WP/08/61

IMF Working Paper

Business Cycle Accounting For Chile

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INTERNATIONAL MONETARY FUND

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Western Hemisphere Department

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Authorized for distribution by Martin Mühleisen

March 2008

Abstract

This Working Paper should not be reported as representing the views of the IMF.
The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

We investigate sources of economic fluctuations in Chile during 1998-2007 within the framework of a standard neoclassical growth model with time-varying frictions (wedges). We analyze the relative importance of efficiency, labor, investment, and government/trade wedges for business cycles in Chile. The purpose of this exercise is twofold: (i) focus the policy discussion on the most important wedges in the economy; and (ii) identify which broad class of models would present fruitful avenues for further research. We find that different wedges have played different roles during our studied period, but that the efficiency and labor wedges have had the greatest impact. We also compare our results with existing studies on Argentina, Brazil, and Mexico.

JEL Classification Numbers: E32
Keywords: Business Cycle Accounting; Chile

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[1] We thank Ellen R. McGrattan for her code and her continuous help. We also thank Brieuc Monfort, Martin Mühleisen, James P. Walsh and Jeromin Zettelmeyer for their comments and suggestions. Research assistance provided by Zlatko Nikoloski is greatly appreciated. Ina Simonovska would also like to thank Costas Arkolakis for his comments and suggestions. All remaining errors are ours. This paper was written while Ina Simonovska was an intern at the Western Hemisphere Department of the IMF.

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I. Introduction

Chile has enjoyed an impressive economic performance over the past decade and a half. The country has been at the forefront among emerging markets in achieving macroeconomic stability and reducing economic vulnerabilities. Moreover, due to strong growth and pro-poor policies, per-capita income has tripled in U.S. dollar terms since 1990 and the poverty rate has been cut by two-thirds. A major challenge going forward is to maintain, or improve, this record. In this context, while Chile's growth potential remains high, it has no doubt declined in recent years. Indeed, average real GDP growth fell from well over 6 percent in the 1990s to just over 4 percent since. There are a number of plausible explanations for this slowdown. For example, by now Chile has strengthened its macroeconomic policy framework to a point where the marginal impact of further improvement may have declined. It is also probable that Chile has already harvested most of the "low hanging fruit" in terms of structural reforms.

Looking forward, Chile's economy needs to be adaptable to global competition and changing global economic circumstances, in order to weather both short-term shocks and longer-term trend changes. For example, there are questions regarding the flexibility of the labor market; hiring and firing costs are high by international standards, and labor participation relatively low, especially among women. In addition, the quality of human capital appears to lag countries at similar level of development, complicating skills-matching and retraining of the labor force. By contrast, Chile's financial system is generally well-developed, providing ample access to financing for households and large corporations. However, embryonic venture and risk capital markets limit financing for new and smaller firms, thereby hampering innovation and entrepreneurship. Other kinds of rigidities may also affect the efficiency of the Chilean economy, and its capacity to cope with shocks.

This study attempts to quantify the relative importance of the type of rigidities or shocks mentioned above for the cyclical behavior of Chile's economy during the 1998-2007 period. The analysis is based on the Business Cycle Accounting (BCA) approach developed by Chari, Kehoe, and McGrattan (2006b). Specifically, we introduce time-varying wedges to a standard neo-classical growth model, representing frictions in the labor and capital markets, and shocks to productivity and government spending or net exports. The purpose of this exercise is twofold: (i) focus the policy discussion on the most important wedges in the economy; and (ii) identify which broad class of models would present fruitful avenues for further research.

II. Analytical framework

Business Cycle Accounting, developed by Chari et al. (2006b), is a simple framework for analyzing the sources of business cycle fluctuations. This methodology is useful for identifying, within a unified framework, the dominating frictions or shocks within the economy. The underlying model is a standard neoclassical growth model, in which a number of time-varying 'wedges' (each representing different types of distortions or shocks) are introduced. The wedges are a labor wedge, an investment wedge, an efficiency wedge, and an 'income accounting' wedge, capturing government spending and net exports (referred to as government wedge in Chari et al., 2006b).

To see how these wedges work, consider a standard neoclassical growth model, with a representative consumer optimizing lifetime utility, derived from consumption and leisure. She maximizes her discounted lifetime utility subject to her budget constraint, law of motion of capital, and non-negativity constraints:

$$\max_{\{c_t, x_t, l_t\}} E \sum_{t=0}^{\infty} \beta^t U(c_t, 1 - l_t) N_t \quad \text{s.t.}$$

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

$$N_{t+1} k_{t+1} = [(1 - \delta) k_t + x_t] N_t$$

$$c_t, x_t \geq 0 \quad \text{in all states}$$

where c_t denotes consumption, l_t labor, x_t investment, k_t capital, r_t rental rate of capital, w_t wage rate, and N_t working-age population[2]. In the above equation, τ_{lt} can be compared to a time-varying tax on labor income, which interferes in the choice between consumption and leisure. All else equal, an increase in this implicit tax leads to a decrease in labor input. Similarly, τ_{xt} can be compared to a tax on investment, which interferes in the representative agent's intertemporal choice between consumption and investment. For purely presentational purposes, we will define $(1-\tau_{lt})$ as the *labor wedge* and $1/(1+\tau_{xt})$ as the *investment wedge*. This definition facilitates visual inspection of the wedges, with an increase in either wedge benefiting growth, just like an increase in the productivity level would. A more extensive discussion on the interpretation of the wedges is presented below.

The representative firm maximizes its profits from sales of final goods:

$$\max_{\{K_t, L_t\}} F(K_t, Z_t L_t) - r_t K_t - w_t L_t$$

where *Zt* represents the efficiency wedge modeled as labor-augmenting technical progress.

[2] In this paper, all lowercase-letter variables represent aggregate (uppercase-letter) variables per working-age person (population aged 15-64) rather than per capita. Bergoeing et al. (2001) argue that this is an appropriate choice since Chile experienced demographic transitions during the 1960-2000 period as population growth rates fell sharply and the percentage of working-age persons in the total population changed. This way, we ensure that no demographic changes are captured in the wedges of the model. In addition, all variables are divided by a labor endowment of 1250 hours per quarter.

Finally, equilibrium requires that the total amount of consumption, investment, and government goods is produced by the representative firm, as well as that capital and labor inputs used by the firm are supplied by the representative consumer, namely:

$$N_t(c_t+x_t)+G_t = F(K_t, Z_t L_t)$$

$$N_t k_t = K_t$$

$$N_t l_t = L_t$$

where G_t is the income accounting wedge, which captures government expenditures and net exports.

We assume the following functional forms for the production function

$$F(K, ZL) = K^{\theta}(ZL)^{1-\theta}$$

and the utility function

$$U(c, 1-l) = \log c + \psi \log(1-l)$$

where ψ is the relative weight of leisure in the utility function.

Hence, the first order conditions are as follows (for details on derivations, see Chari et al., 2006a):

$$\hat{c}_t + \hat{g}_t + (1+g_z)(1+g_n)\hat{k}_{t+1} - (1-\delta)\hat{k}_t = \hat{y}_t \tag{1}$$

$$\hat{y}_t = \hat{k}_t^{\theta}(z_t l_t)^{1-\theta} \tag{2}$$

$$\frac{\psi \hat{c}_t}{1-l_t} = (1-\tau_{lt})(1-\theta)\frac{\hat{y}_t}{l_t} \tag{3}$$

$$\frac{(1+\tau_{xt})}{\hat{c}_t} = \hat{\beta} E_t \frac{1}{\hat{c}_{t+1}}\left[\theta \frac{\hat{y}_{t+1}}{\hat{k}_{t+1}} + (1-\delta)(1+\tau_{xt+1})\right] \tag{4}$$

where g_z is trend growth in labor efficiency (Z) and g_n is working-age population growth, and:

$$\hat{x}_t = \frac{X_t}{N_t z_0 (1+g_z)^t}$$

The actual wedges are derived from the model and the data. The income accounting wedge $\hat{g}_t$ is taken directly from the data on government expenditure and net exports. The efficiency wedge z_t is computed from the production function. The labor wedge $(1-\tau_{lt})$ is calculated from the consumption-leisure condition and the investment wedge $1/(1+\tau_{xt})$ is calculated from the intertemporal consumption condition. Note that all wedges except the investment wedge can be derived directly from the data and static first-order conditions. The investment wedge needs to be estimated, as it depends not only on observable data but also on expectations. To do so, we follow Chari et al. (2006b) and assume that expectations follow an AR(1) process, in which next period's expected wedges can be fully determined by current period data and wedges. In particular, we loglinearize equations (1)-(4) around the steady state of the model and then use Maximum Likelihood Estimation in order to obtain the parameters that govern the processes of the four wedges above.[3]

All variables are expressed in per-capita (actually per-labor force) terms and all (except labor) are detrended by a labor productivity trend g_z. Hence, the productivity wedge shows the progress in productivity relative to this trend.

While the interpretation of the income accounting wedge is straightforward, it is important to keep in mind that the model cannot identify the precise nature of the other wedges. In fact, Chari et al. (2006b) demonstrate that a wide range of models including different types of frictions would produce the same first order conditions as our prototype model. Notably, the labor and investment wedges should not literally be interpreted as taxes. For example, the labor wedge could capture unionization or sticky wages and monetary shocks.

Moreover, the presence of credit restrictions or taxes/subsidies on consumption or capital income would all have similar effects on the investment wedge. Furthermore, if one introduces a consumption tax into the model it would be indistinguishable from the investment wedge. Hence, the latter should be thought of as capturing frictions on investment spending *relative* to consumption. This is important to keep in mind in the case of Chile, because consumer lending has developed significantly in recent years, not least in the form of department store credit cards, which have become available even to the lower-income population. Meanwhile, access to corporate credit remains relatively limited for smaller and less well-established companies.

Furthermore, the efficiency wedge captures the level of total factor productivity as well as any input-financing frictions. Hence, a degree of caution is warranted when interpreting the results. The point of the analysis is to determine which broad class of distortions have played

[3] Throughout this exercise, we use the solution method and estimation suggested by Chari et al. (2006a). In fact, we modify the original code generously provided by Ellen R. McGrattan in order to apply it to our study of Chile. We refer the reader to Chari et al. (2006a) and Chari et al. (2006b) for a detailed explanation of the accounting procedure.

the greatest role for variations in growth, employment, investment, and consumption. The results can also serve as guidance for the appropriate direction of a more detailed analysis.

In order to assess the importance of each wedge for the overall economy, the wedges are fed into the model one by one, and in combinations. Accordingly, to measure the effect of, say, the labor wedge, the model is run with all other wedges fixed at their first-period (Q1 1998) values. Thus, we can identify which one(s) of the four wedges best explains the observed economic fluctuations in Chile during the 1998-2007 period. Note that this is an accounting exercise; by definition, if all wedges are included simultaneously, the model returns the actual data.

