CYCLICAL FISCAL RULES FOR OIL-EXPORTING COUNTRIES

by

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Abstract[1]

Structural budget balance rules with countercyclical elements appear well suited to stabilize the macroeconomic volatility of oil-exporting countries and have been used successfully by other commodity exporters. Using a global DSGE model, I show that the optimal design of such rules depends on the source of oil price fluctuations and the oil exporters' structural characteristics. The output-inflation tradeoff is of particular concern for oil exporters relative to non-oil exporters due to the pass through of oil prices into headline inflation. In addition, such fiscal rules are desirable for a variety of policy frameworks, including subsidized oil and fixed exchange rate regimes.

[1] The author thanks Gregor Smith for his advice and supervision.

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I. INTRODUCTION

The success of Chile's commodity-based fiscal rule has sparked interest in fiscal policy rules for business cycle stabilization in other commodity-exporting countries. This essay examines the appropriate design of cyclical fiscal policy rules for oil-exporting countries using the Global Integrated Monetary and Fiscal model (GIMF). GIMF is a global dynamic structural general equilibrium (DSGE) model and is calibrated with two regions: a small open oil exporter (SOE) and the rest of the world (ROW). The multiple layers of production and detailed international trade linkages allow for an examination of optimal policy to oil price fluctuations arising from multiple sources of foreign disturbances in the global market for crude oil.

Employing a structural budget balance rules with countercyclical elements appears well suited to stabilize the macroeconomic volatility of oil-exporting countries. I find that the optimal fiscal policy rule for business cycle stabilization is countercyclical to oil royalties and tax revenues. I also find that the desired fiscal response depends on the source of the oil price fluctuation, the underlying structural characteristics of the commodity exporter, and the policy framework. Importantly, the situation for oil exporters is complicated by a tradeoff between inflation and output volatility due to oil being directly consumed by households. The structural rule with countercyclical elements is robust to various expenditure and taxations instruments satisfying the fiscal rule.

Several economists have argued that developing countries too often adopt procyclical macroeconomic policies that exacerbate macroeconomic volatility (Gavin and Perotti, 1997; Kaminsky and others, 2004; Talvi and Vegh, 2005; Kaminsky, 2010). Increasingly, empirical evidence suggests that the mismanagement of the commodity revenues may be a primary culprit behind the volatility in commodity-exporting countries (Adler and Sosa, 2011; Frankel, 2011). Commodity price fluctuations have implications for all macroeconomic and prudential policies, but fiscal policy is of primary importance due to state ownership of natural resources in oil-exporting countries (see Husain and others, 2008). Indeed, Husain and others (2008) find that oil price changes affect the economic cycle of oil exporters primarily through their impact on fiscal policy.[2]

The procyclicality of fiscal policy was particularly evident for the oil price shocks of the 1970s and early 1980s. Recent evidence suggests reduced procyclicality during the oil price run up in the 2000s (Céspedes and Velasco, 2011). However, Medina (2010) notes stark differences across countries. For example, Venezuela has exhibited more procyclical policy, whereas Chile, with its explicit fiscal framework, has successfully reduced fiscal volatility to commodity price fluctuations. This had brought calls for the adoption of formal fiscal frameworks to manage the commodity revenue volatility (Kumhof and Laxton, 2010; Frankel, 2011).

Currently, the policy recommendation by the International Monetary Fund (IMF) is that countries adopt acyclical fiscal policy by targeting the non-oil balance (see Barnett and Ossowski, 2003; Davis and others, 2002). Although acyclical fiscal policy may be preferred to procyclical fiscal policy, this recommendation is somewhat surprising, since it is generally understood that policy should be countercyclical over the business cycle (Barro, 1979; Varangis and others, 1995). Indeed, recent research has begun to show that countercyclical fiscal rules are particularly effective at reducing macroeconomic volatility for commodity exporters (Kumhof and Laxton, 2010; Bi and Kumhof, 2009).

Kumhof and Laxton (2009a) find that an optimal countercyclical rule can increase welfare by around 50 percent relative to balanced budget rule when applied to the case of copper for Chile. They assert that this can be achieved with only small increases in fiscal instrument volatility when the appropriate fiscal instruments are utilized. When fiscal and monetary rules are jointly optimized for commodity exporters, Bi and Kumhof (2009) show that welfare gains from optimizing the fiscal rule are larger than from optimizing the

[2] Macroeconomic stabilization in the face of commodity price volatility is only one of many policy priorities for commodity-exporting developing and emerging economies. Others include resource exhaustibility, intergenerational equity, and Dutch disease challenges associated with resource discoveries. The relative priority of addressing various policy challenges depends on country-specific conditions. This essay contributes to the investigation of the policy framework for cyclical objectives, which should be combined with policies frameworks addressing longer-term objectives of commodity exporters. For more information see Baunsgaard and others (2012).

monetary rule in commodity-exporting economies due primarily to the larger presence of non-Ricardian agents.[3]

Almost all of the current studies on the short run management of revenues via fiscal policy rules focus on the case of managing copper revenues in models calibrated for Chile (Kumhof and Laxton 2009a; Bi and Kumhof, 2009; Garcia and others, 2011). However, in order to recommend the general use of fiscal policy rules, their appropriateness should be robustly tested for a wider range of commodity specializations, sources of price fluctuations, *etc*. This is especially applicable given the heterogeneity of oil exporter's structural characteristics, from diversified advanced countries such as Canada and Australia, to OPEC oil specialists such as Saudi Arabia and Qatar.

The analysis of this essay confirms that it is generally preferable to employ a countercyclical response to non-oil tax revenue, consistent with Laxton and Kumhof (2009a), but also to follow a slight countercyclical response to changes in oil royalties. This is due to the pass-through of oil prices into the consumption basket which is highly correlated with oil royalties. The sources of oil price fluctuations creates differing output-inflation tradeoffs, and it is preferable to respond more countercyclically to broad-based foreign demand shocks due to the larger impact on the non-oil economy. In addition, the desired degree of countercyclicality is found to be decreasing in the oil intensity in total output, and increasing in the share of private and foreign ownership due to their impact on the non-oil economy. These fiscal rules are found to be desirable for a variety of policy frameworks, including subsidized oil and fixed exchange rate regimes.

The essay is structured as follows: Section II outlines the structure and calibration of the model. Section III describes the results in three parts. The first part looks at the preferred fiscal policy rules for a benchmark oil exporter in the face of external oil price shocks. This analysis is extended to various structural characteristics of oil exporters. I end this section with a look at the design of these rules under various policies of oil exporters. Section V concludes.

[3] See IMF *World Economic Outlook,* April 2011 for the implications of commodity price shocks for monetary policy.

II. Model and Calibration

This essay uses an annual version of the Global Integrated Monetary and Fiscal model (GIMF) calibrated with two regions: a small open oil exporter (SOE), and the rest of the world (ROW). The entire global economy is modeled which allows for structural shocks originating in the ROW to impact the SOE through a variety of channels including via the effect on the global market for crude oil, as well as from trade and financial linkages. Since the underlying structure of the model and its properties is described in detail elsewhere, this section provides an overview of the model structure and calibration with focus on the relevant aspects of the oil sector and fiscal policy.[4]

GIMF is a global dynamic structural general equilibrium model in wide use at the IMF. The model is micro-founded with optimizing behavior of both households and firms. There are intertemporal stock-flow accounting in the level of government debt, net foreign assets, human wealth, and capital stocks. Keynesian properties are derived from frictions in the form of real and nominal adjustment costs, and the presence of both liquidity-constrained agents and finite planning horizons of households. These Keynesian features provide non-neutrality in both spending- and revenue-based fiscal measures. They also capture the interaction of fiscal and monetary policies, which makes the model particularly suitable to analyze fiscal policy.

Households pay distortionary taxes on labor income and consumption spending, and a non-distortionary lump-sum tax. Liquidity-constrained households (LIQ) consume all of their income in every period. Overlapping-generation households (OLG) are unconstrained and smooth their consumption.[5] The presence of OLG households means that public debt is counted as net wealth due to the benefits from lower taxes enjoyed beyond their planning

[4] The theoretical micro-foundations of the model including the oil sector are described in detail in Kumhof and others (2010). A detailed examination of the GIMF properties can be found in Anderson and others (forthcoming). The technical appendix describes the structure of the oil sector.

[5] See Blanchard (1985) for the basic theoretical building blocks.

horizon.[6] Thus, a decrease in government debt today represents a decrease in OLG household wealth.

Production in GIMF is multi-layered. Capital, labor, and oil produce intermediate tradable and non-tradable goods. Capital is supplied by entrepreneurs with a procyclical financial accelerator *à la* Bernanke and others (1999). Firms have finite planning horizons in accordance with the preferences of their owners, the OLG households. Firms pay capital income taxes to governments and wages and dividends to households. Physical capital is sector-specific, but labor is mobile across sectors. Neither labor nor physical capital is mobile across regions, although trade in investment goods eases the restrictiveness of this assumption.

Domestic and imported intermediate goods are combined to produce consumption and investment goods. A share of oil is consumed directly in the household's consumption basket. Thus, an increase in the price of oil drives up the cost of production as well as the cost of the final consumption basket. The demand for oil, in production as well as in the consumption basket, is highly inelastic. The supply of oil is produced from an exogenous endowment with a small price elasticity of supply with a fifteen-year lag. Oil rents are the difference between the extraction cost and the market price of oil and may accrue to households, the government, or foreign households.

The multi-country structure of GIMF captures the effects of international trade spillovers. Bilateral trade flows of intermediate goods and final consumption and investment goods are modeled explicitly along with the relative prices between each region. Asset markets are incomplete, and the only assets traded internationally are nominal, non-contingent one-period bonds denominated in the rest of the world currency. Government debt is domestically owned and can crowd out the domestic holdings of net foreign assets. Firms are owned domestically and pay lump-sum dividends on a share of profits.

