WP/11/56

IMF Working Paper

Fiscal Rules in a Volatile World: A Welfare-Based Approach

Carlos Garcia, Jorge E.Restrepo, and Evan Tanner

 WP/11/56

IMF Working Paper

IMF Institute

Fiscal Rules in a Volatile World: A Welfare-Based Approach

Prepared by Carlos Garcia, Jorge E. Restrepo, and Evan Tanner[1]

Authorized for distribution by J. Roldós

March 2011

Abstract

It is widely agreed that a fiscal rule should boost discipline and credibility, reduce macroeconomic volatility, and be easily understood. To support such goals, a government may run structural surpluses and accumulate a precautionary cushion of assets on behalf of agents who do not enjoy access to capital markets. As an additional criterion, that level of assets should be bounded. We provide an example of a structural surplus rule that satisfies all such criteria. In our general equilibrium simulations, we show that such a rule benefits credit-constrained consumers but may hurt others.

JEL Classification Numbers: E21, E62, F47, H30, H63

Keywords: Fiscal rule, volatility, structural surplus, consumer welfare, equilibrium model

Author's E-Mail Address: cgarcia@uahurtado.cl; jrestrepo@imf.org; etanner@imf.org

[1] We thank C. Caceres, J.Galí, M. Kumar, C.Vegh, J.de Gregorio, S.Elekdag, J.P. Medina, J.Roldos, and discussants at the University of Chile, Central Bank of Chile, Catholic University of Chile, and the IMF Institute. William Baeza coded several simulations. Remaining errors are the authors' own. Restrepo conducted much of the work at the Central Bank of Chile. The paper was expertly formatted by Patricia Obando and Carolina Ginyovsky.

Contents Page

I. INTRODUCTION

In recent years, many countries have either adopted some sort of fiscal rule or have contemplated doing so.[2] A fiscal rule is widely understood to be a permanent restriction on fiscal policy. In practice, it entails placing a numerical limit on a budget aggregate or on a fiscal performance indicator, such as the deficit, the debt, or one of their components (International Monetary Fund, 2009). In some cases, fiscal rules are legally mandated.

In this paper we address several issues regarding the use and design of a fiscal rule. The need for a fiscal rule typically arises from some problem or 'ill'. Perhaps the main ill is the lack of *fiscal discipline.* Short-sighted politicians and weak institutions may produce a bias toward deficits today. Several authors (Buchanan and Wagner, 1977, Drazen, 2000, and Kopits, 2001) have argued that a fiscal rule may help safeguard future taxpayers against excessive deficits.[3]

A related ill is *low credibility*. Market participants and political pressure groups may not believe that a country is committed to fiscal discipline (time consistency). If expectations of fiscal discipline are not established, imposing that discipline will be even more difficult. As Kydland and Prescott (1977) stressed, a clear and transparent policy rule may anchor such expectations.

Finally, a third ill is *volatility*. For example, in countries whose revenues are tied to a commodity export (for example oil or minerals), politicians may boost spending when the commodity price is high but cut it abruptly when the commodity price falls. In this way, the fiscal authority will *amplify* (rather than attenuate) macroeconomic volatility. Indeed, most available evidence suggests that, in emerging/developing economies, fiscal policy is *procyclical* (Kaminsky, Reinhart, and Végh, 2004, Talvi and Végh, 2005).[4] Hence, countries

---

[2] Examples include the European Community (the 1991 Maastricht treaty) and several less industrialized countries (including the fiscal responsibility laws enacted Brazil and Peru). More recently, Turkey has considered a fiscal rule as a way to build market confidence.

[3] Some have suggested that governments overspend and/or delay fiscal adjustment because public resources have no one specific owner. This 'common pool' problem gives rise to another one of time inconsistency (Kydland and Prescott,1977) since i) authorities try to obtain political dividends in the short run (Alesina and Tabellini,1990), and ii) each area of government tries to spend as much as possible on its preferred projects. Also, coalitions that favor fiscal reform frequently fray at the edges since some members seek to avoid the political costs of its implementation (Velasco, 1994).

[4] Talvi, and Végh (2005) suggest that governments face pressures to spend money at the moment when they receive it. Gavin and Perotti (1997) suggest that governments cut spending during downturns when they are excluded from global credit markets—as often happens during a crisis.

like Chile have enacted fiscal rules that link spending to the long-run (rather than current) price of their main commodity export (in the case of Chile, copper and molybdenum).

Importantly, volatility and fiscal discipline are closely related: fiscal indiscipline today typically leads to disruptive fiscal adjustments in the future. Hence, *a more disciplined fiscal policy today means less volatility* in both policy variables (tax rates, expenditures) and broader macroeconomic aggregates.

Fiscal rules should address these 'ills'. In addition, the rule itself should be *simple, transparent* and *easily understood* by market participants—following Kydland and Prescott's (1977) commonsense advice.

Rules may encompass forms of 'constrained' discretion, implying a degree of flexibility similar to that given to a central bank under an inflation targeting regime. More fundamentally, policy rules are now generally interpreted as reflecting an underlying *objective function*—not an arbitrary and mechanical formula. This point is stressed by Woodford (2003, pp. 459–60).[5]

There is some debate as to what that *objective function* should be. The Ramsey approach has emphasized that policy should be designed to *maximize consumer welfare*.[6] This approach yields several important lessons. It forces us to think about the opportunity set of the agents themselves and how they themselves may optimally react to a given policy, hence addressing the "Lucas critique."

Under this approach, if households have complete access to credit markets—if they are "Ricardian" consumers—they will be able to completely shield themselves from volatility—including that brought on by fiscal policy. They do so by either borrowing and/or building a precautionary cushion of assets for themselves.

Some consumers may not enjoy such opportunities. Such "non-Ricardian" or "hand-to-mouth" households consume their disposable income each period—no more, no less. These households are more vulnerable than their "Ricardian" counterparts to macroeconomic volatility.

In this paper, we assume that well-intentioned governments want to protect these more vulnerable "hand-to-mouth" households from macroeconomic volatility. At a minimum, the

---

[5] Woodford points out that the optimization must be 'timeless'—the authority cannot change the parameters of the objective function, and each period's optimization takes place as if it were the initial period.

[6] Under the Ramsey approach (see for example Végh, 2008) policy makers maximize the *primal* utility functions of market participants themselves, rather than some *dual* objective function which may be ad-hoc in nature. For a detailed critique of the Ramsey approach, see Kocherlakota (2010). However, most would agree ad hoc fiscal rules may be easy to understand and implement—and they may benefit consumers.

fiscal authority should "do no harm." Policies should not amplify macroeconomic volatility. For example, commodity exporters should link their public expenditures to long-run (steady-state) rather than current revenues (as intended under Chile's fiscal rule).

The government may have to do more than simply smooth its expenditures. It may have to acquire a precautionary cushion of assets (or equivalently, provide some kind of insurance) on behalf of the more vulnerable "hand-to-mouth" consumers—something they cannot do for themselves. In so doing, the government will be able to withstand shocks and unforeseen contingencies over time. Insofar as households may have a *bounded* asset target, so should the government.[7] One way to attain this goal would be to run a *structural surplus*: over the business cycle, the government should draw down debt or accumulate assets. Again, Chile is one example of a country that has successfully implemented a structural surplus policy in the past decade.[8]

This paper assesses fiscal rules according to the criteria just mentioned: discipline, credibility, volatility, transparency, links to consumer welfare, and, in the case of a structural surplus, bounded asset accumulation.[9] A structural surplus fiscal rule that satisfies all of these criteria is compared to a balanced budget rule. We simulate both rules in a new-Keynesian dynamic stochastic general equilibrium (DSGE) model.

We find that 'hand to mouth' consumers unambiguously benefit from the structural surplus rule—*but Ricardian consumers do not*. This makes sense: Ricardian consumers will not benefit from publicly provided consumption smoothing. Unlike hand-to-mouth agents, they can already do that job for themselves. Moreover, under a structural surplus, government purchases, which accrue as income to both Ricardian and hand-to-mouth consumers, will occur much later than under a balanced budget. The structural surplus thus takes from Ricardians the opportunity to save and accumulate assets during the initial years that they would have had under the balanced budget.

---

[7] Our model, like other real business cycle models, assumes a steady state around which key variables move, including a net debt or credit position. So they are bounded. From a policy perspective, boundless asset accumulation by the government poses several problems. For example, the government might at some point own large portions of (and have excessive influence over) the economy; this point is noted in IMF (2009).

[8] Originally, Chile's structural surplus—one percent of GDP—was justified by the need to pay off debt incurred by the central bank after the 1982 financial crisis. However, the consolidated debt of the public sector—non-financial plus central bank—fell during the 2000s. More recently, that target was reduced, first to ½ of one percent of GDP, then more recently to zero, thus reducing asset accumulation. On public asset accumulation, see Aiyagari, Marcet, Sargent, and Seppalla (2002).

[9] Fiscal policy and copper prices in Chile is also discussed in Medina and Soto (2007).

The paper is organized as follows. Part II discusses at a general level why fiscal rules may be desirable and how to design them. In Part III, we briefly discuss our simulated model. The model is discussed in greater detail in the appendices. In part IV, we present the welfare assessments of alternative fiscal rules that the model produces. Section V concludes.

II. Fiscal Rules and Fiscal Ills: A Primer

To begin our analysis, consider the one-period budget constraint:[10]

$$B_{t+1}^{G} = B_t^{G} R_t + P_t^{G} G_t - T_t \tag{1}$$

where: B_t^G are net government financial liabilities (or assets if it is negative) at the *beginning* of period t, R_t is the gross discount factor (one plus the real rate of interest r_t), G_t is the volume (quanta) of government goods purchased in period t, P_t^G is the *relative* price of goods purchased by the government, and T_t real tax revenues. Thus, at the end of period t, government debt is B_{t+1}^G.[11] The primary surplus is $PS_t = (T_t - P_t^G G_t)$.

After rearranging (1), progressive substitution over an infinite horizon, beginning in period 0, yields:

$$B_1^G = \sum_{t=1}^{\infty} PS_t \prod_{j=1}^{t} R_j^{-1} + \lim_{t\to\infty} B_t \prod_{j=1}^{t} R_j^{-1} \tag{2}$$

This is the infinite horizon budget constraint. For the sake of simplicity, we may consider a constant rate of interest: $R_t = \overline{R}, \forall t$. In this case, expression (2) reduces to:

$$B_1^G = \sum_{t=1}^{\infty} \frac{1}{\overline{R}^t} PS_t + \lim_{t\to\infty} B_t \overline{R}^{-t} \tag{3}$$

which says that current public debt should be equal to the present value of future primary surpluses. The transversality or "No Ponzi Game" condition which must always hold – no matter what:

---

[10] While the notation used in this section is meant to be a simplification of that used in the general equilibrium simulation in Part IV, it will not exactly conform.