A. Calibration

In order to solve the model, we first calibrate its parameters to match certain observed facts about Chile. The parameters we use in our benchmark calculations are summarized in Table 1 below.

Table 1: Parameter Estimates for Benchmark Economy

Parameter	Value	Source (Assume Chile is in SS in 1998Q1)
θ	0.3000	Bergoeing et al. (2001)
δ	0.0125	Bergoeing et al. (2001)
β	0.9939	Calibration
ψ	3.3631	Calibration
g_n	0.400%	Match 1.6% annual growth rate of population
g_z	0.500%	Assume 2% annual TFP growth rate

As can be seen from Table 1, we follow Bergoeing et al. (2001) in the use of the share of capital in the production function, θ, and the quarterly depreciation rate, δ. In fact, the authors find that, during the 1980s, the share of labor income in production for Chile is 0.53 (which corresponds to $\theta = 0.47$). However, they argue that the measured labor compensation in Chile fails to account for the income of most self-employed and family workers, who amount to a large portion of the total labor force. Moreover, as they point out, Gollin (2002) shows that, for countries for which there is sufficient data to adjust for this mismeasurement, θ tends to be close to the US estimate of 0.3. In Appendix 3, we present results with $\theta = 0.47$, but the qualitative nature of our findings remains unchanged.

Furthermore, Bergoeing et al. (2001) calibrate the annual depreciation parameter for Chile to 0.08 during the 80s and the 90s. However, they opt to use $\delta = 0.05$ (which corresponds to a quarterly depreciation rate of 0.0125) in their calculations because higher values yield an implausibly low capital-output ratio in Chile during the relevant period. In Appendix 3, we simulate the model using $\delta = 0.02$ (which corresponds to an annual depreciation rate of 0.08 as calibrated by Bergoeing et al. (2001)) and we find no qualitative difference in the results.

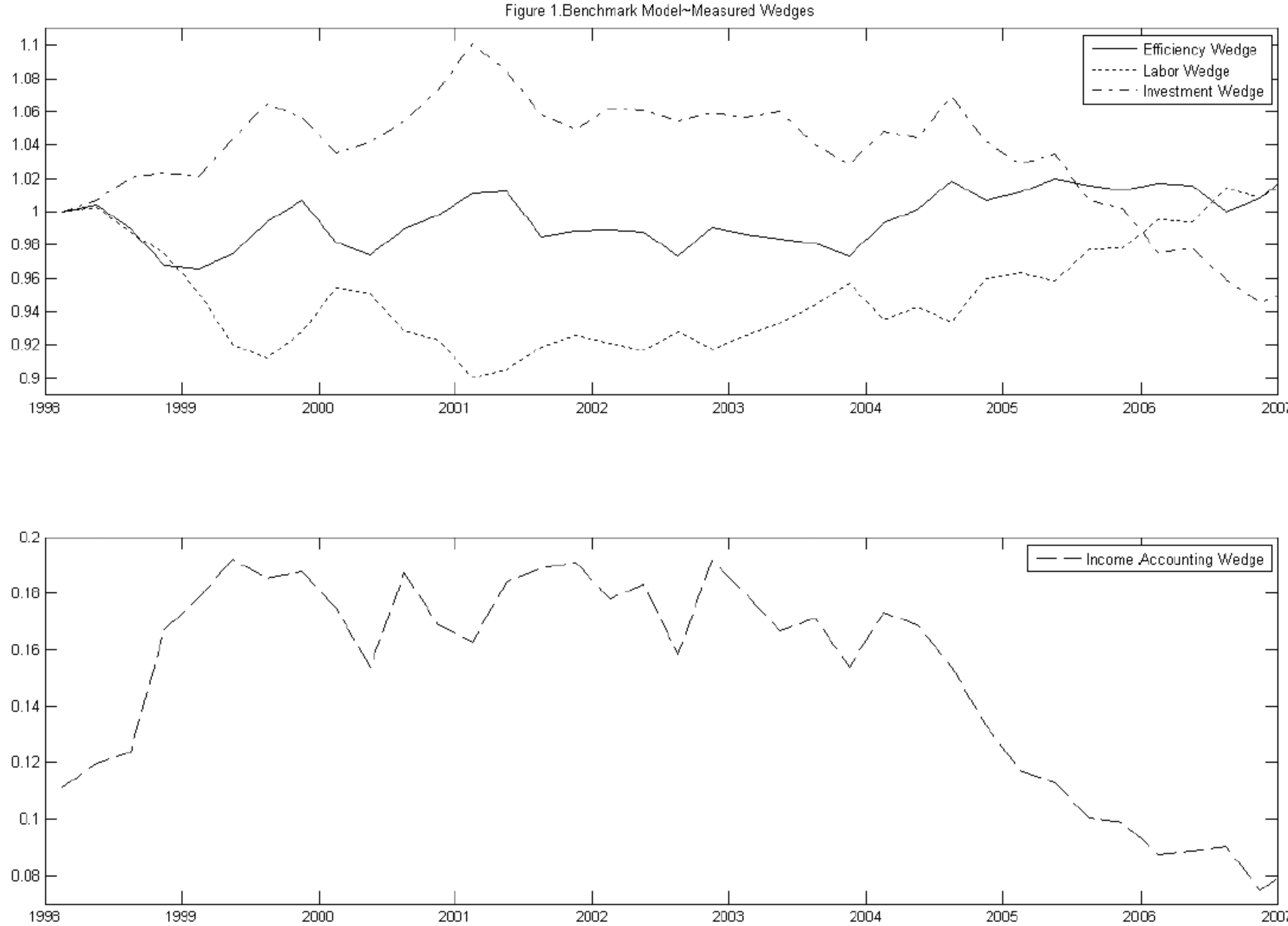
Notice that, in order to calibrate the model, we assume that our first-period observations, namely those corresponding to the first quarter of 1998, represent the steady state of the economy. Then, using the parameters suggested by Bergoeing et al. (2001), together with our data observations, we calibrate the discount factor and the weight of leisure in the utility function as well as the first-period capital stock and efficiency level, in order to satisfy equations (1)-(4) above. In doing so, we normalize the first-period labor and investment wedges to unity. We construct the capital stock according to the law of motion of capital, using actual investment data.

In addition, we take g_n to be the quarterly equivalent of the observed average annual growth rate of the working-age population during the studied period. Finally, we detrend all per-capita variables by the calibrated first-period efficiency level and a 2%-annual TFP growth rate, corresponding roughly to trend productivity growth in Chile during the studied period.

III. RESULTS

Using the calibrated model and quarterly aggregate variable data on Chile for the 1998-2007 period, we first compute the four wedges described in equations (1)-(4). Figure 1 below plots these wedges.

Figure 1.Benchmark Model~Measured Wedges



The upper figure plots the efficiency *(z_t)*, labor *($1-\tau_{lt}$)* and investment *($1/(1+\tau_{xt})$)* wedges normalized to their first-period realizations. The lower figure plots the government wedge ($\hat{g}_t$) as a fraction of total detrended per-capita output. Since the income accounting wedge is much more volatile than the remaining three wedges, we show it on a separate graph.

Notice that during the 1998–99 crisis in Chile, both the efficiency and the labor wedge fell. Since 2001, however, the labor wedge kept improving and it especially picked up starting in 2005. The latter is consistent with the surge in employment in Chile, and may capture recent structural improvements in the functioning of the labor market. As mentioned earlier, however, a more detailed model focusing on labor market imperfections would be required to gain insights into the precise nature of such structural improvements. Beginning in 2004, the efficiency wedge started to increase and surpassed its 1998 levels. Throughout most of the decade, however, both the efficiency and labor wedges remained below their 1998 levels indicating the presence of frictions in the labor or other input markets.

The income accounting wedge has been highly volatile throughout the period. Government consumption has increased in a relatively steady fashion from roughly 13% to 15% of output during the period. Thus, most of the volatility is due to changes in net exports. In particular, the sharp drop of the income accounting wedge beginning in 2004 is mostly due to the sharp increase in imports, which has been matched by increases in consumption and investment.

Finally, the investment wedge also appears to have been rising throughout most of the decade. However, beginning in mid-2004, it exhibits a sharp decline, consistent with the improved access to household credit in Chile mentioned earlier.[4] Notice, however, that the investment wedge exhibits strong negative correlation with the labor wedge, especially in years in which the labor wedge experiences spikes. A plausible explanation for this unexpected behavior of the investment wedge is that it is, in a sense, a residual. It is the only wedge that is estimated rather than taken directly from the data. Moreover, since the total effect of all wedges should by construction replicate the data, the investment wedge absorbs any estimation or calibration errors or exaggerated spikes in the data.

Figure 2 below shows the predictions of the model, simulated with each of the four wedges at a time, for total detrended per-capita output during the 1998-2007 period. In all four subplots, the solid line represents the actual data plotted relative to the first-period observation; other lines correspond to output simulations using one particular wedge.

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[4] Recall that one interpretation of the investment wedge is the relative ease of financing of investment versus consumption.

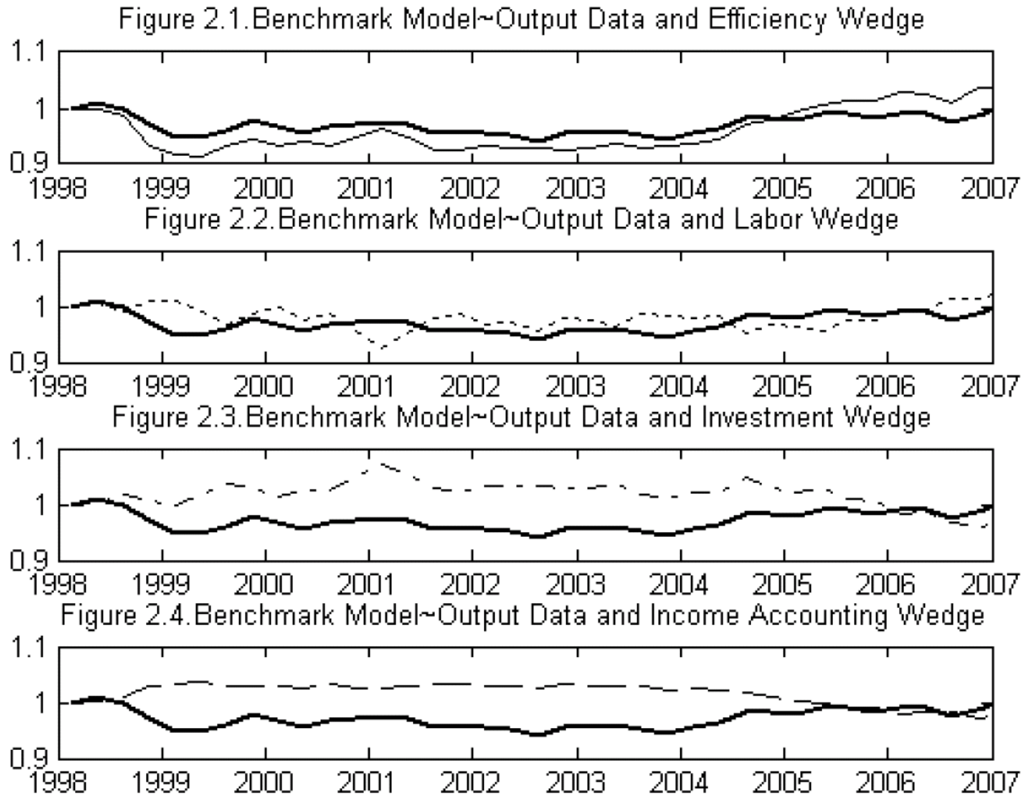


Figure 2.1.Benchmark Model~Output Data and Efficiency Wedge

Figure 2.2.Benchmark Model~Output Data and Labor Wedge

Figure 2.3.Benchmark Model~Output Data and Investment Wedge

Figure 2.4.Benchmark Model~Output Data and Income Accounting Wedge

In 1998, Chile experienced a crisis and thus a drop in output. However, (detrended per-capita) output remained below its 1998 level throughout most of the decade. It began to recover in 2004 and reached its 1998 level in 2007.

