Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 627

Mayo 2011

CHILE'S FISCAL RULE AS SOCIAL INSURANCE

Eduardo Engel Christopher Neilson Rodrigo Valdés

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Agustinas 1180, Santiago, Chile
Teléfono: (56-2) 3882475; Fax: (56-2) 3882231

Documento de Trabajo
N° 627

Working Paper
N° 627

CHILE'S FISCAL RULE AS SOCIAL INSURANCE

Eduardo Engel
Yale University

Chistopher Neilson
Yale University

Rodrigo Valdés
International Monetary
Found

Abstract

We explore the role of fiscal policy over the business cycle from a normative perspective, for a government with a highly volatile and exogenous revenue source. Instead of resorting to Keynesian mechanisms, in our framework fiscal policy plays a role because the government provides transfers to heterogeneous households facing volatile income, albeit with an imperfect transfer technology (a fraction of transfers leak to richer households). We calibrate the model to Chile's highly volatile government revenues derived from copper, and characterize the optimal fiscal reaction. We quantify the welfare gains vis-à-vis a balanced budget rule, and the degree of adequate fiscal countercyclicality. We also analyze simpler rules, such as the structural balance rule in place in Chile during the last decade, more general linear rules, and linear rules with an escape clause. We find that the optimal rule leads to the same welfare gain as doubling the government's copper revenues under a balanced budget rule. Chile's structural balance rule achieves 18% of these gains, while a linear rule with an escape clause achieves 83% of the gains. The degrees of countercyclicality of the optimal rule and the linear rule with an escape clause are similar, and much larger than those of the structural balance rule.

Resumen

Se explora el papel de la política fiscal a través del ciclo económico desde una perspectiva normativa, bajo un gobierno con una fuente de ingresos altamente volátiles y exógenos. En lugar de recurrir a mecanismos keynesianos, en el marco de nuestro trabajo la política fiscal juega un papel, dado que el Gobierno proporciona transferencias a hogares heterogéneos con ingresos volátiles, aunque con una tecnología de transferencia imperfecta (una fracción de las transferencias se filtra hacia los hogares más ricos). El modelo se calibra con los altamente volátiles ingresos del Gobierno de Chile derivados del cobre, y caracterizamos la reacción fiscal óptima. Cuantificamos las ganancias de bienestar derivadas de la regla en relación con un presupuesto equilibrado, y el grado adecuado de anticiclicidad fiscal. También se analizan normas más sencillas, tales como la regla de balance estructural en Chile durante la última década, reglas lineales más generales, y reglas lineales con una cláusula de escape. Se encuentra que la regla óptima conduce a una mejora del bienestar equivalente a duplicar los ingresos del Gobierno derivados del cobre bajo una regla de equilibrio presupuestario. La regla de balance estructural en Chile alcanza un 18% de estas ganancias, mientras que una regla lineal con una cláusula de escape alcanza un 83% de las ganancias. Los grados de contraciclicidad de la regla óptima y la regla lineal con una cláusula de escape son similares entre sí y mucho mayores que los de la regla de balance estructural.

Engel and Neilson: Department of Economics, Yale University, 28 Hillhouse Ave., New Haven, CT 06511. Valdés: International Monetary Fund, 700 19th St NW, Washington DC 20431. E-mails: eduardo.engel@yale.edu, christopher.neilson@yale.edu, and rvaldes@imf.org. This paper was presented during the XIV Annual Conference of the Central Bank of Chile, "*Fiscal Policy and Macroeconomic Performance,*" held on 21-22 October 2010 in Santiago. We thank Rómulo Chumacero, and participants at the above mentioned conference and the IMF WHD seminar for helpful comments and suggestions.

1 Introduction

Well before the Great Recession of 2009 put fiscal policy debates in the front burner, commodity exporting countries had to deal with important fiscal policy dilemmas stemming from revenue volatility and eventual depletion. Chilean policymakers have been at the forefront in this area after adopting a fiscal rule to guide government spending decisions a decade ago. This so called *structural balance rule* (SBR) incorporates fluctuations in copper prices —the main source of volatility in fiscal revenues— and was instrumental to save large part of the windfall during the commodity boom of 2005-2008. Yet when the country went into recession in 2009, the rule was de facto abandoned as authorities implemented a fiscal expansion beyond that suggested by the SBR.

While having a fiscal rule has served Chile well, there are pending questions about the appropriateness of its design. How much would welfare improve if the rule were modified to respond more to accumulated assets? Or if spending were more countercyclical? Furthermore, since the rule is well understood and has gained legitimacy across society, it is desirable to consider improvements that do not entail major departures from its current structure. This raises the question of whether the gains from moving toward a spending policy with a higher propensity to spend out of assets when private income is low can be achieved with a rule similar to the SBR, for example, by adding an escape clause whereby spending is expanded beyond what is prescribed for "normal" times in predetermined "extreme" circumstances.

In this paper we explore from a normative perspective the contours of an optimal spending rule for a government that has volatile revenues from an exogenous source such as a flow from a natural resource, very much like Chile. Specifically, we analyze policies for a government with a precautionary saving motive that decides how much to transfer from volatile copper revenues to impatient agents that differ in their private incomes, which in turn are volatile and correlated with fiscal revenues. Much as in reality, the government can save abroad, has limited space for borrowing against future revenue, and has access to an imperfect technology for targeting transfers (a portion of transfers leaks to richer households). Households' behavior is simple: they consume all available income.

Output is exogenous in our model, that is, fiscal multipliers are zero, so any countercyclical action reflects the desire of increasing transfers at times when household consumption is low and government spending has a higher marginal utility, rather than a Keynesian mechanism. Fiscal policy is ultimately the implementation of social insurance.

We analyze the welfare gains of an optimal rule vis-a-vis a balanced budget rule whereby the government transfers all its revenues to households in each period. We also study the behavior of government assets and the extent to which government spending is countercyclical. We compare the optimal rule prescribed by our model with simpler rules, including the Chilean SBR, a rule that spends the permanent income from copper (à-la Friedman), and linear rules similar to the SBR except that propensities to consume out of assets and structural revenues are chosen optimally. We also analyze the gains from having an escape clause.

The last global cycle made apparent once again that government revenues in Chile are heavily influenced by copper prices. From representing less than 1 percent of GDP (or about 5 percent of total government revenues) in 1998-2003, government mining revenues increased to more than 8 percent of GDP following the rise of copper prices in 2004-2008 (Figure 1). With the subsequent decrease in commodity prices, copper revenues declined to 3 percent of GDP. Non-mining revenues, which are on average higher, have also fluctuated, but their volatility has been considerably lower. Spending decisions, on the other hand, have been guided by a predetermined central government structural result target (1 percent of GDP until 2006, 0.5 percent of GDP in 2007 and 0 percent in 2008). To this end, spending has been based on what is considered "permanent" revenues, stripping out cyclical revenues which include both tax revenues —influenced by the GDP cycle— and the volatile mining revenues affected by the price of copper. In principle, the rule aims at an acyclical fiscal behavior and the full operation of automatic stabilizers on the tax revenue side. Real government spending growth would be relatively stable and change only with innovations in trend GDP growth, changes in tax policy and updates of what is considered the normal or reference copper price. The consequence has been that the overall fiscal result has varied considerably in a few years, with large savings when copper prices were high and large spending when the country went into recession (Figure 2). Government net assets increased to more than 20 percent of GDP in 2008.

Fiscal policy was decisively countercyclical in 2009, when the economy entered into recession following the Lehman collapse. Real government spending increased by 18 percent (year-on-year) providing a fiscal impulse of 3 percent of GDP, one of the highest one year fiscal impulses in emerging market economies during the Great Recession. Part of the fiscal reaction was in the form of targeted transfers to poor families. Unemployment increased to more than 10 percent in 2009, only slightly less than in the previous recession of 1998-1999 that also followed large external shocks. Output contracted by 1.5 percent in 2009, more than the 0.8 percent drop in the previous recession. Interestingly, however, the government approval rating followed very distinct patterns: it increased significantly in 2009, largely due to perceptions of economic policies, while it tanked in 1998-1999 (Figure 3). This suggests that targeted fiscal policies at times of hardship were very welcome by many households.

In our model the gains from moving from a balanced budget rule to an optimal rule are sizeable, which suggests that the profile of fiscal spending can be quite relevant. With the baseline parameters calibrated to the Chilean economy, welfare gains from an optimal rule are equivalent to a proportional increase of copper revenues by 100% under a balanced budget rule. Optimal spending displays significant countercyclicality: a fall of one standard deviation in private income leads, on average, to a rise in government transfers of 50% of the government's median income. The optimal rule is more countercyclical when government expenditures are less targeted, as the relative value of government transfers during recession increases in this case. Put somewhat differently, the inefficiencies of poor targeting are less costly during recessions.