Real returns are equilibrated globally in the global savings and investment market by the equilibrium real interest rate. The SOE can borrow and save at the global equilibrium real

[6] For a more detailed description of wealth implications of fiscal policy in GIMF see Kumhof and Laxton (2009b).

interest rate. This assumes that the SOE is operating from a large enough net asset position, such as a large sovereign wealth fund, and the sovereign risk premium is not responsive to the level of net assets.[7]

1. The Fiscal Rule

The fiscal authority employs a generalized structural surplus tax gap rule with commodity royalties and general taxes added separately, a class of fiscal rules known as budget balance rules. Kumhof and Laxton (2009a) motivate the use of such rules and find that they are welfare improving when compared to instrument rules, debt rules, or output gap rules due to their superior ability to align the adjustment of the fiscal related household income with the macroeconomic cycle. In particular, the tax bases underlying tax revenue gaps provide the fiscal authority with a way to closely observe the adjustment of private incomes of households. The fiscal rule is summarized as follows:

$$gs_t^{rat} = gs^{rat^*} + d^{tax}\,\frac{(\tau_t - \tau_t^{ss})}{gdp_t} + d^{com}\,\frac{(\tau c_t - \tau c_t^{ss})}{gdp_t} + d^{debt}\left(\frac{b_t}{gdp_t} - \bar{b}^{rat}\right) \qquad (1)$$

where gs_t^{rat} is the overall fiscal surplus-to-GDP ratio, gs^{rat^*} is the overall fiscal surplus-to-GDP ratio target, τ_t and τc_t are the level of non-oil and oil revenues, τ_t^{ss} and τc_t^{ss} are the steady-state level of non-oil and oil revenue, respectively. b_t is the nominal level of net savings of the sovereign authorities and $\bar{b}^{rat}$ is the steady-state net savings to GDP ratio. The coefficient d^{debt} is set to zero for most of the analysis and is explored in more detail in section III.3.4.

The rule has two main functions. The first is to stabilize the government debt-to-GDP ratio to its long-run target by centering on the overall government surplus-to-GDP ratio, gs^{rat^*}. This target pins down the long-run net asset position of the general government, eliminates the possibility of default, and ensures dynamic stability. By targeting the overall deficit, the long-run target is inclusive of the potential oil royalties and tax revenues, similar to the rule employed in Chile.[8]

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[7] See Pescatori and Snudden (forthcoming) for an examination of fiscal rules in the presence of the sovereign risk premium.

[8] The calibration of the structural balance, gs^{rat^*}, should address the longer-term objectives of commodity exporters including resource exhaustibility, intergenerational equity, and Dutch disease challenges associated

(continued…)

The second main function of the fiscal rule is to respond to the business cycle. The rule allows the fiscal authority to adjust the overall surplus-to-GDP ratio, gs_t^{rat}, to changes in the non-oil tax revenue gap and oil royalties gap. The gaps are the difference between the actual revenues and the potential level of revenues which the fiscal authority knows with certainty. As summarized in Table 5, potential non-oil revenues are the sum of steady-state consumption, labor income, and capital income taxes multiplied by their respective tax bases. As summarized in Table 6, potential oil revenue is the steady-state level of oil royalties.

This generalized form of the rule allows calibrations of d^{tax} and d^{com} that determine the responsiveness of the surplus-to-GDP ratio to changes in the non-oil tax revenue and oil royalties gaps. In practice, this represents a continuum of rules, of which there are three main categories.

- *A balanced budget rule (BBR):* A calibration of d^{tax} and d^{com} equal to zero denotes a balanced budget rule. Under such a rule, the government budget is balanced in every period, so all exceptional commodity royalties and tax revenues are redistributed immediately to households through lower tax rates or higher spending. This rule is procyclical by design but maintains the fiscal balance and net debt at their long-term targets.
- *A structural surplus rule (SSR):* A calibration of d^{tax} and d^{com} equal to one denotes a structural surplus rule. Under this rule, exceptionally high (low) commodity royalties and tax revenues are (dis)saved (thereby avoiding any change in tax rates or spending). This rule results in a one-for-one change in the overall fiscal balance in response to deviations of royalties and tax revenues gaps. This rule is acyclical, since it does not add or subtract from aggregate demand.
- *A countercyclical rule (CCR):* A calibration of d^{tax} and d^{com} greater than one denotes a countercyclical rule. Under this rule, the fiscal authority *more* than (dis)saves exceptionally high (low) commodity royalties and tax revenues. This rule implies larger changes in budget surpluses and government debt in response to oil

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with resource discoveries. See Baunsgaard and others (2012), Medas and Zakharova (2009), Deaton (1999), Collier and Goderis (2007), and Eyzaguirre and others (2011) for a discussion of some of these issues.

price changes, and acts countercyclically, increasing (reducing) the structural balance during periods of strong (weak) oil prices and/or economic activity.

The rule is a generalized form of the class of budget balance targeting rule and not an instrument rule. Thus, any fiscal instrument can adjust to satisfy the fiscal rule. Specifically, in each period, the fiscal authority determines the level of tax rates or spending to achieve the deficit targeted. In this essay, the baseline fiscal instrument that adjusts to satisfy the fiscal rule is the labor income tax. The labor tax rate is chosen for simplicity and does not constitute a policy recommendation. Considerations regarding the use of alternative fiscal instruments are examined in section III.3.1.[9]

Over the past two decades, there has been an increase in the adoption of rules-based fiscal policy (Schaechter and others, 2012). In practice, fiscal policy behavior in a number of commodity exporters has been broadly influenced by rules of this kind. Chile follows a structural surplus rule, which allows for the presence of automatic stabilizers. Norway's rule targets a structural non-oil balance and also allows for the possibility of countercyclical responses over the business cycle.

2. Monetary Policy Rule

The central bank credibly operates under an inflation targeting regime with a Taylor-type interest rate reaction function. The policy rate, i_t, responds to the three-quarter-ahead gap between projected core inflation, $\tilde{\pi}_t$, and target inflation, $\bar{\pi}_t$, to achieve a stable target rate of inflation.[10] The target rate is assumed to be 2 percent in both the SOE and the rest of the world regions. The monetary policy function is defined as follows:

$$1 + i_t = E_t(1 + i_{t-1})^{\delta_t}\left((1 + r_t^{eq})(1 + \tilde{\pi}_t)\right)^{1-\delta_t}\left(\frac{1+\tilde{\pi}_t}{1+\bar{\pi}_t}\right)^{(1-\delta_t)\delta_\pi}, \qquad (2)$$

[9] In GIMF, the labor income tax rate is distortionary, and broadly corresponds to payroll taxes, regardless of whether they are levied on employees or employers, and personal income taxes.

[10] The targeting of core inflation is understood to be best practice when monetary policy faces oil price shocks. See Hogan and others (2001), and Natal (2009), Coletti and others (2012). Bi and Kumhof (2010) show that when monetary and fiscal policies are jointly optimized for commodity exporters the "optimized monetary rule features super-inertia and a very low coefficient on inflation." This is considered in detail in section III.3.3.

where $(1 + r_t^{eq})(1 + \tilde{\pi}_t)$ is the gross nominal interest rate. The equilibrium real world interest rate r_t^{eq} is a geometric moving average of the risk-adjusted real world equilibrium interest rate. The coefficient on the gap of projected core inflation and target inflation, $\delta_{\overline{\pi}}$, is calibrated to 1.5, with a lag coefficient, δ_t, of 0.3. This calibration closely replicates the estimated inflation dynamics for a wide variety of shocks at annual frequency for Latin American countries in the IMF's Global Projection Model, see Canales-Kriljenko and others (2009). Although the level of the inflation target affects the steady state model, the dynamic properties are little affected and the results are robust to alternative calibrations.

3. Calibration

The comprehensive structure of GIMF is reflected in the ability to replicate the key aspects of the SOE. In the initial simulations I calibrate the model to the average of 35 small, open, oil-exporting countries for which data is available and which oil exports represent over 10 percent of total exports. Later in the essay, I conduct sensitivity analysis around the baseline calibration. A complete catalogue of the calibration is presented in Tables 1 to 9.

The steady-state national account decompositions are roughly calibrated to match recent years from the IMF *International Financial Statistics* database. The gross government debt ratio is calibrated to 30 percentage points of GDP. Private consumption and investment expenditures are 60 and 20 percentage points of GDP, respectively. Trade openness, exports, and imports as a percent of GDP are calibrated to 40 percent of GDP.

The SOE is normalized to one percentage point of global real GDP. Net oil exports-to-GDP are calibrated to 18 percent of GDP. The share of oil consumed domestically is 6.5 percent of GDP. This represents the 4 percent of the consumption basket of households with the remainder used as an input into intermediate goods production. The SOE constitutes a small share of total global oil demand, which implies that domestic demand activity has almost no effect on the real global price of oil.

The resource cost of oil production is 40 percent of the value of oil produced. In the baseline simulations, oil production is domestically owned with no share of foreign ownership. I calibrate the public ownership of oil production according to the mid-range of estimates in IMF (2012), with 75 percent of rents accruing to the government and the remaining 25 percent to households. The long-term price elasticity of oil demand in both production and consumption is 0.08, while the short-term elasticity is 0.02.[11] The endowment of oil has a low price elasticity of supply, 0.03, and responds fully only with a fifteen-year lag.

The calibration of the structural parameters relies heavily on the literature as summarized in Kumhof and others (2010) and Andersen and others (2012) as well as on the previous work on modeling SOEs in GIMF (Kumhof and Laxton, 2010). This includes the trade elasticities, as well as nominal and real rigidities, which are set to match the dynamics to models of SOEs at use in the IMF, summarized in Tables 2 and 9. The share of liquidity-constrained agents in the SOE is calibrated to 50 percent of households. This implies a moderate degree of responsiveness of aggregate consumption with respect to the total income of households.

4. Policy Objective

A loss function is evaluated over a set of parameterizations of the fiscal rule. Specifically, the fiscal authority seeks to minimize macroeconomic volatility which is defined as a weighted average of the standard deviation of the output gap and headline inflation from its target. The minimized loss function is searched over a grid of parameterizations of d^{tax} and d^{com}. Calibrations of d^{tax} are searched up to 5, consistent with Bi and Kumhof (2010).[12] The following loss function is evaluated for each parameterization of the fiscal rule:

$$Loss\ Function = sd(\pi^{gap}) + \lambda_Y * sd(gdp^{gap}) \qquad (3)$$

where π^{gap} is the deviation of actual headline inflation from the two percent inflation target, and gdp^{gap}, is the deviation of real GDP from the steady-state level. The baseline focus on equal stabilization of the headline inflation and the output gap, λ_Y calibrated to one, is

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[11] This is consistent with the calibration of GIMF used in the IMF *World Economic Outlook*, Chapter 4, April 2011.