[11] An equation like (1) may also be expressed in terms of total output; in this case, the interest factor must be adjusted for GDP growth. However, our analysis would apply only to the *dynamically efficient* case wherein the rate of interest exceeds the rate of output growth.

$$\lim_{t \to \infty} B_t \overline{R}^{-t} = 0 \qquad (4)$$

If the government is unable to secure primary surpluses that are sufficient to cover the face value of debt $B_t^G(face)$, the market value of debt must fall—either through an explicit default or by way of inflation. However, we assume that governments wish to avoid this outcome, as it may reduce discipline and credibility (in a repeated game setting).

We now consider two alternative rules. First, a balanced budget (BB) is written:[12]

$$P_t^G G_t(BB) = T_t - B_t^G (R_t - 1) \qquad (5)$$

A BB rule like (5) satisfies two key criteria—discipline and simplicity. However, such a rule will increase (not decrease) volatility, since it may require government to act procyclically, cutting spending or raising taxes during recessions (while doing the opposite during expansions). Moreover, a government may not be able to credibly commit to such a rule.

As a special case, consider a government that receives part of its income from a commodity export produced by a state-run enterprise:

$$T_t = T_t^{DOM} + \tau_x S_t P_t^x Q_t^x \qquad (6)$$

Where T^{DOM} is domestically-based tax revenues, S is the nominal exchange rate, and $P^X Q^X$ are the revenues from the commodity export (price times quantity). Under a rule like (5), expenditures would rise during commodity price booms and fall during price busts. Such a procyclical policy directly transmits commodity price volatility to the economy.

Second, consider an acyclical rule (AC) in which spending is tied to some long-run (rather than current) level of taxes T_t^* Thus, during a recession, $T_t < T_t^*$ while during an expansion $T_t > T_t^*$. Hence, under the AC rule:

$$P_t^G G_t(AC) = T_t^* - B_t^G (R_t - 1) \qquad (7)$$

Superficially, an acyclical rule AC addresses the shortcomings of BB: the government saves during good times and benefits from borrowing opportunities during bad times. However, a deeper analysis requires us to compare how each of the rules affects consumer welfare—as recent literature has emphasized. We should thus ask: What ills do *consumers* face? Does

[12] Only rarely would a budget be exactly balanced. Small unexpected discrepancies might be financed through withdrawals from existing government bank deposits.

volatility affect consumers, and if so, how? What ill (if any) will a fiscal rule solve for consumers *that they cannot solve for themselves*?

Some recent macroeconomic models include both “Ricardian households” who do enjoy access to capital markets and “non-Ricardian” or “hand-to-mouth” households who do not. For “Ricardians,” fiscal volatility may not pose a problem, since they can lend during good times and borrow during bad times. With a *precautionary* motive, Ricardian households will accumulate assets that provide a cushion against macroeconomic uncertainties, including an abrupt fiscal adjustment.[13] By contrast, “non-Ricardian” households consume exactly their disposable income in any period—no more, no less. For them, fiscal volatility may be problematic, since they have no prudential asset cushion.

How can the government help “non-Ricardians?” In an ideal world, government policy would be designed so as to provide the same welfare level to non-Ricardians that they would have obtained as Ricardians, through a sequence of time-varying taxes and transfers. In the real world, an attempt to do so might be complicated and not well understood. Moreover, the government may not know what household preferences are.

Even so, social insurance and safety net programs represent an imperfect attempt to smooth consumption for non-Ricardians. However, during severe recessions, such programs may be jeopardized. Government budgets may be strained since the debt burden rises during recessions, including through both higher interest *rates* (through a risk premium) and interest payments. At an extreme, governments themselves may be cut off from capital markets.

Governments themselves may thus wish to insure that their safety nets will function when they are most needed. If explicit insurance is not available, they should instead accumulate a precautionary cushion of assets—one that “hand-to-mouth” households cannot accumulate for themselves. Since an AC rule alone fails to provide this insurance, the government may choose to supplement that rule by also running a structural surplus (SS). But, the ‘war chest’ accumulated by the government should be bounded. Otherwise, the government may have an excessive influence over the economy.

Accordingly, we propose a structural surplus (SS) rule that satisfies all our criteria:

$$P_t^G G_t(SS) = T_t^* - \kappa - B_t^G (r_t + \mu) \quad (8)$$

where κ is the structural surplus and μ is an adjustment factor ($0 < \mu < 1$). If $\kappa > 0$, the government will accumulate assets. However, if $\mu > 0$, a creditor government will spend

[13] Several authors, including Kimball (1990), Weil (1993), Caballero (1990), Carroll and Kimball (2008), and Carroll (2009) note that a third moment (“prudence”) in the utility function will give rise to a precautionary motive. Hugget and Ospina (2001) note that a third moment is not required generating precautionary savings in the aggregate. However, we refer to individual consumer behavior in this paper.

more than a debtor government; accordingly, the government's long run asset position will be not without an upper limit. Instead, progressive substitution of rule (8) into budget constraint (3) over an infinite horizon yields a finite asset bound:

$$\lim_{t \to \infty} B_t = -\kappa / \mu \tag{9}$$

The right hand side is the present perpetuity value of a constant structural surplus of value κ. Thus, assets will be bounded.

There is an alternative interpretation of the structural surplus: by indefinitely delaying some expenditures, their *present value* falls. This is especially relevant for the case where revenues come from a manna-like resource endowment. A precise calculation of that decline is shown in Appendix I.

There is an important caveat: in this presentation, the level of the structural surplus κ is ad-hoc. For this reason, the limiting value of public assets may differ from what consumers themselves would choose. However, the value of κ may be derived from a more fundamental optimization process. In Appendix II, we show that the desired level of government assets depends on the real interest rate, the elasticity of risk aversion (assumed to be constant), the variance of exogenous shocks (such as a world-determined export commodity price), and the relative importance of such 'hand to mouth' households.

III. Balanced Budgets Versus Structural Surpluses in General Equilibrium

Current dynamic stochastic general equilibrium (DSGE) models tools permit us to simulate the level and variability of key economic variables under alternative policies. In so doing, we may show how policies affect the welfare level of households. We apply such a model to compare the welfare implications of fiscal regimes that are similar to those presented in the previous section. In this section, we present essential elements of that model. Space limitations limit us from fully detailing the model in the body of the paper.

Our model has many key elements of well-known "New Keynesian" frameworks (Clarida, Gali, and Gertler, 1999; Laxton and Pesenti, 2004). We summarize the most important assumptions regarding household labor supply and firms.

A. Households

The model includes two types of households. *Ricardian* consumers are assumed to maximize an intertemporal utility function:

$$E_o \sum_{t=0}^{\infty} \beta^t U\left(C_t^o(i), N_t^o(i)\right), \tag{10}$$

subject to the budget constraint:

$$\begin{aligned} P_t C_t^o(i) &= W_t(i) N_t^o(i) + B_t^o(i) - S_t B_t^{o*}(i) + D_t^o(i) - P_t T_t \\ &\quad - R_t^{-1} B_{t+1}^o(i) + S_t (\Phi(B_{t+1}^*) R_t^*)^{-1} B_{t+1}^{o*}(i), \end{aligned} \tag{11}$$

where $C_t^o(i)$ is consumption, $D_t^o(i)$ are dividends from ownership of firms, $\Phi(B_{t+1}^*)$ is the country risk premium, S_t is the nominal exchange rate, $B_t^{o*}(i)$ is private net foreign debt, $W_t(i)$ is nominal wage, $N_t^o(i)$ is the number of hours of work, $B_t^o(i)$ is government debt held by households, R_t and R_t^* are the gross nominal return on domestic and foreign assets (where $R_t = 1 + i_t$ and $R_t^* = 1 + i_t^*$) and T_t are lump-sum taxes.

Our utility function (Correia et al, 1995) yields realistic values for consumption volatility:

$$U(C_t, N_t) = \frac{(C_t - \psi N_t^{\varphi})^{1-\sigma} - 1}{1-\sigma} \tag{12}$$

Note that $1/\sigma$ is the intertemporal elasticity of substitution in consumption and $1/(\varphi - 1)$ is the elasticity of labor supply to wages. The value of ψ is calibrated to obtain a realistic fraction of steady state hours worked. Note also that the ratio of absolute prudence is $U_{CCC} / U_{CC} = -(1+\sigma) / \left(C_t - \psi N_t^{\phi}\right)$. This statistic is important to explain precautionary savings – one of the most important results of this article. As other authors have noted (Carroll and Kimball, 2008), *for any individual agent*, unless this statistic is non-zero, the level of consumption (and hence savings) will be invariant to volatility.

For "Non-Ricardian" households, utility is:

$$U(C_t^r(i), N_t^r(i)). \tag{13}$$

The functional form is the same as that of Ricardian households. We assume that these households neither save nor borrow (Mankiw, 2000). As a result, their level of consumption is linked one-to-one with their disposable income:

$$P_t C_t^r(i) = W_t(i) N_t^r(i) - P_t T_t. \tag{14}$$

As previously emphasized, wage receipts for both Ricardian and hand-to-mouth consumers are directly affected by government spending. However, Ricardian consumers are indifferent between streams of spending with equal present value but different volatility. They are able to smooth their consumption stream since they have access to capital markets. By contrast, holding present value constant, hand-to-mouth households prefer streams of government spending with lower volatility.

B. Household Labor Supply

Symmetric with the goods markets (discussed below), the continuum of monopolistically competitive households supply a differentiated labor service to the intermediate-goods-producing sector and a labor aggregator combines as much household-labor as is demanded by firms, with a constant-returns technology.

C. Firms

For domestic producers of intermediate goods, we assume a continuum of monopolistically competitive firms that produce differentiated intermediate goods. Their production function indexed by (j) corresponds to a CES combination of capital $K_t\,(j)$ and labor $N_t\,(j)$ that produces $Y_t^D(j)$ according to:

$$Y_t^D(j) = A_t\left[\alpha K_t(j)_t^{\frac{\sigma_s - 1}{\sigma_s}} + (1-\alpha)N_t^{\frac{\sigma_s - 1}{\sigma_s}}(j)\right]^{\frac{\sigma_s}{\sigma_s - 1}} \tag{15}$$

where A_t the technology parameter, and σ_s the elasticity of substitution between capital and labor, are both greater than zero. In the import sector, firms import a homogenous good from abroad and turn it into a differentiated foreign good for the home market using a linear production technology. In both cases, firms face a negatively sloped demand curve. Marginal cost MC^D moves with aggregate demand. Price adjustment is staggered, following Calvo (1983). In any period, some portion $(1-\theta_D)$ of firms will receive a signal to reset their mark-up above marginal cost. At that time, the j^{th} firm optimally resets its price $P_t^{D*}(j)$ so as to maximize the discounted value of its profits:

$$\max \sum_{k=0}^{\infty} \theta_D^k E_t\left\{\Lambda_{t,t+k} Y_{t+k}^D(j)(P_t^{D*}(j) - MC_{t+k}^D)\right\} \tag{16}$$

subject to:

$$Y_{t+k}^D(j) \le \left(\frac{P_t^{D*}(j)}{P_t^D}\right)^{-\varepsilon_D} Y_{t+k}^D \tag{17}$$

where Λ is the discount factor, P^D is the market price, ε_D is the elasticity of substitution between any two differentiated goods. Importantly, staggered price adjustment will result in price rigidities that permit monetary policy to have real effects in the short-run.

