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BUSINESS CYCLE ACCOUNTING FOR CHILE

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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) focusing the policy discussion on the most important wedges in the economy and (ii) identifying 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, labor, and investment wedges have had the greatest impact. We also compare our results with existing studies on emerging and developed economies.

Keywords: Business Cycle Accounting, Wedges, Chile

1. INTRODUCTION

Chile has enjoyed impressive economic performance over the past two decades. The country has been at the forefront among emerging markets in achieving macroeconomic stability and reducing economic vulnerabilities. Moreover, because of strong growth and pro-poor policies, per capita income in U.S. dollar terms has tripled 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, although Chile's growth potential remains high, it has no doubt declined in recent years. Indeed, average real GDP growth has fallen from well over 6% in

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the 1990s to just over 4% 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. In 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 previously for the cyclical behavior of Chile's economy during the period 1998–2007. The analysis is based on the business cycle accounting approach developed by Chari et al. (2007a). Specifically, we introduce time-varying wedges into 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) focusing the policy discussion on the most important wedges in the economy and (ii) identifying which broad class of models would present fruitful avenues for further research.

2. ANALYTICAL FRAMEWORK

Business cycle accounting (BCA henceforth), developed by Chari et al. (2007a), 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 an 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 a government wedge in Chari et al. (2007a)].

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:

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

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

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

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

where c_t denotes consumption, l_t labor, x_t investment, k_t capital, r_t the rental rate of capital, w_t the wage rate, and N_t the working-age population.[1] In the 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 with 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 as an increase in the productivity level would. A more extensive discussion of the interpretation of the wedges is presented later.

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 Z_t represents the efficiency wedge, modeled as labor-augmenting technical progress.

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

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

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and for 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.

The first-order conditions are as follows [for detailed derivations see Chari et al. (2006)]:

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

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

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

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

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. (2007a) and assume that expectations follow an AR(1) process, in which the 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 to obtain the parameters that govern the processes of the four wedges.[2]

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.

Although 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. (2007a) 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 be interpreted literally as taxes. For example, the labor wedge could capture unionization or sticky wages and monetary shocks.

TABLE 1. Parameter estimates for benchmark economy

Parameter	Value	Source
θ	0.3000	Bergoeing et al. (2002a)
δ	0.0125	Bergoeing et al. (2002a)
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

Note: Assume Chile is in SS in 1998Q1.

Moreover, the presence of credit restrictions or taxes/subsidies on capital income would have similar effects on the investment wedge. In addition, if one introduced 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.

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

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 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.

Calibration. 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.

As can be seen from Table 1, we follow Bergoeing et al. (2002a) 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, Golin (2002) shows that, for countries for which there are sufficient data to adjust for this mismeasurement, θ tends to be close to the U.S. estimate of 0.3.[3]

Furthermore, Bergoeing et al. (2002a) calibrate the annual depreciation parameter for Chile to 0.08 during the 1980s and the 1990s. However, they opt to use $\delta = 0.05$ (which corresponds to a quarterly depreciation rate of 0.0125) in their

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calculations because higher values yield an implausibly low capital–output ratio in Chile during the relevant period.[4]

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. (2002a), together with our 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). 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.

3. RESULTS

Using the calibrated model and quarterly aggregate variable data on Chile for the period 1998–2007, we first compute the four wedges described in equations (1)–(4). Figure 1 plots these wedges. The upper part plots the efficiency (z_t), labor ($1 - \tau_{lt}$), and investment $[1/(1 + \tau_{xt})]$ wedges normalized to their first-period realizations. The lower part plots the income accounting wedge ($\hat{g}_t$) as a fraction of total detrended per capita output. Because the income accounting wedge is much more volatile than the remaining three wedges, we show it on a separate graph.

Note that during the 1998–1999 crisis in Chile, both the efficiency and the labor wedge fell. Since 2001, however, the labor wedge has kept improving and it has especially picked up starting in 2005. The latter is consistent with the surge in employment in Chile and may capture the recent structural improvements in the functioning of the labor market discussed later. Furthermore, 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.

According to an extensive report by the OECD (2009), Chile's labor market can be described as a segmented one. The segmentation that the OECD refers to is with respect to the age, sex, and job tenure of workers. Table 1.1 in the report documents the employment-to-population ratios by gender for selected working-age groups among the 35 OECD member and accession countries. Chile represents the median country with respect to the employment ratio for workers of age 55 and above. Furthermore, it falls in the bottom third for employment of working-age men and in the bottom quarter for employment of youths aged up to 24. Finally,

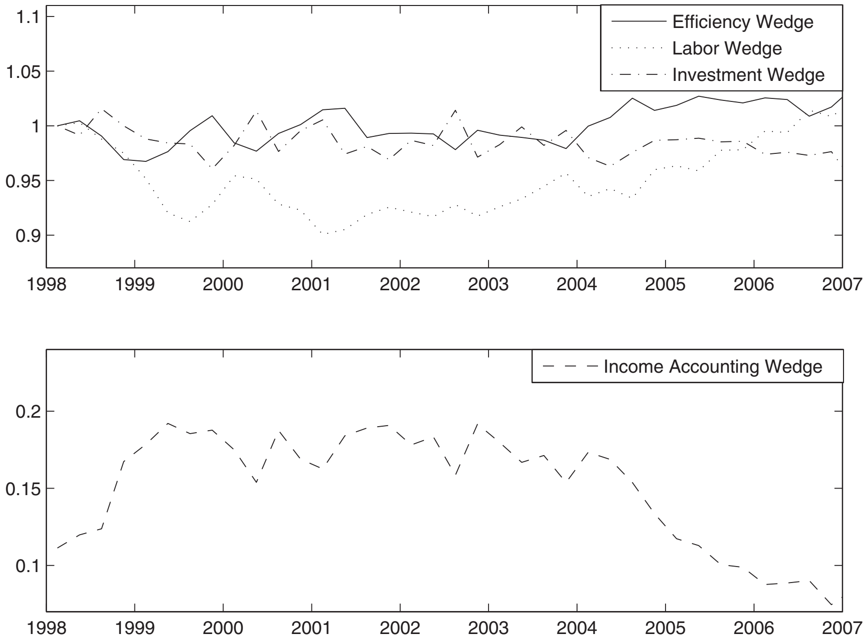

FIGURE 1. Benchmark model: Measured wedges.

Chile's employment rate for working-age women amounts to a mere 39%, which is the lowest among all OECD countries, except for Turkey.

The OECD report argues that the high degree of labor market segmentation in Chile can largely be attributed to high entry barriers for underrepresented groups such as youths and women. The particular policy that gives rise to entry barriers is the high severance pay as a function of job tenure for indefinite-duration contracts, which represent the standard labor arrangement in Chile [see also Edwards et al. (2000) for a detailed description of the labor market reforms in Chile during the period 1970–2000]. First, it is not possible for a firm to dismiss workers on the basis of lack of skill. Second, although it is possible to dismiss workers for economic reasons (for example, during a recession), the severance pay amounts to one month's salary for each year of service, up to a total of eleven months' salary. Such severance pay is high relative to the typical OECD country, where firms pay up to four months' worth of salary upon employee dismissal and workers are entitled to government-sponsored unemployment benefits thereafter.

To avoid incurring the high labor adjustment costs, firms in Chile turn to alternative labor arrangements such as subcontracting and the use of temporary work agencies (TWAs). The first refers to performing separate work processes outside of the boundaries of the firm, whereas the second amounts to hiring temporary workers via intermediary firms. Unlike most OECD countries, where

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standard labor laws apply to TWAs, both subcontracting and the use of TWAs were unregulated in Chile until 2007. According to a survey of firms with five or more workers, by the mid-2000s, over 40% of employers relied on subcontractors and TWAs. This widespread use of labor intermediaries rose considerably during the late 1990s and early 2000s during an attempt by the Chilean government to pass reforms that were aimed at strengthening job security for employees. Labor reforms were finally passed by the year 2007, and they included a regulation of TWAs, whose role in the labor market became less dominant in subsequent years.

Overall, throughout the first half of the decade examined in the present paper, the combination of Chile's labor practices and the inability of the administration to pass labor reforms likely hampered the flexibility of firms to adjust their labor inputs efficiently and therefore lowered average labor productivity, which potentially manifested itself in the labor and efficiency wedges in the benchmark neoclassical model. The reforms that were implemented during the second half of the decade likely led to increased levels of employment. As mentioned earlier, however, a more detailed model focusing on labor market imperfections would be needed to gain insights into the precise nature of such structural changes.

To continue, 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.

The investment wedge appears to be negatively related to the efficiency wedge throughout most of the decade. Moreover, beginning in 2004, it declines below its steady-state (1998) level. Given that one interpretation of the investment wedge is the relative ease of financing of investment versus consumption, the decline in this wedge is consistent with the improved access to household, relative to corporate, credit in Chile in the mid-2000s.

In particular, several capital market reforms took place in Chile during the period 1998–2007. Livacic and Saez (2001) document that Chile dismantled all capital controls by 1997. However, the authors also argue that, at the same time, banking oversight began to strengthen considerably. This policy effectively precluded smaller and less well-established companies from enjoying the benefits of the inflow of foreign capital. Furthermore, according to the Credit and Loan Reporting Systems Report for Chile, during the early years of the new millennium, banks and large department stores in particular began extending consumer credit. The argument is further supported by Figure D.3 in Appendix D, which plots the ratio of consumer loans to commercial loans in Chile between January of 2001 and March of 2007. Notice that the ratio of consumer to commercial loans nearly doubled between 2002 and 2007.