Simpler rules also provide significant welfare gains. The SBR rule attains 18% of the gains obtained under the optimal rule, a Friedman-type rule does somewhat better, achieving 20% of possible gains. Gains increase substantially when considering linear rules where, by contrast with the Chilean SBR and Friedman-type rules, the marginal propensities to spend out of assets and wealth are chosen optimally to reflect heterogeneous households, imperfect targeting and borrowing constraints. The results suggest a considerably lower propensity to consume out of structural copper revenues and a higher one with respect to assets, in comparison to the SBR. These parameters narrow the distribution of assets. The best linear rule attains 74% of the gains obtained under the optimal rule. Furthermore, allowing for rules that switch between two linear regimes depending on the GDP cycle further increases welfare to 83% of the gain under the optimal rule. As expected, the propensity to spend out of assets and structural revenue is higher in the low GDP regime. In fact, the main difference between rules with one and two linear regimes is that the former are pretty much acyclical while the latter capture the degree of countercyclical expenditure present in the optimal rule. We interpret the quasi-optimality of a regime switching rule as the gains from having escape clauses for extreme events which simple rules are not able to cope with adequately.

The paper is organized as follows. Section 2 provides a brief literature review. Section 3 describes the model. Section 4 implements the model with Chilean data. This section describes the optimal fiscal rule, evaluates welfare gains, and analyzes its behavior under different environments and shocks. Section 5 investigates whether alternative simpler rules provide useful approximations to the optimal solution, with special focus on Chile's structural rule and variations that could help improve it. Finally, section 6 presents some concluding remarks.

2 Relation to the literature

This paper is related to two literatures. First, it draws from works on optimal consumption with self-insurance. The starting point is the "income fluctuation problem", where a risk averse consumer receives an exogenous, stochastic income stream and maximizes her expected discounted utility, subject to an exogenous credit constraint that assumes all debts are repaid.[2] The agent has a precautionary saving motive and is impatient, as in Zeldes (1989), Deaton (1990), and Carroll (1992, 1997).[3] The model in this paper may be viewed as an income fluctuations problem where a planner with volatile income saves and spends to maximize the sum of expected discounted utilities of heterogenous, impatient households with their own sources of volatile incomes.

This paper also relates to the "cost of business cycles" debate triggered by Lucas (1987).[4] We consider a government with a highly volatile source of income and compare the welfare implications of spending incomes upon receipt ('balanced budget rule') with those of using a fiscal rule. Our results show that a fiscal rule aimed at stabilizing the incomes of the poor during downturns leads to considerably larger welfare gains than those obtained by Lucas.

A second type of work connected to this paper is the study of fiscal policy rules. For the most part, the applied literature has focused on issues of fiscal sustainability and whether having fiscal rules is, from a positive perspective, useful to that end. IMF (2009) and several of the chapters of Kopits (2004) are good examples of this type of analysis. The former documents that fiscal rules have become more common in recent years, with almost 80 countries having rules in place in early 2009 (from less than 10 in 1990), and that, on average, they have been associated with improved fiscal performance and more prudent fiscal policies. The latter compiles several case studies to analyze conditions under which rules have succeeded and concludes that political support and transparency are critical, while the extent to which a rule is legally enshrined is largely irrelevant.

One particular strand of the fiscal policy rules literature has studied the challenges arising from revenues tied to nonrenewable commodities with volatile prices (e.g., oil and copper). Villafuerte, López-Murphy and Ossowski (2010) analyze the recent experience with fiscal policy of commodity rich Latin American countries, concluding that, on average, policies have been somewhat procyclical, that countries that pursued more conservative fiscal policies during the boom were able to implement more aggressive countercyclical fiscal policies during the downturn, and that these dimensions of fiscal policy were not linked to fiscal rules or resource funds.

There also exists closely related work on fiscal rules from a normative perspective with focus on commodity-related revenues. A standard approach has been to apply Friedman's permanent-income-hypothesis and prescribe rules that spend the annuity value of the commodity-related wealth. Segura (2006) is one of several papers based on this approach, which is attractive because of its simplicity but has several shortcomings precisely for the same reason. Among the shortcomings is that it neglects both that households have other sources of income beyond transfers, and that precautionary savings can be particularly important given commodity price volatility. Engel and Valdés (2000) analyze the intergenerational distribution of an exhaustible commodity (oil, in their case) when household income is increasing over time, as well as appropriate precautionary saving given volatile prices and imperfect insurance markets. Maliszewski (2009) applies the framework to oil-producing countries concluding that ad-hoc rules perform relatively poorly. Drexler, Engel and

[2] See Schechtman (1976) for the seminal paper and Chamberlain and Wilson (2000) for a recent contribution with a good overview.

[3] As noted by Schechtman (1976), in this setting an agent with infinite marginal utility at zero consumption optimally acts as if she were liquidity constrained even if there are no such constraints.

[4] See Barlevy (2004), Lucas (2003) and Yellen and Akerlof (2004) for surveys of this literature with diverging conclusions on where it stands. Also see Krusell et al. (2009) for a recent contribution.

Valdés (2002) apply the framework to Chile and copper, noting that actual fiscal policy has been closer to the prescriptions of a model with precautionary saving than to those of a model based solely on smoothing government expenditures. The focus in their paper is the distribution of natural resource wealth across generations, not across households over the cycle as in this paper.

Finally, there are papers that have studied the implications of different fiscal rules for macroeconomic volatility, including the effects of the Chilean fiscal rule, through new-Keynesian DSGE models. In general, these papers assume some form of non-Ricardian behavior (so that fiscal policy has non trivial effects) through the existence of liquidity constrained consumers (in the form of rule-of-thumb or hand-to-mouth decisions, very much like in our model). Andres and Domenech (2006) analyze whether there is a tradeoff between sustainability of public finances and their countercyclicality power, concluding that this is not the case. Kumhof and Laxton (2009) compare a balanced budget rule with rules that embed a more active countercyclicality, including one with a structural balance. They conclude that there are high potential welfare gains from using more active rules and that, in the case of commodity-driven revenues, automatic stabilizers should be allowed to operate fully (keeping spending stable). In the specific case of the Chilean fiscal rule, both Kumhof and Laxton (2010) and Batini, Levine and Pearlman (2009) conclude that a balanced-budget rule is inferior when compared to a structural budget rule. The first paper also concludes that a rule with more activism than the structural balance rule lowers output volatility with a minor cost in inflation volatility but considerable movements in the fiscal instrument. None of these papers deals with imperfect targeting of fiscal policy or heterogeneous agents and the income distribution, as we do in this paper.

3 Model

We analyze the optimal program of a planner that can save and spend incomes from a natural resource to maximize the sum of discounted utilities of agents representing the economy's income quintiles. An important departure from previous work is that the planner cannot target households at will but is constrained by an exogenous "transfer technology".

3.1 Households

Time is discrete. Total private income follows an exogenous stochastic process, Y_t^p. Income quintiles are indexed, from the poorest to the richest, by $i = 1, 2, ..., 5$. Each quintile is represented by one household, all of which have subjective discount rate $\delta > 0$. The income share of quintile i, which remains constant over time, is denoted by s_i, with $0 \leq s_1 \leq s_2 \leq \cdots \leq s_5$ and $\sum_{i=1}^{5} s_i = 1$. Households consume all their income.[5]

3.2 Planner

The planner receives an exogenous, stochastic income stream Y_t^g derived from a natural resource (we could extend the model to incorporate tax revenues). The planner can save at an exogenous riskless real rate r with $r < \delta$ so that households (and therefore the planner representing them) are impatient.

The planner faces an exogenous debt limit B that allows her to pay back her debt with probability one,[6] which she does. That is, if the planner spends $G_t \geq 0$ in period t, beginning of period assets evolve according to

$$A_{t+1} = (1 + r)(A_t + Y_t^g - G_t)$$

[5] This admittedly strong assumption avoids modeling the strategic interaction between the planner and households, and provides a role for fiscal rules. In Engel, Neilson and Valdés (2011) we relax this assumption.

[6] That is, B is less than or equal to the planner's "natural debt limit", defined at the minimum present value of income.

and the borrowing constraint takes the form

$$A_{t+1} \geq -B.$$

The planner's expenditures are distributed across quintiles according to an exogenous, time-invariant, targeting function α, so that quintile i receives $\alpha_i G$ when the planner spends G, with $\alpha_i \geq 0$ and $\sum_{i=1}^{5} \alpha_i = 1$.