[12] The tax revenue gap is endogenous to the labor tax rate. Since the labor tax rate is distortionary, the non-oil revenues gap approaches zero as the parameter, d^{tax}, approaches infinity. However, in practice this would imply an unrealistic degree of precision and credibility of the fiscal authority so the search of d^{tax} is limited up to 5.

consistent with the broad objective of business cycle stabilization for policy makers. Examinations of alternative specifications of the loss function are considered, including variations in the weight on the output gap, as well as for an examination on household welfare in section III.3.5.

III. RESULTS

The preferred fiscal policy rule is searched for different sources of temporary oil price fluctuations on a generic SOE. Specifically, I explore the desired fiscal rule when the SOE is faced with a foreign demand shock in the form of a temporary increase in foreign liquidity and a foreign decline in the supply of oil. The tradeoffs between output and inflation volatility are also explored. The analysis is complimented with an evaluation of optimal fiscal rules under alternative structural characteristics that differ across oil exporters. Under almost all cases, a countercyclical rule is found to be desirable; however, the gains from adopting the optimal fiscal rule and the desired degree of countercyclicality differ depending on the source of the shock and the SOE's structural characteristics.

1. Temporary Demand and Supply Shocks to the Price of Oil

This section examines the desired fiscal rule for both demand and supply shocks for a 'baseline' calibration of the SOE. I assume that (i) oil production is owned almost wholly by the government, which receives 75 percent of the associated rent (through "oil royalties"); (ii) oil constitutes a large share of overall production, 19 percent of GDP, and 45 percent of exports; (iii) there are no subsidies on domestic oil consumption; and (iv) there is no foreign ownership in domestic oil production. In practice, this is more representative of countries such as Algeria, Azerbaijan, Kazakhstan, Kuwait, Syria, and Venezuela.

Two sources of external oil price fluctuations are explored. In the first scenario, the oil price increases in response to an unexpected increase to global activity. In the second scenario, the increase is due to a shock to global oil production. In both scenarios, the shocks are calibrated so that they result in a 20 percent increase in the price of oil. In addition, the price of oil increases for 3 years, consistent with empirical findings of the average persistence of oil price fluctuations in IMF (2012). Also consistent with those findings, the two sources of fluctuations have different effects on the SOE.

External supply-driven oil price increase. Under this scenario, a temporary decline in the external supply of oil increases the real price of oil by 20 percent in the first year, gradually returning over the next two years, as in figure 1. As the rest of the world's GDP declines, so does the real external demand for all goods exported by the SOE. However, the fall in external demand is offset by the increase in the real value of the SOE's oil exports, thereby improving the trade balance, as in figure 2. Despite the increase in headline inflation from higher oil prices, depressed global demand reduces the real price of final goods and causes core inflation to fall, partly mitigated by a slightly more stimulatory monetary policy.

External demand-driven oil price increase. Under this scenario, a temporary increase in liquidity in the rest of the world broadly boosts global demand, as shown in figure 3. The increase in foreign liquidity is generated by an exogenous temporary reduction in the risk-free, economy-wide, nominal interest rate. As the cost of borrowing declines, credit expands as agents borrow to finance a boom in consumption and investment. There is a fall in net savings, and the real exchange rate depreciates in the ROW. A downturn follows the boom as agents deleverage and increase their saving back to initial levels. The higher demand drives up the real price of oil by about 20 percent in the first three years, after which oil prices decline and experience a boom-bust cycle. Contrary to a supply-driven oil price shock, the global demand boom drives up the demand and prices of *all* of the SOE's exports. Overall, the SOE experiences higher inflation and output volatility than under a case of a relative price increase in oil from a reduction in oil supply, as shown in figure 4.

1.1.Interpreting the Fiscal Stance

The aggressiveness of the fiscal policy stance can be interpreted from the coefficients on the tax gaps and the change in the overall fiscal balance. Since the fiscal rule coefficients respond to the tax gaps, the cyclical balance depends on both the size of the gap and the coefficient. Thus, in Table 10 and 12, both the coefficients and the difference between the overall fiscal balance of the optimal fiscal policy rule and the structural surplus rule (SSR) as a percent of GDP are reported. The aggressiveness of the fiscal balances is generally described in terms of the difference between the overall deficit-to-GDP ratio of the countercyclical rule (CCR) relative to the SSR.

1.2. Optimal Fiscal Policy to Temporary Increases in the Price of Oil

For both the external supply and external demand driven oil price shock, the countercyclical rule constitutes the optimal fiscal response. In the simulations, the need for countercyclical responses to the oil royalties is small. This largely reflects the baseline assumption that most of the oil royalties accrue to the government, which in turn implies that insulating the economy from changes in government oil revenues is broadly sufficient for stabilization.

Figures 5 and 6 plot the evaluated loss function for alternative calibrations of the fiscal rule with a weight of 1 on output gap, λ_Y. The optimal response of the fiscal authority for both types of shocks is to respond aggressively to the change in the tax revenues (d^{tax}, equal to 5). The tax revenue gap is endogenous to the labor tax rate so the more aggressively the fiscal authority responds, the less of a tax revenue gap is realized. Since the labor tax rate is distortionary, the non-oil revenues gap approaches zero as the parameter, d^{tax}, approaches infinity, without the risk of overshooting. For almost all cases considered, d^{tax} is found to be the upper limit of the search: 5.

In the case of the supply shock, households' income from non-oil goods production falls, so there is little to increase demand once oil revenues are taken away. Thus, both output and inflation return very close to baseline under a SSR, and the optimal response is to save slightly more than the additional oil royalties (d^{com}, equal to 1.2). For the foreign oil supply shock, the price of consumption goods begins to fall once oil royalties are removed due to fall in external demand. This causes core inflation to fall, easing monetary policy. Thus, fiscal policy is not as effective due to an unaccommodative monetary stance in the case of a supply shock and must be slightly more countercyclical. Overall, the difference in the fiscal balance of the optimal rule less the SSR is 0.39 percent of GDP.

In contrast, a demand shock increases the demand for all goods. In this case, even with no change in labor taxes, households still experience an increase in their income. Thus, a CCR can have larger gains over a SSR for a demand shock driving the price of oil, and monetary policy remains complementary with the fiscal rule. The optimal policy for a demand-driven increase in the price of oil is to more than save the additional oil royalties (d-

Oil Revenues, d^{com}, equal to 1.1). Overall the difference in the fiscal balance of the optimal rule less the SSR is 0.45 percent of GDP.

1.3. Inflation and Output Volatility Tradeoff

For oil exporters, since oil constitutes a higher share in the consumption basket relative to non-oil commodities, there are larger gains from responding countercyclically to oil royalties due to the higher volatility of headline inflation. In contrast, since copper production in Chile is not directly consumed, Laxton and Kumhof (2009a), find that the optimal fiscal response to the oil royalties gap is a SSR. This is explored in more detail in section 2.5.

I illustrate the inflation-output tradeoff by constructing the policy efficiency frontiers which are traced by varying the calibration of the weight on output gap, λ_Y, in the loss function, as shown in figures 5.A and 6.A. In both cases, lower output volatility can be achieved with a tradeoff of slightly higher inflation and fiscal volatility if a higher weight is placed on output in the loss function. When the oil price is supply-driven, output falls quickly once royalties are removed relative to the case of a foreign demand-driven shock.

This parallels the finding in the optimal monetary policy literature. In particular, Coletti and others (2012) find that the optimal response of both inflation and price level targeting to foreign oil price shocks is muted due to the inability of the small open economy to directly affect the change in the oil price, which is the underlying cause of the increase in inflation. In an effort to reduce inflation volatility, responding too aggressively to inflation can cause large fluctuations in output. However, unlike monetary policy, the use of fiscal policy can have a direct impact on aggregate demand making it more able to impact headline inflation. In addition, fiscal policy has a larger selection of policy instruments to choose from and the required degree of fiscal response depends on the multipliers of the fiscal instruments on output and inflation, which is examined in section 2.4.

2. Implications under Alternative Structural Characteristics

In this section I consider major structural characteristics that differ across oil exporters and evaluate their impact on the design of the preferred fiscal rule. In particular, five characteristics are considered: (i) when oil is largely domestically privately owned (ii) when oil constitutes a larger or smaller share of overall production; (iii) when there is a high degree of foreign ownership of production; (iv) when the SOE has different non-oil tax bases; and (v) when the type of commodity exported is different from oil. Under all cases, a countercyclical rule is still found to be desirable; however, the gains from adopting the optimal fiscal rule and the degree of countercyclicality differ depending on the economies structural characteristics, as shown in table 10.

2.1.Private or Public Ownership

Optimal fiscal policy is more countercyclical to oil price shocks in an economy where oil is produced and rents accrue to private companies. This includes countries such as Australia or Canada. To explore the case of private ownership of oil, I contrast the baseline case of high public ownership, to the case were oil is owned and produced by private agents in the SOE.[13] In particular, I assume that the fiscal authority collects ten percent of the oil rents, relative to the 75 percent in the baseline. The saving behavior of agents can smooth output variation, but there are still gains from the variation in headline inflation. I find that the desired degree of countercyclicality with respect to oil royalties is increasing in the share of private ownership of oil, but the fiscal authority primarily reduces inflation volatility at the expense of output volatility.

There are two important factors which influence the results when there is a high share of private ownership. First, ceteris paribus: since the majority of oil revenues go to OLG agents and they already smooth a large share of the change in the oil incomes, output is generally less volatile than under a BBR when revenues are distributed through changes in labor tax (which affects LIQ agents) or through public absorption (which directly impacts aggregate demand).[14] Second, the oil royalties collected by the fiscal authority are smaller, so a given coefficient in the fiscal rule implies less change in the fiscal balance. Overall, these factors result in a larger coefficient for oil royalties in the fiscal rule, d^{com}, even though there

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[13] Previous work by Kumhof and Laxton (2009) focuses on the case where royalties are collected primarily by the public authority.