The combination of the last two policies effectively made consumption relatively cheaper than domestic investment. Thus, the decline in the investment wedge may

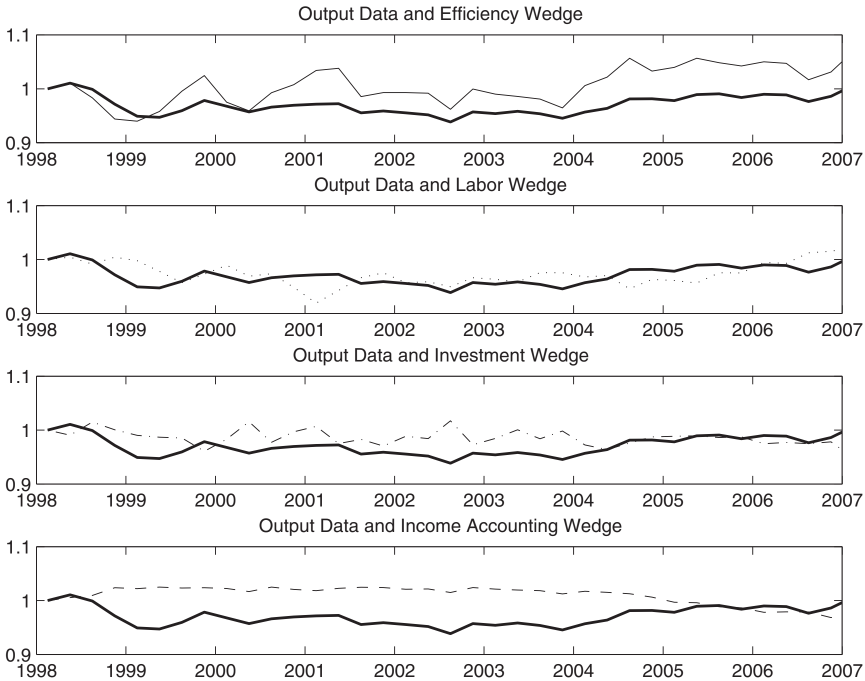

FIGURE 2. Benchmark model: Output.

reflect these changes in the Chilean economy. As argued earlier, however, a detailed model focusing on capital market imperfections would be needed to make more precise statements.

Finally, as mentioned earlier, the investment wedge exhibits a negative correlation with the efficiency wedge, especially in years in which the efficiency 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 being taken directly from the data. Moreover, because 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 shows the predictions of the model, simulated with each of the four wedges at a time, for total detrended per capita output during the period 1998–2007. 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.

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 of predicting the fluctuations in output in Chile during the period 1998–2007. Although the efficiency wedge generates the initial drop in output and tracks the fluctuations of output well, it does not maintain output sufficiently below trend and it overpredicts the recovery.

The labor wedge aids the efficiency wedge in accounting for the behavior of output during the period. At the beginning of the 1998–1999 crisis, the labor wedge predicts a fall in output. It also appears to explain the movement in output in 1999 as well as during the period 2001–2003. The wedge predicts a recovery beginning in mid-2004.

The investment wedge does not predict the observed movements in output well until mid-2004, because it generates consistently counterfactual fluctuations. It does, however, track the recovery in output beginning in mid-2004 quite well. The income accounting wedge suggests that output should have remained nearly unchanged and perhaps should have risen slightly.

We have also simulated the impact of each wedge on hours worked, investment, and consumption (see Appendix B). Overall, the efficiency and investment wedges play a central role in explaining the movement in investment, and the labor and investment wedges track hours well, whereas the income accounting wedge predicts the observed fall and recovery in consumption.

Our results are consistent with similar studies in other Latin American countries. Graminho (2006) 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 period 1980–2000. Applying a slightly modified BCA model, Lama (2011) 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. (2002a, 2002b, 2002c), 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.

Moreover, BCA studies of advanced economies have obtained similar results. In their seminal paper, Chari et al. (2007a) demonstrate that the efficiency and the labor wedge account for the majority of the fluctuations in the U.S. economy during the Great Depression and the 1982 recession. Kersting (2008) finds that the labor wedge was largely responsible for the business cycle fluctuations in the United Kingdom in the 1980s. Similarly, Kobayashi and Inaba (2006) argue that the labor wedge best accounts for the Japanese recession in the 1990's. In contrast, Chakraborty (2009b) argues that the efficiency and investment wedges were critical in accounting for the behavior of the Japanese economy over the period 1980–2000. The author also offers an illuminating discussion of the sources of the different findings across the two studies and sheds light on the importance of various assumptions in BCA exercises.

TABLE 2. Parameter estimates for alternative economy

Parameter	Value	Source
θ	0.3000	Bergoeing et al. (2002a)
δ	0.0125	Bergoeing et al. (2002a)
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

Note: Assume Chile is in SS in 1998Q1.

4. ALTERNATIVE SPECIFICATION: ADJUSTING FOR COPPER INVESTMENT

Chile is the biggest copper producer in the world, and although 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 nonmining 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 nonmining sectors. The latter may be of less concern, because 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. Second, because we have sectoral FDI data only at an annual frequency, we assume that the mining sector's share of FDI is 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, because mining is a relatively small and stable share of total GDP.

We replicate the calibration procedure for the benchmark model using the modified data series. The results are reported in Table 2. 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 presented previously. In the calibration, only the parameter β changes, because we only modified the definition of investment.

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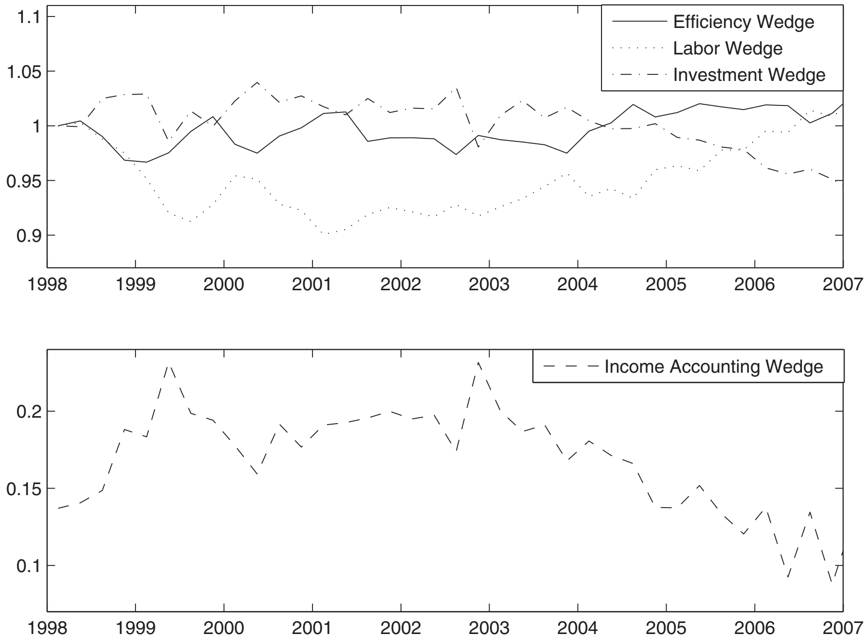

FIGURE 3. Alternative model: Measured wedges.

Figure 3 plots the four wedges of the alternative model.

Relative to Figure 1, the investment wedge is at a higher level, but it falls below its steady-state level in 2004 and it exhibits a stronger and more persistent decline since then. 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, because it is computed directly from the aggregate data series. The efficiency wedge differs only slightly from the previous exercise.

Figure 4 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 period 1998–2007.

Once again, the efficiency wedge does the best job of predicting the fluctuations in output in Chile during the period 1998–2007. Similarly to the benchmark model, the efficiency wedge does not maintain output sufficiently below trend and it overpredicts the recovery. Furthermore, the labor wedge once again aids the efficiency wedge in accounting for the behavior of output during the period.

The investment wedge performs worse relative to the benchmark exercise. In particular, it not only generates consistently counterfactual fluctuations, but also no longer tracks the recovery in output. Finally, the income accounting wedge effectively predicts no changes to output, as in the benchmark specification.

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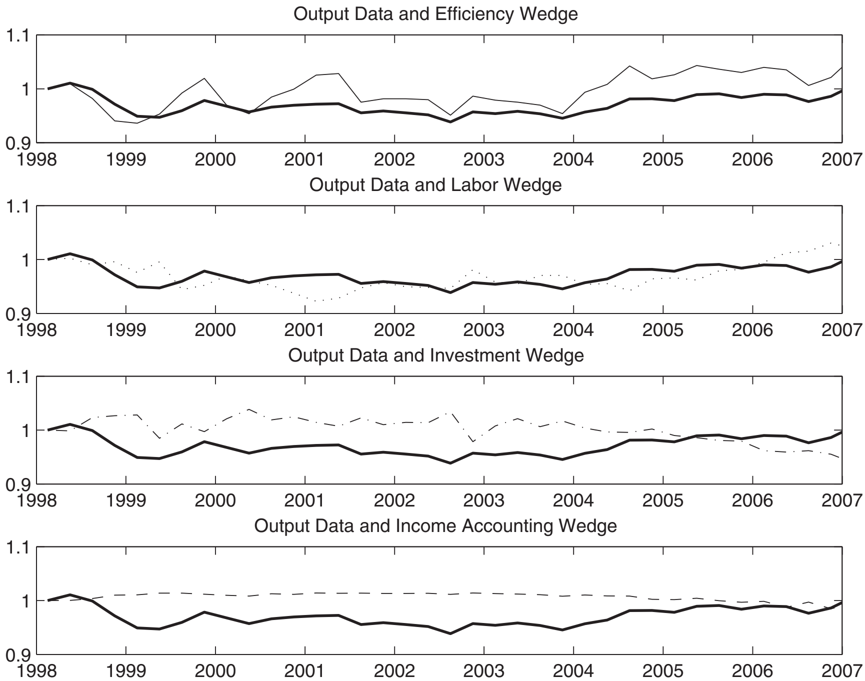

FIGURE 4. Alternative model: Output.