Overall, the efficiency wedge does the best job predicting the movement in output in Chile during the 1998-2007 period. Although it tracks the direction of movement of actual output very well, the efficiency wedge overpredicts the fall in output until 2005 and also overpredicts its recovery since.

At the beginning of the 1998–99 crisis, the labor wedge predicts a fall in output. However, overall, it does a poor job explaining the remainder of the crisis. It appears to explain the movement in output during the 2002–03 period well and it predicts a recovery beginning in mid-2004 as well.

The investment wedge does not predict the observed movements in output particularly well, while the income accounting wedge predicts counterfactual movements in output. The latter is consistent with the findings of Chari et al. (2005) for the Mexican crisis in the mid-1990s. The authors argue that when a sudden stop occurs, the fall in the capital account must be balanced out by an increase in the current account, namely an increase in net exports due to a fall in imports. In and by itself, this would stimulate output, but this impact is obviously superseded by other manifestations of the sudden stop. Nevertheless, this explains why the income accounting wedge counterfactually predicts that, during the crisis, output should increase rather than decrease. Similarly, the income accounting wedge predicts a fall in output rather than a recovery beginning in 2004.

Our results are consistent with similar studies on other Latin American countries. Graminho (2004) uses the BCA approach and finds that the efficiency wedge plays a central role in explaining the fluctuations of the major aggregates in the Brazilian economy during the 1980–2000 period. Applying a slightly modified BCA model, Lama (2005) finds that business cycle fluctuations in the 1990s were mostly explained by the labor wedge in Argentina, and by efficiency fluctuations in Brazil and Mexico. Using a standard growth accounting methodology, Bergoeing et al. (2001, 2002a, and 2002b), find that total factor productivity fluctuations play a central role in explaining the behavior of output in Chile and Mexico during the 1980s and 1990s.

We have also simulated the impact of each wedge on hours worked, investment, and consumption (see Appendix 2). Overall, the efficiency wedge plays a central role in explaining the movement in investment and hours, while the income accounting wedge predicts the observed fall in consumption.

IV. Alternative Specification: Adjusting for Copper investment

Chile is the biggest copper producer in the world, and while mining as a percentage of total GDP is in the single digits, copper exports and copper-related investment can be quite substantial and volatile. Under the plausible assumption that resource extraction behaves differently than the rest of the economy, it would be of interest to replicate the BCA exercise on the non-mining sector of the Chilean economy. Unfortunately, available data do not permit isolating the mining sector's share in consumption, investment, and imports. Moreover, apart from mining revenues to the government, no data are available on flows between the mining and non-mining sectors. The latter may be of less concern, since the copper sector can be looked at as an enclave, with only limited links to the rest of the economy.

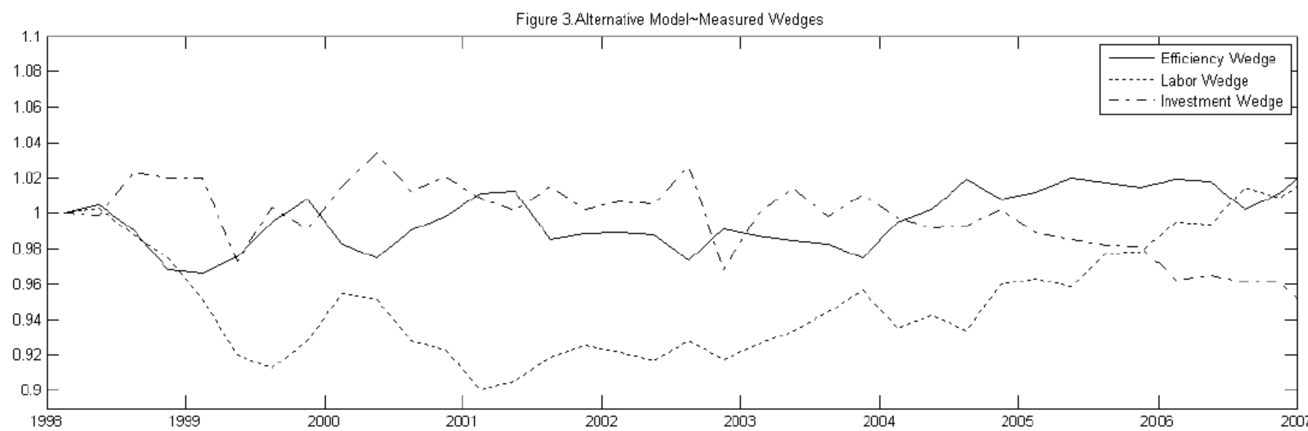
We do, however, have annual data on mining FDI. As a sensitivity check, we make a rough attempt to correct the investment wedge for mining investment. For this purpose, we are forced to make a number of simplifying assumptions. First, we approximate mining investment by mining FDI. On one hand, this ignores the fact that a part of FDI is for purposes other than investment, and on the other it neglects investment by CODELCO, the Chilean state-owned copper company. Secondly, because we have sectoral FDI data only at an annual frequency, we assume the mining sector's share of FDI constant throughout the year. We then subtract mining FDI from the quarterly investment observations and move it to the income accounting wedge. Clearly this is just a partial solution, in that we cannot adjust for mining on the supply side, as long as we do not have full information on the sector's demand components. However, this should not be a major shortcoming, since mining is a relatively small and stable share of total GDP.

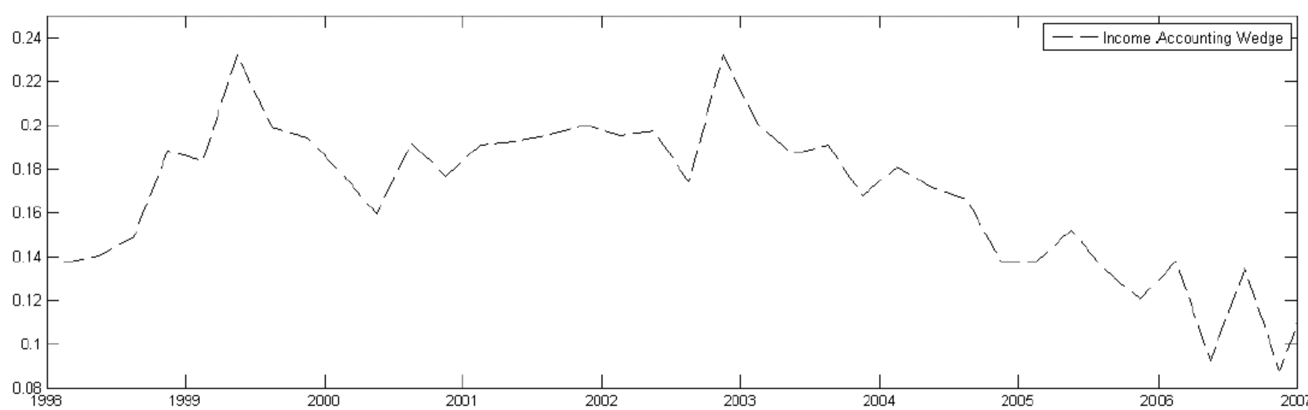
We replicate the calibration procedure to the benchmark model using the modified data series. The results are reported in Table 2 below. We consider this our preferred model, and as such, we also present more detailed results on hours worked, investment, and consumption. The results are similar to those from the benchmark model above. In the calibration, only the parameter β changes, since we only modified the definition of investment.

Table 2: Parameter Estimates for Alternative Economy

Parameter	Value	Source (Assume Chile is in SS in 1998Q1)
θ	0.3000	Bergoeing et al. (2001)
δ	0.0125	Bergoeing et al. (2001)
β	0.9915	Calibration
ψ	3.3631	Calibration
g_n	0.400%	Match 1.6% annual growth rate of population
g_z	0.500%	Assume 2% annual TFP growth rate

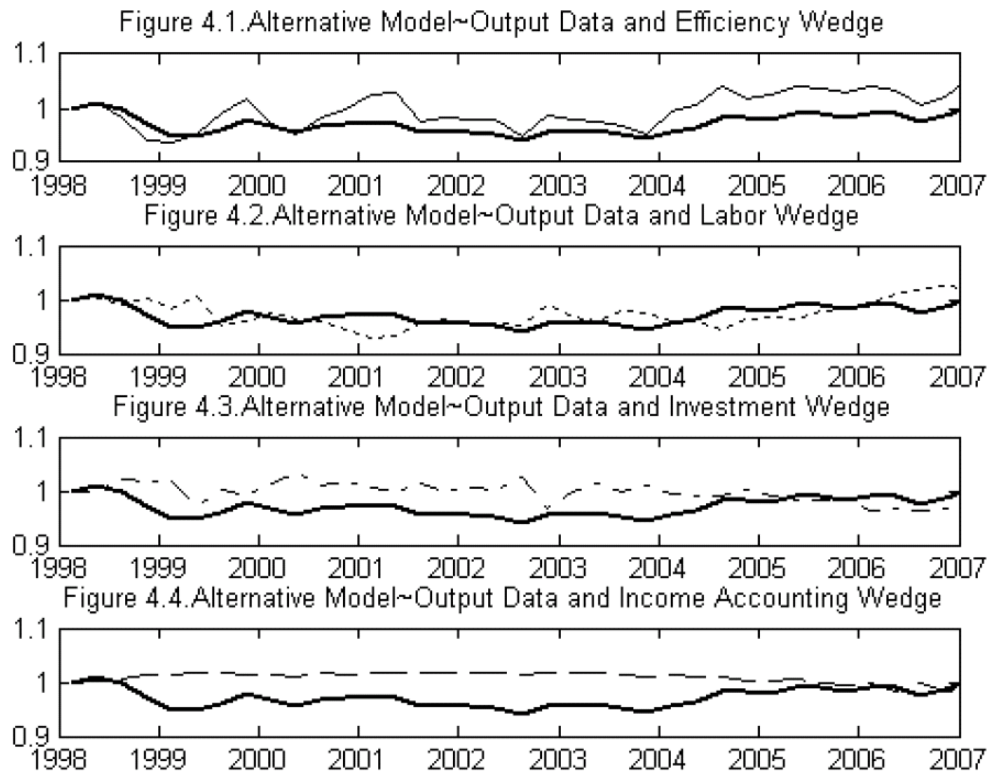
Figure 3 below plots the four wedges of the alternative model.