D. Fiscal Policy and Fiscal Rules

The government obtains revenue from a commodity export (copper) that falls manna-like from the sky. Its volume each period is assumed to be constant $Q_t^{cu} = \overline{Q^{cu}}$ and its world-determined price fluctuates randomly each period according to $P_t^{cu} = \overline{P^{cu}}(1+\varepsilon_t)$, where $\varepsilon_t \sim N(0,\sigma_{cu})$. Thus, copper revenue is $\tau_{cu}(S_t P_t^{cu} Q^{cu})$ where τ_{cu} is the government's share of total copper production. The government also receives a lump-sum tax that is assumed to be constant and policy invariant: $P_t T_t = \overline{PT}, \forall t$. Thus total government revenue is the sum of these two elements: $IT_t = \overline{PT} + \tau_{cu}(S_t P_t^{cu} \overline{Q^{cu}})$

The government uses its revenues to purchase goods and services—both imported and domestic. Since the latter are supplied by households, government spending raises domestic household income. Otherwise, government expenditures are assumed to be inherently useless, appearing in neither utility nor production functions.

The government budget constraint is:

$$IT_t + R_t^{-1} B_{t+1}^G + S_t (\Phi(B_{t+1}^*) R_t^*)^{-1} B_{t+1}^{G*} = B_t^G + S_t B_t^{G*} + P_t^G G_t \tag{18}$$

where B_t^G is domestic public debt, $S_t B_t^{G*} = v_b B_t^G$ is public foreign debt (a fixed proportion of domestic public debt), $P_t^G G_t$ is public spending and $\Phi(B_{t+1}^*), \Phi' > 0$ is a risk premium on public debt. Following Schmitt-Grohé and Uribe (2003) this element closes the model.

A *fiscal rule* determines how much manna the government spends and when it spends it. Thus, the fiscal rule affects both the level and volatility of government spending and through it all other variables.

E. The Balanced-Budget (BB) Rule

Our benchmark is a **balanced-budget** (*BB*) rule in which government spends always all its revenues running neither a deficit nor a surplus:

$$P_t^G G_t(BB) = IT_t - r_t B_t^G \tag{19}$$

where $\tilde{r}_t$ is a weighted average (effective) interest rate on total debt (domestic plus foreign), namely:

$$\tilde{r}_t \equiv \frac{R_t - 1}{R_t} \equiv \left[\frac{R_t - 1}{R_t} + \frac{R_t^* \Phi(B_{t+1}^*) - 1}{R_t^* \Phi(B_{t+1}^*)} v_b \right] \tag{20}$$

and B^G is a weighted average of domestic and foreign-held government debt. The BB rule has advantages: it is simple and transparent, and it limits government debt to a constant (zero). But, the BB rule has a drawback: it transmits copper price volatility.

F. The Acyclical (AC) Rule

The *acyclcical* (*AC*) or structural balance rule remedies this. Under this rule, spending is linked one-to-one with steady-state (or structural—permanent) government revenues net of interest payments, but with a small adjustment factor for the debt level (μ_x). In the AC rule the government spends only its permanent or steady state revenue:

$$P_t^G G_t(AC) = \overline{IT} - \left[\mu_x + \frac{R_t - 1}{R_t}\right] B_t^G(AC) \tag{21}$$

Essentially, under the *AC* rule, government spending tracks steady-state revenues more closely than current revenues. Procyclicality under AC, while substantially less than under BB, is not entirely eliminated. When there is an adverse shock to copper prices $\varepsilon_t < 0$, there is an *incipient* rise in future debt $B_{t+1}^G < 0$. This raises the risk premium. According to the AC rule, expenditures must fall. In the other direction, for a beneficial shock $\varepsilon_t > 0$, spending increases.

In Appendix II we show that under the AC rule, the authority must accumulate a precautionary cushion of assets. Moreover, we show that under rule AC, asset accumulation must be bounded. In that sense, the AC rule is in essence a structural surplus—similar in spirit to rule (8) in the above section.

G. Transmission of Shocks

Simulations of the model are performed in Dynare (Juillard, 1996). We assess shocks to the world price of an export commodity ("copper"). The volume of copper (tons) is assumed to be fixed, and copper is owned in total by the government, so government revenue responds one-to-one to copper price shocks, in percent.

Figure 1 reveals the balanced-budget BB rule (black line) to be procyclical: changes in copper prices and hence government revenue are spent in their entirety. This raises firm income. The demand for labor, Ricardian and non-Ricardian alike, rises, along with their wages and hours worked. Ricardians save the bulk of their windfall, both labor income and profits, and their consumption is largely unchanged. By contrast, non-Ricardians consume the entirety of their windfall; they do not save. Under the AC regime, the additional government revenue is saved, not spent. Accordingly, even while copper prices have risen, labor demand, wages, and hours are largely unchanged.

Figure 2a shows that, for Ricardians, consumption is only slightly less volatile under AC than under BB. Since Ricardans can smooth consumption on their own, AC yields little benefit compared to BB. But they consume less under AC than under BB. *Why?* Under BB government spending is more volatile than under AC—and it is higher during the initial periods. This is a bonanza for Ricardians that permits them to accumulate more wealth under BB than under AC.

By contrast, for non-Ricardians, consumption is substantially less volatile under AC than under BB. They benefit from AC's publicly provided consumption smoothing. However, since they do not save, they are unable to capitalize on the initial bonanza—unlike Ricardians.

Unsurprisingly, our welfare calculations (see below) show that while Ricardians prefer BB to AC, the reverse holds for non Ricardians.

Under AC, the government saves in the initial periods, and government financial assets increase. This reduces income and wealth to all agents in the initial periods (relative to BB). Ricardians optimally reduce their saving and draw down their financial assets under the less volatile AC regime—as Figures 2a and 2b show. Doing so also helps them flatten their long-term consumption profile, offsetting the upward tilt of government spending. Importantly, the government saves according to a *mechanical* rule under AC. Hence, publicly provided consumption smoothing is suboptimal for Ricardians: they are better off if they do that job for themselves.

IV. How Does The Fiscal Rule Affect Consumer Welfare?

In this section we show welfare implications over the continuum of fiscal rules presented in the previous section. Welfare is measured in terms of steady-state consumption as in Lucas (1987) in a way that is similar to calculations presented by Kollman (2002), Kim and Kim (2003), Elekdag and Tchakarov (2004), Bergin et al (2007), and Schmitt-Grohé and Uribe (2007).We use the second order approximations developed by Schmitt-Grohé and Uribe (2004) to solve the whole system of equations of the model.[14]

A. General Fiscal Rule

It is easily shown that rules *BB* and *AC* are merely two polar cases along a continuum of possibilities in a general rule (*GR*):

$$P_t^G G_t(GR) = \overline{IT} - \left[R_t + \mu_x \right] B_t^G + \alpha_r (IT_t - \overline{IT}) \tag{22}$$

[14] As Kim and Kim (2003) note, log-linearized business-cycle models are inappropriate for welfare analysis since they are unable to account for the effect of the variance of the shocks on economic decisions. Thus, we compute the welfare gains generated by moving from one rule to the other, finding the change in steady-state consumption (ξ) required to make any household indifferent (in expected utility terms) between the procyclical balanced budget and the acyclical spending rule.