3.3 Dynamic formulations

The sequential formulation for the planner's problem at time 0 is:

$$\begin{aligned}
\max_{G_0, G_1, \ldots} \quad & \mathrm{E}_0 \sum_{t \geq 0} (1+\delta)^{-t} \sum_{i=1}^{5} u(s_i Y_t^p + \alpha_i G_t) \\
\text{s.t.} \quad & (Y_0^p, Y_0^g) \text{ given}, \\
& (Y_t^p, Y_t^g) \text{ exogenous process}, \ t = 1,2,3,\ldots \\
& A_t = (1+r)(A_{t-1} + Y_{t-1}^g - G_{t-1}), \ t = 1,2,3,\ldots \\
& A_t + B \geq 0, \ t = 1,2,3,\ldots \\
& G_t \geq 0, \ t = 0,1,2,\ldots
\end{aligned}$$

And the problem's recursive formulation is:

$$\begin{aligned}
V(A_t, Y_t^g, Y_t^p) \quad = \quad & \max_{0 \leq G_t \leq A_t + Y_t^g + (1+r)^{-1} B} \sum_{i=1}^{5} u(s_i Y_t^p + \alpha_i G_t) \\
& + (1+\delta)^{-1} \mathrm{E}_t V((1+r)(A_t + Y_t^g - G_t), Y_{t+1}^g, Y_{t+1}^p).
\end{aligned}$$

In periods where the solution is interior, a straightforward calculation starting from the sequential formulation yields the Euler equation

$$\sum_i \alpha_i u'(s_i Y_t^p + \alpha_i G_t) = \frac{1+r}{1+\delta} \mathrm{E}_t \sum_i \alpha_i u'(s_i Y_{t+1}^p + \alpha_i G_{t+1}). \tag{1}$$

The planner spends resources to equalize a weighted sum of current marginal utilities with the corresponding discounted expected weighted sum of next period's marginal utilities. The weights given by the targeting function: quintiles that benefit more from government expenditures receive a higher weight. The Euler equation also shows that an increase in expected future private incomes leads to higher current spending by the planner.

By contrast with (1), in periods where the borrowing constraint is binding we have:

$$\sum_i \alpha_i u'(s_i Y_t^p + \alpha_i G_t) > \frac{1+r}{1+\delta} \mathrm{E}_t \sum_i \alpha_i u'(s_i Y_{t+1}^p + \alpha_i G_{t+1}).$$

3.4 Perfect Targeting

One of the main departures from the literature in this paper is to allow for imperfect targeting. This motivates considering first the case with perfect targeting, which requires allowing the α_i to vary over time and will serve as a useful benchmark.

When the planner can target expenditures at will, there exists a simple characterization of the distribution of government expenditures across households, conditional on the choice of G_t.[7] Expenditures are distributed across quintiles so as to equalize marginal utilities among the poorer quintiles until G_t is exhausted. Richer quintiles do not receive any transfers while remaining households achieve a common consumption level, so that poorer quintiles receive higher transfers.

More precisely, denoting by $\widetilde{G}_k$ total transfers needed to equalize total incomes of quintiles 1 through k with private income of quintile $k+1$, a straightforward calculation shows that

$$\widetilde{G}_k = \sum_{i=1}^{k} i(s_{i+1} - s_i) Y_t^p, \qquad k = 1, 2, \ldots, 4,$$

where we adopt the convention that $s_0 = 0$, $\widetilde{G}_0 = 0$ and $\widetilde{G}_5 = \infty$.

Since the sequence $\widetilde{G}_k$ is increasing, given a level $G \geq 0$ of government expenditure there exists a unique non-negative integer k such that $\widetilde{G}_k \leq G < \widetilde{G}_{k+1}$. The optimal allocation of G_t across quintiles transfers resources only to quintiles 1 through $k+1$, and does so in a way that equalizes their total incomes. Denoting by G_i the transfer to quintile i this means that:

$$G_i = (s_{k+1} - s_i) Y_t^p + \frac{G_t - \widetilde{G}_k}{k+1}.$$

It follows that finding G_t is equivalent to solving a standard incomes fluctuation problem where the planner's instantaneous marginal utility from government expenditures is equal to

$$u'(s_{k+1} Y_t^p + \frac{G_t - \widetilde{G}_k}{k+1}),$$

with k given by the piecewise constant, increasing function of G_t described above.

4 Implementation and Results

In this section we implement the model described in Section 3 with data from Chile. The trusting (or impatient) reader can skip section 4.1 that describes our parameter and functional choices and move directly to section 4.2 that describes the optimal policy.

4.1 Parameter choices

To determine the joint process of private and government revenues, we considered annual data for the 1990-2009 period. We proxied Y^p by the difference between GDP and government expenditures per capita (data source: Central Bank of Chile), and detrended $\log Y^p$ using a quadratic trend. The resulting stationary variable is denoted by y^p in what follows. We work with detrended Y^p to highlight the relation between *cyclical* fluctuations and optimal fiscal policy.

We proxied Y^g by per capita fiscal revenues derived from copper, both directly from state owned CODELCO, and indirectly via taxes on privately held copper companies (source Dirección de Presupuesto). We denote $\log Y^g$ by y^g.

We fitted a first-order VAR to (y^p, y^g) and, under the identifying assumption that current innovations to y^p have no effect on current y^g, found no statistically significant effect of past innovations of y^p on y^g (see Figure 4 for the resulting impulse-response functions). We therefore chose as our benchmark income

[7] Engel and Valdés (2000) derive a similar result in a model that distributes natural resource wealth across generations.

process, a specification of the form:

$$\begin{aligned} y_t^p &= F_0^p + F_{pp} y_{t-1}^p + F_{pg} y_{t-1}^g + \varepsilon_t^p, \\ y_t^g &= F_0^g + F_{gg} y_{t-1}^g + \varepsilon_t^g, \end{aligned}$$

where only contemporaneous innovations are allowed to be correlated. In Section 4.3 we consider two alternative specifications, one where past values of y^g have no effect on current y^p ($F_{pg} = 0$), the other where past values of y^p influence y^g.[8]

Since we are interested in fiscal rules that are relevant in coming years, we set the average value of Y_g at 2.1% of the average value of Y_p —which is somewhat lower than the 3% observed in the data— to account for the fact that Y^p was much higher toward the end of the period than at the beginning.

The planner's problem is solved using a Tauchen discretization for the joint distribution of (y^p, y^g). This discretization has 25 states: y^p takes five values and associated with every value of y^p there are five possible values of y^g. Table 1 shows the probabilities of the 5 values of y^p and the magnitudes of the corresponding deviations from trend.

We set the annual risk free interest rate, r, at 5% and the subjective discount factor, δ, at 8%. A useful way to capture the notion that poor households value relatively more having smoother consumption across periods and states of nature than wealthier households is to consider an instantaneous utility function u that is a Stone-Geary extension of a constant elasticity of intertemporal substitution felicity function:[9]

$$u(c) = \begin{cases} \frac{1}{1-\theta}(c-c^*)^{1-\theta}, & \theta \neq 1, \\ \\ \log(c-c^*), & \theta = 1. \end{cases} \tag{2}$$

Where c^* denotes the subsistence level. We consider a coefficient of relative risk aversion, θ, of 3 in the benchmark model and set c^* at 98% of the income of the poorest quintile in the worst aggregate income scenario, which corresponds to an annual per capita income of approximately 800 US dollars (the poverty line has varied around 1,200 US dollars during the period considered).

To solve the model we impose an upper bound on accumulated assets equal to average private income; this restriction is rarely binding and results do not change making it looser. We also impose a lower bound of zero on assets ($B = 0$).

Table 2 shows the values for the income share and expenditure share parameters, s_i and α_i, for each quintile. They correspond to values reported by MIDEPLAN in 2009 which are calculated using the CASEN 2009 household survey. Social expenditure targeting in Chile is considerably better than in most developing countries, Figure 1 in Rey de Marulanda, Ugaz and Guzman (2006) suggests that the "typical" targeting function in Latin America is close to 'uniform targeting', that is, to having $\alpha_i = 1/5$ for all quintiles.

[8]The latter could reflect, for example, that a negative shock to private income leads to a depreciation of the peso, thereby increasing revenues from copper measured in pesos. Alternatively, a negative GDP shock might lead the government to ask CODELCO to lower its investment and increase transfers to the government. Even though, as mentioned above, our VAR analysis found no statistically significant effect of past GDP shocks on current copper revenues, the estimated coefficients are economically significant which, given the relatively short series at hand, suggests this case may be relevant as well.

[9]See, for example, Deaton and John Muellbauer 1980, chapter 3. An alternative route is to allow for a marginal utility of consumption that is decreasing in wealth, as in Blundell, Browning and Meghir (1991), Attanasio and Browining (1995), Atkeson and Ogaki (1996), and Guvenen (2006). We are exploring this route in ongoing work.

4.2 Optimal policy

The left panel in Figure 4 shows optimal government expenditure as a function of government assets, for three values of private income. Government income is held (approximately) constant at its median value.[10] The dash-dotted (lower) curve assumes high private income (highest value in the discretization), the solid (intermediate) curve intermediate private income (median value) and the dashed (higher) curve low private income (lowest value in the discretization). Both G and A are normalized by average private income (referred to as average GDP in what follows). The right panel is similar except that now Y^g is held (approximately) constant at its lowest value.