Notice that, in contrast to Figure 1, the investment wedge no longer shows a strong negative correlation with the labor wedge. In addition, the investment wedge falls below trend in certain periods and shows a strong decline starting in 2005 as in Figure 1. The income accounting wedge, which now incorporates mining investment, is slightly more volatile than before, but maintains its downward trend in recent years consistent with Figure 1. As expected, the labor wedge remains unchanged, since it is computed directly from the aggregate data series. The efficiency wedge differs only slightly from the previous exercise.

Figure 4 below shows the predictions of the model adjusted for mining FDI, simulated with each of the four wedges at a time, for total detrended per-capita output during the 1998–2007 period.



Notice that the efficiency wedge still tracks the direction of the movement of output best. However, in late 1999 and early 2001, it predicts that output should be slightly above its 1998 realization, which is in contrast with the data. Also, the recovery the efficiency wedge predicts in this case is much stronger than in the benchmark model.

Although the labor wedge still portrays some counterfactual movements in output, it explains the behavior of output in the latter part of the crisis until mid-2000, and also from mid-2001 until mid-2002, which are precisely the periods in which the efficiency wedge predicts that output would be too high.

The investment wedge still does not explain the movements in output very well, while the income accounting wedge gives contrary predictions as discussed earlier.

Figure 5.1.Alternative Model~Investment Data and Efficiency Wedge

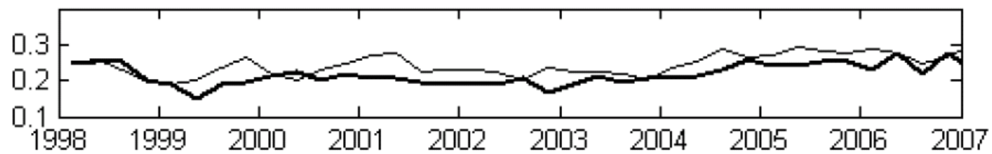


Figure 5.2.Alternative Model~Investment Data and Labor Wedge

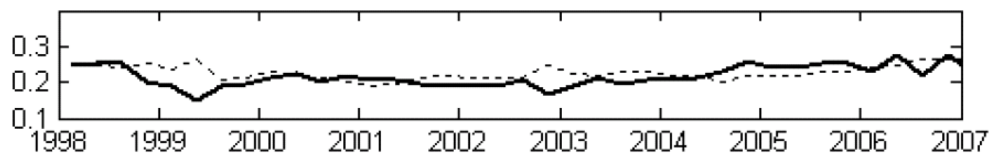


Figure 5.3.Alternative Model~Investment Data and Investment Wedge

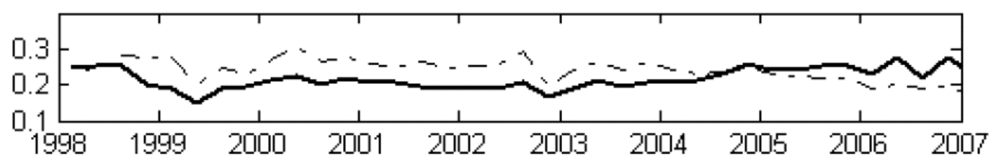


Figure 5.4.Alternative Model~Investment Data and Income Accounting Wedge

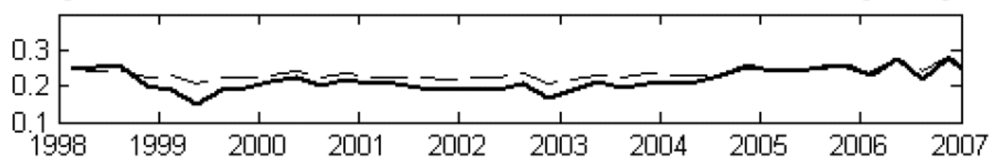
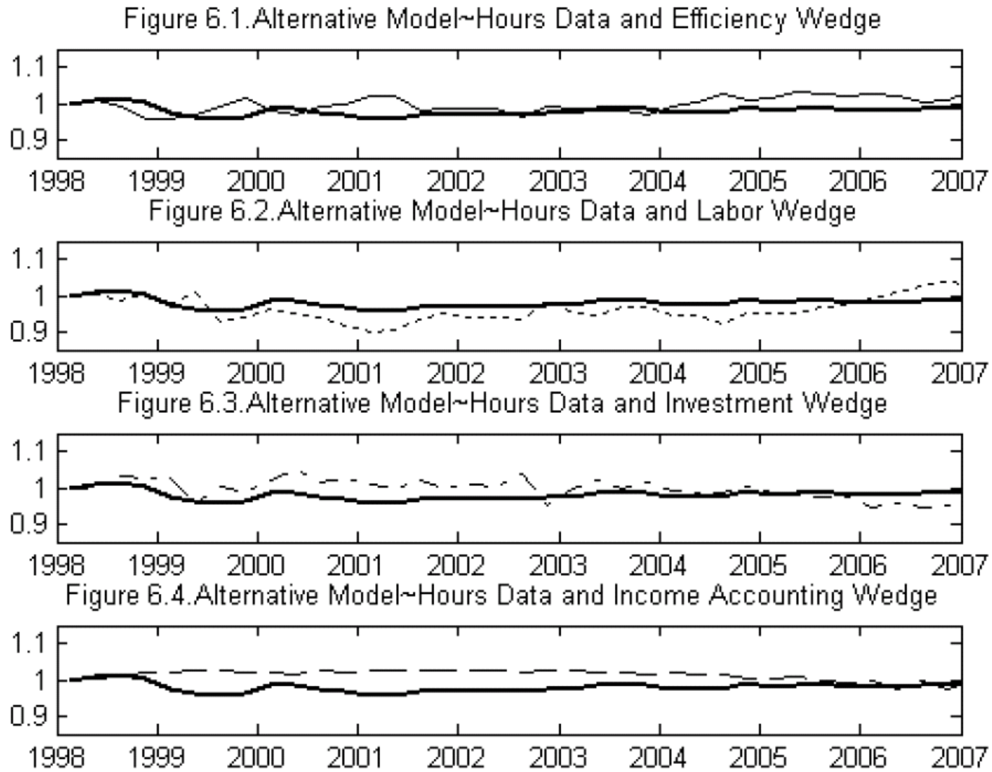
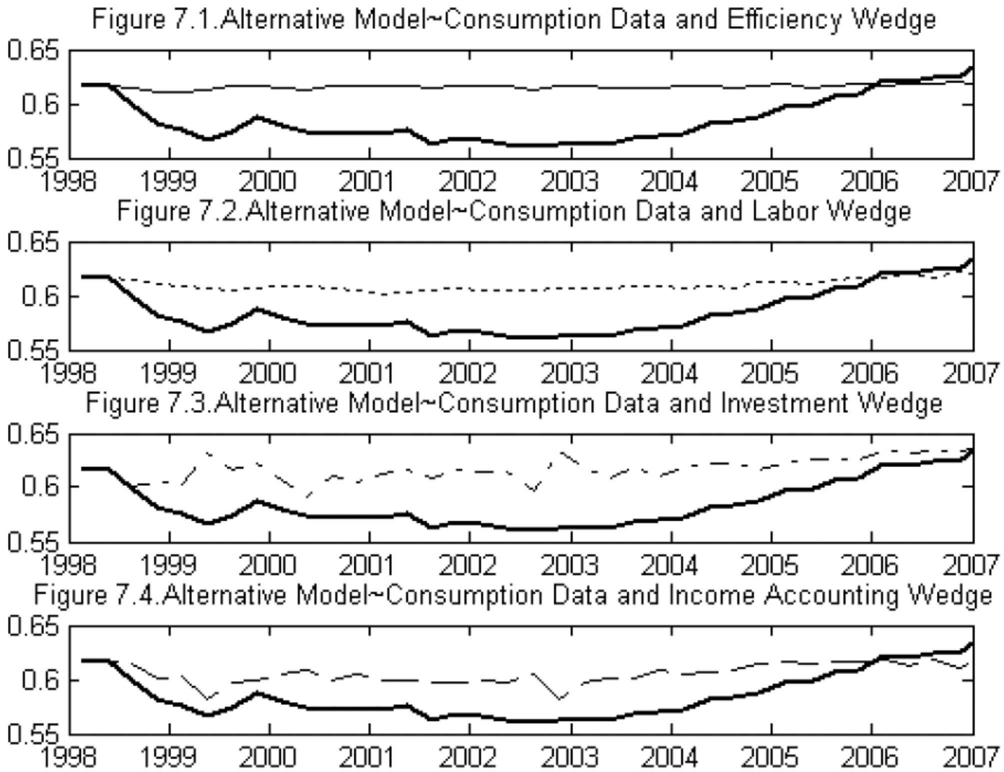


Figure 5 above plots predicted and actual investment. Although the efficiency wedge generally tracks the actual movements of investment, the income accounting wedge does a much better job at explaining investment. This may at first come across as puzzling since the investment series no longer contain the mining FDI component, while the income accounting wedge does. However, since the income accounting wedge is largely driven by changes in net exports, it is not surprising that it does a fair job at explaining investment movements as investment goods in Chile are predominantly imported. Finally, although the investment wedge does not generate enough of a fall in investment throughout the period, it does track the direction of investment movements very well for a large part of the decade. Beginning in 2005, it does however predict a much larger fall in investment as it captures the increase in consumer credit discussed earlier.



The movements in total hours worked do not seem to be explained very well by any particular wedge (Figure 6), although the efficiency and labor wedges do explain the general behavior of these series during certain sub-periods. Both wedges, however, predict a much higher volatility in hours than suggested by the data. Total hours worked are calculated as the product of total quarterly employment, average weekly hours worked per person, and the number of weeks in a quarter. Since average weekly hours worked per person were only available at an annual basis (see Appendix 1 for details), this may be contributing toward the smoothness of the series.

It is interesting to note that actual hours worked did not fall immediately as the 1998–99 crisis took place, but rather seem to show a downward trend with a lag. As expected, the efficiency wedge predicts a fall in hours and a recovery consistent with the movements in output shown in Figure 4. The labor wedge predicts a much larger fall in hours throughout most of the period as well as a much stronger recovery than actually observed, which may in part be due to data issues (see Appendix 1). Finally, the income accounting wedge predicts a rise in hours throughout the period, which is consistent with its “sudden-stops” predictions for output discussed earlier.



