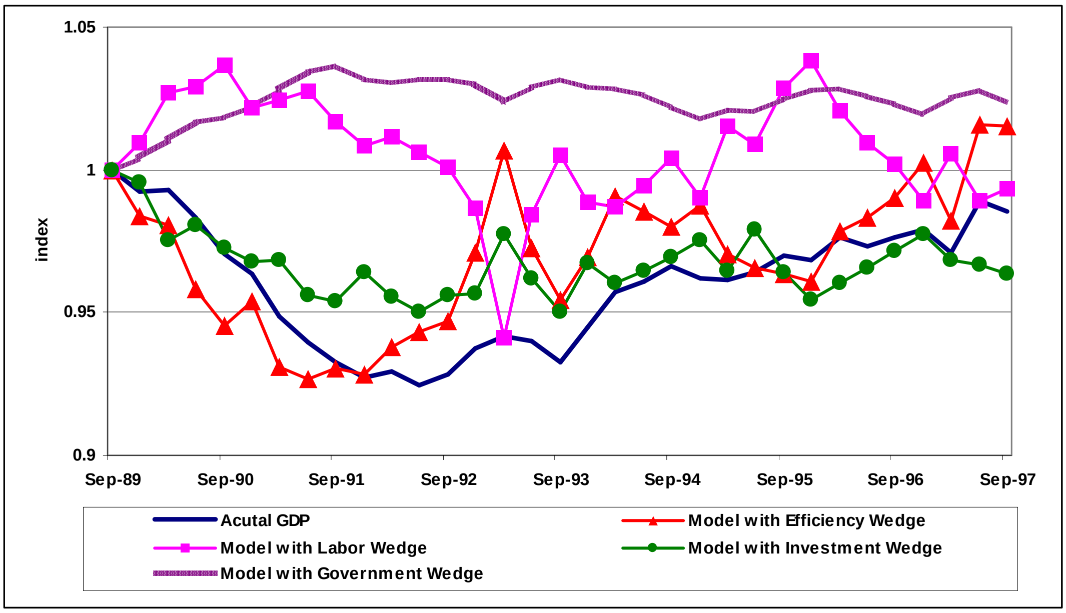

Figure 7: Detrended Actual Output vs. Models with A Combination of Efficiency Wedge and Another Wedge in Australia, 1989:Q3 – 1997:Q3, Normalized to equal 1 in 1989:Q3.

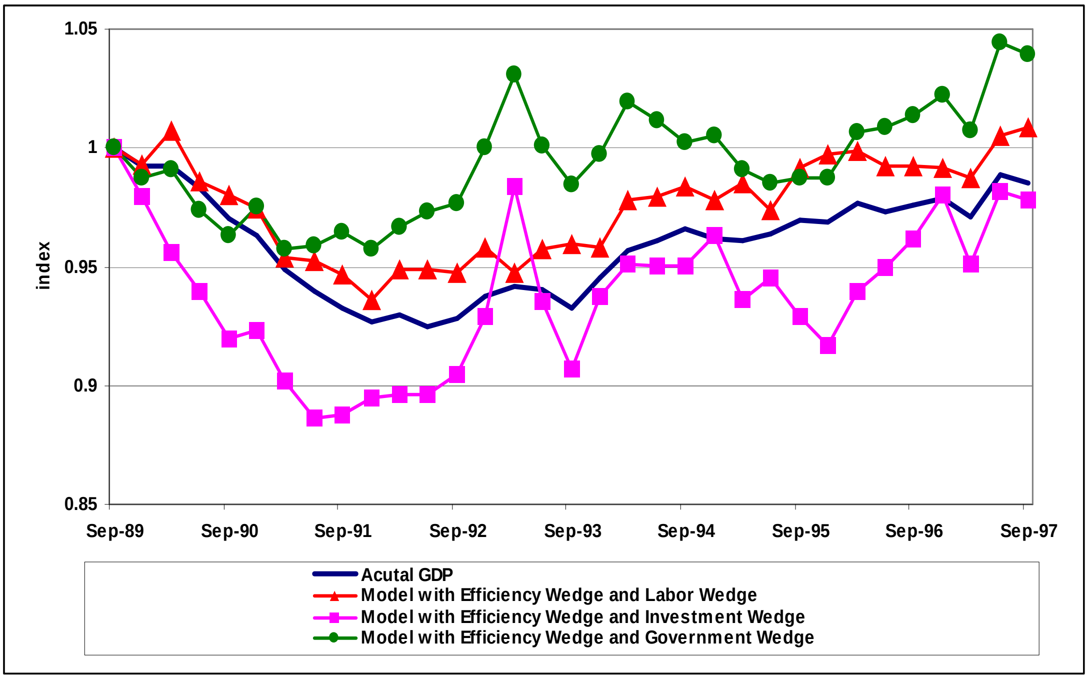

Figure 8: Detrended Actual Output vs. Models with A Combination of Two Wedges (No Efficiency Wedge) in Australia, 1989:Q3 – 1997:Q3, Normalized to equal 1 in 1989:Q3.