Other things equal, expenditures are higher when private sector output is lower, that is, when the marginal utility of private consumption is higher. The government saves during good times to be able to spend in bad times. The expenditure functions are concave (in the regions with positive expenditure), implying a marginal propensity to spend out of assets that decreases with assets. Concavity of the expenditure function for low asset values is more pronounced during recessions (low values of Y^p), reflecting the interplay between the precautionary motive and impatience.

Comparing both panels in Figure 4 shows that government expenditures are lower when current fiscal income is lower. In fact, when fiscal revenues are low and private income is sufficiently high, there exists a range of asset values where the government finds it optimal not to spend at all.

4.2.1 Asset Accumulation

Mean and median assets in steady state are equal to 38.9 and 32.9% of average GDP, even though assets accumulate slowly. Starting from zero, mean and median assets during the first 25 years of the rule are 13.2 and 6.1% of GDP, respectively; Figure 6 depicts the corresponding histogram (based on 4,000 simulations with 25 periods each, that is, 100,000 observations).

4.2.2 Welfare gain

To gauge the welfare gains under the optimal rule, we quantify the associated welfare improvement with that obtained under a balanced budget rule where the government does not incur in debt or save from current income. To do this we solve for γ in:

$$\mathrm{E}_0\left[\sum_{t\geq 0}(1+\delta)^{-t}\sum_i u(s_i Y_t^p + \alpha_i(1+\gamma)Y_t^g + \alpha_i \frac{r}{1+r}A_0)\right] = \mathrm{E}_0\left[\sum_{t\geq 0}(1+\delta)^{-t}\sum_i u(s_i Y_t^p + \alpha_i G_t)\right].$$

Thus γ measures the fraction by which fiscal revenue must increase when the government spends all its income upon receipt, to achieve the same level of expected welfare than under the optimal rule.[11] We obtain a value for γ of 1.001 starting from $A_0 = 0$. The welfare gain under the optimal fiscal rule is considerable.

An alternative welfare measure compares gains under the optimal rule with a scenario with no natural resource income. Denoting by Q the ratio of average government and private incomes, we solve for γ^* in:

$$\mathrm{E}_0\left[\sum_{t\geq 0}(1+\delta)^{-t}\sum_i u(s_i(1+\gamma^* Q)Y_t^p + s_i \frac{r}{1+r}A_0)\right] = \mathrm{E}_0\left[\sum_{t\geq 0}(1+\delta)^{-t}\sum_i u(s_i Y_t^p + \alpha_i G_t)\right]. \quad (3)$$

The normalization constant Q is such that $\gamma^* = 1$ when $s_i = \alpha_i$ for all i and the natural resource income is equal to a constant fraction of private income, in all periods and for all quintiles ($Y_t^g = \lambda Y_t^p$). Starting

[10] As described above, the discretization we consider leads to small differences in y^g across the three states considered.

[11] When $A_0 > 0$ we assume that in the balanced budget counterfactual the government spends the annuity value from A_0.

with no assets, the value of γ^* is equal to 3.122 for the optimal program. Thus, even though copper revenue equals, on average, only 2.1% of GDP, the welfare improvement it leads to under the optimal fiscal rule is akin to increasing private income by 6.6%. This happens because targeting is considerably better than having transfers proportional to quintile income, and because the natural resource revenue is far from perfectly correlated with private income (correlation of 0.45). It is also possible to calculate γ^* for the balance budget rule, by solving (3) with

$$G_t = Y_t^g + \frac{r}{1+r} A_0.$$

The solution is denoted by γ^*_{BB} and equal to 1.65 in our basline, implying that welfare under a balanced budget rule is the same than under a 3.5% increase in private incomes and no natural resource revenue ($3.5 \cong 1.65 \times 2.1\%$).

4.2.3 Cyclical behavior

The macroeconomic implications of the optimal fiscal rule for the cyclical behavior of government expenditure can be captured in various ways. Obvious options are the correlation between the economic cycle, as measured by (detrended) Y_t^p, and government expenditures or savings. We would expect the latter to be procyclical and the former to be countercyclical.

Denoting government saving by S_t, we have $S_t = Y_t^g - G_t$ and a straightforward calculation shows that

$$\sigma(S_t)\rho(S_t, Y_t^p) + \sigma(G_t)\rho(G_t, Y_t^p) = \sigma(Y_t^g)\rho(Y_t^g, Y_t^p), \tag{4}$$

where $\rho(x_t, y_t)$ denotes the (time-series) correlation between x_t and y_t while $\sigma(x_t)$ denotes the standard deviation of x_t. Equation (4) shows that procyclical government saving is equivalent to countercyclical government spending only when private and government income are uncorrelated. When both sources of income are positively correlated, as is the case in most countries with significant revenues from natural resources, including Chile, the possibility of procyclical saving and expenditure arises. This is the case for the optimal policy in our benchmark model: the correlation between government saving and the economic cycle is 0.30 while the correlation between government spending and the cycle is 0.26. By comparison, these correlations are zero and 0.45 for a balanced budget rule, respectively.

An alternative way to quantify the extent to which optimal spending varies with the business cycle, Y^p, is to estimate, via OLS, a linear approximation to the optimal rule of the form:

$$G_t = c_0 - c_p Y_t^p + c_g Y_t^g + c_a A_t + \text{error}$$

and measure the degree of countercyclicality by:

$$\mathrm{CCG} \equiv c_p \times \frac{\sigma(Y^p)}{\mathrm{med}(Y^g)}, \tag{5}$$

where $\mathrm{med}(x_t)$ denotes the median of x_t. CCG captures the response of government expenditures, as a fraction of median government income, associated with a decrease of one standard deviations in private income. For the benchmark model we obtain CCG = 0.49, which implies that government expenditure, as a fraction of median government income, increases by 49%, on average, when private income drops by a standard deviation.

4.3 Alternative Parametrizations

Column 1 in Table 3 shows the main statistics for the benchmark model: welfare gains, both compared with a balanced budget rule and with the scenario with no natural resource income (γ and γ^*); measures of asset accumulation under the optimal rule (median accumulation during the first 25 years and in steady state), two indices for countercyclical behavior (correlation between savings and the cycle, and the CCG measure defined in (5)), and welfare gains under a balanced budget rule, γ^*_{BB}. The first three and the last statistic assume initial assets equal to zero, the 4th, 5th and 6th rows report steady-state values.

Columns 2 through 8 show summary statistics for the optimal rule if we modify parameters from the benchmark model that characterize household preferences, one at a time. The cost of moving to the optimal rule starting with a low level of assets is front loaded, since the planner must accumulate assets to spend in times where the marginal utility of consumption is high. By contrast and for the same reason, the benefits from adopting a fiscal rule are back loaded. This explains why an increase in the households's subjective discount factor lowers welfare gains and asset accumulation (column 2) while a decrease has the opposite effect (column 3).

The elasticity of intertemporal substitution for the instantaneous utility defined in (2) is

$$\text{EIS} \equiv -\frac{u'(c)}{cu''(c)} = \frac{c-c^*}{\theta c},$$

which is decreasing in θ and c^*. This explains why columns 4 through 8 show that the benefits from a fiscal rule are larger when households have a stronger preference for a smoother consumption over time (smaller EIS). Also, fiscal policy is more countercyclical when households, particularly those in the poorest quintile, are less able to smooth consumption over time. Even though smaller in some cases than for the benchmark model, the countercyclical measures of fiscal policy are significant in all cases.

Table 4 considers changes in the income processes. Columns 2 and 3 fit separate AR(1) processes to y^p and y^g and assume independent innovations (column 2) and correlated innovations (column 3, the correlation is 0.40). The value of owning copper, compared to a scenario with no natural resource revenues, is larger when innovations are independent than when they are positively correlated, both under the optimal policy and under a balanced budget policy (γ^*_{BB} of 3.81 vs. 2.45, γ^* of 5.24 vs. 4.12). The reason for this is that a revenue stream that is uncorrelated with private income provides more insurance than a positively correlated income source.

Column 4 of Table 4 considers a first order VAR where, by contrast with the benchmark income process, past private income shocks are allowed to affect current commodity revenues (see footnote 8). Following a negative innovation to private income, we now have that revenues from the natural resource can be expected to rise in the next period, which allows the planner to spend more aggressively today, since there is less need to save resources for future periods. This explains why the value of the optimal policy, both as measured by γ and γ^*, is higher than in the benchmark case and the cases with standard AR specifications.

Columns 5 through 8 show that the benefits of a fiscal rule increase with the volatility of income, both fiscal and private, when compared with a balanced budget rule, leading to higher values of γ. In the case of a change in the volatility of fiscal revenues, this improvement largely reflects that the value of a balanced budget rule deteriorates significantly when volatility increases (see the γ^* reported in the last row of the table): an increase in the volatility of copper revenues, which is positively correlated with private income, decreases the extent to which this income stream provides insurance.