The efficiency and labor wedges are poor predictors of movements in consumption (Figure 7). In general, the benchmark model produces rather smooth consumption series due to the assumption of rational expectations and the representative consumer's consumption-smoothing preferences. However, the income accounting wedge does predict a drop in consumption, especially during the crisis. Again, as in the case of investment, this may be driven by the changes in net exports as consumption goods to a large degree are imported. Finally, notice that the investment wedge correctly predicts an increase in consumption in recent years, consistent with the consumer credit increase discussed earlier.

V. Conclusions and Policy Recommendations

In summary, our business cycle accounting exercise suggests that productivity and labor market considerations best explain the behavior of aggregate economic variables in Chile throughout the 1998–2007 period. The investment wedge does not appear to play a major role in explaining the observed patterns of aggregate data, except in recent years, when it correctly predicts an increase in consumption relative to investment. The latter is consistent with the increased access to credit on the part of the consumers. Finally, the income accounting wedge generates counterfactual predictions for output when the economy experiences a sudden stop, but it does explain the observed movements in investment and consumption rather well.

The predictive power of the efficiency and labor wedges suggests that labor market rigidities should be a focus for policy. In addition, the results from the model with an investment wedge suggest that policy should also focus on improving access to corporate credit along the lines of the consumer credit market improvements already observed in Chile. However, specific policy recommendations would require a closer look at a more detailed model that incorporates frictions that manifest themselves as efficiency and/or labor wedges.

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APPENDIX 1. DATA SOURCES AND CALCULATIONS

Table 1. Quarterly Data for Chile, 1998–2007

Code	**Description of Data**	**Unit**	**Source**
O.1	Gross Domestic Product	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.2	Total Consumption	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.3	Gross Fixed Capital Formation	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.4	Change in Inventories	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.5	Government Consumption	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.6	Exports of Goods and Services	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.7	Imports of Goods and Services	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.8	Employment: Quarterly Moving Average Ended in Specified Month	(SA by Haver, Thousands)	Instituto Nacional de Estadíticas
O.9	Net VAT Revenue	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.10	Import Duties	(SA, Mil.2003.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.I.1	Total FDI (Liabilities in Chile)	(NSA, Mil.US$)	Banco Central de Chile
O.I.2	Exchange Rate	(Ch$/US$)	Banco Central de Chile
O.I.3	Gross Fixed Capital Formation	(SA, Mil.Ch Pesos)	Banco Central de Chile/Haver Analytics
O.I.4	Change in Inventories	(SA, Mil.Ch Pesos)	Banco Central de Chile/Haver Analytics

Table 2. Annual Data for Chile, 1998–2007

Code	Description of Data	Unit	Source
O.11	Population ages 15-64[1/]	(Thousands)	WBWDI
O.12	Hours actually worked, Men and Women (Weekly Average Hours)[2/, 3/]	(Hours per Person)	ISIC-Rev.2
O.I.5	Mining fraction of FDI	(NSA, Fraction of Total)	

1/ Only available for 1998–2004. In this paper we assume that population grows at a constant rate given by the quarterly equivalent of the annual growth rate of the available observations.

2/ Only available for 1998–2005. We take the 2005 observation for 2006–07. Since weekly hours per person have been declining in Chile, a linear interpolation of the last two observations resulted in estimates that were too low.

3/ We assume that the yearly observation does not change for different quarters and use it as if it were quarterly data. As discussed below, the relevant variable in the paper, namely total hours worked, is calculated using employment for which quarterly data is available.

Table 3. Constructed Data for Chile, 1998-2007[1/]

Code	Description of Variable
C.1=O.1-O.9-O.10	Yt = GDP - Net Vat Revenue - Import Duties
C.2=O.2-O.5	Ct = Total Consumption - Gov't Cons – VAT - Import Duties
C.3=O.3+O.4	Xt = Gross Fixed Capital Formation + Change in Inventories
C.4=O.5+O.6-O.7	Gt = Gov't Consumption + Exports - Imports
C.5=O.11 repeated quarterly	Population (Yearly Observation Repeated 4 Times)
C.6=% Changes in C.5	γ_n = Population Growth Rate
C.8=O.12 quarterly	Average Weekly Hours Actually Worked
C.9=C.8*O.8*52/4	Lt = Total Hours Worked per Quarter

1/ Original and constructed data series available from authors upon request.

APPENDIX 2. RESULTS FROM BENCHMARK MODEL

This sections reports the results for investment, hours worked, and consumption from the benchmark model. Figures A2.1-A2.3 summarize our findings.