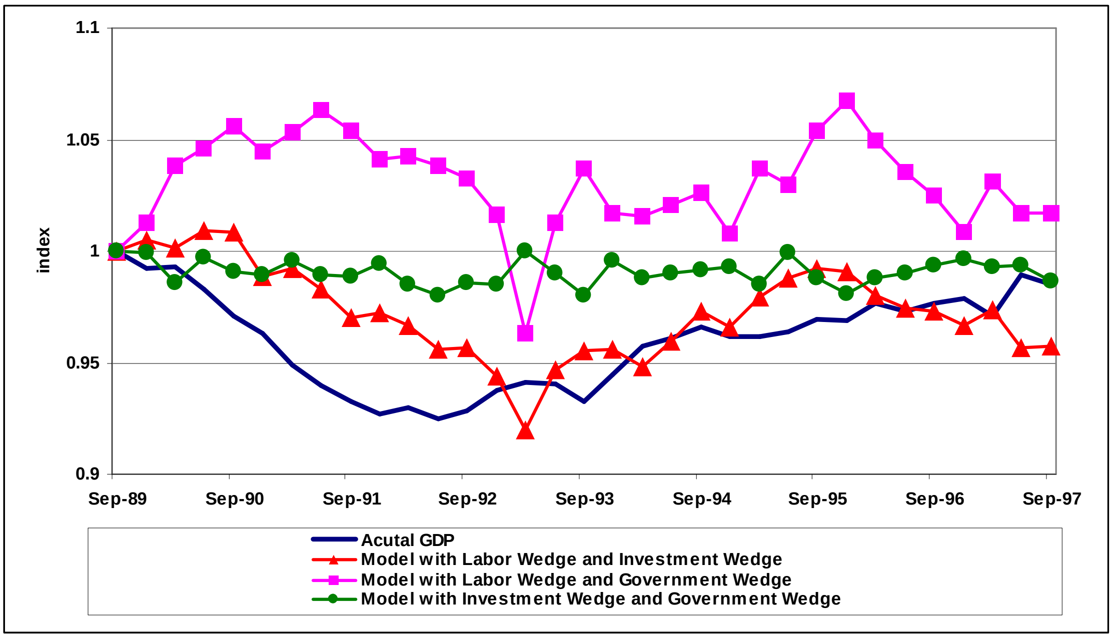

Figure 9: Detrended Actual Output vs. Model with a Combination of Three Wedges in Australia, 1989:Q3 -1997:Q3, Normalized to equal 1 in 1989:Q3.

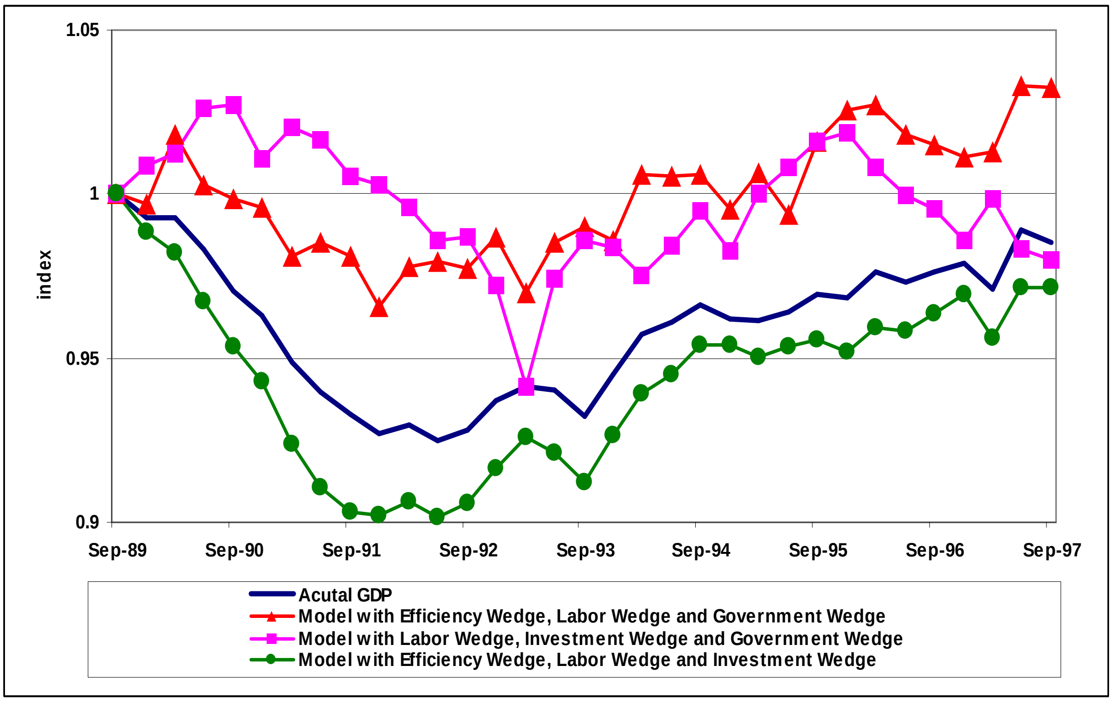

Figure 10: Detrended Actual Output vs. Model with the Efficiency Wedge alone in Australia, 1979:Q3 - 2006:Q4, Normalized to equal 1 in 1979:Q3.