[14] I assume that changes in oil rents go to OLG agents. In practice, the firm pays out oil rents gradually to shareholders in addition to changes in firm savings. Thus, the assumption that higher shares of oil rents are saved should be consistent with the model assumptions.

is less of a change in domestic public debt, since the majority of savings is done by the owners of the firms.

For the commodity supply shock, the volatility of inflation is still large. It is optimal for the fiscal authority to respond countercyclically to the oil royalties gap with d^{com} equal to 2, and to the tax revenues gap with d^{tax} equal to 5, as shown in table 10. However, output falls primarily due to LIQ consumption as they experience erosion in their real income. Overall, consumption falls, since the slight increase in OLG consumption is not sufficient to offset the fall in aggregate demand. Hence, attempts at reducing inflation by a countercyclical response induce an inflation-output tradeoff.

In the case of a foreign demand shock, it is optimal for the fiscal authority to respond countercyclically to changes in oil royalties with d^{com} equal to 1.8, and tax revenues with d^{tax} equal to 5. The foreign demand shock increases the demand for all exports and a share of the income goes to liquidity constrained agents. A boom remains in the domestic economy under a SSR and there are gains from adopting a CCR. The optimal fiscal rule still results in a small fall in output after the first year as the authority tries to reduce the pass-through of inflation, and LIQ agents' consumption falls.

In an economy with a high share of private ownership, it is costly in terms of output to respond countercyclically. Increased savings and consumption by OLG households begin to be offset from a fall in LIQ households' consumption from deterioration in their purchasing power. Hence, increases in tax revenues can quickly begin to reduce output. Nevertheless, fiscal policy can help primarily reduce inflation volatility for the foreign supply shock and both output and inflation volatility for foreign demand shock.

2.2.Intensity of Oil in Output/Exports

The desired degree of countercyclicality is decreasing as the share of oil in the economy increases. In an economy that is highly dependent on oil production, the non-oil economy contributes a smaller share to overall demand fluctuations. Merely removing fluctuations in income driven by changes in oil rents is almost sufficient to dampen aggregate demand volatility. This is particularly true of many OPEC countries and others including Iran, Iraq, Libya, Nigeria, Oman, Saudi Arabia, and Yemen. In addition, as an economy increases its dependence on oil, a SSR and CCR lead to larger deficit and debt fluctuations.

Conversely, the desired degree of countercyclicality is increasing in more diversified economies.

I optimize the evaluated loss functions for a foreign supply and demand shock when the SOE has net oil exports of 10 percentage points of GDP. This constitutes a quarter of total exports which is almost half of that in the baseline calibration. This calibration more closely resembles countries such as Cameroon, Ecuador, Egypt, Indonesia, Papua New Guinea, Russia, Tunisia, and Vietnam. For both the demand and supply shock, it is optimal to respond countercyclically to the tax revenues gap with d^{tax} equal to 5. The optimal coefficient on the oil royalties gap, d^{com}, is equal to 1.3 for the foreign supply shock and 1.2 for the foreign demand shock.

The optimal coefficients on the oil royalties gap, d^{com}, are higher than the baseline calibration primarily for two reasons. First, the volatility of output in the case of a BBR is smaller in more diversified economies, since the royalty fluctuations and incomes are smaller. Second, a larger share of the non-oil economy is exposed to external demand pressures. This is especially true for the foreign demand shocks as the increase in demand for final goods induces income and demand fluctuations. For the case of a supply shock, the fall in external demand results in the smaller desired degree of countercyclicality, since output is falling even as inflation is rising, leading to an inflation-output tradeoff.

Kumhof and Laxton (2009a) find that welfare gains are significantly lower for more open economies due to the potentially higher import leakages of fiscal policy in the face of changes in the relative price of oil. However, the above analysis underscores the importance of commodity intensity in those exports. A more open economy with diversified exports in the face of foreign demand shocks would have a larger gain from a CCR due to the impact on the non-oil economy. In addition, a SOE with a domestic production base may have lower import intensities for fiscal instruments such as public absorption.

2.3.Foreign Ownership of Oil

In an economy with a share of foreign ownership of oil (ceteris paribus) a smaller share of rents is collected domestically by the fiscal authority. If private agents still receive the same share of oil rents, there is a similar degree of domestic demand fluctuation. In this case, the fiscal authority has a similar desired degree of countercyclicality of the fiscal balance. In order to achieve that change, the coefficients in the fiscal rule are larger. When the SOE has a fifty percent foreign claim on oil rents, the fiscal authority's claim on oil rents is a third of the size relative to the baseline. This calibration is consistent with countries that employ joint ownership with foreign companies for production or have royalties on the oil production of foreign companies such as Botswana and Papua New Guinea. In this case, for both the demand and supply shock, it is optimal to respond countercyclically to the tax revenues gap with d^{tax} equal to 5. The optimal coefficient on the oil royalties gap, d^{com}, is equal to 1.6 for the foreign supply shock and 1.3 for the foreign demand shock.

2.4.Composition of the Non-Oil Tax Revenues

The source of non-oil tax revenues and its share in total revenues affects the operation of the fiscal rule by changing the response of the non-oil tax revenue gap to business cycles. The non-oil tax revenue gap serves as a good proxy to observe adjustments in income and output fluctuations, because tax revenues adjust with their underlying tax bases: consumption, labor, and capital. However, non-oil revenue fluctuations are reduced in countries that have sizable informal labor markets or small non-oil tax revenues. I find that different structures of the tax base do not pose a limitation to the use of a tax revenue gap-based rule, because the tax bases respond similarly. In addition, the size of the coefficients on the tax revenue gaps can increase to compensate for the reduced volatility of the tax revenue gaps.

In the case of the foreign oil supply shock, there is very little difference for optimal policy, since the non-oil economy does not have large fluctuations, with an optimal coefficient on the tax revenues and oil royalties gap, d^{tax} and d^{com}, equal to 5 and 1.2 as shown in table 10. However, since the non-oil economy is more volatile from a foreign demand shock, reduced non-oil tax revenue gap volatility is compensated by a larger response to the oil royalties gap, and so d^{com} equals 1.2. Further, since labor, capital, and consumption tax base movements have similar profiles to foreign oil price shocks, the composition of the non-oil tax revenues has very little effect on the optimal policy rule.

2.5.Type of Commodity Specialization

These results are broadly similar to those of Kumhof and Laxton (2009a) for the case of copper in Chile, but I find that it is optimal to respond countercyclically to the oil-revenues gap. The main difference is that oil price shocks have larger effects on headline inflation compared with copper and other industrial raw materials, since oil is consumed directly in the consumption basket. I replicate the baseline simulations under the assumption that oil is not consumed in the consumption basket. In such a case, I find that the optimal rule is much closer to a SSR for the oil royalties' gap and consistent with Kumhof and Laxton (2009a), as shown in table 10. This suggests that the optimal size of the countercyclical fiscal response increases with the share of the commodity in the consumption basket.

In addition, Kumhof and Laxton (2009a) consider a foreign commodity-specific demand shock, while a broad-based demand shock is considered in this essay. When the commodity is not consumed directly in the consumption basket, the optimal fiscal policy for a broad-based demand shock is to respond aggressively to the oil royalties' gap, with d^{com} equal to 1.5, as shown in table 10. In such a case, the fiscal authority has a less extreme output-inflation tradeoff and can respond to the remaining volatility in the economy without sacrificing output volatility. This is because demand pressures remain once oil royalties are removed, and the volatilities of inflation and output are more similar in magnitude,

Quantifying the optimal cyclical fiscal policy for other types of commodities will depend on the characteristics of those markets in conjunction with the structure of the economy. For example, the impact on headline inflation might be more pronounced for agricultural goods, since they constitute a large share in the consumption basket in developing economies. Also, commodity characteristics, such as domestic demand and supply elasticities, the heterogeneity of commodity prices across regions, and the amount of production rents, will influence the design of optimal policy. Countries that are more diversified across commodities are less likely to experience domestic fluctuations from global supply shocks compared with broad-based global demand shocks. Moreover, structural characteristics such as public ownership and high commodity intensity in total production are more applicable to metal and oil production than to agricultural commodities. I leave a full examination of optimal fiscal rules for agriculturally dependent economies to further research.

3. Implications under Alternative Policy Assumptions

This section, considers alternative policy assumptions around the baseline for the design of the preferred fiscal rule. In particular, five cases are considered: (i) when the instrument other than labor taxes are used, (ii) when monetary policy employs a fixed exchange regime, (iii) when fiscal and monetary policy are jointly optimized, (iv) when the authority is concerned with debt volatility, (v) when the authority is concerned with welfare volatility. In all cases, I find that a structural rule with countercyclical elements reduces volatility relative to an SSR.

3.1.The Choice of the Countercyclical Instrument

A desirable countercyclical instrument to satisfy the fiscal rule would achieve the desired impact on output and inflation with the smallest possible volatility in fiscal instruments. Implementation issues aside, instruments that directly affect LIQ households' income tend to be the most effective on output due to LIQ households' inability to smooth consumption from income fluctuations (Kumhof and Laxton, 2009a). In particular, targeted transfers to LIQ agents or government absorption (if it enters private utility) are preferred to labor taxes due to the impact on LIQ utility.[15]

The simulations assumed thus far consider labor taxes to satisfy the fiscal rule. An increase in the labor tax rate increases the deadweight loss in the labor market and lowers the marginal productivity of labor. This causes upward pressure on inflation counteracting the downward pressure on demand and resulting in overall inflation and output movements of approximately similar magnitude, a multiplier of 0.25, as shown in table 11. The use of expenditure- based instruments as shown in Laxton and Kumhof (2009a) would make the output impact stronger and increase the impact on output relative to inflation.