Figure 5 plots predicted and actual investment. Although the investment wedge tracks the fluctuations in investment during the first half of the studied period, it fails to capture the drop in the level of investment. Moreover, beginning in 2005, it counterfactually predicts a large fall in investment. However, relative to the benchmark exercise, the income accounting wedge does a much better job at explaining investment. This may at first come across as puzzling, because the investment series no longer contains the mining FDI component, whereas the income accounting wedge does. However, because 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.

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 subperiods. 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. Because average weekly hours worked per person were only available on an annual basis (see Appendix A for details), this may be contributing to the smoothness of the series.

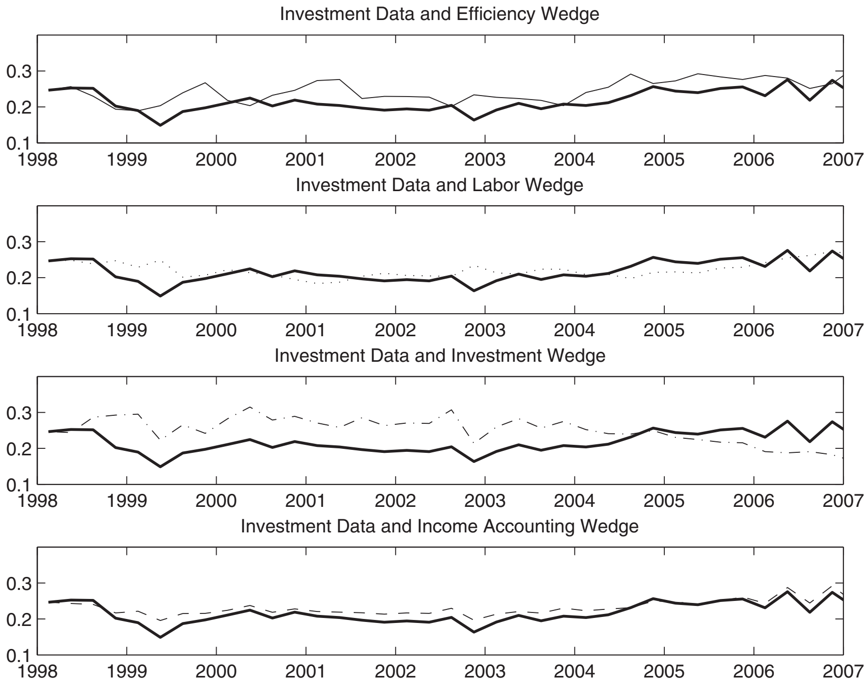

FIGURE 5. Alternative model: Investment.

It is interesting to note that actual hours worked did not fall immediately as the 1998–1999 crisis took place, but rather seem to show a downward trend with a lag. This may be due to the high firing costs that characterized the labor markets during the period. As expected, the efficiency wedge predicts a fall in hours and a recovery consistent with the movements in output shown in Figure 6. 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 A). Finally, the income accounting wedge yields little to no movement in hours throughout the period, which is consistent with its 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 because of 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.

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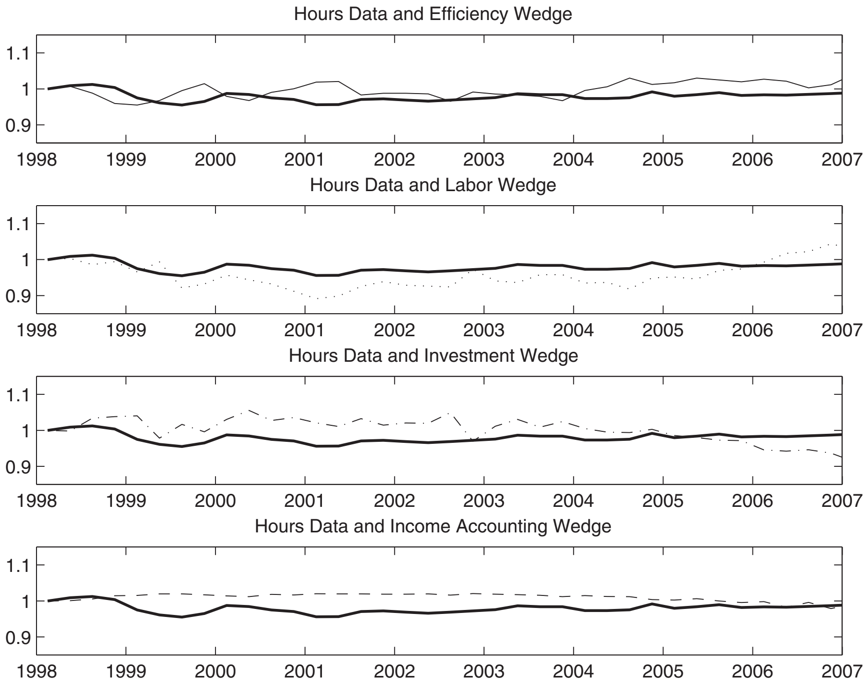

FIGURE 6. Alternative model: Hours.

In sum, relative to the benchmark exercise, the notable difference in the results lies in the performance of the investment wedge. Although this wedge, once purged of mining FDI, falls short of the income accounting wedge in predicting the behavior of investment, it does account for the rise in consumption during the recovery. Given that one interpretation of the investment wedge is the relative ease of financing of investment versus consumption, the observed decline in this wedge is consistent with the improved access to household credit discussed earlier. Should the investment wedge reflect these changes in the Chilean economy, it would predict a fall in investment and a rise in consumption.

5. DISCUSSION ON ROBUSTNESS OF RESULTS

5.1. Economy with Taxes on Capital Income

The benchmark and the alternative exercises produced different results regarding the importance of the investment wedge in accounting for the business cycle fluctuations in Chile during the period 1998–2007. Drawing stark conclusions about the importance of the investment wedge may be of concern in light of the recent work by Christiano et al. (2006), who argue that small changes in the implementation of the BCA procedure may yield different results relative to

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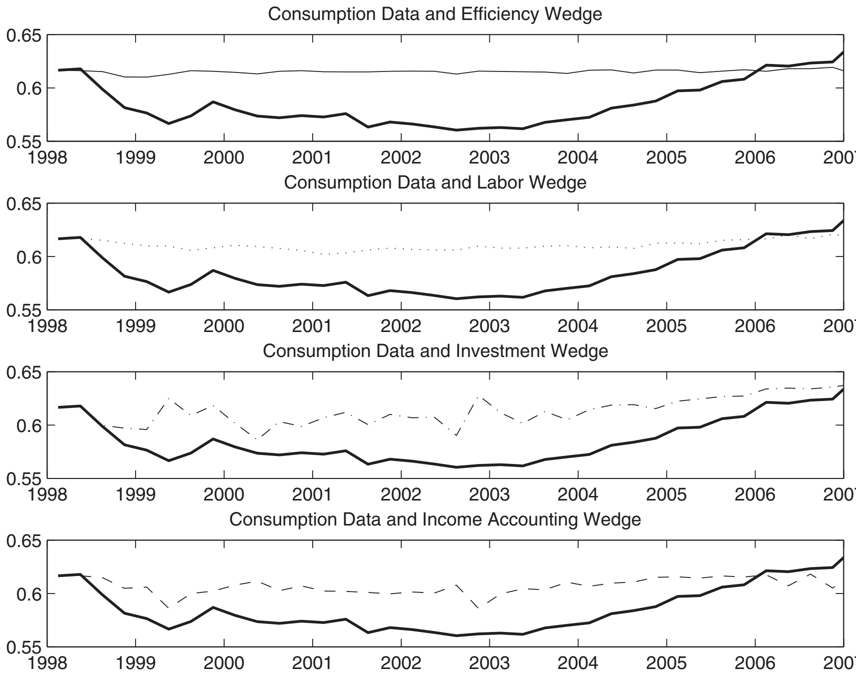

FIGURE 7. Alternative model: Consumption.

the benchmark specification. In particular, the authors argue that financial frictions that manifest themselves as taxes on capital income, rather than taxes on investment, may affect the fluctuations of key macroeconomic variables differently.

Hence, for robustness purposes, we repeat the analysis using capital rather than investment taxes. Following the arguments of Chari et al. (2007b), we introduce taxes on gross capital income. Let τ_{kt} denote the capital tax rate in period t. Then the Euler equation in expression (4) becomes

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

As Chari et al. (2007b) demonstrate, there is equivalence between capital and investment taxes, if capital taxes are chosen to satisfy

$$(1 - \tau_{kt+1}) \left[\theta \frac{\hat{y}_{t+1}}{\hat{k}_{t+1}} + 1 - \delta \right] = \frac{\theta \frac{\hat{y}_{t+1}}{\hat{k}_{t+1}} + (1 - \delta)(1 + \tau_{xt+1})}{(1 + \tau_{xt})}.$$

Although the equivalence holds in theory, in practice taxes are estimates obtained from the data. Hence, different estimates may potentially affect the quantitative

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results of the BCA exercise. For these reasons, we reestimate the benchmark economy from Table 1 with capital taxes instead of investment taxes.