Figure 1. Responses to a Price of Copper Shock

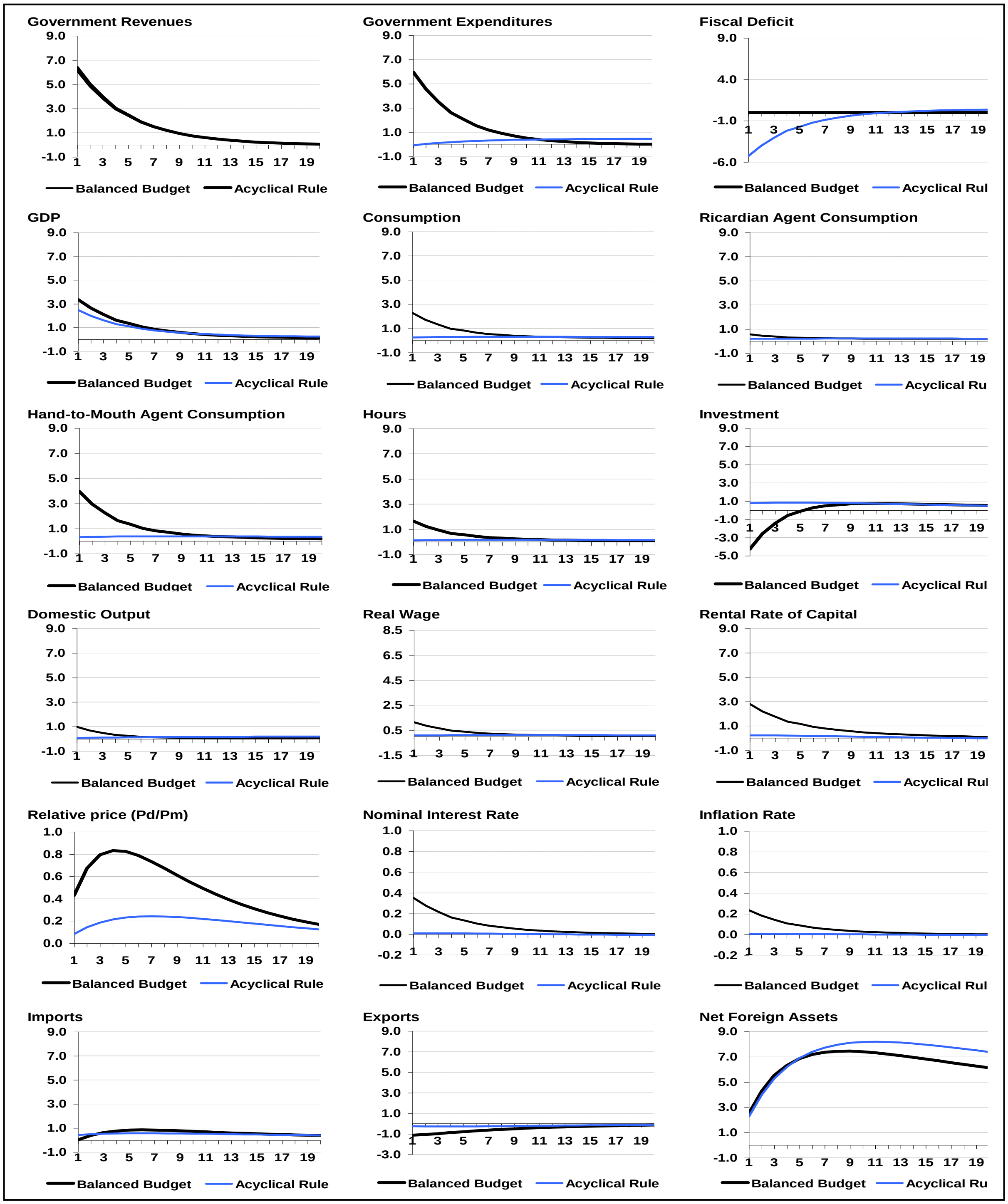


Figure 2a. Average of Simulated Series

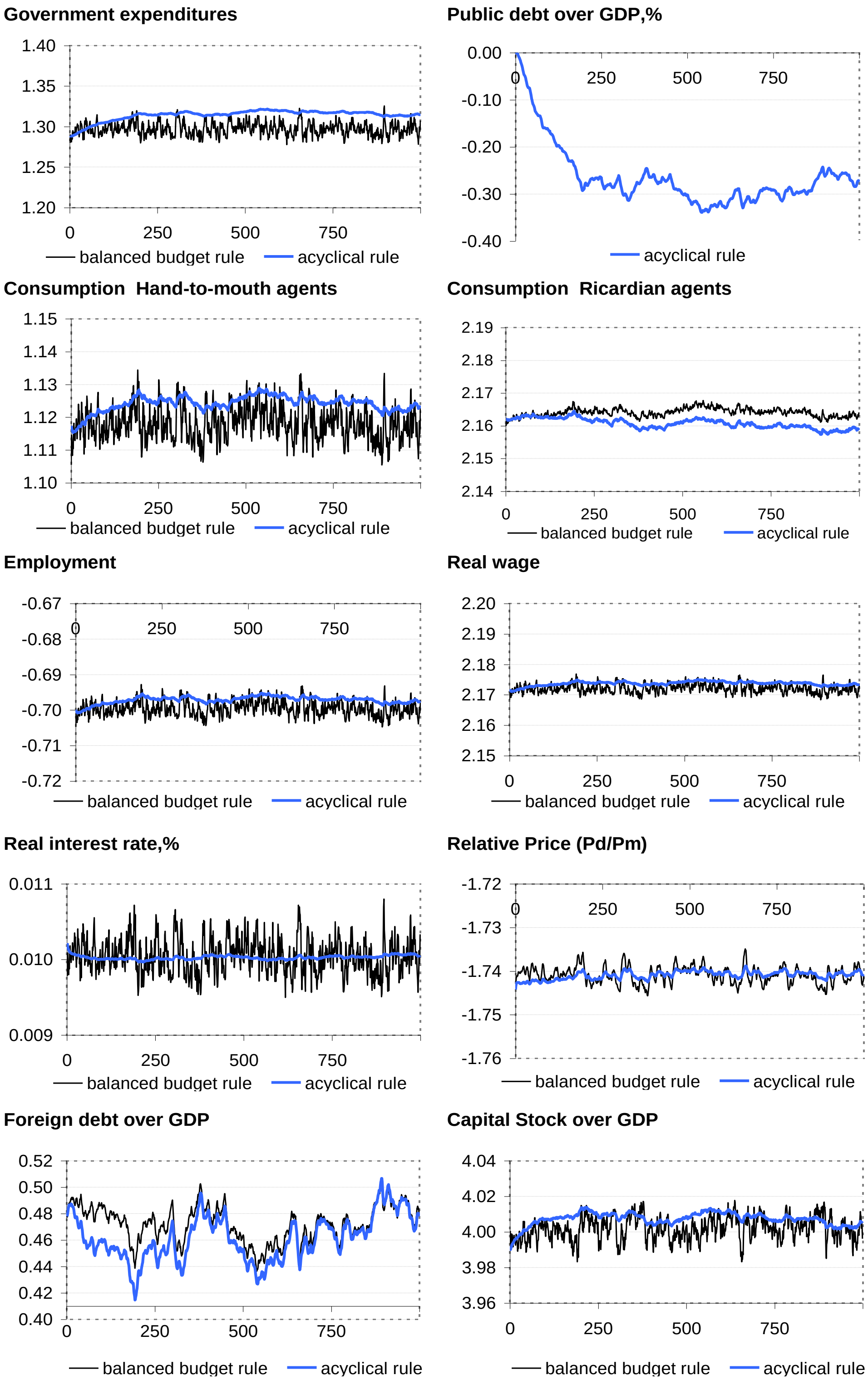
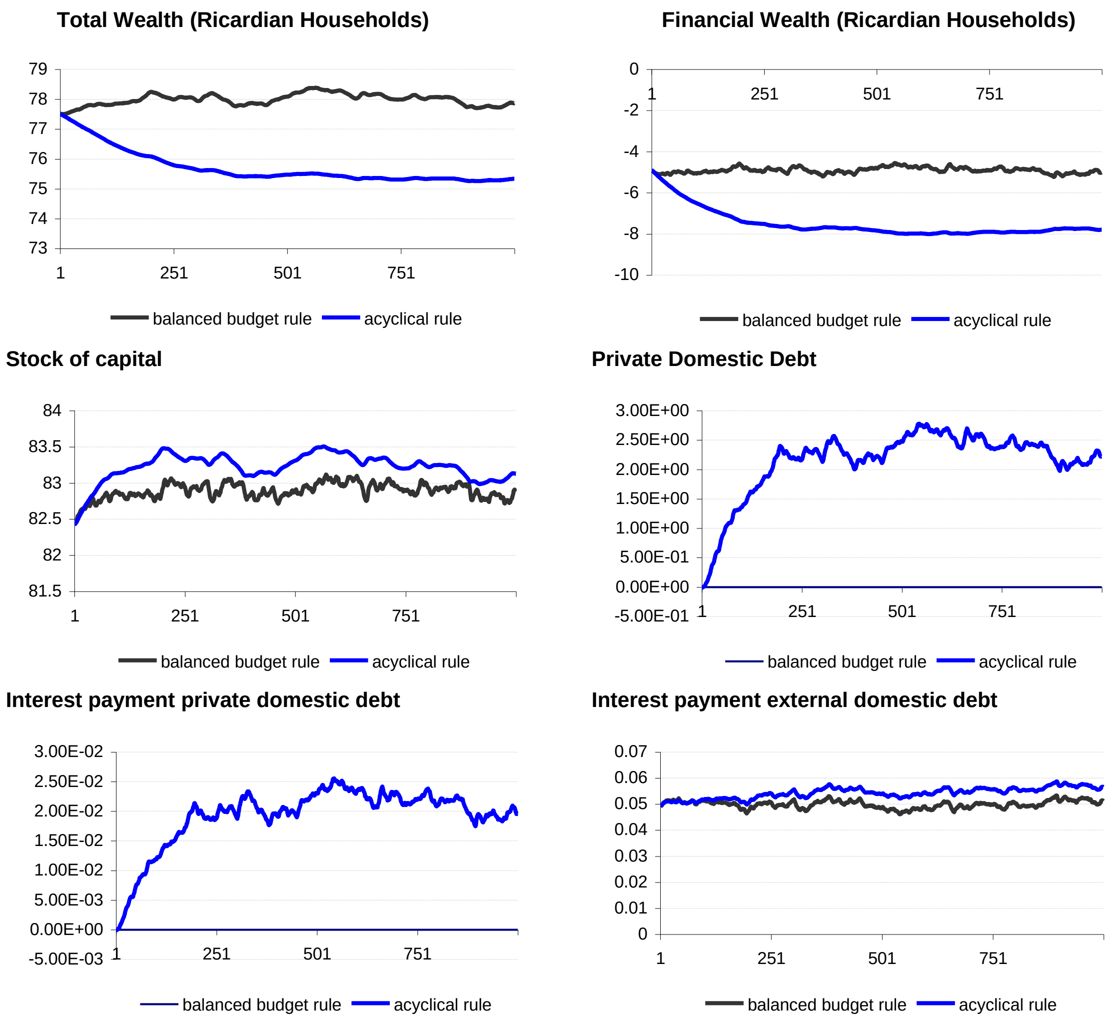


Figure 2b. Average of Simulated Series



Thus, with $\alpha_\gamma = 1, \mu_x = 0$ this rule becomes *BB* and with $\alpha_\gamma = 0,$ and $0 < \mu_x < R^{-1}$ rule (22) coincides with the *AC* regime. We may thus think of a *continuum* of intermediate rules for which $0 < \alpha_\gamma < 1,$ and $0 < \mu_x < R^{-1}$. Here, alternative pairings of $[\alpha_\gamma, \mu_x]$ summarize the degree of procyclicality in public spending. In this sense, the fiscal rule affects both the level and volatility of government spending. We thus calculate the welfare gains of moving from BB to alternative pairings of $[\alpha_\gamma, \mu_x]$ over this continuum.

For alternative values of α_γ, μ_x, we solve for the percentage change in welfare in BB versus alternative, $\xi^{alternative}$ *across steady states* according to:

$$U((1+\xi^{alternative})C, N) = (1-\beta)\sum_{t=0}^{\infty} \beta^t E_o\left[U(C,N)\right] \tag{23}$$

That is, in order to make the consumer indifferent between some alternative regime $[\alpha_\gamma, \mu_x]$ and the BB regime, we would have to change BB consumption by the amount $C\xi^{alternative}$.

B. Simulation results

Our simulations yield several key results:

1. Discounted welfare for both types of consumers will increase either when spending increases or when the time profile of government expenditures is shifted towards the present. This implication is uncontroversial. It simply reflects the fact that the government has an exclusive right to spend its manna from heaven (copper revenues) when it chooses (according to the rule). More spending raises the demand for domestic (as well as imported) goods and services, whose ultimate suppliers are the economy's households – both Ricardian and non-Ricardian.

2. Reducing the variance of government expenditures helps non-Ricardian consumers more than Ricardian ones; the latter are able to smooth their consumption stream on their own.

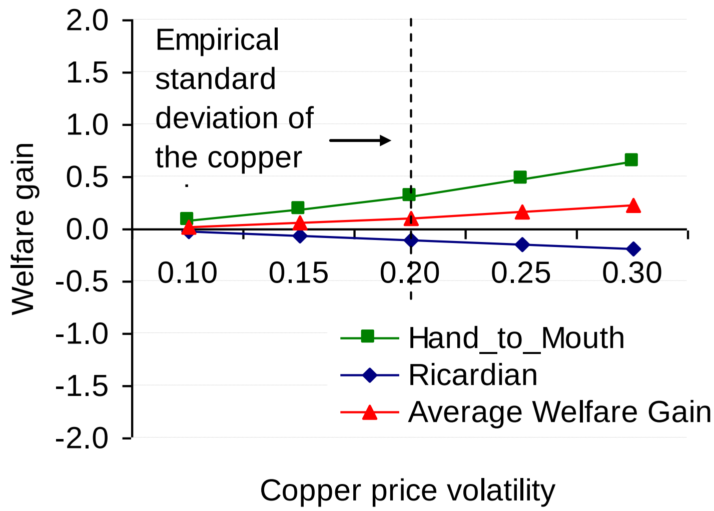
3. Reducing the variance of government expenditures reduces asset accumulation by Ricardian consumers. In a more volatile environment, Ricardians can take advantage of the commodity price booms by saving and accumulating assets. In a smoother environment (AC versus BB), Ricardians have both less incentive to save – and also less *opportunity* to do so.