To review the implication of using alternative instruments, the baseline calibration is reanalyzed with general transfers to OLG and LIQ agents satisfying the fiscal rule. Table 12 contains the results. Since general transfers have a slightly smaller multiplier than labor

[15] The choice of a countercyclical instrument should also take into account inequality and distortionary issues which are beyond the scope of this essay. It should also be acknowledged that many developing economies do not rely as heavily on labor taxes and those that do pay at an annual frequency which may make them infeasible to adjust over a business cycle.

taxes, a larger reduction in the deficit is required to induce a similar output and inflation response. This results in larger debt volatility.[16]

Many SOEs subsidize gasoline consumption and oil in domestic production reducing the pass-through of changes in the price of oil into headline inflation. Spending on gasoline subsidies generates a negative correlation of headline inflation and output since it reduces the real price of oil in the consumption basket. In addition, the output response from oil subsidies is low due to the real rigidities in consumption. Thus, spending some of the changes in oil revenues on gasoline subsidies can directly reduce headline inflation with only a slight increase in output.

A procyclical fiscal rule is preferred for a foreign demand and supply shock when the SOE uses gasoline taxes to satisfy the fiscal rule, as table 12 shows. It is optimal to respond with coefficients for the non-oil tax revenues and oil royalties gap, d^{tax} and d^{com}, equal to 5 and 0.75 for the foreign supply shock and 0 and 0.9 for the foreign demand shock. Overall, it is found that spending some of the changes in oil revenues on gasoline subsidies generates the lowest macroeconomic volatility, as measures by the loss function, of the instruments considered.[17]

In practice, using a combination of spending on gasoline subsidies and responding to the remaining volatility with countercyclical spending instruments directly tackles the inflation-output tradeoff and results in the smallest degree of macroeconomic volatility. Gasoline subsidies reduce the inflation-output tradeoff observed in standard fiscal and monetary policy frameworks. In addition, combining procyclical gasoline subsidies with countercyclical spending reduces the required fiscal volatility and leads to smaller changes in debt.

The choice of the fiscal instrument also has technical constraints. The automatic stabilizers in advanced countries primarily constitute the savings of the cyclical tax revenues,

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[16] The short-term impact on the macroeconomy from fiscal instruments in GIMF is consistent with other structural models as documented in Coenen and others (2012).

[17] This analysis assumes no gasoline subsidization at steady state oil prices. A full analysis of the desirability of gasoline and oil subsidies should take into account the long-term viability of these subsidies, which I leave to further research.

see Girouard and André (2005). However, the optimal response of the fiscal balance in the baseline SOE requires adjustment beyond that of the changes in tax revenues of approximately 0.5 percent of GDP for a 20 percent increase in the price of oil.

The appropriate type of fiscal policy to implement this cyclicality should depend on the underlying structure of the society. For example, it may be advisable for SOE to establish unemployment benefit regimes for business cycle stabilization since such regimes target households who have a high marginal propensity to consume.[18] However, the optimal degree of countercyclicality requires large fluctuation in targeted transfers that may be technically infeasible. Thus, it may be required to implement additional automatic stabilizers, to make up the difference with changes in taxes or spending. In addition, the presence of these stabilization mechanisms may require a positive amount of spending in steady state, the cost of which would need to be compared to the benefit of business-cycle stabilization and would depend on the country of interest.

3.2. Fixed Exchange Rate Regimes

This section compares the optimization of the cyclical fiscal rule in conjunction with fixed exchange rate monetary policy regimes. For a fixed exchange rate regime, I assume that the SOE targets the nominal bilateral exchange rate with the rest of the world. Under a fixed exchange rate region, the SOE has to import the monetary policy of the rest of the world to equalize the returns on assets across the two countries as per the uncovered interest parity condition.

A fixed exchange rate regime is one circumstance that Taylor (2000) proposes when discretionary fiscal policy can enhance macroeconomic stability. In the case of an oil exporter, an increase in the oil price tends to appreciate the currency of the SOE (even more so when the increase is demand-driven). The central bank expands the monetary base to offset the appreciation inducing more macroeconomic volatility than under an inflation-targeting regime. I find that an SSR has the largest reduction in volatility relative to the BBR compared to all other types of sensitivity analysis examined. The increased volatility is

[18] It should be noted that business cycle stabilization is only one of the motives for implementing unemployment benefit regimes and is probably not the most important.

consistent with the empirical findings (see also Broda, 2004; Adler, and Sosa, 2011; Kaminsky, 2010; and Rafiq, 2011).

The relative gains of the CCR over a SSR are smaller under a fixed exchange rate regime primarily due to the increased cost of fiscal volatility. Under a fixed exchange rate, the fiscal authority must be more aggressive due to the uncomplimentary monetary policy resulting in additional fiscal volatility. In the case of an oil price increase, the stronger the countercyclicality, the greater the reduction in government debt. A reduction in the debt level puts pressure for the currency to appreciate. In response, the monetary authority continues to ease monetary policy further stimulating demand and inflation. This generates a feedback loop where a countercyclical fiscal policy causes appreciation which must be offset by additional monetary easing, further stimulating demand and inflation. Hence, there are smaller benefits of saving the additional oil royalties.

The impact of this feedback loop is stronger for the foreign demand shock due to the larger nominal exchange rate pressures, as shown in figures 7 and 8. While a CCR is still optimal for the foreign demand shock, it requires more fiscal adjustment due to this negative feedback loop. Thus, the optimal countercyclical rule results in smaller absolute reduction in output and inflation volatility than an inflation-targeting regime. In the case of the decrease in foreign supply, it is optimal to respond countercyclically by a similar degree as under an inflation targeting case due to the small impact on the nominal exchange rate. Figures 9.A and 10.A show a policy efficiency frontier for the temporary shocks under a fixed exchange rate regime. The curve is much steeper and kinked implying a much larger reduction in output volatility for a given increase in inflation volatility relative to an inflation-targeting regime.

3.3. Joint Monetary Policy Considerations

The above analysis assumes that the monetary authority responds with a coefficient of 1.5 to the deviation of core inflation from the target level. This calibration is consistent with findings for the joint optimization of monetary and fiscal policy in Bi and Kumhof (2012). However, similar to Colletti and others (2012), I find that the small open oil exporter faces the problem of a high inflation-output tradeoff due to the large real adjustment costs in the oil sector. By responding aggressively to the deviation of inflation from target, the authorities can reduce inflation volatility and apply a less countercyclical fiscal rule to increase output. This allows two instruments to adjust, generating more flexibility to influence the inflation-output tradeoff.

For the case of a foreign supply shock, core inflation falls under an SSR, and it is optimal for monetary policy to ease by more, with d^{π} equal to 5, to raise output. Since the non-oil tax revenue is still positive and fiscal policy has a more symmetric impact on output and inflation, the joint optimization can reduce the volatility of inflation relative to output and have a slightly less responsive fiscal balance. However, the loss function achieves nearly the same degree of reduction in volatility than the baseline case. When the fiscal authority targets headline inflation, it increases the real interest rate by 50 basis points. This increase helps reduce inflation but results in a fall in the tax revenue gap. Hence, fiscal policy is less countercyclical, as shown in table 12.

In the case of a foreign supply shock, core inflation rises under an SSR, and it is optimal for the monetary policy to respond aggressively, with d^{π} equal to 5. This changes the profile of the non-oil tax revenue gap, causing it to fall in the short run and rise in the medium-run. Overall, when the monetary authority targets core inflation, there is a similar debt profile to an SSR over the medium term. Hence, the optimal policy is to use monetary policy as much as possible with countercyclical fiscal elements. In such a scenario, volatility can be reduced by an additional 10 per cent relative to the baseline scenario. Targeting headline inflation results in a jump in interest rates in the short run and a larger fall in output. In such a case, there is more macroeconomic volatility relative to the baseline.

The use of both fiscal and monetary instruments creates more flexibility for the authorities to tackle the inflation-output tradeoff. Overall, for foreign, demand-driven shocks, it is preferable for monetary policy to respond to the core inflation deviation and for fiscal policy to follow an SSR due to the positive correlation of core inflation and output. In the case of a foreign supply shock, an aggressive monetary policy rule allows the fiscal rule to be more simulative helping to improve the inflation-output tradeoff. Although the specific details of this relationship depend on the choice of the fiscal instrument used, they are all able to achieve some degree of improvement relative to the case when the two policies are not coordinated.

3.4. Debt Volatility

A non-BBR response invokes net savings volatility that creates macroeconomic consequences due to expected future changes in taxes or spending and changes in the borrowing costs. This essay considers the case where the sovereign risk premium does not respond to the debt level, consistent with the assumption of operating from a sovereign wealth fund or a low net debt position. Further, the relatively small size of the SOE implies that it should have no impact on the global equilibrium real interest rate.[19] However, it is still the case that a change in the net debt level is returned to the level implied by the surplus target by the nominal rate of growth, 5% per annum. Hence, an increase in debt causes a small, but persistent, reduction in the net worth of OLG households.

To assess if this adjustment in the net debt position is optimal, I jointly optimize the coefficients to the tax and royalties gaps to the responsiveness, d^{debt}, of the debt level above its implied target. As shown in table 13, I find that the baseline non-responsiveness of debt in the fiscal rule is optimal, d^{debt} equal to zero, under the above-mentioned assumptions.[20] This result is robust to alternative assumptions of the instrument satisfying the fiscal rule.

3.5. Policy Objectives

The objective function of the fiscal authority thus far is assumed to be business cycle stabilization. Due to the OLG framework in GIMF, one is not able to do an exact second-order approximation of household utility to compute welfare directly. However, one can compute an approximation of the welfare measure by evaluating the average utility functions across generations weighted by the share of OLG and LIQ agents. By doing so, I find that the first-order effects dominate the second-order effects on household welfare. However, there may be other reasons for the fiscal authority to reduce consumption and labor volatility so I

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[19] This may be an unreasonable assumption if all commodity exporters' savings react in an identical fashion. In such a case the joint savings of all oil royalties, if large enough, could have consequences for the global equilibrium interest rate.

[20] For the implication under alternative assumptions see Pescatori and Snudden (forthcoming).

consider the case there the fiscal authority seeks to minimize an approximation of the volatility of welfare. Doing so raises interesting implications.