The results from the exercise are reported in Appendix C. There are two notable findings. First, the capital wedge follows the investment wedge closely, but is more volatile and at a lower level. Clearly, the remaining three wedges are identical to the benchmark economy because they are computed directly from the data. Second, because of the drop in level, relative to the investment wedge, the capital wedge better accounts for the drop in output and investment during the recession. As in the benchmark exercise, the capital wedge fails to capture the recovery in investment, which appears to be mainly driven by the efficiency wedge. Finally, the findings related to hours worked and consumption remain unchanged.

Overall, the robustness exercise yields results nearly identical to those for the benchmark. This finding reinforces the conclusions regarding the behavior of the investment wedge in Chile throughout the period. Hence, much like Chari et al. (2007b) and Šustek (2011), we conclude that the particular modeling choice for the investment wedge does not change the nature of the results in the BCA exercise.

5.2. Importance of Income Accounting Wedge

Sudden stops. Both in the benchmark and in the alternative specification, the estimated income accounting wedge is very volatile. Yet the wedge predicts virtually no change in output and hours worked throughout the decade. In fact, the wedge predicts an almost indistinguishable increase in the variables.

One may be concerned that the poor performance of this wedge stems from the failure of the BCA exercise to account for sudden stops in capital inflows. To understand the argument, refer to Chari et al. (2005), who examine 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.

Chakraborty (2009a) demonstrates that a BCA exercise with an alternative preference specification and an assumption of a small open economy allows the income accounting wedge to generate a drop in output and hours during a sudden stop episode. In particular, the author advocates the preference parameterization in Greenwood et al. (1988), where the marginal rate of substitution between consumption and leisure is independent of consumption. In this environment, a sudden stop does not affect current-period hours and output, but it generates a negative wealth effect that depresses current consumption. Consequently, the marginal utility of consumption rises, which depresses investment in the next period, as well as the capital stock. A reduction in hours worked and output in the future period follows.

Although this mechanism is admittedly very useful in accounting for the behavior of macroeconomic variables during sudden stop episodes, it is unlikely to improve the performance of the income accounting wedge in the present exercise because there is no evidence that Chile's downturn was caused by a sudden stop.

To support this claim, we follow Chari et al. (2005), who examine the Mexican crisis in the mid-1990s, and we analyze the behavior of the current and financial accounts one year before and after the start of the economic downturn. Figures D.1 and D.2 in Appendix D plot Chile's current and financial account, respectively, as well as their main subaccounts, during the 1997–1999 period.[5] The solid line represents the main account, whereas the dashed line captures the particular subaccount in each subplot.

Denoting the year of 1998 as marking the beginning of the downturn, notice that there is no reversal in the behavior of the current or the financial account in the previous year, 1997. Figure D.1 shows that Chile continued to run a current account deficit throughout 1997 and 1998, mainly because of the negative trade balance. The country briefly attained a trade surplus in 1999. Throughout the three-year period, Chile continued being a net factor payee, which is likely attributable to dividend payments to the foreign owners in the copper sector, and it remained a net transfer recipient.

Figure D.2 shows that Chile enjoyed capital inflows throughout 1997 and 1998 and suffered a slight outflow in the first quarter of 1999. An inspection of the subaccounts suggests that, throughout the three-year period, foreign investors continued to invest in Chile, but they changed the composition of their portfolios. Moreover, the Chilean government continued to improve its reserve asset position during 1997 and 1998, which suggests that there was no attempt to remedy an apparent sudden stop of capital inflow. Hence, it is reasonable to conclude that Chile's downturn was not associated with a sudden stop.

International borrowing constraints. Given the size of the Chilean economy and its asset base, it is reasonable to argue that Chile is a small open economy. With this assumption in mind, one may hypothesize that the recovery of the Chilean economy beginning in late 2003 and the associated steady rise in investment, and especially in consumption, is due to a loosening in the borrowing constraints on Chilean consumers and firms on international markets. In particular, one may be led to believe that consumers have begun to enjoy more favorable terms of borrowing from abroad relative to firms, given the sharp increase in the consumer-to-commercial loan ratio during the period depicted in Figure D.3 in Appendix D.

Unfortunately, detailed data on Chilean consumer and commercial loans by country of origin are not available. However, in order to evaluate whether the aggregate economic recovery in Chile is an artifact of loosening international borrowing constraints, we introduce international debt in the presence of convex portfolio adjustment costs into a small open economy that borrows from the world at a constant exogenous interest rate. In particular, motivated by Schmitt-Grohe and Uribe (2003), we modify the consumer budget constraint in Section 2 as

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follows:

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

$$td_t = d_{t+1} - (1 + r^*)d_t - \frac{\phi}{2}(d_{t+1} - \bar{d})^2,$$

$$\lim_{j\to\infty} E_t \frac{d_{t+j}}{\Pi_{s=0}^{j}(1 + r^*)} \leq 0.$$

In this expression, td_t represents the trade deficit (or the negative trade balance, $-tb_t$), which is governed by foreign debt dynamics. d_{t+1} represents external debt, which requires interest payments at the world rate of $r^* = 1/\tilde{\beta} - 1$, where $\tilde{\beta} = \beta(1 + g_n)$. The quadratic term represents the cost of adjusting the debt portfolio from the steady-state level of debt, $\bar{d}$.

We repeat the benchmark business cycle accounting exercise with four standard wedges: efficiency, labor, investment, and government spending. Foreign debt represents an additional endogenous variable in the model that interacts with all other macroeconomic variables. Moreover, the foreign-debt dynamics fully guide the movements in the trade balance, which in turn account for the majority of the fluctuations in the income accounting wedge (comprising government spending and the trade balance).

We follow Schmitt-Grohe and Uribe (2003) to estimate the two new parameters, $\bar{d}$ and ϕ. In particular, we let ϕ be 0.00074, as in Schmitt-Grohe and Uribe (2003). Furthermore, we estimate $\bar{d}$, together with the remaining parameters of the model, to match the volatility of the current-account-to-GDP ratio over the period of study. The resulting parameter value is $\bar{d} = 4.1416$.

The results from the exercise are reported in Appendix E. Figure E.1 plots the four measured wedges as well as the income accounting wedge, which comprises the government wedge and the trade balance. The wedges resemble closely the ones obtained for the benchmark economy. Furthermore, Figures E.2–E.5 plot the predicted series for output, investment, hours worked, and consumption in economies with each one of the four wedges. Finally, Figure E.6 plots the predicted net inflow of foreign capital—the key new variable of interest in the small open economy model.

Much as in the benchmark model, the efficiency and labor wedges continue to account for the majority of the fluctuations during the period. Furthermore, the behavior of the net capital inflow tracks the evolution of consumption during the period closely. This observation is in line with earlier arguments that the fall and recovery in consumption during the period can be attributed to a loosening in international borrowing constraints. Overall, however, the increase in foreign capital inflow since the turn of the century does not appear to account for the recovery in the remaining macroeconomic variables such as investment.

6. CONCLUSION

In summary, our business cycle accounting exercise suggests that productivity and labor market considerations best explain the behavior of output and hours worked in Chile throughout the period 1998–2007. The investment wedge tracks the fluctuations in investment, but it fails to predict its recovery. Moreover, in an exercise that isolates the mining sector from the investment series, the investment wedge correctly predicts an increase in consumption relative to investment in recent years. The latter is consistent with the increased access to credit on the part of Chilean consumers. Finally, the income accounting wedge generally reflects fluctuations in the trade balance and does not account for the behavior of the main macroeconomic aggregates in Chile. However, the wedge explains the behavior of consumption during the studied period, which is consistent with the argument that the majority of consumption goods in Chile are imported.

The predictive power of the efficiency, labor, and investment wedges suggests that relaxing labor market rigidities and improving access to corporate credit should be a focus for policy. However, specific policy recommendations would require a closer look at a more detailed model that incorporates frictions that manifest themselves as efficiency, labor, and investment wedges.

NOTES

1. In this paper, all lower case letter variables represent aggregate (upper case letter) variables per working-age person (population aged 15–64) rather than per capita. Bergoeing et al. (2002a) argue that this is an appropriate choice because 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. In 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 1,250 hours per quarter.

2. Throughout this exercise, we use the solution method and estimation suggested by Chari et al. (2006). 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. (2006) and Chari et al. (2007a) for a detailed explanation of the accounting procedure.

3. We repeat the analysis with $\theta = 0.47$ and we find no qualitative difference in the results. The detailed results are available from the authors upon request.

4. We repeat the analysis with $\delta = 0.02$ [which corresponds to an annual depreciation rate of 0.08 as calibrated by Bergoeing et al. (2002a)] and we find no qualitative difference in the results. The detailed results are available upon request from the authors.

5. The quarterly data were obtained from the Statistics Database of the Central Bank of Chile, available at http://si3.bcentral.cl/Siete/secure/cuadros/home.aspx.

REFERENCES

Bergoeing, R., P.J. Kehoe, T.J. Kehoe, and R. Soto (2002a) A decade lost and found: Mexico and Chile in the 1980s. *Review of Economic Dynamics* 5, 166–205.

Bergoeing, R., P.J. Kehoe, T.J. Kehoe, and R. Soto (2002b) Decades lost and found: Mexico and Chile since 1980. *Minneapolis Quarterly Review* 26(1), 3–30.

Bergoeing, R., P.J. Kehoe, T.J. Kehoe, and R. Soto (2002c) Policy-driven productivity in Chile and Mexico in the 1980’s and 1990’s. *American Economic Review* 92, 16–21.