Columns 9 and 10 consider changes in the importance of copper revenues: a 50% decrease and increase, respectively. The value of the optimal program, compared with the balanced budget rule, is larger when copper revenue is less important. The marginal benefit of additional natural resource income is smaller when overall resources are larger, as these resources are likely to be spent at times when marginal utility of additional government expenditures is lower.

Finally, Table 5 summarizes the effects of changes in the targeting technology. Welfare gains increase when Chile's targeting parameters are replaced by less focalized uniform targeting ($\alpha_i = 1/5$ for all i) while countercyclicality increases considerably. The relative social value of targeting during recessions is much higher when targeting is poor. Welfare gains also increases considerably under perfect targeting (γ^* in the second row provides the correct measure in this case).

Table 6 provides an alternative comparison of the three targeting technologies. It reports average expenditures for the five private income scenarios (see Table 1). The first column considers a balanced budget policy, where no effort is made to use copper income to smooth household consumption or provide precautionary saving, the remaining columns consider the same targeting technologies as in Table 5. The last row of this table shows that, as expected, total expenditures are higher when the government accumulates assets. Given the extremely high volatility of copper revenues and its positive correlation with private incomes, this results in highly procyclical government transfers, explaining the dramatic difference between columns 2–4 and column 1. Government expenditures when private income is low increase considerably (by a factor between 6 and 20, depending on the policy and low income state considered) when the government moves beyond a balanced budget policy.

Expenditures are more countercyclical when targeting is less focussed, for example, government transfers are at least 10% higher under Chile's relatively good targeting than under uniform targeting. Nonetheless, expenditures are highest, on average, when private income is highest. The reason is that copper revenues are procyclical and highly persistent, so that the wealth effect associated with high copper revenues dominates over the precautionary motive.

5 Simple Rules

There are many reasons why fiscal rules used in practice should be simple. First, to help communicate the constraints imposed by the rule on public spending to elected officials and the public in general. This helps legitimize the rule and makes less likely that it is abandoned. Second, because often fiscal rules are written into laws and this is not easy with rules that require tabulations of the values used to plot figures like those in Figures 6 to characterize how much is spent and how much is saved in a given year. That is, to be useful, rules need to be easily replicable in terms of their calculation. Third, because sometimes, as in the Chilean case, the starting point is a simple rule that has earned legitimacy among policymakers and the public, so that moving to a much more complex rule may come at the cost of losing this social capital.

5.1 Rules considered

Our starting point is a version of the Chilean Structural Balance Rule (SBR) and the question we address is how much closer we can get to the optimal rule discussed in Section 4.2 with a simple variant of the SBR.

Our version of Chile's structural balance rule is

$$G_t = \mathscr{S}_t^G + \frac{r}{1+r} A_t, \tag{6}$$

where $\mathscr{S}_t^G$ is the "structural government income", defined as:[12]

$$\mathscr{S}_t^G = \frac{1}{10}\sum_{k=0}^{9} \mathrm{E}_t Y_{t+k}^G,$$

where E_t denotes expectations based on information available in period t, which in our case is current and past values of both income processes. The SBR prescribes spending the sum of the current structural income, equal to the best estimate for average income over the next decade, and the (long term) interest obtained on assets saved.

The SBR is similar to the optimal spending/saving rule implied by Friedman's permanent income theory of consumption, with structural income in place of wealth. For this reason we also consider the following Friedman-type rule:

$$G_t = \frac{r}{1+r}[\mathscr{W}_t^G + A_t], \tag{7}$$

with

$$\mathscr{W}_t^G = \sum_{k\geq 0}(1+r)^{-k}\mathrm{E}_t Y_{t+k}^G$$

denoting government wealth.

We consider the following simple variant of the SBR, which keeps the basic linear structure but free up the values for the marginal propensities:

$$G_t = c_0 + \theta_s \mathscr{S}_t^G + \theta_a A_t. \tag{8}$$

Equation (8) defines a rule that is linear in structural income and assets, but optimizes over the corresponding coefficients.

As mentioned in the introduction, real government spending increased by 18 percent (year-on-year) in 2009, going beyond the increase suggested by the SBR and providing a fiscal impulse of 3 percent of GDP. Some analysts argued at the time that this increase could be justified by the fact that the SBR did not allow for a marginal propensity to spend out of assets that increased during recessions.[13] This motivates considering linear spending rules with coefficients that vary with the level of private income, such as

$$G_t = c_0 + \begin{cases} \theta_{sl}\mathscr{S}_t^G + \theta_{al}A_t, & \text{if } Y^p \text{ low,} \\ \\ \theta_{sh}\mathscr{S}_t^G + \theta_{ah}A_t, & \text{if } Y^p \text{ normal or high.} \end{cases} \tag{9}$$

The marginal propensities are allowed to vary with the economic cycle, as captured by private income Y^p. We consider the case where these coefficients can take two (optimally chosen) values, depending on whether private income is low (lowest two values in Table 1) or normal/high (highest three values in Table 1).

Rule (9) is a regime switching rule with two simple linear regimes, that can be thought of as a rule with an escape clause. A simple linear rule operates most of the time (75% in our case), and this rule is abandoned in "extreme" circumstances, when private income (in deviation from trend) is below a certain threshold.

In the case of all the simple rules we study in this section, we impose the same borrowing constraints considered when deriving the optimal rule in Section 3, that is, $A_t \geq 0$ and $G_t \geq 0$.[14]

To estimate the parameters in models (8) and (9) we proceed as follows: We generate 1,000 time-series for

[12] We focus on copper-related revenue and continue ignoring tax revenue. In practice, every year the Finance Minister appoints a committee of experts that provides an estimate for $\mathscr{S}_t^G$. See Frankel (2011) for a discussion of the institutional design of the rule.

[13] See, for example, the interview to one of this paper's authors in *La Segunda* on July 24, 2009.

[14] Thus, for example, the rule in (8) actually has $G_t = \max(0, c_0 + \theta_s\mathscr{S}_t^G + \theta_a A_t)$.

private and government income, each with 100 observations: $Y^p_{k,t}$ and $Y^g_{k,t}$, $k = 1,...,1,000$; $t = 1,...,100$. Next we use the Nelder-Mead Simplex Method to find the parameter configuration, θ within the family of rules being considered, Θ, that maximizes $\gamma(\theta)$ defined via:

$$\sum_{k=1}^{1,000}\sum_{t=0}^{99}(1+\delta)^{-t}\sum_{i=1}^{5}u(s_i Y^p_{k,t}+\alpha_i(1+\gamma(\theta))Y^g_{k,t}+\alpha_i\frac{r}{1+r}A_0)=\sum_{k=1}^{10,000}\sum_{t=0}^{99}(1+\delta)^{-t}\sum_{i=1}^{5}u(s_i Y^p_{k,t}+\alpha_i G(A_{k,t},\mathscr{S}^g_t,Y^p_{k,t};\theta)).$$

Where $A_{k,t}$ denotes the value of assets and $G(A_{k,t},\mathscr{S}^g_t,Y^p_{k,t};\theta)$ optimal expenditure, both for the k-th time-series, under rule $\theta\in\Theta$, at time t. This determines the optimal rule, $\widehat{\theta}$. To avoid overfitting, the value of γ we report for $\widehat{\theta}\in\Theta$ is obtained by rerunning the above procedure with 4,000 series of newly generated income series of length 100 each.

5.2 Results

Table 7 presents the summary statistics for the simple rules considered in this section. The SBR and the Friedman-type rule attain 18 and 20% of the welfare gain obtained under the optimal rule, respectively. These rules tend to underaccumulate assets when compared with the optimal rule and, not surprisingly, both of them vary very little, if at all, with the economic cycle.[15]

An SBR-type rule where the marginal propensities to spend out of current government income and assets are chosen optimally, leads to higher welfare, approximately 74% of the gain under the optimal rule. Table 8 reports the estimated marginal propensities to consume out of assets in this case, showing that the improvement in performance is achieved by more than doubling the propensity to spend out of assets and reducing by more than two thirds the propensity to spend out of structural income. This suggests that the SBR is too responsive to changes in structural income and responds too little to changes in assets. This insight is robust across specifications: the median value for the marginal propensity to spend out of assets across the 19 models considered in Tables 3–5 is 0.117 with an interquartile range of 0.025, . Similarly, the median value for the propensity to spend out of structural revenue is 0.335 with an interquartile range of 0.293 (the range of values goes from 0.116 to 0.747).

The regime switching rule achieves a significant welfare gains, attaining 83% of the gains obtained under the optimal rule (γ of 0.830 vs. 1.001). Both rules accumulate considerably fewer assets than the optimal rule and, more important, the rule with an exit clause achieves a degree of countercyclicality similar to that of the optimal rule while the optimal linear rule does not.