4. For these reasons, it is expected that non-Ricardians will prefer AC over BB while (based on the first two implications) Ricardians might prefer BB over AC.

Detailed results are shown in Figure 3. Table 1 shows the average welfare gains obtained using the conditional expectations for a given volatility of the commodity price shocks, as measured in consumption units for both consumers over a grid of values for μ_x and α_r.

As one would expect, raising either μ_x or α_r helps Ricardians but hurts hand-to-mouth households. However, raising μ_x is not identical to raising α_r. As Table 1 suggests, if we maintain the acyclical element (keep $\alpha_\tau = 0$) but increase somewhat the debt targeting parameter μ_x, we can benefit Ricardian agents at a very small cost to the hand to mouth agents. This result cannot be obtained by raising α_r: while Ricardian households always gain, the loss suffered by "hand-to-mouth" households is even greater.

Figure 3. Welfare Gain (WG) and Variance of Copper Prices (σ Copper)



WG: welfare under acyclical minus welfare under balanced budget regime (measured in percent of steady state consumption).

Table 1. Average Welfare Gains

μ_x \ α_x	0	0.25	0.5	0.75	1
0.010	0.1038	0.0981	0.0792	0.0447	0.00
0.033	0.1076	0.1008	0.0810	0.0456	0.00
0.055	0.1091	0.1016	0.0828	0.0480	0.00
0.078	0.1085	0.1032	0.0831	0.0486	0.00
0.100	0.1075	0.1047	0.0861	0.0495	0.00

Intuitively, α_r is a larger and blunter instrument than μ_x. If μ_x rises, the stock of debt (or assets) must return to zero more quickly than otherwise. If α_r rises, more volatility is introduced directly—through the commodity price channel. By contrast, if μ_x rises, more volatility is introduced but less directly—through the spending channel.

Indeed, we find that, conditional on $\alpha_r = 0$, there is a value of μ_x that maximizes average welfare gains. Therefore, we say that it is the best degree of government spending stabilization. So long as the gain to Ricardian consumers from increasing μ_x exceeds the loss suffered by "hand to mouth" agents, the former can compensate the latter. Note however, that such an optimum will only coincide with one that a social planner would choose for a special case, namely where the social planner's weights on the utility of "hand-to-mouth" and Ricardians coincide *exactly* with the values of λ and (1-λ), as defined above.

V. Summary and Conclusions

Initially, we reviewed several fiscal "ills" that my be remedied by a fiscal rule. These ills were fiscal indiscipline, low credibility of the authority, and volatility. We noted that a fiscal rule should be designed so as to directly address these ills. In addition, we noted that a rule should be transparent and easily understood by market participants.

We then drew the link between a policy rule and some underlying objective function (Woodford, 2003). That objective function should approximate the underlying welfare of consumers themselves as much as possible, even if a pure Ramsey planning solution is infeasible.

In this vein, non-Ricardian or "hand-to-mouth" households have special needs. Optimally, they would save and amass a precautionary cushion of assets—if they had access to capital markets. Because they do not, the government should instead act on their behalf by running a structural surplus. In so doing, the government accumulates assets on behalf of hand-to-mouth households who cannot save for themselves. However, we noted that such asset accumulation should be bounded—not infinitely large.

Accordingly, we proposed a fiscal rule that confronts the main ills and provides hand-to-mouth consumers with such a bounded cushion of assets. Our rule should be simple and transparent to implement, provided that the steady-state export price can be estimated. We also noted that such a regime, when compared to a simple balanced budget rule, might not benefit everyone in society.

As one example, we considered a commodity exporting government that uses its export revenues to purchase goods and services from domestic residents, to whom the spending accrues as income. When it implements a structural surplus, the government shifts such spending into the future. In present value terms, domestic income must fall.

To compensate, the government provides a less volatile income stream. However, this mainly benefits hand-to-mouth consumers; they are willing to pay for lower volatility. By contrast, Ricardian households, who would be able to smooth their own consumption anyway, are not compensated for their lost income.

We presented such ideas in an intuitive fashion. We then simulated similar fiscal regimes in a dynamic, stochastic, general equilibrium (DSGE) model. Our simulations help illustrate the point that a structural surplus can benefit some, but not all, households in an economy.

We believe that there is much room for further work in this area. As a future research project, we plan to generalize our equilibrium model to also consider domestic revenues that are generated from distortionary taxes. In this vein, we would also consider the implications of productivity shocks (in addition to those to the terms-of-trade that we currently examine) in our DSGE model.

Appendix I. The Reduction of Expenditures in Present Value Terms

Under an alternative interpretation of the structural surplus, since we indefinitely delay some expenditures, the *present value* of such expenditures will fall. To see this, we substitute fiscal rule (8) into budget constraint (3), we assume a constant rate of interest $r_t = r$, price of government expenditures are equal to unity $P^G = 1$, the domestic element of tax revenues are equal to zero, and the manna-like resource revenues are equal to a constant $P^X Q^X = \overline{T}$. Doing so reveals that the present value of government expenditures $PV(G)$ is:

$$\begin{aligned} PV(G) &= [\overline{T} - \kappa]*\{(1+r)/r\} + [\kappa(r+\mu)/\mu]*\{(1+r)/r\} \\ &[-\kappa(r+\mu)]/\mu\}[(1+r-\mu-\mu r)/(r-\mu-\mu r) \end{aligned} \quad \text{(A.I.1)}$$

Expression (A.I.1) highlights two effects that running a fiscal rule like (8) has on the present value of expenditure. The present value of government spending declines proportionally to the perpetuity value of the structural surplus; this term is $-\kappa(1+r)/r$. Second, we may think of a 'dividend' that the government reaps because it amasses a 'war chest'; that term is $\kappa(r+\mu)/\mu*(1+r)/r$. The higher is the terminal value of assets (κ/μ), the higher will be government spending – *eventually*. The last term tells us that the present value of our dividend is reduced since those dividends converge to their long-run value only in the distant future. That term is: $-k(r+m)/m*(1+r-\mu-r\mu)/(r-\mu-r\mu)$. Combined, these three terms tell us the difference between the present value of spending under a balanced budget regime (which would be simply $\overline{T}(1+r)/r$) and the corresponding level of spending under a structural surplus rule (of κ each period).

Appendix II. Optimal Structural Surplus

A precautionary savings motive lies at the heart of our structural surplus rule. We have known since Hayne Leland's (1968) article that such a motive implies a non-zero third derivative on the utility function—the 'prudence' parameter. Other than Caballero's (1990) demonstration with an exponential constant absolute risk aversion (CARA) utility function (a very specific case) there is no general closed form solution for precautionary saving. In this appendix we derive optimal precautionary saving for a constant relative risk aversion function—which we also simulate in the model. For expositional ease, we use a well-known technique, namely a Taylor approximation (see Talmain, 1998, Gourinchas and Parker, 2004).

For a hand to mouth consumer, (nominal) consumption in any period must equal disposable income:

$$\underbrace{P_t C_t^r}_{Consumption} = \underbrace{W_t N_t^r - P_t T_t}_{Disposable\ Income} = Y_t^d \tag{A.II.1}$$

In our model, the government uses the (manna-like) commodity revenue to make purchases. In this way, an increase in government purchase means an increase in disposable income.

By assumption, hand-to-mouth consumers do not have access to credit instruments. For this reason, they do not save. Counterfactually, if they enjoyed such access, they might save some amount Z. We want to know (a) what their optimal saving Z would be and (b) whether Z varies with the volatility of disposable income? Total utility is:

$$U(total) = U\left(Y_1^d\right) + \beta_1 E_1[U\left(Y_2^d\right)] \tag{A.II.2}$$

We analyze a small perturbation around the steady state: $\beta R = 1$ and $Y_1^d = E(Y_2^d)$. Hence, we examine small changes around a "hand-to-mouth" equilibrium—$C_1 = E(C_2)$. Our analysis, however, will show that equality will not in general hold. Instead, if their future income is uncertain, consumers will consume less today and save for a rainy day—or the benevolent (Ramsey) planner will do so for them. The optimum is summarized by the Euler equation:

$$U^{'}\left(C_1\right) = E_1\left[\beta R U^{'}(C_2)\right] \tag{A.II.3}$$

Taking a Taylor expansion around C_1 on the right hand side of (A.II.3) yields:

$$U^{'}\left(C_1\right)=U^{'}\left(C_1\right)+E\left[U^{"}(C_1)*(C_2-C_1)\ \right]+E\left[.5*U^{"'}(C_1)*(C_2-C_1)^2\ \right]+... \quad \text{(A.II.4)}$$

Recognizing that *current* consumption C_1 is certain, we simplify this term:

$$C_1=E(C_2)+\left[.5*\frac{U^{"'}(C_1)}{U^{"}(C_1)}*E\,(C_2-C_1)^2+...\ \right] \quad \text{(A.II.5)}$$

Note that the ratio $U^{"'}/U^{"}$ is sometimes called the "absolute prudence level" (see Kimball, 1990); in a well-behaved utility function, this term is *negative* ($U^{"}<0, U^{"'}>0$). Note also that $E(C_2-C_1)^2$ is the variance of consumption $\text{var}(C)$ in period 2 (which is proportional to the variance of disposable income). Note that equation (A.II.5) helps illustrate a special case: if there is no variability in output, or if the prudence term is zero, consumption follows a random walk (Hall (1979)). By contrast, if the prudence term is non-zero—as is the case in our simulation model—and there is variability in output, the time path of consumption will be tilted toward the future. This is precautionary savings; expression (A.II.5) is similar to a term found in Caballero (1990); the technique is similar to Talmain (1998) and Parker and Gourinchas (2004).

We may now consider a functional form that is similar to the one in our equilibrium model:

$$U(C)=\frac{C^{1-\sigma}-1}{1-\sigma} \quad \text{(A.II.6)}$$

Higher derivatives of the utility function are:

$$U^{'}(C)=C^{-\sigma}$$
$$U^{"}(C)=-\sigma C^{-(\sigma+1)}$$
$$U^{"'}(C)=\sigma(\sigma+1)C^{-(\sigma+2)}$$

Substituting these terms back into the Euler relationship (A.II.5) yields:

$$C_1=E(C_2)-\{.5*(1+\sigma)*\frac{\text{var}(C)}{C_1}\}+... \quad \text{(A.II.7)}$$

Thus, savings in the first period $Y_1^d - C_1$ is directly proportional to the prudence factor σ —a parameter in the utility function—and the (scaled) variability of consumption; more variability means more precautionary saving.