Chakraborty, S. (2009a) Modeling sudden stops: The nontrivial role of preference specifications, *Economics Letters* 104, 1–4.
Chakraborty, S. (2009b) The boom and the bust of the Japanese economy: A quantitative look at the period 1980–2000. *Japan and the World Economy* 21, 116–131.
Chari, V.V., P.J. Kehoe, and E.R. McGrattan (2005) Sudden stops and output drops. *American Economic Review* 95, 381–387.
Chari, V.V., P.J. Kehoe, and E.R. McGrattan (2006) Appendices: Business Cycle Accounting. Staff report 362, Research Department, Federal Reserve Bank of Minneapolis.
Chari, V.V., P.J. Kehoe, and E.R. McGrattan (2007a) Business cycle accounting. *Econometrica* 75, 781–836.
Chari, V.V., P.J. Kehoe, and E.R. McGrattan (2007b) Comparing Alternative Representations, Methodologies, and Decompositions in Business Cycle Accounting. Staff report 384, Research Department, Federal Reserve Bank of Minneapolis.
Christiano, L.J. and J.M. Davis (2006) Two Flaws In Business Cycle Accounting. NBER working paper 12647, National Bureau of Economic Research.
Edwards, S., A.C. Edwards, S. Bentolila, and J. Gali (2000) Economic reforms and labour markets: Policy issues and lessons from Chile, *Economic Policy* 15, 181–229.
Gollin, D. (2002) Getting income shares right. *Journal of Political Economy* 110(2).
Graminho, F. M. (2006) A Neoclassical Analysis of the Brazilian "Lost-Decades." Working paper 123, Central Bank of Brazil, Research Department.
Greenwood, J., Z. Hercowitz, and G.W. Huffman (1988) Investment, capacity utilization, and the real business cycle. *American Economic Review* 78, 402–417.
Kersting, E.K. (2008) The 1980s recession in the UK: A business cycle accounting perspective. *Review of Economic Dynamics* 11, 179–191.
Kobayashi, K. and M. Inaba (2006) Business cycle accounting for the Japanese economy. *Japan and the World Economy* 18, 418–440.
Lama, R. (2011) Accounting for output drops in Latin America. *Review of Economic Dynamics* 14, 295–316.
Livacic, E. and S. Saez (2001) The banking supervision agenda in Latin America. *CEPAL Review* 74, 119–131.
OECD (2009) *OECD Reviews of Labour Market and Social Policies: Chile*. Paris: OECD.
Schmitt-Grohe, S. and M. Uribe (2003) Closing small open economy models. *Journal of International Economics* 61, 163–185.
Šustek, R. (2011) Monetary business cycle accounting. *Review of Economic Dynamics* 14, 592–612.

APPENDIX A: DATA SOURCES AND CALCULATIONS

TABLE A.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
O.2	Total consumption	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.3	Gross fixed capital formation	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.4	Change in inventories	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.5	Government consumption	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.6	Exports of goods and services	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.7	Imports of goods and services	SA, Mil.2003.Ch pesos	Banco Central de Chile

TABLE A.1. Continued

Code	Description of data	Unit	Source
O.8	Employment: quarterly moving average ended in specified month	SA by Haver, thousands	Instituto Nacional de Estaditicas
O.9	Net VAT revenue	SA, Mil.2003.Ch pesos	Banco Central de Chile
O.10	Import duties	SA, Mil.2003.Ch pesos	Banco Central de Chile
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
O.I.4	Change in inventories	SA, Mil.Ch pesos	Banco Central de Chile

TABLE A.2. Annual data for Chile, 1998–2007

Code	Description of data	Unit	Source
O.11	Population ages 15–64	Thousands	WDI
O.12	Hours actually worked, men and women (weekly average hours)	Hours per person	ISIC-Rev.2
O.I.5	Mining fraction of FDI	NSA, fraction of total	Banco Central de Chile

Notes: Population data only available for 1998–2004. We assume that population grows at a constant rate given by the quarterly equivalent of the annual growth rate of the available observations.
Hours data only available for 1998–2005. We take the 2005 observation for 2006–2007. Because weekly hours per person have been declining in Chile, a linear interpolation of the last two observations resulted in estimates that were too low. We assume that the yearly observation does not change for different quarters and use it as if it were quarterly data. As discussed in the main text, the relevant variable in the analysis—total hours worked—is calculated using employment for which quarterly data are available.

TABLE A.3. Constructed data for Chile, 1998–2007

Code	Description of variable
C.1=O.1-O.9-O.10	Y_t = GDP – net VAT revenue – import duties
C.2=O.2-O.5	C_t = total consumption – gov't consumption – VAT – import duties
C.3=O.3+O.4	X_t = gross fixed capital formation + change in inventories
C.4=O.5+O.6-O.7	G_t = gov't consumption + exports – imports
C.5=O.11 repeated quarterly	Population (yearly observation repeated four 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	L_t = total hours worked per quarter

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APPENDIX B: RESULTS FROM BENCHMARK MODEL

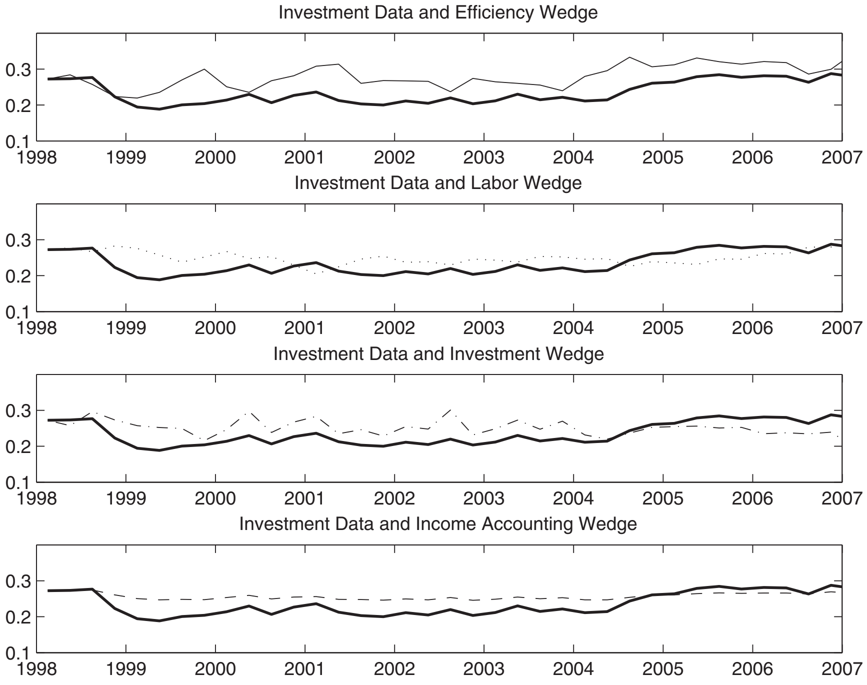

FIGURE B.1. Benchmark model: Investment.

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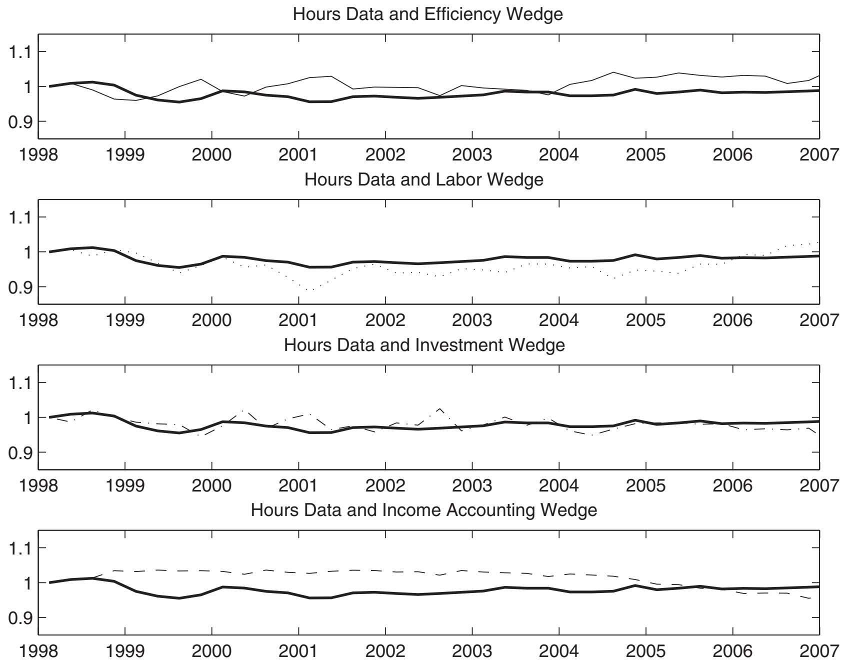

FIGURE B.2. Benchmark model: Hours.

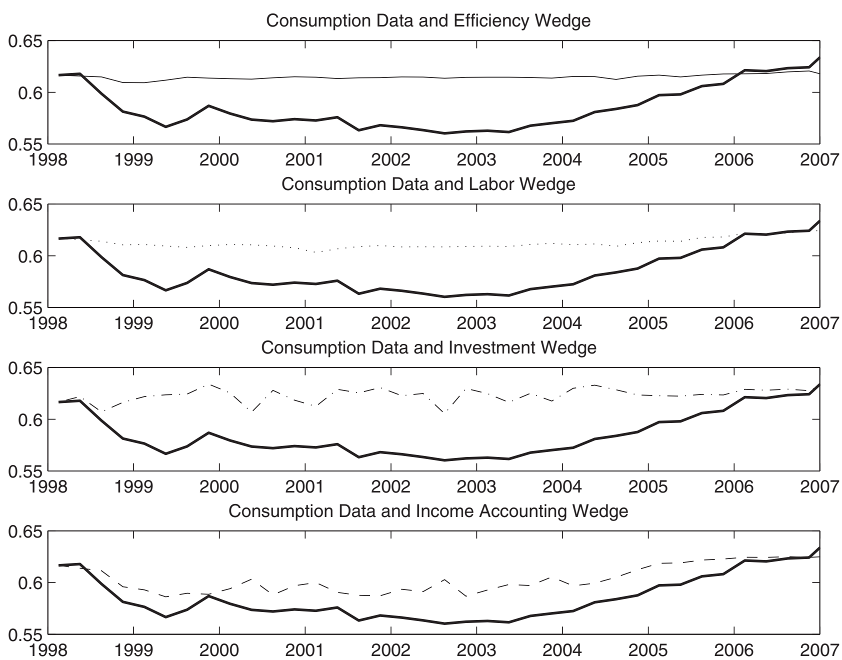

FIGURE B.3. Benchmark model: Consumption.