Table 8 also shows that the propensities to spend out of the government's assets under the rule with an exit clause is considerably larger during recessions than under the linear rule where these propensities are chosen optimally but not allowed to vary over the cycle. By contrast, the propensities to spend during expansions are similar under both rules where this propensity is chosen optimally. As far as the propensity to spend out of structural income is concerned, rule (9) has a propensity that is higher than that of rule (8) during recessions, but lower during normal times or expansions. A linear rule has a hard time capturing the countercyclical behavior of the optimal rule, while a rule with an exit clause can capture this feature with a marginal propensity that is higher when income is low.

The above insight can be applied to gauge how much government expenditures should have increased when the economy went into recession in 2009. Compared with a linear rule, the rule with an escape clause suggests an increase of almost one percentage point of GDP when accumulated assets are 20% of GDP, the net assets the central government in Chile had going into 2009. Similarly, assuming structural government

[15] In fact, the SBR is somewhat *procyclical*, reflecting that structural revenue is procyclical and that the linear term in assets is not important enough to undo this effect.

revenue was at its average value of 2.1%, moving to the linear rule with an escape clause leads to additional expenditures of approximately 0.4% of GDP. The combined effect is an increase of 1.4% of GDP beyond that suggested by the rule in normal times, a meaningful fiscal expansion.

Summing up, a simple linear rule with an exit clause (that leads to a different, equally simple, linear rule) does a remarkably good job at capturing the non-linearities present in the optimal policy. Furthermore, this rule leads to lower asset accumulation and can be explained as a straightforward generalization of the SBR, both factors that should enhance its political viability.

6 Conclusion

We have explored the qualitative and quantitative implications of different ways to conduct fiscal policy, that is, the decision of how much to spend out of government income, in a framework where fiscal expenditure has non trivial effects because households are hand-to-mouth consumers and both household and government incomes face unpredictable shocks. Government income is particularly volatile, as it depends on the price of a primary commodity.

The basic intuition guiding government expenditures is straightforward: help the private sector smooth consumption by combining a precautionary motive with a smoothing-of-transitory-income-shocks (à-la-Friedman) motive, with the following twist: the government does not only consider its own revenue and assets when deciding how much to spend, but also looks at how the private sector is doing, spending more when the private sector's income is low. Furthermore, because there is income heterogeneity across households, and the government has only a limited ability to transfer income to the poor, the government faces a non trivial tradeoff when implementing its spending rule: imperfect targeting increases the level of expenditure needed to achieve a given level of consumption for the poorest households, which in turn makes the optimal policy more countercyclical than if targeting were perfect. It follows that better targeting leads to less countercyclical government spending, implying that countries that have less capacity to target transfers should run a more countercyclical effort.

The application of our model to Chile using plausible parameters describing income fluctuations and correlations, the household income distribution and the targeting technology, allows us to quantify the welfare benefits of different alternatives for conducting fiscal policy, from a (complex) optimal policy function to simple linear rules, including the Chilean SBR. In comparison to a balanced budget rule, the optimal rule improves welfare by the equivalent of a 100% increase of government copper revenue per year under our baseline calibration, which includes positive effects from copper prices to private sector income. The optimal policy involves significant expected asset accumulation as a buffer stock, equivalent to around 33% of GDP in our baseline, although it takes many years to reach large values. More important, the optimal policy implies a considerable degree of countercyclicality: a fall in private income of one standard deviation translates into an average 50% rise in government transfers relative to median government income. In certain states (high private income, low copper revenues and low assets) the optimal policy is to save all current income and cut transfers to zero.

The SBR used in Chile during the past decade and a Friedman-type rule attain meaningful welfare gains of around 20 percent of those achieved by the optimal rule. On average, both simple rules accumulate less assets than the optimal policy and are close to acyclical. Optimizing the marginal propensities to spend out of assets and structural government income for an SBR-type rule, results in a propensity to spend out structural/permanent copper revenues much lower than one, and a propensity to spend out of assets much higher than the annuity value. This rule yields considerable additional gains, attaining a surprising 74 percent of gains obtained under the optimum. The result that the Chilean rule tends to spend too much out of copper and too little out of assets is robust across parameter specifications.

Finally, motivated by the quantitative importance of the optimal rule's countercyclical behavior, we also explored the gains from a regime switching rule with two linear rules, which allows for higher spending when household income is particularly low (private sector in recession). This higher spending in certain states of nature obviously needs higher savings in normal times. The welfare gain in this case is a surprising 83 percent of the optimum. The policy implication is that there would be substantial benefits from adding an escape clause to the Chilean SBR for recessions, when countercyclical spending is valued most, increasing the propensities to spend out of assets and structural income, even though the latter remains below one. The fact that the SBR was effectively abandoned during the 2009 possibly is not coincidental, as it allowed the rule to provide social insurance.

References

[1] Andres, J. and R. Domenech. 2006. "Fiscal Rules and Macroeconomic Stability." *Hacienda Pública Española* 176(1): 9-42.

[2] Atkeson, A. and M. Ogaki. 1996. "Wealth-Varying Intertemporal Elasticities of Substitution: Evidence from Panel and Aggregate Data." *J. of Monetary Economics*, 38(3): 507Ű34.

[3] Attanasio, O. and M. Browining. 1995. "Consumption over the Life Cycle and over the Business Cycle." *American Economic Review*, 85(5): 1118Ű37.

[4] Barlevy, G. 2004. "The Cost of Business Cycles and th Benefits of Stabilization: A Survey." NBER Working Paper No. 10926.

[5] Batini, N., P. Levine and J. Pearlman. 2009. "Monetary Policy Rules in an Emerging Small Open Economy." IMF Working Paper No. 09/22.

[6] Blundell, R., M. Browning and C. Meghir. 1991. "Consumer Demand and the Life-Cycle Allocation of Household Expenditures." *Review of Economic Studies*, 61(1): 57Ű80.

[7] Carroll, C. 1992. "The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence." *Brookings Papers on Economic Activity*. 2: 61Ű135.

[8] Carroll, C. 1997. "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis." *Quarterly Journal of Economics*. 112(1): 1Ű55.

[9] Chamberlain, G. and R. Wilson. 2000. "Optimal Intertemporal Consumption under Uncertainty. *Review of Economic Dynamics*. 3, 365-395.

[10] Deaton, A. 1990. "ŞSaving and Liquidity Constraints." *Econometrica*. 59(5): 1221Ű48.

[11] Deaton, A. and J. Muellbauer. 1980. *Economics and Consumer Behavior*. Cambridge and New York: Cambridge University Press.

[12] Drexler, A., E. Engel and R. Valdés. 2002. "Copper Uncertainty and the Optimal Fiscal Strategy in Chile." In F. Morandé and R. Vergara, eds., *Análisis Empírico del Ahorro en Chile*. Santiago: Banco Central de Chile.

[13] Engel, E., C. Neilson, and R. Valdés. 2011. "Fiscal Rules as Social Policy." Mimeo.

[14] Engel, E., and R. Valdés. 2000. "Optimal Fiscal Strategy for Oil Exporting Countries". IMF Working Paper No. 00/118.

[15] Frankel, J. 2011. "A Solution to Fiscal Procyclicality: The Structural Budget Institutions Pioneered by Chile." Mimeo.

[16] Guvenen, F. 2006. "Reconciling Conflicting Evidence on the Elasticity of Intertemporal Substitution: A Macroeconomic Perspective." *J. of Monetary Economics*, 53(7): 1451Ű72.

[17] International Monetary Fund. 2009. "Fiscal Rules: Anchoring Expectations for Sustainable Public Finances." Board Paper, November.

[18] Koptis G. (ed). 2004. *Rules Based Fiscal Policy in Emerging Markets*. New York: Palgrave MacMillan.

[19] Krusell, P., T. Mukoyama, A. Sahin and A. Smith. 2009. "Revisiting th welfare effects of eliminating business cycles." *Review of Economic Dynamics*. 12: 393-404.

[20] Kumhof, M. and D. Laxton. 2009. "Simple, Implementable Fiscal Policy Rules." IMF Working Paper No. 09/76

[21] Kumhof, M. and D. Laxton. 2010. "Un Modelo para Evaluar la Regla de Superávit Fiscal Estructural de Chile." *Economía Chilena*, 13(3): 5-32.

[22] Lucas, R. 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.

[23] Lucas, 2003. "Macroeconomic Priorities." *American Economic Review*. 93(1): 1-14.

[24] Maliszewski, W. 2009. "Fiscal Policy Rules for Oil-Producing Countries: A Welfare-Based Assessment." IMF Working Paper No. 09/126.

[25] Rey de Marulanda, N., J. Ugaz and J. Guzmán. "La Orientación del Gasto Social en América Latina." Inter-American Development Bank. Documento de trabajo I-64. 2006.

[26] Schechtman, J. 1976. "An Income Fluctuations Problem." *J. of Economic Theory*. 12: 218-241.