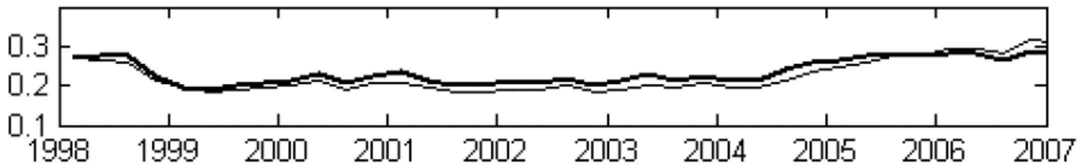


Figure A2.1.1.Benchmark Model~Investment Data and Efficiency Wedge

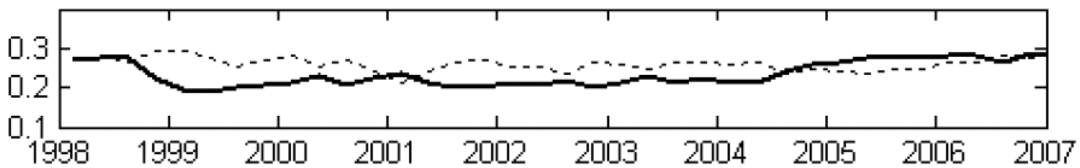


Figure A2.1.2.Benchmark Model~Investment Data and Labor Wedge

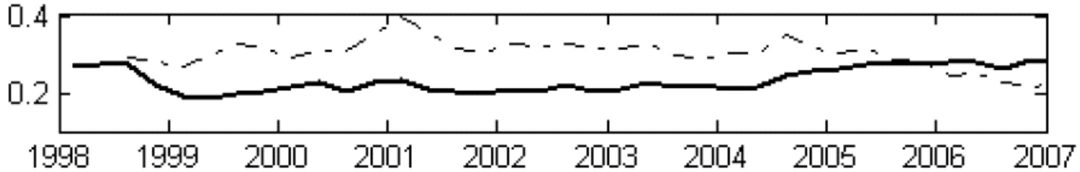


Figure A2.1.3.Benchmark Model~Investment Data and Investment Wedge

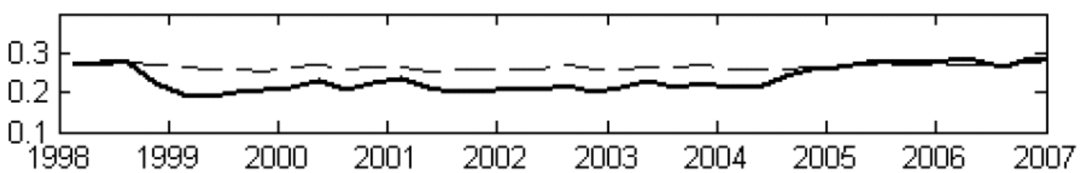


Figure A2.1.4.Benchmark Model~Investment Data and Income Accounting Wedge

Figure A2.2.1.Benchmark Model~Hours Data and Efficiency Wedge

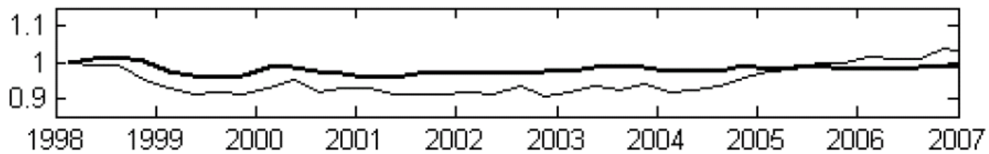


Figure A2.2.2.Benchmark Model~Hours Data and Labor Wedge

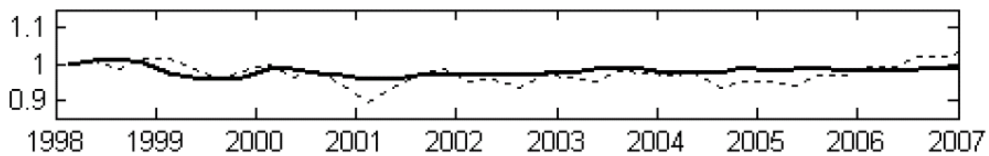


Figure A2.2.3.Benchmark Model~Hours Data and Investment Wedge

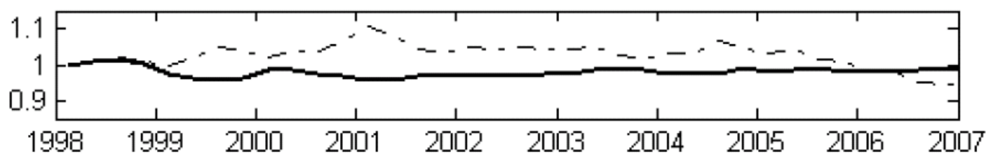


Figure A2.2.4.Benchmark Model~Hours Data and Income Accounting Wedge

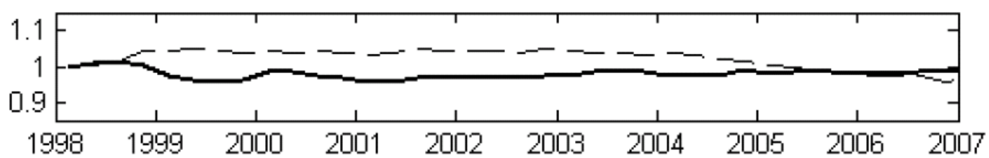


Figure A2.3.1.Benchmark Model~Consumption Data and Efficiency Wedge

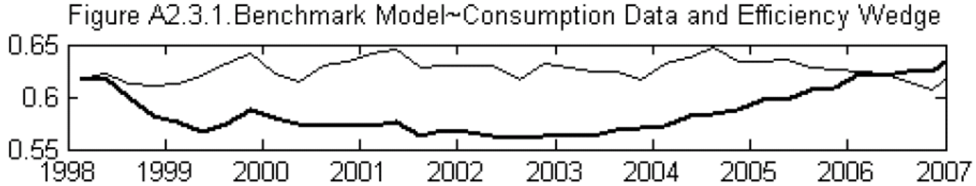


Figure A2.3.2.Benchmark Model~Consumption Data and Labor Wedge

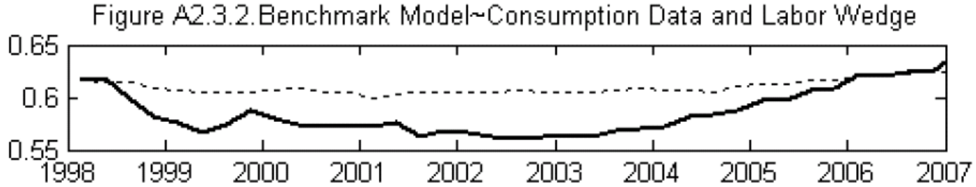


Figure A2.3.3.Benchmark Model~Consumption Data and Investment Wedge

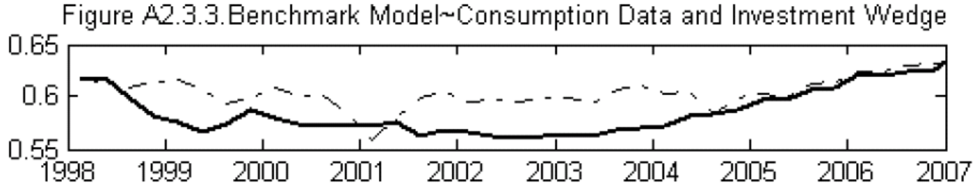
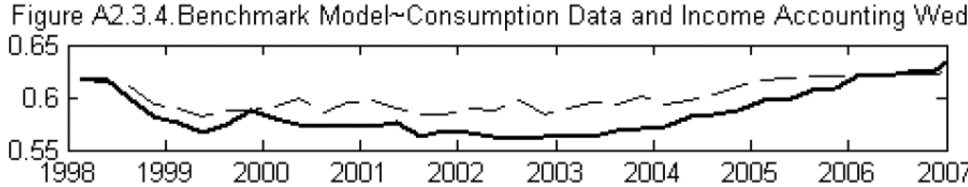


Figure A2.3.4.Benchmark Model~Consumption Data and Income Accounting Wedge



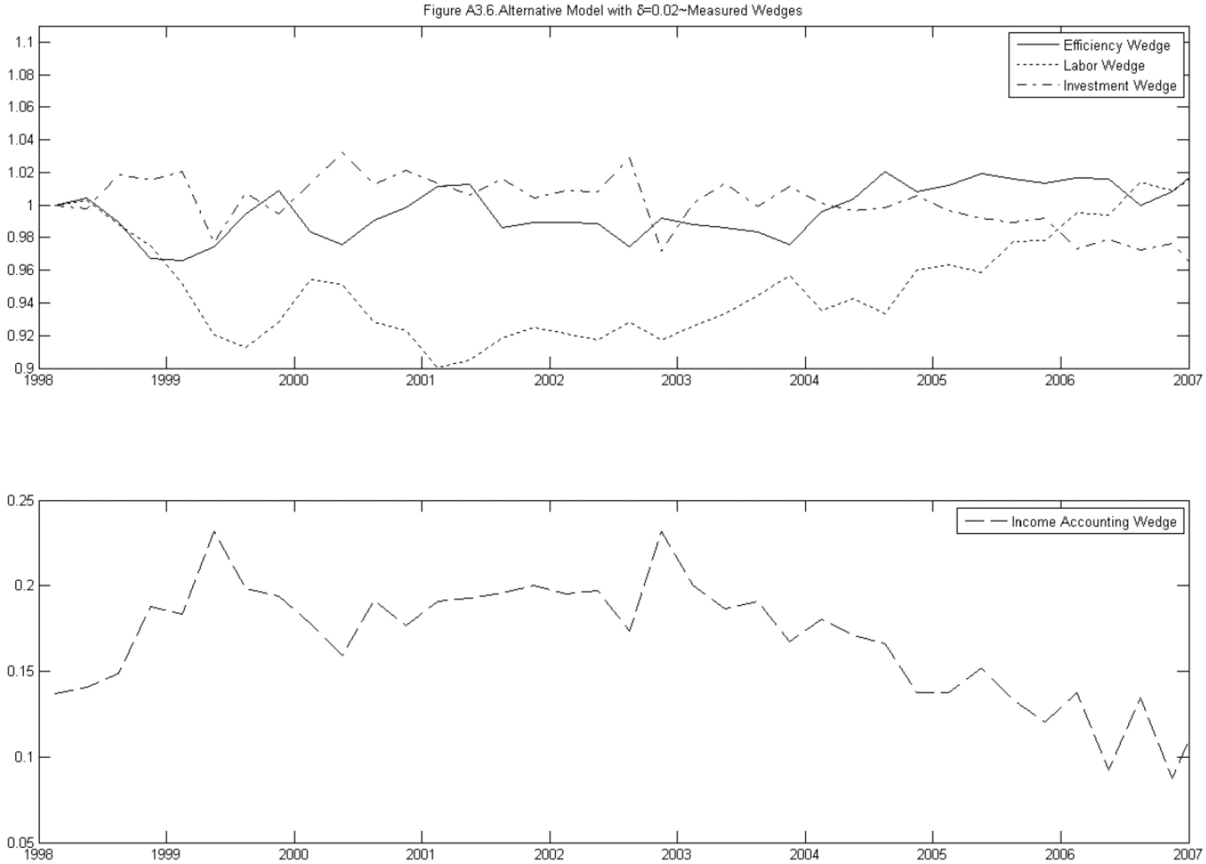
Clearly, the efficiency wedge plays a central role in explaining the fluctuations of investment and hours worked in Chile throughout the 1998-2007 period. However, the income accounting wedge best explains the behavior of consumption.

APPENDIX 3. SENSITIVITY ANALYSIS

In this section, we report the results from our sensitivity analysis. We conduct two sets of experiements: one with respect to the deprication rate, δ, and the other with respect to the share of capital in the production function, θ. In both cases, we recalibrate the alternative model and we proceed to simulate the model with one wedge at a time in order to compare the results with the original data series.[1]

Figures A3.6-A3.10 below summarize the results using δ=0.02.

Figure A3.6.Alternative Model with δ=0.02~Measured Wedges



In this case, adjusting the model for copper FDI again results in a weaker correlation between the labor and investment wedges when compared to the benchmark model in figure A3.1.

[1] The corresponding sensitivity test results for the benchmark model are available on request.

Figure A3.7.1.Alternative Model with δ=0.02~Output Data and Efficiency Wedge

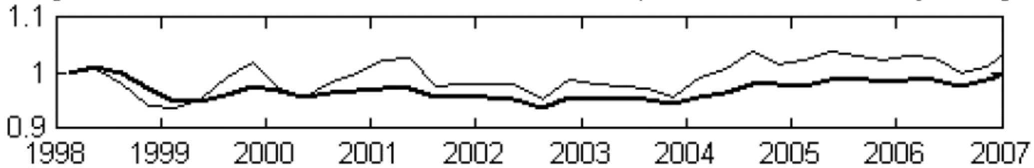


Figure A3.7.2.Alternative Model with δ=0.02~Output Data and Labor Wedge

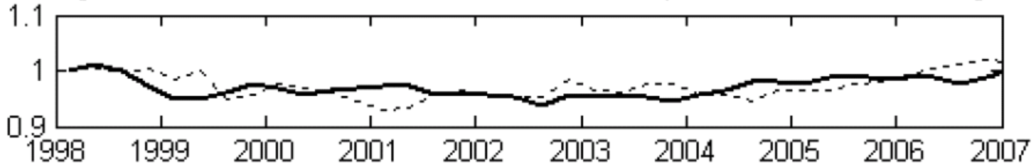


Figure A3.7.3.Alternative Model with δ=0.02~Output Data and Investment Wedge

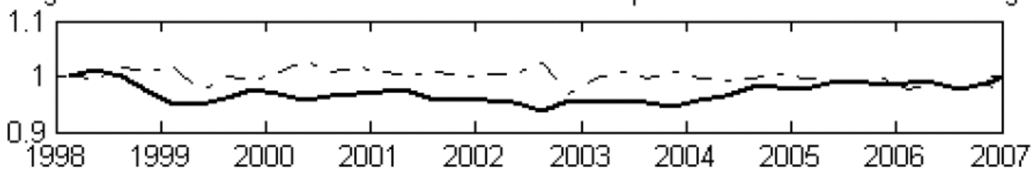


Figure A3.7.4.Alternative Model with δ=0.02~Output Data and Income Accounting Wedge

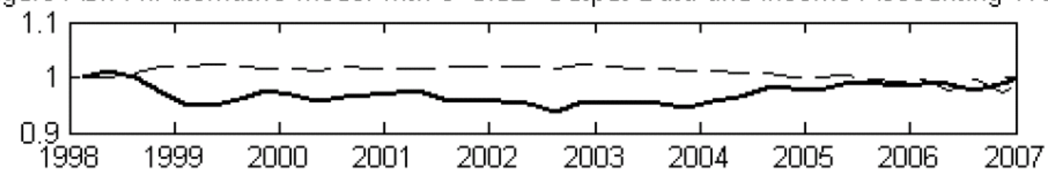


Figure A3.8.1.Alternative Model with δ=0.02~Investment Data and Efficiency Wedge

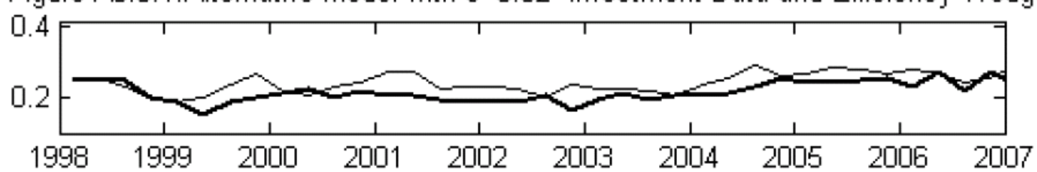


Figure A3.8.2.Alternative Model with δ=0.02~Investment Data and Labor Wedge

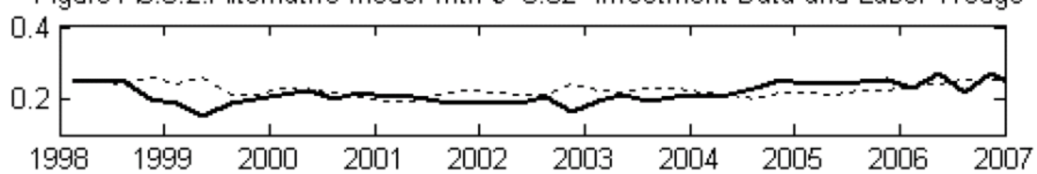


Figure A3.8.3.Alternative Model with δ=0.02~Investment Data and Investment Wedge

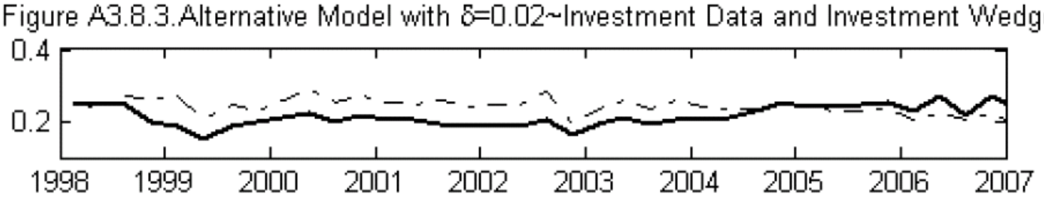


Figure A3.8.4.Alternative Model with δ=0.02~Investment Data and Income Accounting Wedge