APPENDIX C: RESULTS FROM BENCHMARK MODEL WITH CAPITAL TAXES

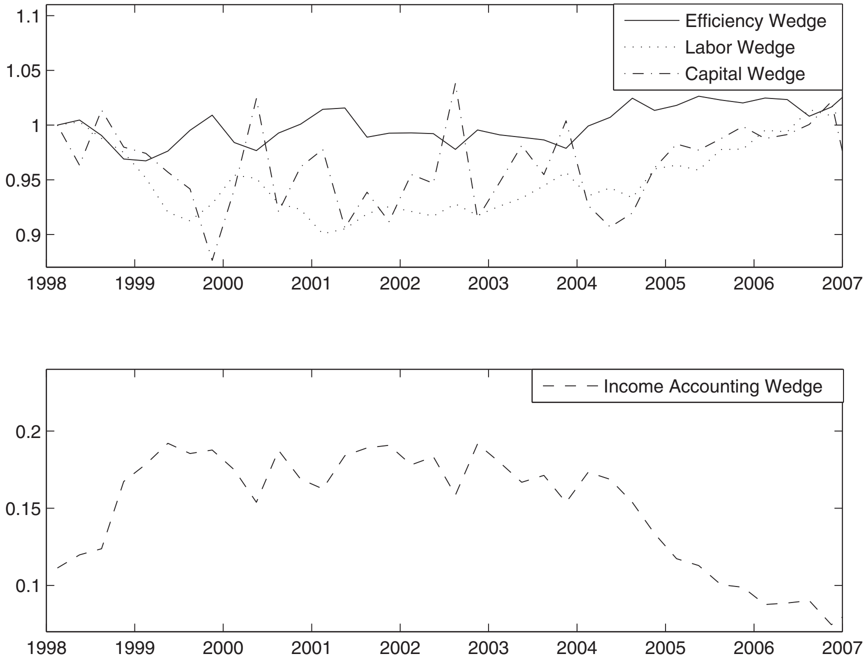

FIGURE C.1. Benchmark model with capital wedge: Measured wedges.

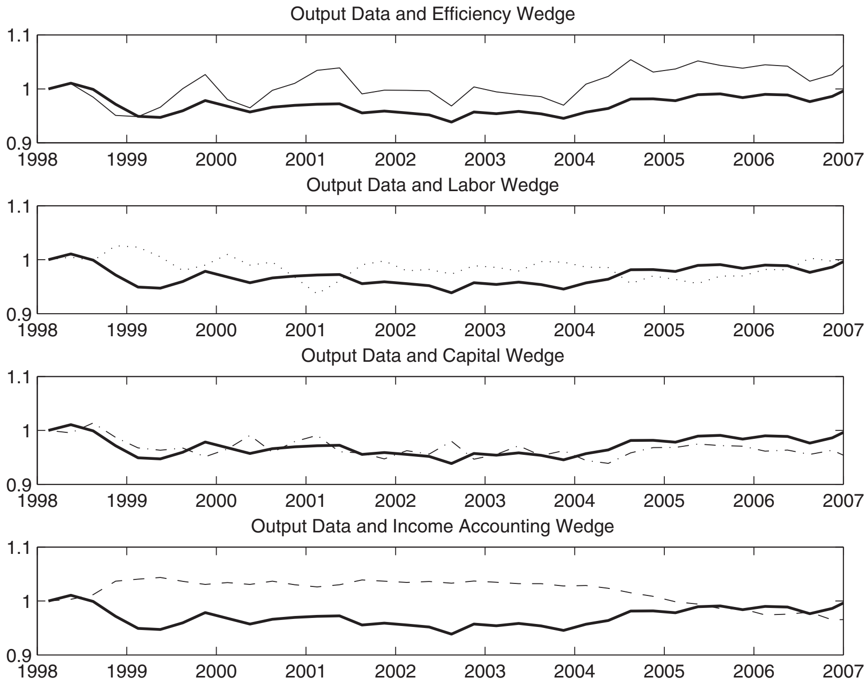

FIGURE C.2. Benchmark model with capital wedge: Output.

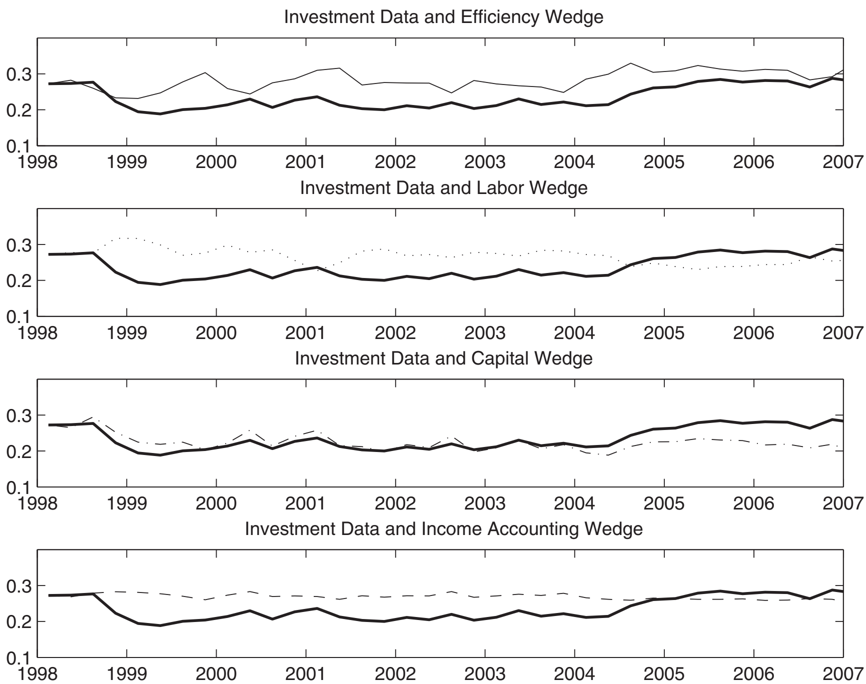

FIGURE C.3. Benchmark model with capital wedge: Investment.

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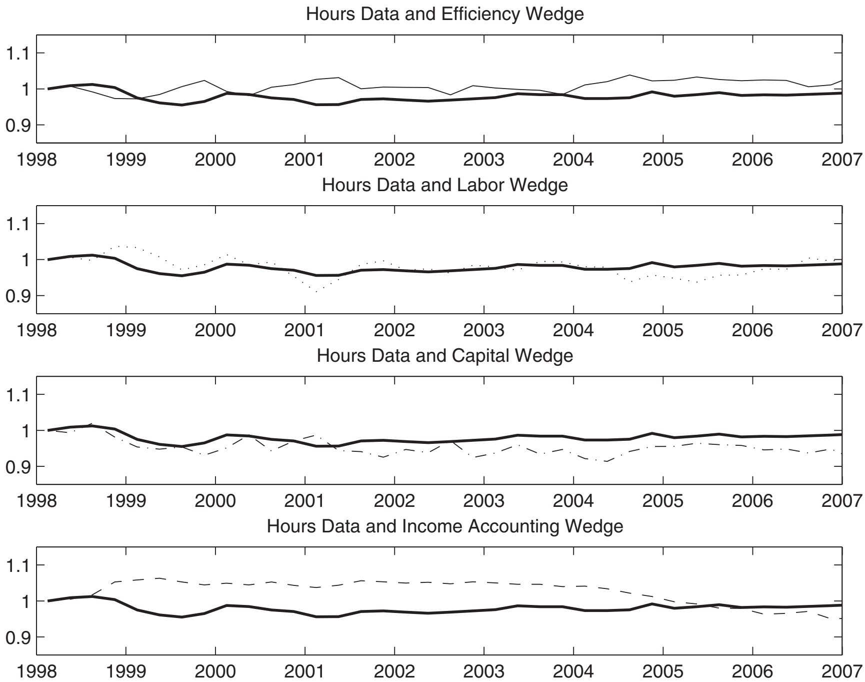

FIGURE C.4. Benchmark model with capital wedge: Hours.