[27] Segura, A. 2006. "Management of Oil Wealth Under the Permanent Income Hypothesis: The Case of Sao Tome and Principe." IMF Working Paper No. 06/183

[28] Villafuerte, M., P. Lopez-Murphy and R. Ossowski. 2010. "Riding the Roller Coaster: Fiscal Policies of Nonrenewable Resource Exporters in Latin America and the Caribbean." IMF Working Paper No. 10/251.

[29] Yellen, J. and G. Akerlof. 2004. "Stabilization Policy: A Reconsideration." Federal Reserve Bank of San Francisco speech. July.

[30] Zeldes, S. 1989. "Consumption and Liquidity Constraints: An Empirical Investigation." *J. of Political Economy*, 97(2): 305Ű46.

Table 1: Private income states in the discretization of the state space

State	Probability (%)	Deviation from trend (%)
1	2.12	−11.9
2	22.83	−6.2
3	50.10	0
4	22.83	6.2
5	2.12	11.9

Table 2: Income and expenditure shares. Chile 1990-2009.

Quintile	Income share (%) $100 \times s_i$	Expenditure share (%) $100 \times \alpha_i$
1	3.6	44.2
2	8.3	24.6
3	12.7	16.6
4	19.6	10.3
5	55.8	4.3

Source: MIDEPLAN and CASEN 2009

Table 3: Alternative preferences

	1	2	3	4	5	6	7	8
	Benchm.	$\delta = 0.1$	$\delta = 0.06$	$\theta = 5$	$\theta = 1$	$c^* = 0$	c^*: 50%	c^*: 90%
γ	1.001	0.806	1.307	1.526	0.131	0.176	0.275	0.557
γ^*	3.244	2.920	3.747	1.199	4.222	6.705	6.793	5.093
$\text{Med}(A_{25})$	0.061	0.054	0.070	0.024	0.015	0.006	0.016	0.044
$\text{Med}(A_{ss})$	0.329	0.225	0.512	0.055	0.047	0.039	0.105	0.264
$\rho(S, Y^p)$	0.299	0.288	0.299	0.196	0.232	0.236	0.266	0.295
CCG	0.491	0.412	0.557	0.809	0.117	0.097	0.262	0.451
γ^*_{BB}	1.647	1.635	1.662	0.594	3.836	5.919	5.672	3.642

Table 4: Alternative income processes

	1	2	3	4	5	6	7	8	9	10
	Benchm.	Indep AR	Correl. AR	Unrestr. VAR	$\sigma(y^p)$ ↓25%	$\sigma(y^p)$ ↑25%	$\sigma(y^g)$ ↓25%	$\sigma(y^g)$ ↑25%	$\mu(Y^g)$ ↓50%	$\mu(Y^g)$ ↑50%
γ	1.001	0.546	0.897	1.170	0.882	1.093	0.458	1.837	1.153	0.906
γ^*	3.244	5.245	4.211	4.409	3.152	3.379	5.416	1.792	3.542	3.039
Med(A_{25})	0.061	0.040	0.051	0.053	0.060	0.061	0.054	0.060	0.038	0.086
Med(A_{ss})	0.329	0.263	0.293	0.270	0.336	0.326	0.253	0.369	0.174	0.446
$\rho(S, Y^p)$	0.299	0.070	0.271	0.296	0.283	0.314	0.338	0.260	0.332	0.283
CCG	0.491	0.304	0.390	0.613	0.437	0.521	0.216	1.133	0.481	0.476
γ^*_{BB}	1.647	3.813	2.451	2.245	1.728	1.617	3.735	0.695	1.671	1.635

Table 5: Alternative targeting technologies

	1	2	3
	Benchmark	Unif. targ.	Perf. targ.
γ	1.001	1.297	2.941
γ^*	3.244	1.713	6.155
Med(A_{25})	0.061	0.077	0.060
Med(A_{ss})	0.329	0.209	0.329
$\rho(S, Y^p)$	0.299	0.367	0.293
CCG	0.491	0.865	0.455
γ^*_{BB}	1.647	0.759	3.634

Table 6: Average G conditional on y^p (in %) for alternative targeting technologies

		1	2	3	4
			Targeting		
		BB	Uniform	Chile	Perfect
	Low	0.19	3.64	3.05	2.98
	Below avge.	0.55	3.55	3.19	3.16
Private inc.	Avge.	1.54	3.65	3.59	3.58
	Above avge.	4.19	4.49	4.74	4.77
	High	11.30	8.97	9.36	9.38
	Overall avge. G (%)	2.10	3.93	3.87	3.87

Table 7: Simple Rules

Rule	Welfare gain γ ($A_0 = 0$)	Steady state median assets	CCG
Benchmark:	1.001	0.329	0.491
Chile's SBR:	0.180	0.095	−0.159
Friedman:	0.205	0.161	−0.001
Linear rule (8):	0.743	0.160	0.092
Rule with exit clause (9):	0.830	0.154	0.454

Table 8: Simple Rules and Marginal Propensities to Spend

Rule	A	$\mathscr{S}^G$	Const.
Chile's SBR:	0.048	1.000	—
Linear rule (8):	0.118	0.290	−0.0006
Rule with exit clause (9):			
Y^p low:	0.164	0.467	
			−0.0023
Y^p normal or high:	0.120	0.261	