Regarding our simulations, we note that the variability of disposable income for hand-to-mouth consumers under the balanced budget (BB) rule stems entirely from the variance of government expenditures, G. Thus, the savings term on the right hand side will be proportional to $0.5*(1+\sigma)\lambda*\text{var}(G)/C$, where λ is the share of hand-to-mouth consumers in the economy. Insofar as $\text{var}(G)$ is a constant, so is the savings term.

However, we assume that hand-to-mouth consumers do not save. Instead, we may think of a "dual" objective function in which the government itself allocates expenditures over time in a way to smooth revenues and hence protect the more vulnerable hand to mouth consumers. We may write the government's Euler equation as:

$$G_1 = E(G_2) + .5*\frac{U'''(G_1)}{U''(G_1)}*(G_2 - G_1)^2 + ... \qquad \text{(A.II.8)}$$

We assume that the government's resource base varies in two ways. First, revenues will vary: $\text{var}(T) > 0$. In our simulation model, such variability is entirely due to fluctuations in the world copper price. Second, interest payments may vary: $\text{var}(rB) > 0$. In our model this is a second-order effect that reflects both the central bank's inflation target (i.e. its Taylor rule) and a risk premium. Accordingly, the government will run a primary surplus that is proportional to:

$$T_1 - G_1 = .5*\frac{U'''}{U''}(G_1)*[\text{var}(T) + \text{var}(rB)] + ... \approx \overline{ps} + \mu B \qquad \text{(A.II.9)}$$

Equation (A.II.9) is essentially the acyclical structural surplus (AC) that we simulate; the rule permits the government itself to smooth its expenditures. Importantly, we assume that there is no market for country insurance against such shocks.[15] Since a contingency-based insurance scheme may be less expensive than reducing consumption and accumulating assets, precautionary saving might be seen as self-insurance – a second best. In this way, the government will not need to abandon the rule in the presence of very large adverse shocks. Since some spending is social insurance, by saving the government essentially provides a "safety net" for its safety net.[16]

---

[15] Menguy (2008) proposes a fiscal rule for Europe which is similar to ours.

[16] Mendoza and Oviedo (2004) find that in emerging economies under uncertainty, the "aversion to a collapse in outlays leads the government to respect a "natural debt limit" equal to the annuity value of the primary balance in a fiscal crisis."

Additionally, it can be shown that the presence of a risk premium $\Phi(B)$ gives rise to a critical asymmetry in the model. Starting from a neutral position of $B=0$, if there is an adverse shock, the government becomes a debtor and its fiscal rule dictates an increase of the primary surplus whose magnitude is $B^*(r+\Phi(B)+\mu)$. For a beneficial shock of equal magnitude, the government becomes a creditor and it will reduce its primary surplus by $-B^*(r+\Phi(-B)+\mu)$. It is easily shown that if $|\Phi(B)|=|\Phi(-B)|$, it follows that:

$$\underbrace{|B^*(r+\Phi(B)+\mu)|}_{\text{Adverse shock: retrenchment}}>\underbrace{|-B^*(r+\Phi(-B)+\mu)|}_{\text{Beneficial shock: expansion}}$$

In absolute terms, the fiscal retrenchment is greater than the fiscal expansion. In our model, the government compensates for such an asymmetry by accumulating assets.

Appendix III. The Model

A. Households

We assume a continuum of infinitely lived households indexed by $i \in$ [0,1]. Following Galí et al. (2007), a fraction of households λ consume their current labor income; they do not have access to capital markets and hence neither save nor borrow. Such agents have been termed "hand-to-mouth" consumers. The remainder $1-\lambda$ save, have access to capital markets, and are able to smooth consumption. Therefore, their intertemporal allocation between consumption and savings is optimal (Ricardian or optimizing consumers). Both segments optimize on the intratemporal margin in labor markets.

B. Consumption by Ricardian Households

The representative household maximizes expected utility

$$E_o \sum_{t=0}^{\infty} \beta^t U\left(C_t^o(i), N_t^o(i)\right), \qquad \text{(A.III.1)}$$

Subject to the budget constraint

$$\begin{aligned} P_t C_t^o(i) = W_t(i) N_t^o(i) + B_t^o(i) - S_t B_t^{o*}(i) + D_t^o(i) - P_t T_t \\ - R_t^{-1} B_{t+1}^o(i) + S_t (\Phi(B_{t+1}^*) R_t^*)^{-1} B_{t+1}^{o*}(i), \end{aligned} \qquad \text{(A.III.2)}$$

where $C_t^o(i)$ is consumption, $D_t^o(i)$ are dividends from ownership of firms, $\Phi(B_{t+1}^*)$ is the country risk premium, S_t is the nominal exchange rate, $B_t^{o*}(i)$ denotes private net foreign assets, *where we define a positive value of* $B_t^{o*}(i)$ *as debt*, $W_t(i)$ is nominal wage, $N_t^o(i)$ is the number of hours of work, $B_t^o(i)$ is government debt held by households, R_t and R_t^* are the gross nominal return on domestic and foreign assets (where $R_t = 1 + i_t$ and $R_t^* = 1 + i_t^*$) and T_t are lump-sum taxes.

Our utility function is known as GHH preferences because it was proposed by Greenwood, Hercowitz and Huffman (1988), and according to Correia et al (1995) it yields realistic values for consumption volatility in a small open economy:

$$U(C,N) = \frac{(C - \psi N^{\varphi})^{1-\sigma} - 1}{1-\sigma} \qquad \text{(A.III.3)}$$

Note that $1/\sigma$ is the intertemporal elasticity of substitution in consumption and $1/(\varphi - 1)$ is the elasticity of labor supply to wages. The value of ψ is calibrated to obtain a realistic fraction of steady state hours worked. Note also that the consumer's prudence factor is $\left(C_t^0(i) - \psi N_t^{\,0}(i)^{\varphi}\right) U_{CCC} / U_{CC} = -(1+\sigma)$. This statistic is important to explain precautionary savings—one of the most important results of this article. As other authors have noted (Carroll and Kimball, 2008), *for any individual agent*, unless this statistic is non-zero, the level of consumption (and hence savings) will be invariant to volatility.

C. Consumption by Hand-to-Mouth Households

For "Non-Ricardian" households, utility is:

$$U(C_t^r(i), N_t^r(i)). \tag{A.III.4}$$

We assume that these households neither save nor borrow (Mankiw, 2000). As a result, their level of consumption is given by their disposable income:

$$P_t C_t^r(i) = W_t(i) N_t^r(i) - P_t T_t. \tag{A.III.5}$$

D. Labor Supply

Symmetric with the goods markets (discussed below), the continuum of monopolistically competitive households supply a differentiated labor service to the intermediate-goods-producing sector and a labor aggregator combines as much household-labor as is demanded by firms, with a constant-returns technology. The aggregate labor index has the CES form:

$$N_t = \left[\int_0^1 N_t(i)^{\frac{1}{1+\theta_\omega}} di \right]^{1+\theta_w} \tag{A.III.6}$$

where $N_t(i)$ is the quantity of labor used from each household. The representative labor aggregator minimizes the cost of producing a chosen amount of the aggregate labor index, given each household's wage rate $W_t(i)$. Then, she sells units of labor index at their unit cost W_t (with no profit), to the production sector:

$$W_t = \left[\int_0^1 W_t(i)^{-\frac{1}{\theta_\omega}} di \right]^{-\theta_\omega} \tag{A.III.7}$$

Note that, while prices are sticky (à la Calvo), wages adjust instantaneously. Nominal wages are set by households so as to maximize their intertemporal objective function (A.III.1) subject to the intertemporal budget constraint (A.III.2).

E. Demand for Domestic and Imported Consumption Goods

Consumption is a CES aggregate of consumption of domestic $C_t^D(i)$ and imported goods $C_t^F(i)$, where η_C is the elasticity of substitution between domestic and foreign goods and α_C is the steady-state share of imported goods in total consumption:

$$C_t = \left(\alpha_c^{\frac{1}{\eta_C}} \left(C_t^D\right)^{\frac{\eta_c - 1}{\eta_C}} + (1-\alpha_c)^{\frac{1}{\eta_C}} (C_t^F)^{\frac{\eta_c - 1}{\eta_C}} \right)^{\frac{\eta_C}{\eta_C - 1}} \qquad \text{(A.III.8)}$$

F. Firms

Domestic intermediate-goods firms

We assume a continuum of monopolistically competitive firms, indexed by $j \in$ [0, 1] producing differentiated intermediate goods. The production function of the representative intermediate-good firm, indexed by (j) corresponds to a CES combination of capital $K_t\,(j)$ and labor $N_t\,(j)$, to produce $Y_t^D(j)$ and is given by:

$$Y_t^D(j) = A_t\left[\alpha K_t(j)_t^{\frac{\sigma_s - 1}{\sigma_s}} + (1-\alpha) N_t^{\frac{\sigma_s - 1}{\sigma_s}}(j)\right]^{\frac{\sigma_s}{\sigma_s - 1}} \qquad \text{(A.III.9)}$$

where A_t the technology parameter, and σ_s the elasticity of substitution between capital and labor, are both greater than zero.

When firm (j) receives a signal to optimally set a new price à la Calvo (1983), it maximizes the discounted value of its profits, conditional on the new price:

$$\max \sum_{k=0}^{\infty} \theta_D^k E_t \left\{ \Lambda_{t,t+k} Y_{t+k}^D(j)(P_t^{D*}(j) - MC_{t+k}^D) \right\} \qquad \text{(A.III.10)}$$

subject to:

$$Y_{t+k}^D(j) \leq \left(\frac{P_t^{D*}(j)}{P_t^D} \right)^{-\varepsilon_D} Y_{t+k}^D \qquad \text{(A.III.11)}$$

Where the probability that a given price can be reoptimized in any particular period is constant and is given by $(1-\theta_D)$ and ε_D is the elasticity of substitution between any two differentiated goods. Where the discount factor is $\Lambda_{t,t+k} = \beta^k \left(\frac{C_{t+k}^0 - \psi N_{t+k}^{0\ \varphi}}{C_t^0 - \psi N_t^{0\varphi}} \right)^{-\sigma} \left(\frac{P_t}{P_{t+k}} \right)$.

Firms that did not receive the signal will not adjust their prices. Those who do reoptimize choose a common same price, P_t^{D*}. Finally, the dynamics of the domestic price index P_t^D is described by the equation:

$$P_t^D = \left[\theta_D (P_{t-1}^D)^{1-\varepsilon_D} + (1-\theta_D)(P_t^{D*})^{1-\varepsilon_D} \right]^{\frac{1}{1-\varepsilon_D}} \qquad \text{(A.III.12)}$$

Intermediate-goods importing firms

As in the domestic sector, price setting in the import sector reflects little exchange rate pass-through in the short run (as in Galí and Monacelli, 2005, and Smets and Wouters, 2002). Such an assumption, while simplistic, provides realistic simulations (impulse response functions). This sector consists of firms that import a homogenous good from abroad and turn it into a differentiated foreign good for the home market using a linear production technology. Import firms are only allowed to change their price when they receive a random price-change signal. Thus, the dynamics of the import price index is also described by an equation similar to (A.III.12). But in this case, firms reset their price in response to variations in the exchange rate or the foreign price; they optimally charge the import price abroad expressed in domestic currency.

$$P_t^F = \left[\theta_F (P_{t-1}^F)^{1-\varepsilon_F} + (1-\theta_F)(S_t P_t^{F*})^{1-\varepsilon_F} \right]^{\frac{1}{1-\varepsilon_F}} \qquad \text{(A.III.13)}$$

Note $(1-\theta_F)$ and ε_F have the same definition as before but here they apply to the intermediate-goods importing firms.