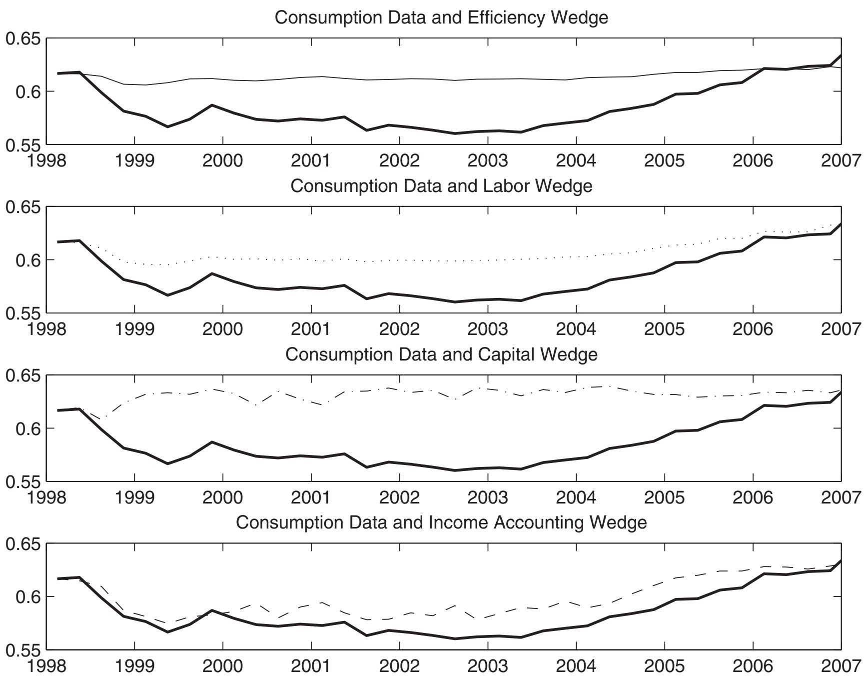

FIGURE C.5. Benchmark model with capital wedge: Consumption.

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APPENDIX D: CREDIT AND THE BALANCE OF PAYMENTS IN CHILE

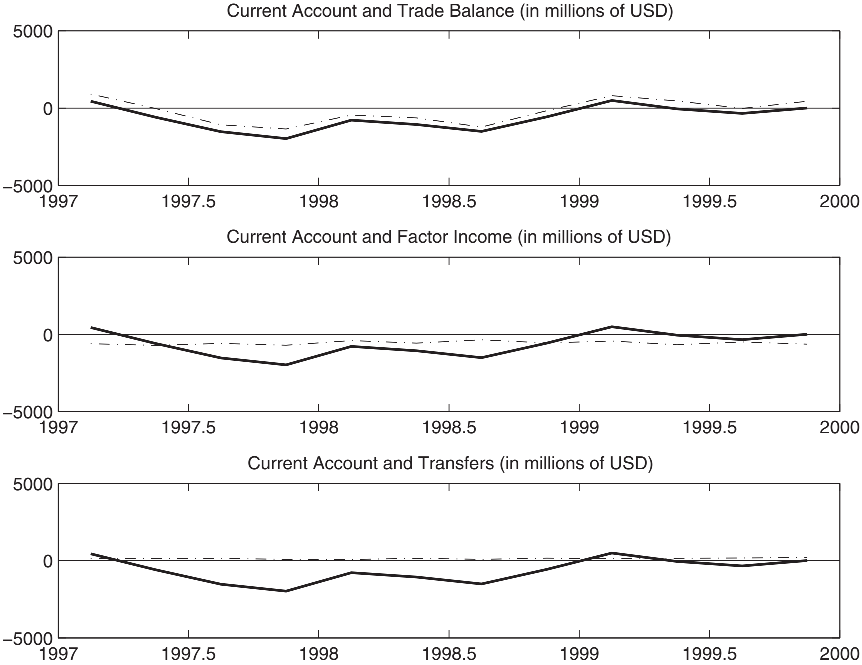

FIGURE D.1. Current account and subaccounts.

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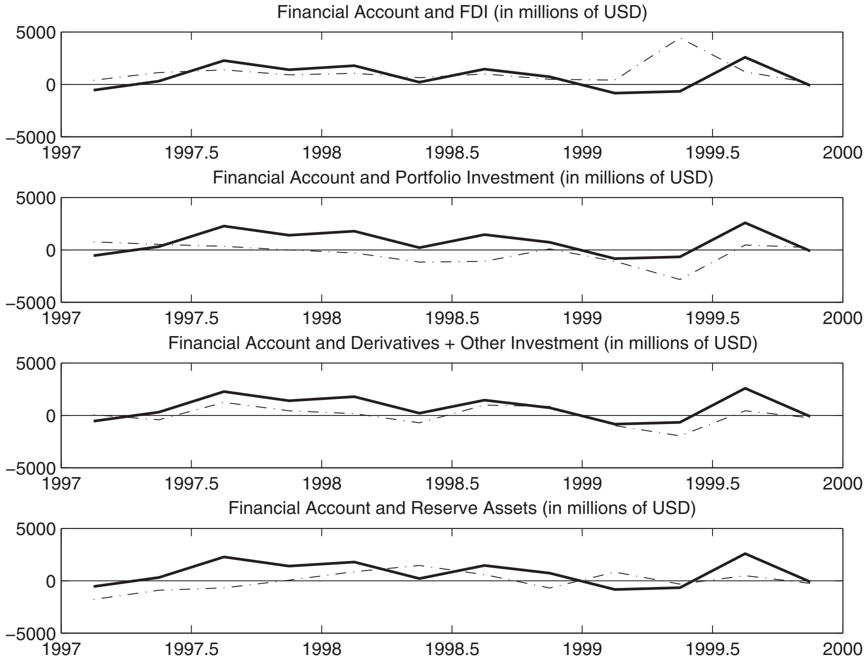

FIGURE D.2. Financial account and subaccounts.

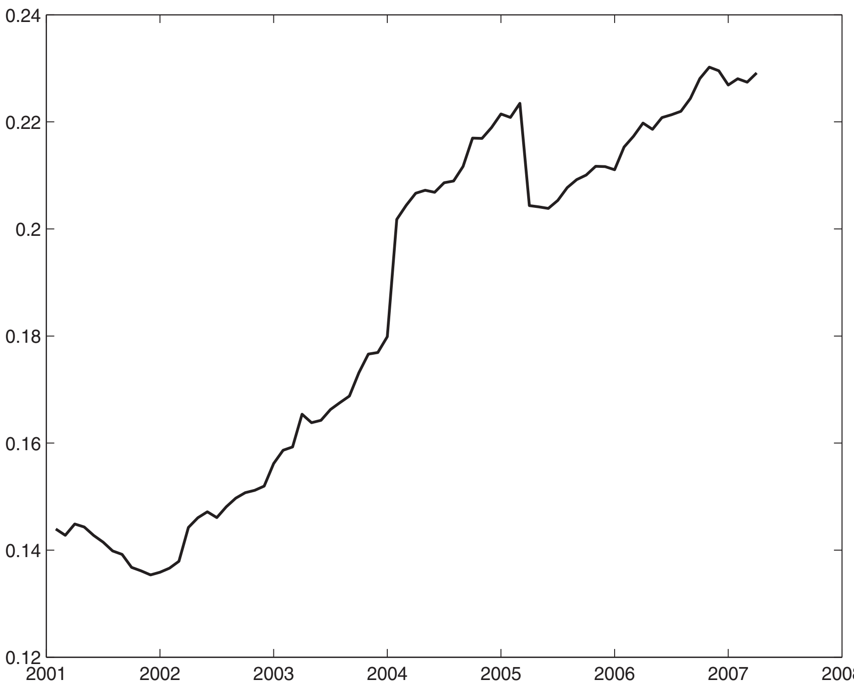

FIGURE D.3. Consumer and comercial loans: Consumer to commercial loan ratio (in billions of Ch. pesos).

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APPENDIX E: RESULTS FROM SMALL OPEN ECONOMY MODEL

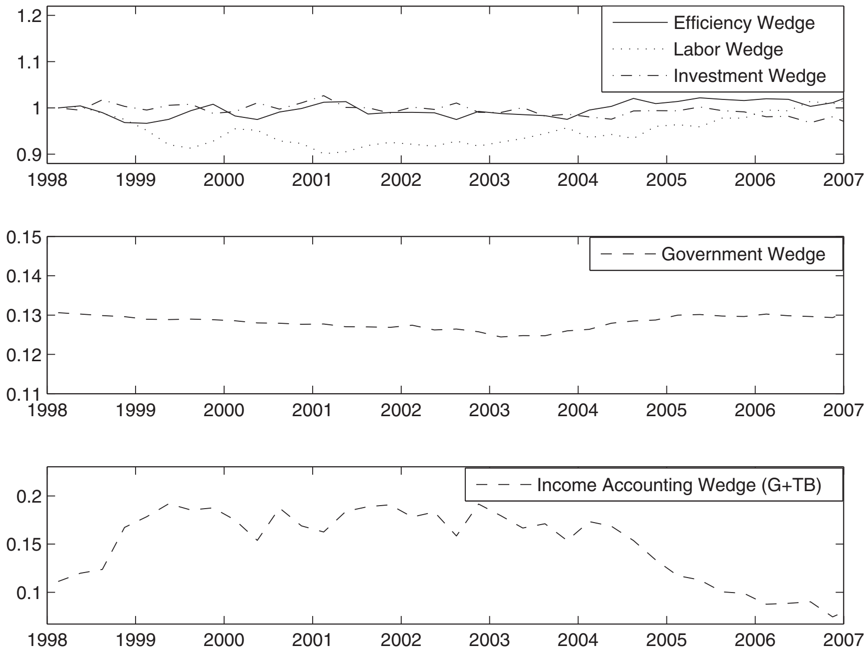

FIGURE E.1. Small open economy model: Measured wedges.