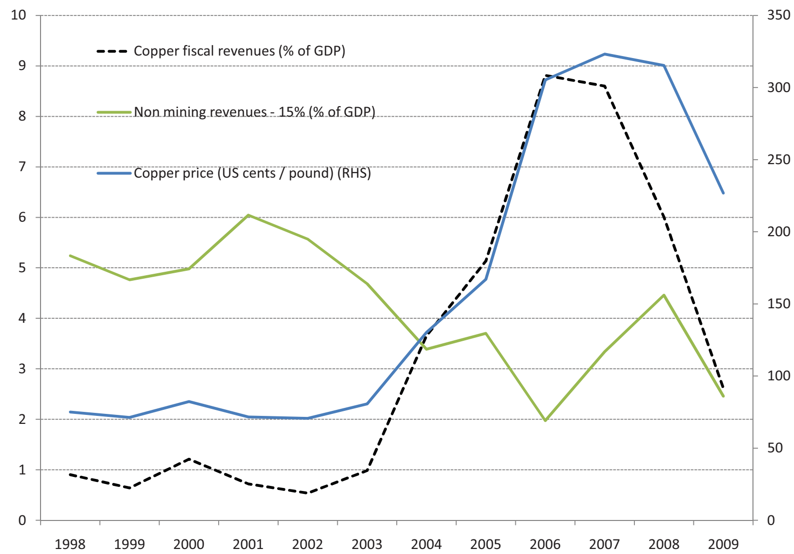


Figure 1: Copper and Fiscal Revenue Volatility

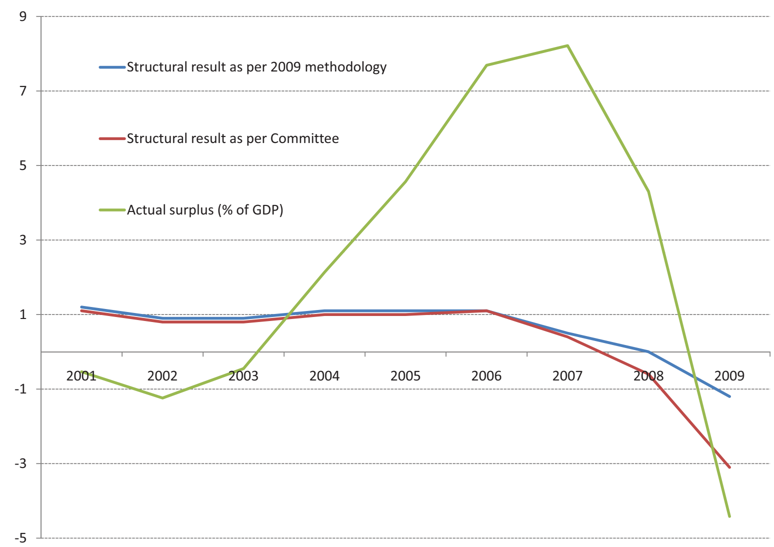


Figure 2: Structural Balance Rule (SBR) and Actual Fiscal Funds

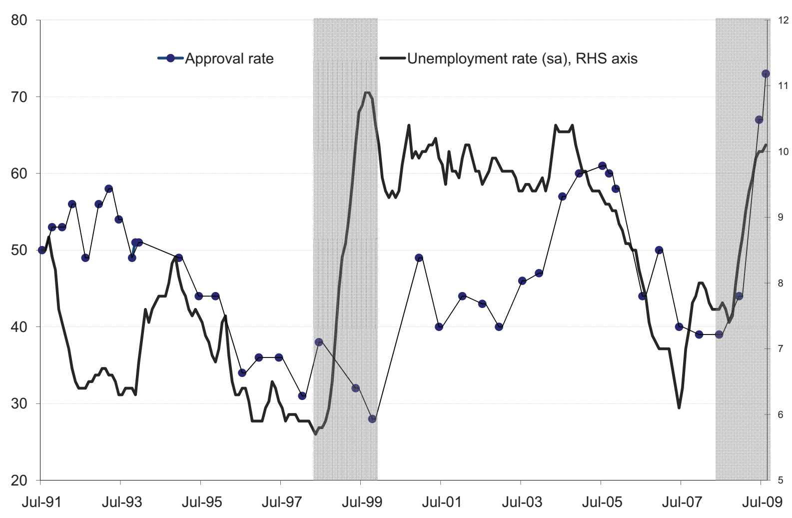
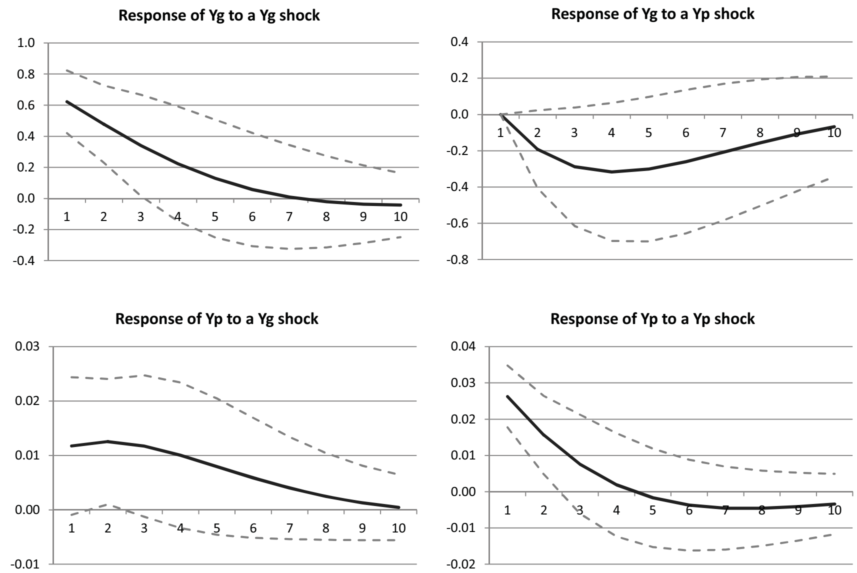


Figure 3: Chile: Two recessions, two very different political approval dynamics



Cholesky decomposition with Yg the most exogenous. Dashed lines are +/- 2 standard deviations.

Figure 4: Impulse-Responses of government copper revenues and private income

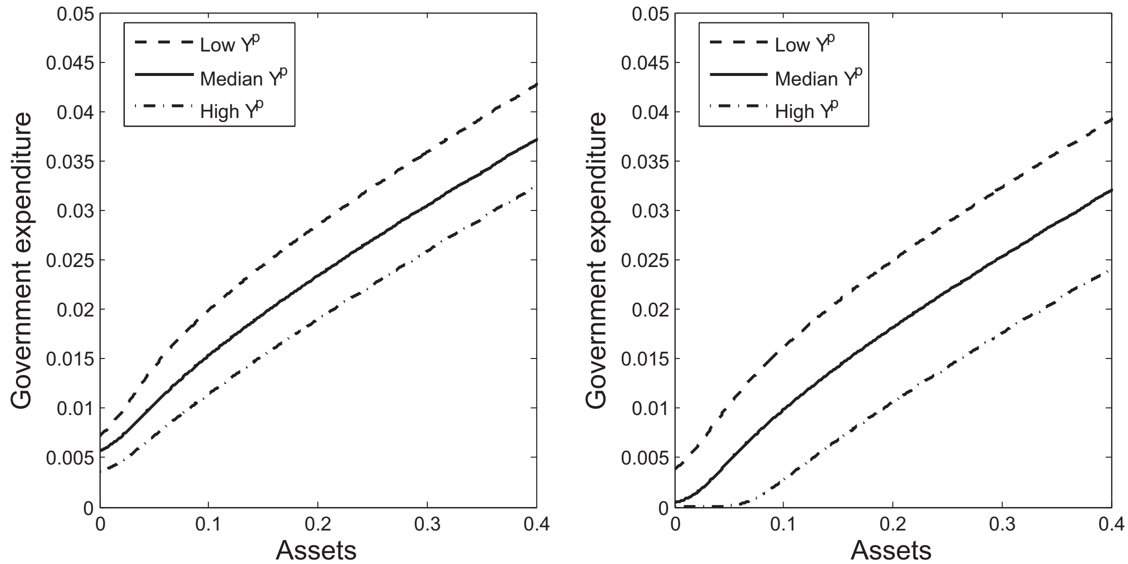


Figure 5: Optimal Fiscal Spending. Y^g at median value (left panel) and low value (right panel).

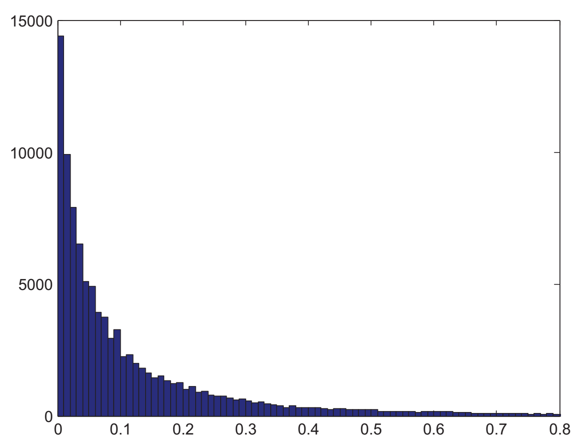


Figure 6: Distribution of Assets under Optimal Rule – First 25 Years.

Documentos de Trabajo Banco Central de Chile	**Working Papers Central Bank of Chile**
NÚMEROS ANTERIORES	PAST ISSUES

La serie de Documentos de Trabajo en versión PDF puede obtenerse gratis en la dirección electrónica: www.bcentral.cl/esp/estpub/estudios/dtbc. Existe la posibilidad de solicitar una copia impresa con un costo de $500 si es dentro de Chile y US$12 si es para fuera de Chile. Las solicitudes se pueden hacer por fax: (56-2) 6702231 o a través de correo electrónico: bcch@bcentral.cl.

Working Papers in PDF format can be downloaded free of charge from: www.bcentral.cl/eng/stdpub/studies/workingpaper. Printed versions can be ordered individually for US$12 per copy (for orders inside Chile the charge is Ch$500.) Orders can be placed by fax: (56-2) 6702231 or e-mail: bcch@bcentral.cl.

DTBC – 626 — Mayo 2011
Short – term GDP forecasting using bridge models: a case for Chile
Marcus Cobb, Gonzalo Echavarría, Pablo Filippi, Macarena García, Carolina Godoy, Wildo González, Carlos Medel y Marcela Urrutia

DTBC – 625 — Mayo 2011
Introducing Financial Assets into Structural Models
Jorge Fornero

DTBC – 624 — Mayo 2011
Procyclicality of Fiscal Policy in Emerging Countries: the Cycle is the Trend
Michel Strawczynski y Joseph Zeira

DTBC – 623 — Mayo 2011
Taxes and the Labor Market
Tommaso Monacelli, Roberto Perotti y Antonella Trigari

DTBC – 622 — Abril 2011
Valorización de Fondos mutuos monetarios y su impacto sobre la estabilidad financiera
Luis Antonio Ahumada, Nicolás Álvarez y Diego Saravia

DTBC – 621 — Abril 2011
Sobre el nivel de Reservas Internacionales de Chile: Análisis a Partir de Enfoques Complementarios
Gabriela Contreras, Alejandro Jara, Eduardo Olaberría y Diego Saravia

DTBC – 620 Marzo 2011
Un Test Conjunto de Superioridad Predictiva para los Pronósticos de Inflación Chilena
Pablo Pincheira Brown

DTBC – 619 Marzo 2011
The Optimal Inflation Tax in the Presence of Imperfect Deposit – Currency Substitution
Eduardo Olaberría

DTBC – 618 Marzo 2011
El Índice de Cartera Vencida como Medida de Riesgo de Crédito: Análisis y Aplicación al caso de Chile
Andrés Sagner

DTBC – 617 Marzo 2011
Estimación del Premio por Riesgo en Chile
Francisca Lira y Claudia Sotz

DTBC – 616 Marzo 2011
Uso de la aproximación TIR/Duración en la estructura de tasas: resultados cuantitativos bajo Nelson – Siegel
Rodrigo Alfaro y Juan Sebastián Becerra

DTBC – 615 Marzo 2011
Chilean Export Performance: the Rol of Intensive and Extensive Margins
Matías Berthelom

DTBC – 614 Febrero 2011
Does Leariry of the Dynamics of Inflation Gap and Unemployment Rate Matter?
Roque Montero

DTBC – 613 Febrero 2011
Modeling Copper Price: Regime Switching Approach
Javier García – Cicco y Roque Montero