Final goods distribution

Total final output is expressed with a CES aggregator function (across firms). There is a perfectly competitive aggregator, which distributes the final good using a constant return to scale technology. It is valid for both K= D (domestic) and F (imported) goods:

$$Y_t^K = \left(\int_0^1 Y_t^K(j)^{\frac{\varepsilon_K - 1}{\varepsilon_K}} dj \right)^{\frac{\varepsilon_K}{\varepsilon_K - 1}} \qquad \text{(A.III.14)}$$

$Y_t^K(j)$ is the quantity of the intermediate good (domestic or imported) included in the bundle that minimizes the cost of any amount of output Y_t. The aggregator sells the final good at its unit cost P_t with no profit:

$$P_t^K = \left(\int_0^1 P_t^K(j)^{1-\varepsilon_K} dj \right)^{\frac{1}{1-\varepsilon_K}} \qquad \text{(A.III.15)}$$

where P_t is the aggregate price index. Finally, demand for any good $Y_t^K(j)$ depends on its price $P(j)$, which is taken as given, relative to the aggregate price level P_t:

$$Y_t^K(j) = \left(\frac{P(j)}{P_t}\right)^{-\varepsilon_K} Y_t^K \qquad \text{(A.III.16)}$$

Optimizing investment firms and Tobin's Q

There are firms that produce homogenous capital goods and rent them to the intermediate-goods firms. Firms are owned exclusively by Ricardian households. Firms invest the amount so as to maximize firm value:

$$V^t(K_t^o) = R_t^k K_t^o - P_t^I I_t^o + E_t(\Lambda_{t,t+1} V^{t+1}(K_{t+1}^o)) \qquad \text{(A.III.17)}$$

subject to a capital accumulation constraint that includes an adjustment cost function $\phi(.)$.

$$K_{t+1}^o = (1-\delta)K_t^o + \phi\left(\frac{I_t^o}{K_t^o}\right)K_t^o \qquad \text{(A.III.18)}$$

Demand for investment goods

Overall investment is equal to a CES aggregate of domestic and imported goods. Where η_I is the elasticity of substitution between domestic and foreign goods and α_I is the steady-state share of domestic goods in total investment.

$$I_t = \left(\alpha_I^{\frac{1}{\eta_I}} (I_t^D)^{\frac{\eta_I - 1}{\eta_I}} + (1-\alpha_I)^{\frac{1}{\eta_I}} (I_t^F)^{\frac{\eta_I - 1}{\eta_I}}\right)^{\frac{\eta_I}{\eta_I - 1}} \qquad \text{(A.III.19)}$$

Exports

The demand for total domestic (non-copper) exports from foreign countries is:

$$X_t^D = \left(\int_0^1 X_t^D(j)^{\frac{\varepsilon_D - 1}{\varepsilon_D}} dj\right)^{\frac{\varepsilon_D}{\varepsilon_D - 1}} \qquad \text{(A.III.20)}$$

Exports of good *J* depend on its own relative price:

$$X_t^D(j) = \left(\frac{P_t^D(j)}{P_t^D}\right)^{-\varepsilon_D} X_t^D \qquad \text{(A.III.21)}$$

There is a demand for each set of differentiated domestic goods, which in turn depends on both total consumption abroad and on the home price of domestic goods (relative to its price in the foreign country):

$$X_t^D = \left[\left(\frac{P_t^D}{S_t P_t^{D*}} \right) \right]^{-\eta*} C_t^{D*} \tag{A.III.22}$$

Aggregation

Total consumption is a weighted sum of consumption by Ricardian and rule-of-thumb agents:

$$C_t = \lambda C_t^r + (1-\lambda) C_t^o = \int_0^\lambda C_t^r(i) di + \int_\lambda^1 C_t^o(i) di \tag{A.III.23}$$

Since only Ricardian households invest and accumulate capital, total investment is equal to $(1-\lambda)$ times optimizing investment:

$$I_t = (1-\lambda)(I_t^o) \tag{A.III.24}$$

Likewise, the aggregate capital stock is:

$$K_t = (1-\lambda)(K_t^o) \tag{A.III.25}$$

Again, only optimizing households hold financial assets:

$$B_t = (1-\lambda)(B_t^o) \tag{A.III.26}$$

Foreign assets (or debt) include fiscal B_t^{G*} and private held assets B_t^{o*}:

$$B_t^* = B_t^{G*} + (1-\lambda) B_t^{o*} \tag{A.III.27}$$

Hours worked are given by a weighted average of labor supplied by each type of consumer:

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o \tag{A.III.28}$$

Finally, in equilibrium each type of consumer works the same number of hours:

$$N_t = N_t^r = N_t^o \tag{A.III.29}$$

Monetary policy

Even while this paper focuses on fiscal policy, price stability requires there also be an active central bank. Thus, in abbreviated way, we also include monetary policy: the central bank sets the nominal interest rate according to the following rule:

$$R_t = \overline{R}\left(\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi}\left(\frac{YR_t}{\overline{YR}_t}\right)^{\phi_y}\right) \tag{A.III.30}$$

where $\overline{R}$ is the steady state nominal interest rate, Π_t is total inflation, Π is steady state total inflation (assumed to be zero), YR_t is GDP without the natural resource and $\overline{YR}$ is its steady state value.

Government demand for domestic and imported goods

The government demands domestic and imported goods, according to:

$$G_t = \left(\alpha_G^{\frac{1}{\eta_G}}(G_t^D)^{\frac{\eta_G - 1}{\eta_G}} + (1-\alpha_G)^{\frac{1}{\eta_G}}(G_t^F)^{\frac{\eta_G - 1}{\eta_G}}\right)^{\frac{\eta_G}{\eta_G - 1}} \tag{A.III.31}$$

where η_G is the elasticity of substitution between domestic and foreign goods and α_G is the steady-state share of domestic goods in total government expenditure.

Market-Clearing Conditions

The factor market-clearing conditions are total employment by all firms j:

$$N_t = \int_0^1 N_t(j)dj \tag{A.III.32}$$

and full capital utilization

$$K_t = \int_0^1 K_t(j)dj \tag{A.III.33}$$

The good market-clearing condition is:

$$Y_t^D = (C_t^D + I_t^D + G_t^D + X_t^D) \tag{A.III.34}$$

where the total supply of domestic goods equals total demand of the domestic produced good for consumption, investment, government spending and exports. Finally, the economy-wide budget identity can be expressed as:

$$\begin{aligned} P_t C_t = & -P_t^G G_t - P_t^I I_t + P_t^D Y_t^D + (P_t^F Y_t^F - S_t P_t^{*F} Y_t^F) + \\ & S_t \left(\Phi\left(B_{t+1}^*\right) R_t^*\right)^{-1} B_{t+1}^* - S_t B_t^* + \\ & \tau_{cu} (S_t P_t^{cu} Q^{cu}) \end{aligned} \tag{A.III.35}$$

Equation (A.III.36) has an intuitive interpretation. First note that GDP is (approximately) the sum of domestically produced goods plus value added on the distribution of imports, plus copper exports:[17]

$$P_t Y_t = P_t^D Y_t^D + (P_t^F Y_t^F - S_t P_t^{*F} Y_t^F) + (S_t P_t^{cu} Q^{cu}) \tag{A.III.36}$$

Thus, according to the national income accounting identity, consumption must equal GDP minus investment (I) and government expenditures G plus foreign debt (positive values of B_t^*), which is written:

$$S_t \left(\Phi\left(B_{t+1}^*\right) R_t^*\right)^{-1} B_{t+1}^* - S_t B_t^* \tag{A.III.37}$$

The risk premium ensures that the economy returns to the steady state[18], thus this variable increases with the foreign debt.

[17] We assume for simplicity that there are no private copper exports; we treat them as if they were transfers from abroad.

[18] See Schmitt-Grohé and Uribe (2003).

Appendix IV. Calibration of the Model

We choose Chile as our benchmark country for the calibration because it has been a leader within emerging commodity exporters in implementing an acyclical fiscal rule.[19] Unfortunately, many parameters have never been obtained using Chilean data. For this reason, we calibrate the model taking sensible values from different studies (see Table A.II.1).[20] For example, the discount factor β is 0.99, close to the values found elsewhere in the literature. The risk aversion coefficient σ is greater than one (2.0) as the evidence indicates for small open economies.[21] Thus, the relative prudence coefficient is:

$\left(C_t^0(i)-\psi N_t{}^0(i)^{\varphi}\right) U_{CCC}/U_{CC} = -(1+\sigma)$=-3. This ensures that Ricardian agents will save more as output volatility rises.[22]

The elasticity of substitution across intermediate goods, ε_D and ε_F, is 6. In order to have a mark-up of 20 percent. The fraction of firms that keep their prices unchanged each period, θ_D and θ_F, is 0.75 and the rate of depreciation δ is 0.025. These values are standard in recent New Keynesian models (Woodford, 2003, Galí and Monacelli, 2005, and Galí et al, 2007).

For the labor market, we assume the same mark up as in the good market, i.e. θ_w is 0.2. The value of φ (=1.7) comes from Correia et al (1995), who introduced GHH utility function in RBC models for small open economies to explain the higher volatility of consumption observed in these countries. As they do, we choose a value for ψ (=7.02) to ensure that hours worked in steady state coincide with actual data in our benchmark country. The value of the investment adjustment cost ϕ is 1/15, which is half of the value of Correia et al (1995). Half of households are hand-to-mouth, i.e. λ is 0.5, which is within the range of values considered in other studies (Mankiw, 2000, and Galí et al, 2007). We assume that government spending is heavily biased towards domestic goods. Indeed, the share of domestic goods in the government consumption basket α_G is 0.99.

---

[19] The steady state values are consistent with those obtained for the Chilean Economy where foreign debt is around 50 percent of GDP. See for example Restrepo and Soto (2006).

[20] We assume that each period corresponds to one quarter.

[21] See Agénor and Montiel (1996), Table 10.1, page 353.

[22] For our chosen utility function, there is no closed form solution linking consumption and volatility.