Compared to Kumhof and Laxton (2009a) I find that, since LIQ agents are not assumed to receive the rents from oil, there is little need to smooth their consumption. In particular, the majority of the response generated in the SOE from a foreign oil price shock is the increase in GDP from a rise in net exports. The optimal fiscal policy is an SSR with slight procyclical elements. The reason is that there exists a disutility from increased labor supply that can be offset from a small increase in consumption. This result is precarious primarily due to the absence of the extensive margin of labor supply. Hence, an increase in labor, although it could be a reduction in unemployment, is always counted as a disutility. When minimizing consumption volatility, the optimal rule remains SSR with countercyclical elements. Thus, I find that the desired degree of countercycality is increasing in the importance placed on output volatility relative to welfare volatility. In addition, the desired degree of countercycality is increasing in the share of LIQ agents share of oil rents, consistent with Kumhof and Laxton (2009a).

IV. Conclusions

This essay evaluates the appropriateness of budget balance rules for oil exporters. I find that budget balance rules with countercyclical elements are well suited to stabilize the macroeconomic volatility of oil-exporting countries. A larger countercyclical response is warranted for external demand shocks relative to supply factors due to their impact on the non-oil economy. This tradeoff and its impact on the design of the preferred fiscal rule also depend on the major structural characteristics and policy environments that differ across oil exporters.

The underlying structural characteristics of the commodity exporter influence the appropriate policy response. In an economy with a share of foreign ownership of oil and higher private domestic ownership, the fiscal authority collects a smaller share of rents. A countercyclical rule is preferred, but the response to the revenues gaps must increase to achieve a similar degree of countercyclicality. Also, as the dependence on oil increases, the desired level of countercyclicality relative to a structural rule decreases. Removing fluctuations in income driven by changes in oil rents is sufficient to dampen macroeconomic volatility, since the non-oil economy contributes a smaller share to overall demand fluctuations.

I find that the size and source of non-oil tax revenues does not pose a limitation to the use of a tax revenue gap fiscal-based rule, since the tax bases respond similarly and the size of the coefficients on the tax revenue gaps can increase to compensate for the reduced volatility of the tax revenue gaps. In practice, using a combination of spending on gasoline subsidies and responding countercyclically to the remaining volatility with spending instruments results in the smallest degree of volatility. Gasoline subsidies reduce the inflation-output tradeoff observed in standard fiscal and monetary policy frameworks. In addition, combining procyclical gasoline subsidies with countercyclical spending reduces the required fiscal volatility and requires smaller changes in debt.

Generally, the results for oil exporters are also applicable to other types of commodity exporters. My results are broadly in line with the results found for the case of copper in Chile, but with more volatility in headline inflation due to oil's importance in the consumption basket. The optimal degree of countercyclicality increases with the share of the commodity in the consumption basket for oil-specific shocks. In addition, in the presence of a broad-based demand shock when the commodity is not consumed directly in the consumption basket, I find that it is optimal to respond countercyclically to the oil-revenues gap. This is in contrast to the commodity-specific demand shock considered by Kumhof and Laxton (2009a).

In particular, the majority of the response generated in the small open economy from a foreign oil price shock is the increase in GDP from a rise in net exports. Thus, I find that the desired degree of countercycality is increasing in the importance placed on output volatility relative to consumption volatility. Further, the fiscal authority does not need to respond to changes in the net debt position if they are operating in an environment where the interest rate is unresponsive to changes in net savings positions.

I find that fixed exchanges rates increase the cost of fiscal volatility. A countercyclical fiscal rule should still be used in conjunction with a fixed exchange rate regime, but the relative gain from fiscal policy action is diminished from an unsupportive monetary policy. A fixed exchange rate increases the costs of changes in the level of debt, since it imparts exchange rate pressure. This pressure is offset by the monetary authority and counteracts the gains from fiscal policy.

In addition, I find that the joint coordination of countercyclical monetary and fiscal policy creates more flexibility for the authorities to take the inflation output tradeoff. Overall, for foreign demand driven shocks, it is preferable for monetary policy to respond to the core inflation deviation and follow a structural surplus rule due to the positive correlation of core inflation and output. In the case of a foreign supply shock, an aggressive policy rule allows the fiscal rule to be more stimulative helping to improve the inflation-output tradeoff.

In general, oil exporters have been moving in the right direction. Some are already operating effectively under a structural or countercyclical fiscal rule or are in the process of formalizing fiscal institutions.[21] However, countries await further gains from formalized fiscal policy frameworks. This is especially true for oil-exporting economies due to their unique challenges of inflation volatility. Fortunately, the gains from these rules are robust to many of the structural characteristics and policy environments that differ across oil exporters.

[21] See Céspedes and Velasco (2011), and IMF (2009).

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VI. TECHNICAL APPENDIX

This appendix focuses on the oil sector which has been slightly modified from the oil sector in technical description of Kumhof and others (2010). All other structural foundations of the model are true to Kumhof and others (2010). The oil sector is characterized by a low price elasticity of supply and for analyitical tractibility is modeled by an exogenous endowment of oil flow, X_t^{exog}, in each period for each country. This oil flow grows at growth rate, $T_t n^t$, and can be stored and drawn from a stockpile, O_t, which exists primarily for computational reasons to act as an escape valve for real adjustment costs. This feature is not central to the dynamics of the model and is calibrated so that there is almost no oil storage in the dynamics but so that the real adjustment costs do not cause computantional problems. Specifically the cost of storage is given by:

$$G_t^O = \frac{\phi_O}{2(T_t n^t)} O_t^2 - \kappa_O O_t \quad (4)$$

where G_t^O is the cost of storage, T_t is the productivity growth rate, n^t is the population growth rate, ϕ_O and κ_O are parameters determining the cost of storage. The raw material producer's optimization problem is given by:

$$\max_{\{O_{t+s}\}_{s=0}^{\infty}} E_t \sum_{s=1}^{\infty} \bar{R}_{t,s} P_{t+s}^X \left(X_{t+s}^{exog} - (O_{t+s} - O_{t+s-1}) - G_{t+s}^O\right), O_t \quad (5)$$

where P_t^X is the nominal market price of crude oil, and $\bar{R}_t$ is the steady state real interest rate. The first order condition is:

$$1 - \kappa_O + \phi_O \check{O}_t = E_t \frac{\theta}{\check{r}_t} \frac{p_{t+1}^X}{p_t^X}, \quad (6)$$

where, θ, is the probability of survival of OLG agents, $\check{O}_t$ is real oil supply where $\check{O}_t = O_t / T_t n^t$, and $\check{r}_t$ is the real interest rate payable by the private sector. The real supply of crude oil, $\check{X}_t^{sup}$, is given by:

$$\check{X}_t^{sup}, = \check{X}_t^{exog} - (\check{O}_t - \frac{\check{O}_{t-1}}{gn}) - \check{G}_t^O \quad (7)$$

The exogenous oil supply, $\check{X}_t^{exog}$, is subject to shocks to domestic supply, e_t^X. The size of the endowment has a small positive elasticity, ε^X, to the ten-year, backward-looking moving average of the oil price with a five-year lag:

$$log(\check{X}_t^{exog}) = \rho^X log(\check{X}_{t-1}^{exog}) + log(\bar{X}^{exog}) + \varepsilon^X log(p_{t-5}^{x_{ave}} / \bar{p}^x) + e_t^X \quad (8)$$

where ρ^X is the AR(1) coefficient of shock persistence, and $\bar{p}^x$ is the steady-state price of crude oil. The elasticity of oil supply, ε^X, is 0.03 to permanent oil price increases and takes 15 years to fully effect the flow of oil supply.

The total demand of crude oil in each country is given by $\check{X}_t^{dem}$, and is the sum of the demand for oil in production in the tradable goods, $\check{X}_t^T$, non-tradables goods, $\check{X}_t^N$, and via direct household consumption, $\check{X}_t^C$:

$$\check{X}_t^{dem} = \check{X}_t^T + \check{X}_t^N + \check{X}_t^C \tag{9}$$

The normalized value of each country's net crude oil exports is given by:

$$\check{X}_t^x = p_t^x(\check{X}_t^{sup} - \check{X}_t^{dem}) \tag{10}$$

The supply of crude oil is sold into a global market which is perfectly competitaive with a single global market price of crude oil. Oil rents are the difference between the extraction cost and the market price of oil and may accrue to households, the government, or foreign households. A constant share of normalized steady-state crude oil revenue, s_f^x, is paid to domestic OLG agents as a dividend, $\check{d}_t^X$, given by:

$$\check{d}_t^X = s_d^x \check{p}_t^X \check{X}_t^{sup}. \tag{11}$$

The remaining profits, *(1-* s_d^x *)* $p_t^X \check{X}_t^{sup}$, are distributed by constant share, s_f^x, via dividends to the foreign OLG agents in the ROW, $\check{f}_t^x$, and to payments to the government $\check{g}_t^x$, where:

$$\check{f}_t^x = s_f^x(p_t^X \check{X}_t^{sup} - \check{d}_t^X), \textit{ and} \tag{12}$$

$$\check{g}_t^x = p_t^X \check{X}_t^{sup} - \check{d}_t^X - \check{f}_t^x. \tag{13}$$

By international arbritrage the domestic price of oil is given by:

$$p_{t,j}^X = p_t^X e_t. \tag{14}$$

where e_t is the nominal bilaterial exhange rate against the ROW. Similarly, the dividends received by the rest of the world for ownership of the SOE oil production are given by:

$$\check{d}_{t,ROW}^x = \check{f}_{t,SOE}^x / e_t. \tag{15}$$

The market-clearing condition for the crude oil market world wide is given by:

$$\sum_{j=1}^N (\check{X}_t^{sup(j)} - \check{X}_t^{dem(j)}) = 0. \tag{16}$$

VII. TABLES AND FIGURES

Table 1. Long-run Growth Rates and Interest Rates (percent per annum)

	SOE	ROW
Technology growth	1.5	1.5
Population growth	1	1
Long-run Real Interest Rate	3	3
Steady-state inflation rate	2	2
Depreciation Rates		
Private Capital Stock	10	10
Public Capital Stock	4	4

Table 2: Elasticities of Substitution

	SOE	ROW
Nontradables: Capital-Labor	1	1
Tradables: Capital-Labor	1	1
Final Good Import Agents: Different Countries	1.5	1.5
Tradables Import Agents: Different Countries	1.5	1.5
Distributors: Home-Foreign Tradables	1.5	1.5
Inv. Goods Producers: Home-Foreign Tradables	1.5	1.5
Cons. Goods Producers: Home-Foreign Tradables	1.5	1.5
Distributors: Tradables-Nontradables	0.5	0.5
Government: Consumption-Investment Goods	0.5	0.5
Price Elasticity of Oil Supply	0.03	0.03