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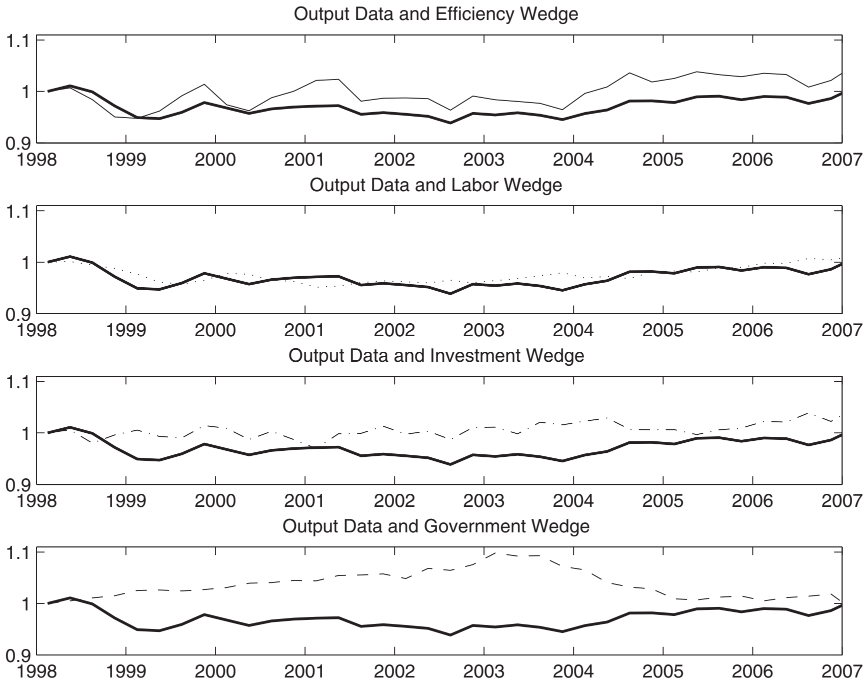

FIGURE E.2. Small open economy model: Output.

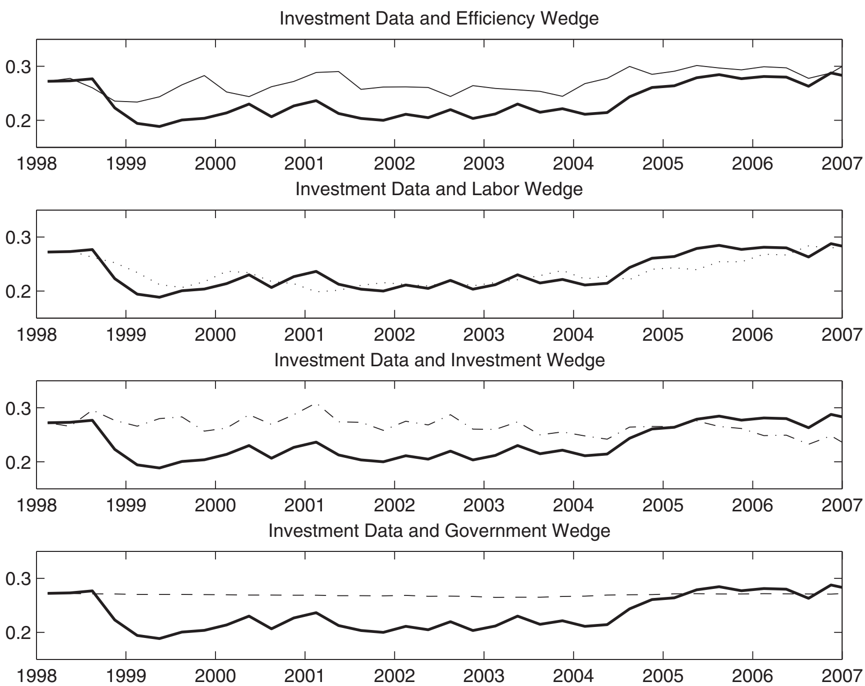

FIGURE E.3. Small open economy model: Investment.

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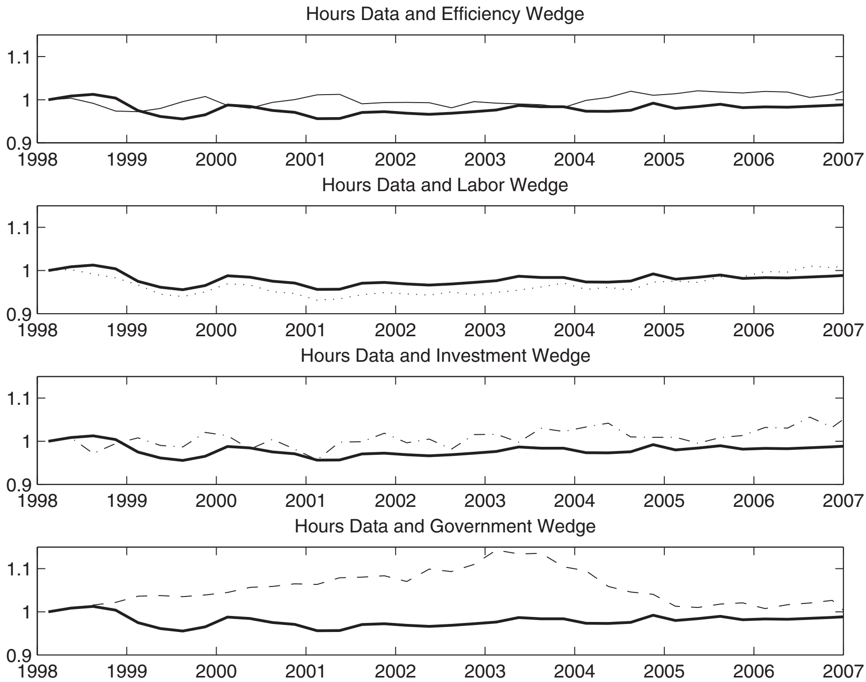

FIGURE E.4. Small open economy model: Hours.

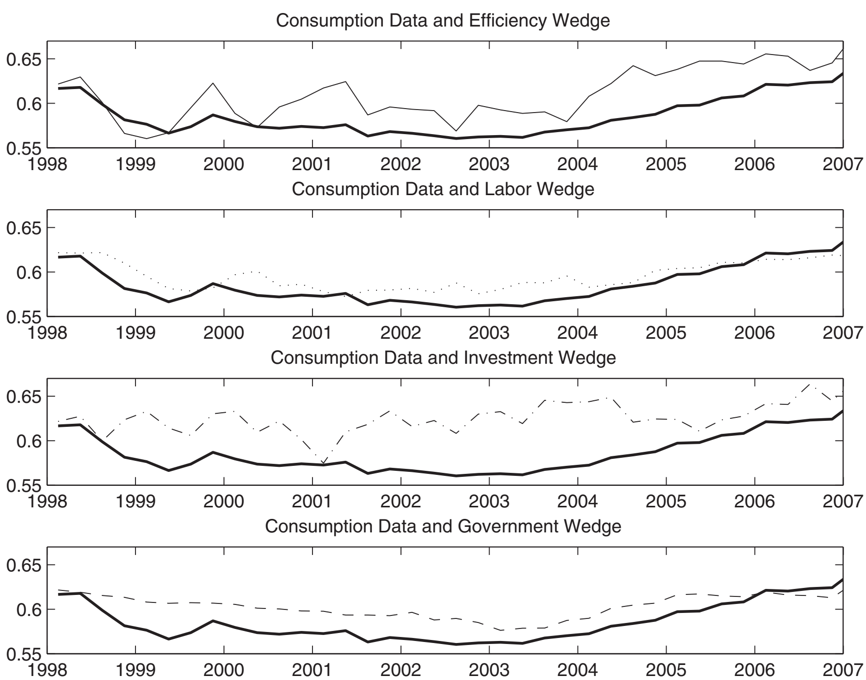

FIGURE E.5. Small open economy model: Consumption.

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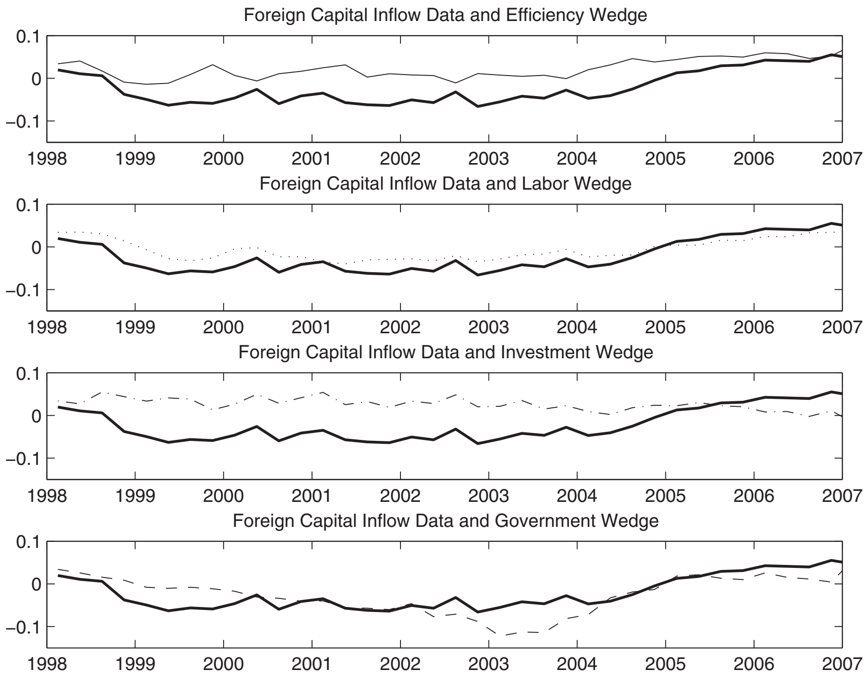

FIGURE E.6. Small open economy model: Foreign capital inflow.

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