Table A.II.1. Baseline Parameters

Baseline Parameters	
Discount factor (β)	0.99
Risk aversion coefficient (σ)	2.00
Disutility parameters, worked hours (N)	
φ	1.70
ψ	7.02
Weight of rule-of-thumb consumers (λ)	0.50
Rate of depreciation (δ)	0.025
Investment adjustment cost ϕ	1/15
Elasticity of substitution across intermediate goods (ε_D, ε_F)	6.00
Parameter of CES production function (α)	0.40
Fraction of firms that keep their prices unchanged (θ_D, θ_F)	0.75
Real wage mark-up ($1+\theta_W$)	1.20
Elasticity of substitution between capital and labor (σ_S)	1.00
Response of monetary authority to inflation (φ_π)	1.50
Response of monetary authority to output (φ_{yr})	0.00
Autoregressive coefficient of copper price	0.80
Share of the production of the natural resource owned by the government (τ_{cu})	0.50
Amount produced of the natural resource (Q^{cu})	0.45
Weight of domestic good in consumption (α_C)	0.60
Weight of domestic good in investment (α_I)	0.50
Weight of domestic good in government expenditure (α_G)	0.99
Foreign-domestic good (consumption) elasticity of substitution (η_C)	0.99
Foreign-domestic good (investment) elasticity of substitution (η_I)	0.99
Foreign-domestic good (government) elasticity of substitution (η_G)	0.99
Acyclical rule, debt weight (μ_X)	0.01
The share of external public debt over total public debt v_b	0.21
Elasticity of interest rate to external debt	0.001
Elasticity of domestic exports to real exchange rate (η^*)	1.00

This allows us to replicate a stylized fact: in many commodity exporting countries, increases in government spending cause real appreciations (Edwards, 1989). We do not have information about the values of the elasticity of substitution between domestic and foreign goods (η_C, η_I, and η_G), thus we assume values close to 1 one (following Galí and Monacelli, 2005). For the same reason we choose values for α_C and α_I close to 0.5 (also following Galí and Monacelli, 2005) as a measure of openness.

Even though public debt is not exactly zero in Chile, we assume it to be so in our model's steady state. This assumption helps us to compare the acyclical rule with the balanced budget regime: to do so, both policies must share the same steady state. Also, we assume that 21 percent of public debt is held by foreigners (v_b =0.21); this value comes directly from historic Chilean data. In our baseline simulation, the coefficient in the monetary rule with respect to inflation ϕ_π is 1.5, which is a standard one for Taylor rules. The interest rate response with respect to the output gap ϕ_{yr} is assumed to be zero. Likewise, the elasticity of substitution between capital and labor σ_S is 1.0. Thus α is the capital share and is assumed to be 0.4 given that this value in Chile is higher than in other countries (in the US, α =0.33). The elasticity of domestic exports to the real exchange rate η^* is 1.0 in line with estimations for developing countries (Ghei and Pritchett, 1999).

The autoregressive coefficient of the real price of copper ρ is 0.8 obtained from quarterly data from 1973 through 2005. We choose small values for the debt weight μ_X (=0.01) in the acyclical rule and the elasticity of the interest rate to external debt (0.001). Both coefficients warrant the stability of the model. The first one makes public debt a stationary variable. The second one forces the current account to be stationary as well as net foreign assets.

References

Aiyagari, R., Marcet, A., Sargent, T. Seppälä, J., 2002, "Optimal Taxation without State-Contingent Debt," *Journal of Political Economy* 110, pp. 1220–254.

Agénor, P.R., Montiel, P., *Development Macroeconomics*, Princeton University Press.

Bergin, P., Shin, H., and Tchakarov, I., 2007, "Does Exchange Rate Variability Matter for Welfare? A quantitative Investigation of Stabilization Policies," *European Economic Review*, 51(4), pp. 1041–58.

Buchanan, J., and R. Wagner, 1977, *Democracy in Deficit: The Political Legacy of Lord Keynes* (New York: Academic Press).

Caballero, R., 1990."Consumption Puzzles and Precautionary Savings." *Journal of Monetary Economics,* 25, 113–36.

Calvo, G., 1983, "Staggered Prices in a Utility Maximizing Framework," *Journal of Monetary Economics*, 12, pp. 383–98.

Carroll, C. D, 2009, "Precautionary Saving and the Marginal Propensity to Consume Out of Permanent Income," *Journal of Monetary Economics*, v. 56, iss. 6, pp. 780–90 AN: 1077566 (September).

Carroll, C. D, and M. Kimball, 2008, "Precautionary Savings and Precautionary Wealth," *The New Palgrave Dictionary of Economics.*

Clarida, R., Galí, J., Gertler M., 1999, "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 37, pp. 1661–707.

Correia, I. Neves, J. Rebelo, S., 1995, "Business Cycles in a Small Open Economy," *European Economic Review,* 39, pp. 1089–1113.

Drazen, Allan, 2000, *Political Economy in Macroeconomics*, (Princeton: Princeton University Press).

Edwards, S.1989, *Real Exchange Rates, Devaluation, and Adjustment,* MIT Press.

Elekdag, S., Tchakarov, I., 2004, "Balance Sheets, Exchange Rate Policy, and Welfare," IMF Working Paper 04/63 (Washington: International Monetary Fund).

Galí, J., and T, Monacelli, 2005, "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies*, 72, pp. 707–734.

Galí, J., López-Salido, J. D., Vallés, J., 2007, "Understanding the Effects of Government Spending on Consumption, " *Journal of the European Economic Association* 5, pp. 227–70.

Gavin, M., Perotti, R., 1997, "Fiscal Policy in Latin America," in Bernanke, B., Rotemberg, J. (Eds.), NBER Macroeconomics Annual (Cambridge: MIT Press).

Ghei, N., L. Pritchett, 1999, "The Three Pessimisms: Real Exchange Rates and Trade Flows in Developing Countries," in P. Montiel and L. Hinkle, eds, *Exchange Rate Misalignment: Concepts and Measurement for Developing Countries*, (Oxford and New York: Oxford University Press for the World Bank).

Greenwood, J., Z. Hercowitz, G. Huffman, 1988, "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, v. 78, iss. 3 (June), pp. 402–17.

Hugget, M., Ospina, S., 2001, "Aggregate Precautionary Savings: When is the Third Derivative Irrelevant," *Journal of Monetary Economics*, 48, pp. 373–96.

Juillard, M., 1996, "Dynare: A program for the Resolution and Simulation of Dynamic Models with Forward Variables through the Use of a Relaxation Algorithm," CEPREMAP, Couverture Orange 9602.

International Monetary Fund, 2009, "Fiscal Rules―Anchoring Expectations for Sustainable Public Finance," IMF Policy Paper (Washington, D.C.)

Kaminski, G., Reinhart, C., Végh, C., 2004, "When it Rains it Pours: Procyclical Capital Flows and Macroeconomic Policies," in Gertler, M., Rogoff, K. (Eds.), *NBER Macroeconomics Annual*, pp. 11–82 (Cambridge: MIT Press).

Kim, J., and S. Kim, 2003, "Spurious Welfare Reversals in International Business Cycle Models, " *Journal of International Economics*, 60, pp. 471–500.

Kimball, M., 1990, "Precautionary Savings in the Small and in the Large," *Econometrica*, Vol. 58, No. 1, pp. 53–74.

Kollman, R., 2002, "Monetary Policy Rules in the Open Economy: Effects on Welfare and Business Cycles," *Journal of Monetary Economics*, 49, pp. 989–1015.

Kopits, G., 2001, "Fiscal Rules: Useful Policy Framework or Unnecessary Ornament?," *IMF Working Paper* 01/145 (Washington: International Monetary Fund).

Kydland, F. and E. C. Prescott, 1977, "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, vol. 85(3), pp. 473–91 (June).

Kocherlakota, N. R., 2010, *The New Dynamic Public Finance* (Princeton: The Princeton University Press).

Laxton, D.,and P. Pesenti, 2003, "Monetary Rules for Small Open, Emerging Economies," *Journal of Monetary Economics*, 50, pp. 1109–46.

Lucas, R., 1987, *Models of Business Cycles*, Blackwell.

Mankiw, G., 2000, "The Savers-Spenders Theory of Fiscal Policy Shocks?," *American Economic Review*, 90, pp. 120–25.

Medina, J. P., and C. Soto, 2007, "Copper Price, Fiscal Policy and Business Cycle in Chile," Working Paper 458, Central Bank of Chile.

Mendoza, E., and M. Oviedo., 2004, "Public Debt, Fiscal Solvency and Macroeconomic Uncertainty in Latin America: The Cases of Brazil, Colombia, Costa Rica, and Mexico," NBER Working Paper 10637.

Menguy, S., 2008, "A Dynamic Rule Applied to the Threshold Imposed on the European Budgetary Deficits," *Journal of Policy Modeling*, v.30, 6; pp. 929–1132 (November-December).

Restrepo, J.E., and C. Soto, 2006, "Regularidades Empíricas de la Economía Chilena: 1986–2005," *Economía Chilena* 9, pp. 15–40.

Schmitt-Grohé, S, and M. Uribe, 2003. "Closing Small Open Economy Models," *Journal of International Economics*, 61, pp. 163–85.

Schmitt-Grohé, S. and M. Uribe, 2004, "Solving Dynamic General Equilibrium Models Using a Second-order Approximation to the Policy Function," *Journal of Economic Dynamics and Control* 28, pp. 755–775.

Schmitt-Grohé, S, Uribe, M., 2007, "Optimal Simple and Implementable Monetary and Fiscal Rules," *Journal of Monetary Economics*, 54, September 2007, pp. 1702–25.

Smets, F., Wouters R., 2002, "Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy," *Journal of Monetary Economics*, 49, pp. 947–81.

Tabellini, G, and A. Alesina, 1990, "Voting on the Budget Deficit," *American Economic Review*, American Economic Association, vol. 80(1), pp. 37–49.

Talmain, G., 1998, "An Analytical Approximate Solution to the Problem of Precautionary Savings," *Journal of Economic Dynamics and Control*, 23, pp. 113–124.

Talvi, E., and C. Végh, 2005, “Tax Base Variability and Procyclical Fiscal Policy in Developing Countries,” *Journal of Development Economics,* 78, pp. 156–190.

Tanner, E., 2004, “Fiscal Rules and Countercyclical Policy: Frank Ramsey meets Gramm–Rudman–Hollings,” *Journal of Policy Modeling*, V. 26, 6, pp. 719–31 (September).

Tanner, E., and K. Carey, 2008, “The Perils of Tax Smoothing: Sustainable Fiscal Policy with Random Shocks to Permanent Output,” *Czech Journal of Economics and Finance*, V.58, Issue, 11–12, pp. 502–524.

Végh, C., 2008, “Optimal Fiscal Policy in the Open Economy,” Chapter 11 in forthcoming book.

Velasco, A., 1994, “A Model of Endogenous Fiscal Deficits and Delayed Fiscal Reforms,” CV Starr Center Working Paper (New York University).

Weil, P., 1993, “Precautionary Savings and the Permanent Income Hypothesis,” *Review of Economic Studies,* 60, pp. 367–84.

Woodford, M., 2003, *Interest & Prices: Foundations of a Theory of Monetary Policy* (Princeton: Princeton University Press).