Table 3: Oil Sector Ratios

	SOE	ROW
Oil Supply / GDP	24.5	4.32
Oil Demand / GDP	6.5	4.5
for consumption	4.0	1.4
for non-tradables	1.1	1.9
for tradables	1.4	1.2
Cost of Production / GDP	9.8	1.73
Oil Income / GDP	14.7	2.6
to OLG agents	3.7	2.2
to government	11.0	0.4
to foreigners	0.0	0.0

Table 4: Steady-state Factor Shares		
	SOE	**ROW**
Nontradables Labor Income / GDP	60	60
Tradables Labor Income / GDP	66	66
Nontradables Output / Manufacturing Output	50	50
Consumption Goods Input / Government Output	50	50

Table 5: Utility Functions		
	SOE	**ROW**
Average Planning Horizon in Years	10	10
Average Remaining Working Life	20	20
Intertemporal Elasticity of Substitution	0.25	0.25
Labor Supply Elasticity	0.5	0.5
Share of Liquidity-constrained Agents	0.5	0.3
Dividend Share of Liq. Constrained Agents	0	0

Table 6. Steady-state GDP Ratios		
	SOE	**ROW**
Share in World GDP	**1.1**	**98.9**
National Accounts		
Consumption / GDP	60.0	61.5
Private Investment / GDP	20.0	19.0
Government Investment / GDP	3.0	2.5
Government Consumption / GDP	17.0	17.0
Exports / GDP	**40.0**	**-**
Final Goods Exports / GDP	12.0	-
Intermediate Goods Exports / GDP	10.0	-
Net Oil Exports / GDP	18.0	-
Imports / GDP	**40.0**	**-**
Consumption Goods Imports / GDP	20.0	-
Investment Goods Imports / GDP	12.0	-
Intermediate Goods Imports / GDP	8.0	-
Fiscal Accounts		
Government Debt / GDP	30	60
Labor Tax Revenue / GDP	15.5	15.5
Capital Tax Revenue / GDP	3.0	3.0
Consumption Tax Revenue / GDP	7.5	7.5

Table 7: Financial Accelerator Sector

	SOE	ROW
Leverage in Nontradables in %	100	100
Leverage in Tradables in %	100	100
Annual Bankruptcy Rate in Nontradables in %	8	8
Annual Bankruptcy Rate in Tradables in %	8	8
External Finance Premium in Nontradables in %	2.5	2.5
External Finance Premium in Tradables in %	2.5	2.5

Table 8: Monetary and Fiscal Rule Parameters

	SOE	ROW
Monetary-policy Reaction Function		
Lagged Nominal Interest Rate, δ_t	0.3	0.3
Inflation, δ_π	1.5	1.0
Inflation target, $\bar{\pi}$	2	2
Lead on inflation (in quarters)	3	3
Fiscal Rule Parameters		
Change in deficit to output gap, d^{gdp}	-	0.0

Table 9: Adjustment Costs

	SOE	ROW
Price Adjustment Costs		
Unions	40	40
Distributors	40	40
Non Tradable Sector	40	40
Tradable Sector	40	40
Imported Final Goods	30	30
Imports Intermediary Goods	30	30
Quantity Adjustment Costs		
Consumption	2	2
Investment	1	1
Labor Demand	1	1
Trade Flows of Final Goods	1	1
Trade Flows of Intermediary Goods	1	1
Oil in Non-tradables Production	25	25
Oil in Tradables Production	25	25
Oil in Consumption	25	25
Stock of Reserves of Refined Oil	100000	100000

Table 10: Optimal Fiscal Rule by Source of Oil Price Fluctuation and Characteristic of the SOE

	d^{com}	d^{tax}	Optimal less SSR/ GDP[22]	Loss Function SSR	Loss Function Optimal[23]	Loss Function Gain
Temporary Reduction in Oil Supply						
Baseline	1.2	5	0.39	0.08	0.06	23%
Private Ownership of Oil Production	2	5	0.32	0.06	0.05	17%
Low Dependence of Oil in Exports/Production	1.3	5	0.42	0.07	0.06	19%
High Dependence of Oil in Exports/Production	1.2	5	0.56	0.11	0.08	28%
Foreign Share in Ownership of Oil Production	1.6	5	0.35	0.06	0.05	18%
Low Level of Labor Taxes in Total Revenue	1.2	5	0.46	0.07	0.06	21%
No Direct Consumption of Oil	1.05	5	0.17	0.03	0.02	32%
Temporary Increase in Liquidity						
Baseline	1.1	5	0.45	0.13	0.10	18%
Private Ownership of Oil Production	1.8	5	0.55	0.12	0.10	14%
Low Dependence of Oil in Exports/Production	1.2	5	0.59	0.13	0.10	18%
High Dependence of Oil in Exports/Production	1.1	5	0.3	0.15	0.12	18%
Foreign Share in Ownership of Oil Production	1.3	5	0.57	0.13	0.10	19%
Low Level of Labor Taxes in Total Revenue	1.2	5	0.61	0.13	0.11	16%
No Direct Consumption of Oil	1.5	5	0.81	0.11	0.08	27%

Table 11: Two Year Multiplier of Fiscal Instruments

	Real GDP	Headline Inflation
Public Absorption	0.53	0.28
Public Investment	0.64	0.34
General Transfers	0.14	0.23
Targeted Transfers	0.32	0.50
Labor Taxes	0.25	0.22
Capital Taxes	0.14	0.09
Consumption Taxes	0.20	-0.48
Gasoline Taxes	0.07	-0.33

[22] This measure is the difference of the overall deficit between the optimal fiscal policy rule and the SSR as a percent of GDP.

[23] This is the evaluated loss function of the optimal fiscal policy rule.

Table 12: Optimal Fiscal Rule by Source of Oil Price Fluctuation and Policy

	d^{com}	d^{tax}	d^{*}[24]	**Optimal less SSR/ GDP**[25]	**Loss Function SSR**	**Loss Function Optimal**[26]	**Loss Function Gain**
Temporary Reduction in Oil Supply							
Baseline	1.2	5	-	0.4	0.08	0.06	23%
General Transfers Satisfying the Fiscal Rule	1.4	5	-	0.7	0.06	0.05	29%
Gasoline Taxes Satisfying the Fiscal Rule	0.8	5	-	-0.2	0.05	0.03	50%
Fixed Exchange Rate	1.2	5	-	0.4	0.09	0.06	28%
Joint Baseline and Reaction to Debt Optimization	1.2	5	0	0.4	0.08	0.06	23%
Joint Gasoline Taxes and Labor Tax Optimization	0.5	5	0.8	-1.4	0.08	0.03	59%
Joint Core Monetary and Fiscal Optimization	1.2	5	5	0.3	0.08	0.06	23%
Joint Headline Monetary and Fiscal Optimization	1.3	5	5	0.1	0.08	0.05	33%
Temporary Increase in Liquidity							
Baseline	1.1	5	-	0.5	0.13	0.10	18%
General Transfers Satisfying the Fiscal Rule	1.2	5	-	0.6	0.12	0.10	18%
Gasoline Taxes Satisfying the Fiscal Rule	0.9	0	-	-0.9	0.09	0.08	11%
Fixed Exchange Rate	1.0	5	-	0.9	0.26	0.21	19%
Joint Baseline and Reaction to Debt Optimization	1.1	5	0	0.5	0.13	0.10	18%
Joint Gasoline Taxes and Labor Tax Optimization	0.9	5	1	-0.3	0.13	0.09	25%
Joint Core Monetary and Fiscal Optimization	1.1	5	5	-0.1	0.13	0.08	34%
Joint Headline Monetary and Fiscal Optimization	1.1	5	5	-0.4	0.13	0.12	6%

[24] The coefficient on the other instrument being optimized: d^{debt} for optimal debt adjustment, d^{π} for core inflation targeting, d^{Π} for headline inflation targeting.

[25] This measure is the difference of the overall deficit between the optimal fiscal policy rule and the SSR as a percent of GDP in the first year proceeding the shock.

[26] This is the evaluated loss function of the optimal fiscal policy rule.

Figure 1: Temporary Reduction in Oil Supply in the Rest of the World, Effects on the Rest of the World
(x-axis in years)