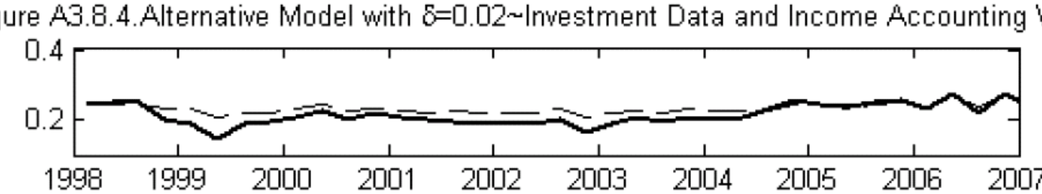


Figure A3.9.1.Alternative Model with δ=0.02~Hours Data and Efficiency Wedge

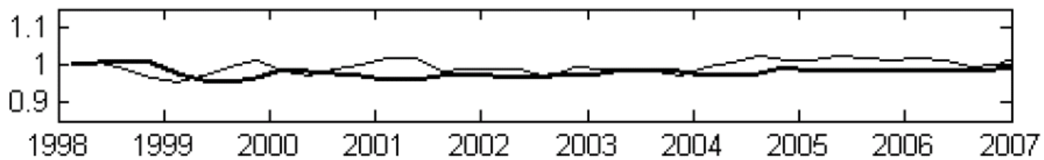


Figure A3.9.2.Alternative Model with δ=0.02~Hours Data and Labor Wedge

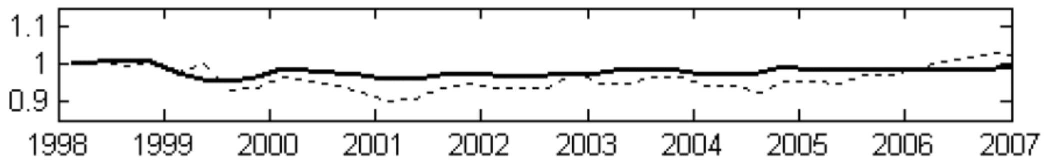


Figure A3.9.3.Alternative Model with δ=0.02~Hours Data and Investment Wedge

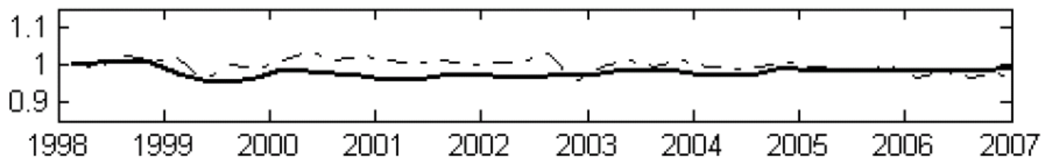


Figure A3.9.4.Alternative Model with δ=0.02~Hours Data and Income Accounting Wedge

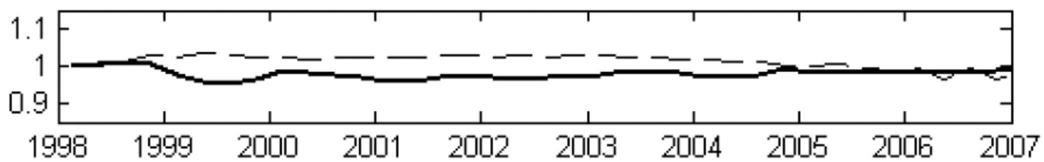


Figure A3.10.1.Alternative Model with δ=0.02~Consumption Data and Efficiency Wedge

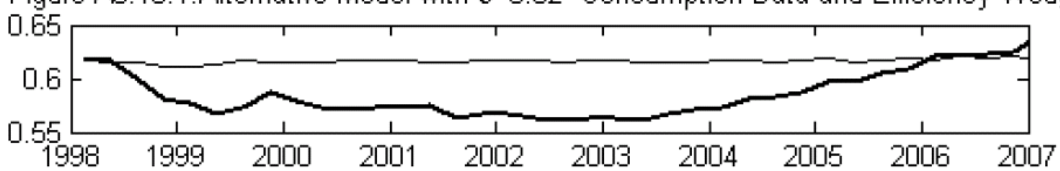


Figure A3.10.2.Alternative Model with δ=0.02~Consumption Data and Labor Wedge

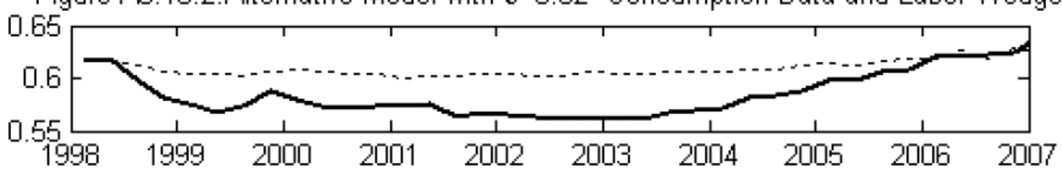


Figure A3.10.3.Alternative Model with δ=0.02~Consumption Data and Investment Wedge

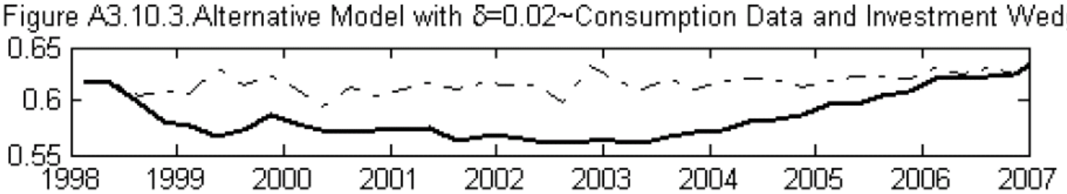
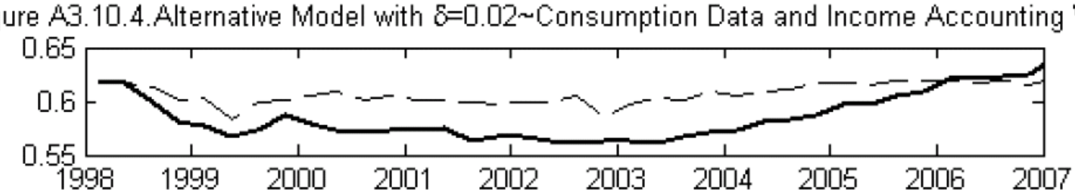


Figure A3.10.4.Alternative Model with δ=0.02~Consumption Data and Income Accounting Wedge



In the four figures above, output and hours variations are still largely explained by the efficiency and labor wedges, while consumption is mostly explained by the income accounting wedge. The investment and the income accounting wedges also play a central role in explaining the behavior of the investment series throughout the period.

Finally, Figures A3.16-A3.20 below summarize the results using θ=0.47.

Figure A3.16.Alternative Model with θ=0.47~Measured Wedges

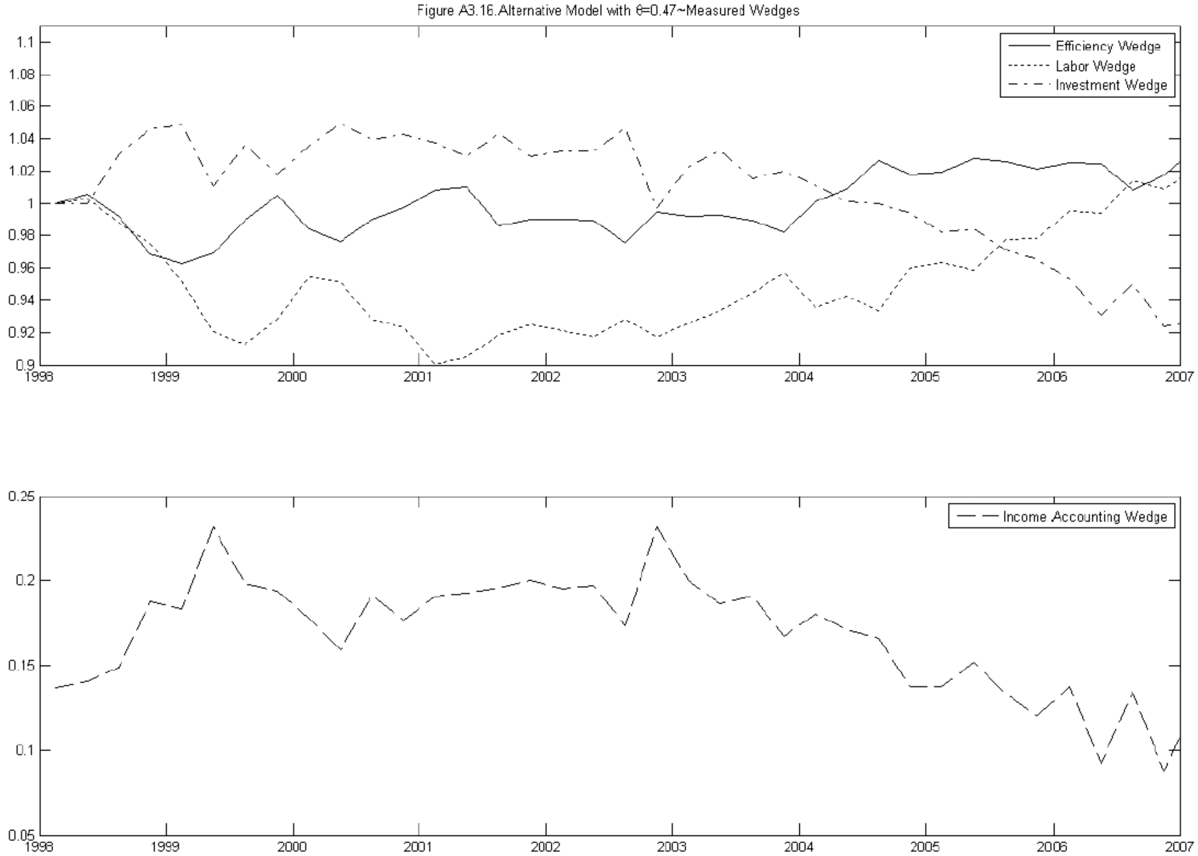


Figure A3.17.1.Alternative Model with θ=0.47~Output Data and Efficiency Wedge

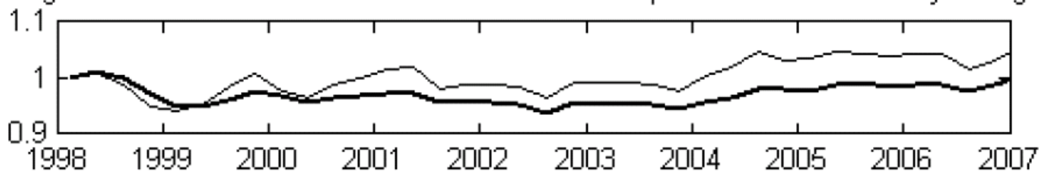


Figure A3.17.2.Alternative Model with θ=0.47~Output Data and Labor Wedge

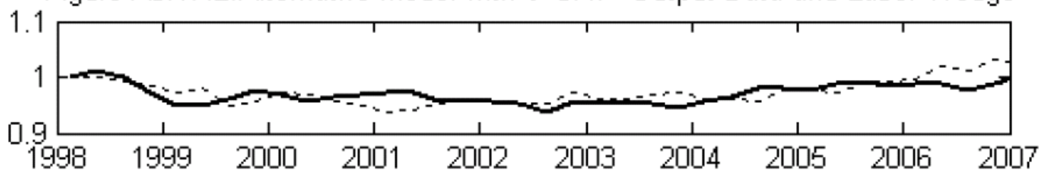


Figure A3.17.3.Alternative Model with θ=0.47~Output Data and Investment Wedge

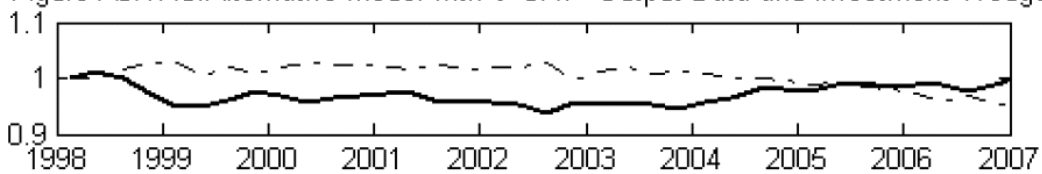


Figure A3.17.4.Alternative Model with θ=0.47~Output Data and Income Accounting Wedge

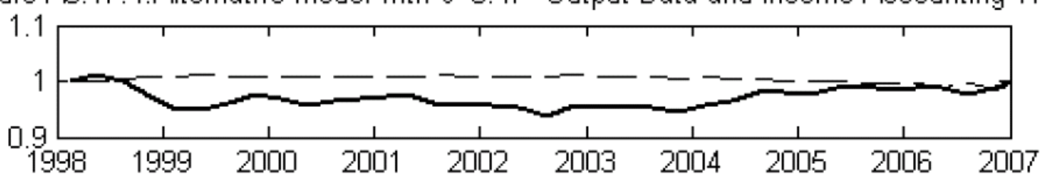


Figure A3.18.1.Alternative Model with θ=0.47~Investment Data and Efficiency Wedge

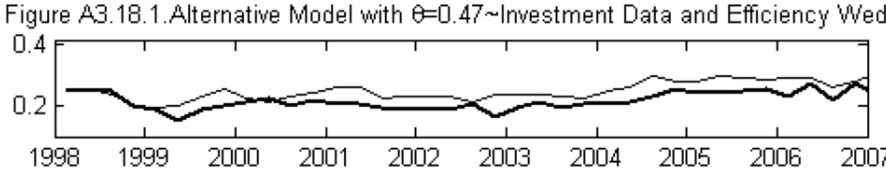


Figure A3.18.2.Alternative Model with θ=0.47~Investment Data and Labor Wedge

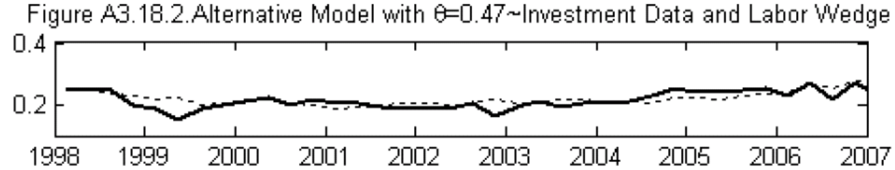


Figure A3.18.3.Alternative Model with θ=0.47~Investment Data and Investment Wedge

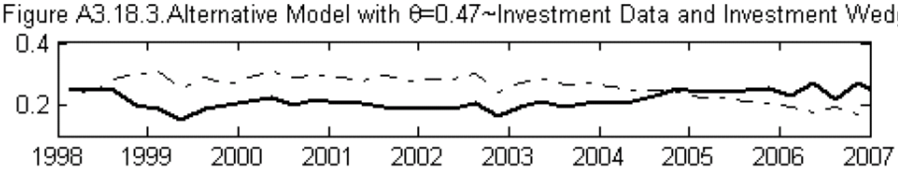


Figure A3.18.4.Alternative Model with θ=0.47~Investment Data and Income Accounting Wedge

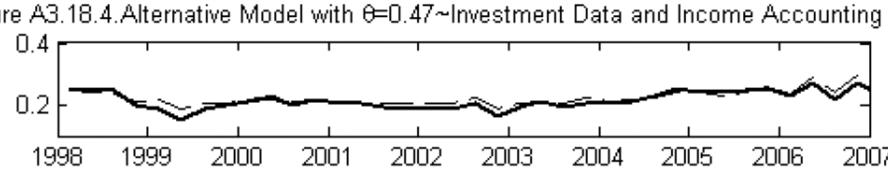


Figure A3.19.1.Alternative Model with θ=0.47~Hours Data and Efficiency Wedge

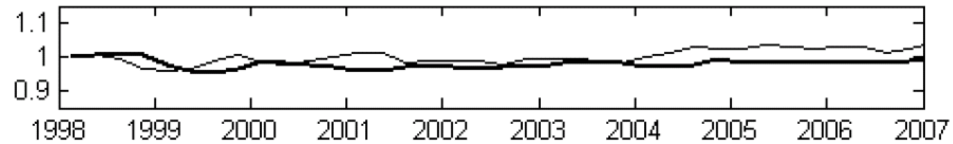


Figure A3.19.2.Alternative Model with θ=0.47~Hours Data and Labor Wedge

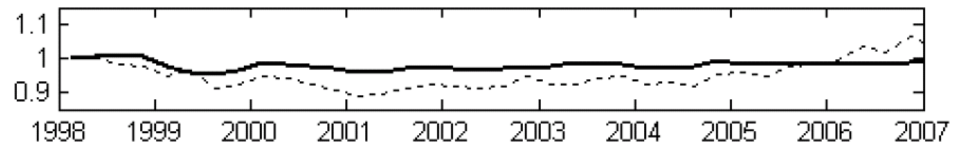


Figure A3.19.3.Alternative Model with θ=0.47~Hours Data and Investment Wedge

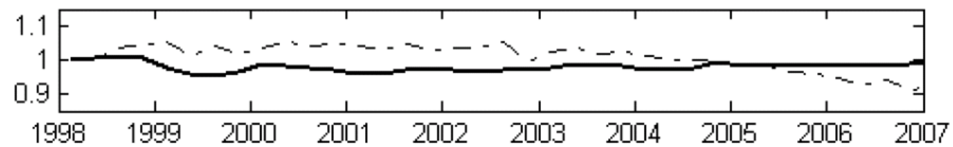


Figure A3.19.4.Alternative Model with θ=0.47~Hours Data and Income Accounting Wedge

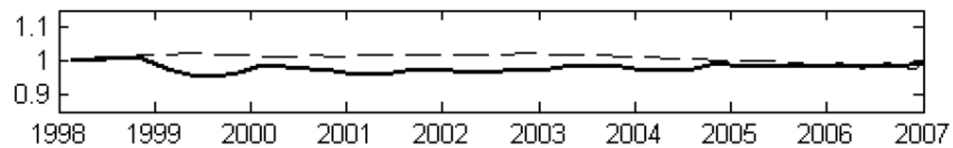


Figure A3.20.1.Alternative Model with θ=0.47~Consumption Data and Efficiency Wedge

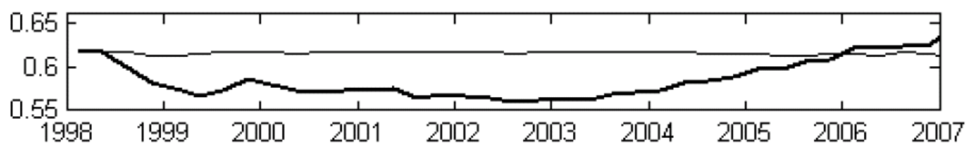


Figure A3.20.2.Alternative Model with θ=0.47~Consumption Data and Labor Wedge

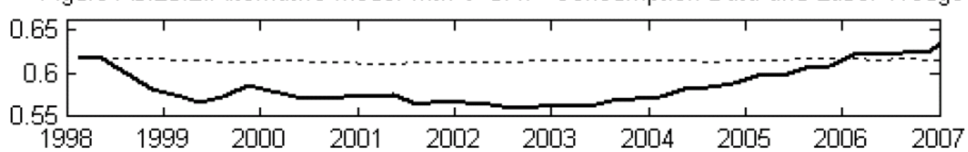


Figure A3.20.3.Alternative Model with θ=0.47~Consumption Data and Investment Wedge

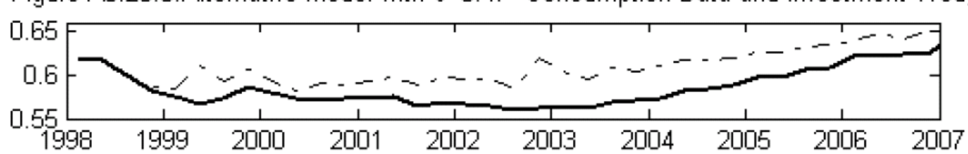
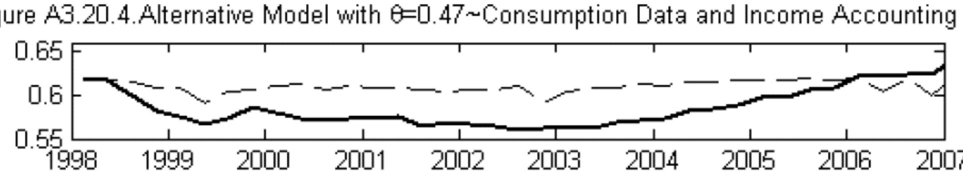


Figure A3.20.4.Alternative Model with θ=0.47~Consumption Data and Income Accounting Wedge



The results from the alternative model using the share of capital in production corresponding to 0.47 are in line with the ones described in the paper. The efficiency wedge plays a central role in explaining the fluctuations in output, while the labor wedge best explains the behavior of hours worked. Finally, the income accounting wedge tracks the movements in both investment and consumption.