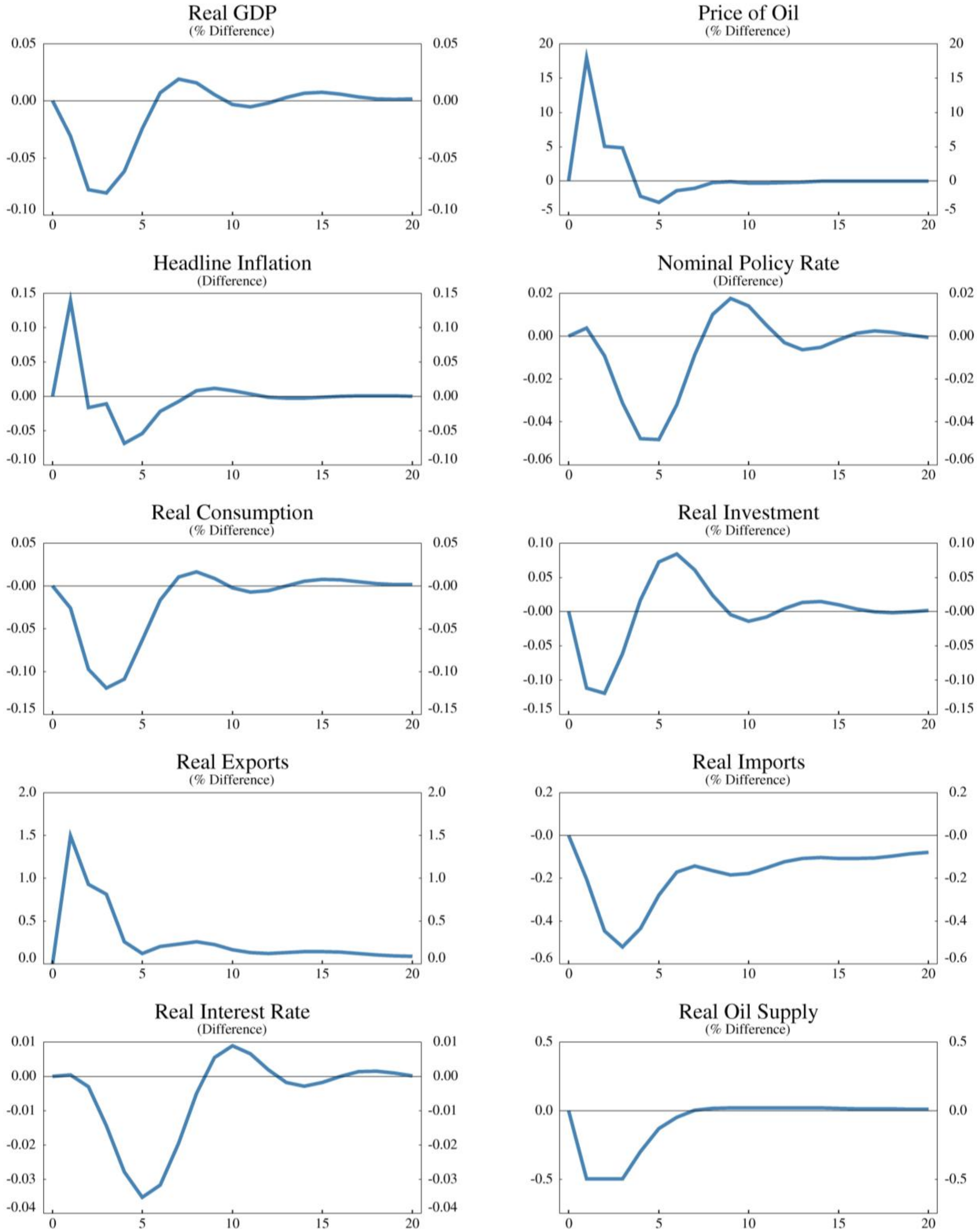


Figure 2: Temporary Reduction in Oil Supply in the Rest of the World, Effects on the SOE
(x-axis in years)

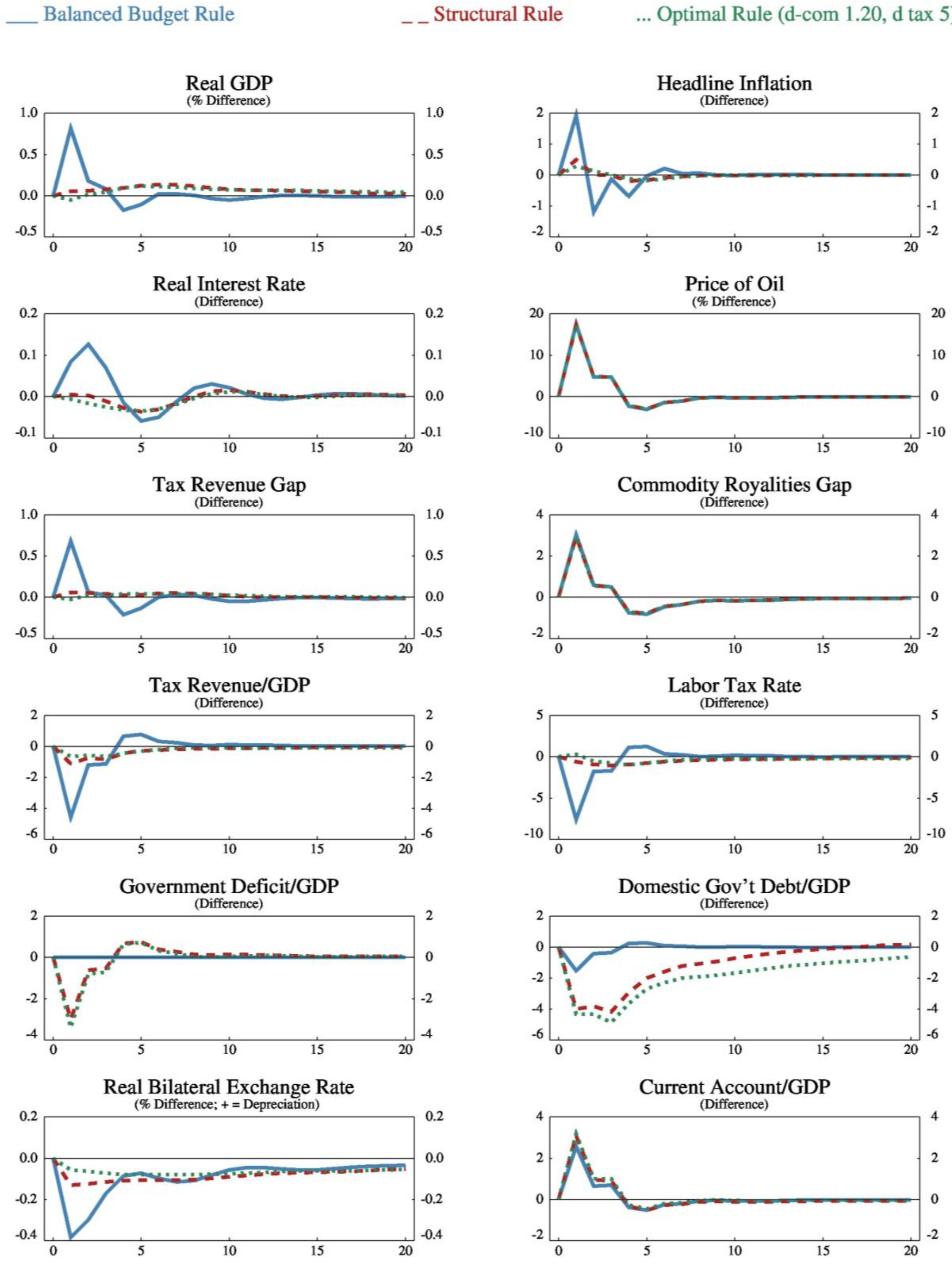


Figure 3: Temporary Increase in Liquidity in the Rest of the World, Effects on the Rest of the World
(x-axis in years)

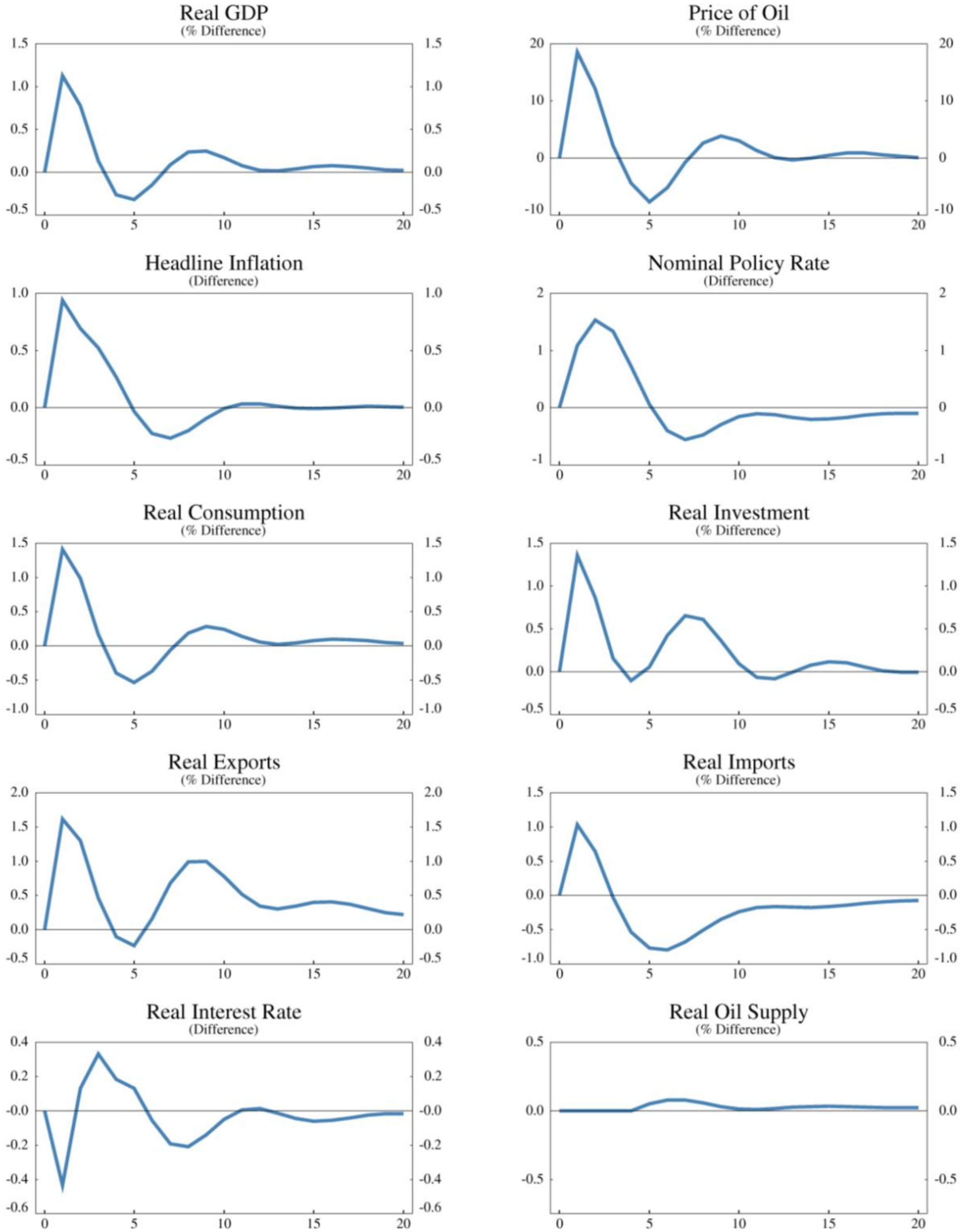


Figure 4: Temporary Increase in Liquidity in the Rest of the World, Effects on the SOE
(x-axis in years)

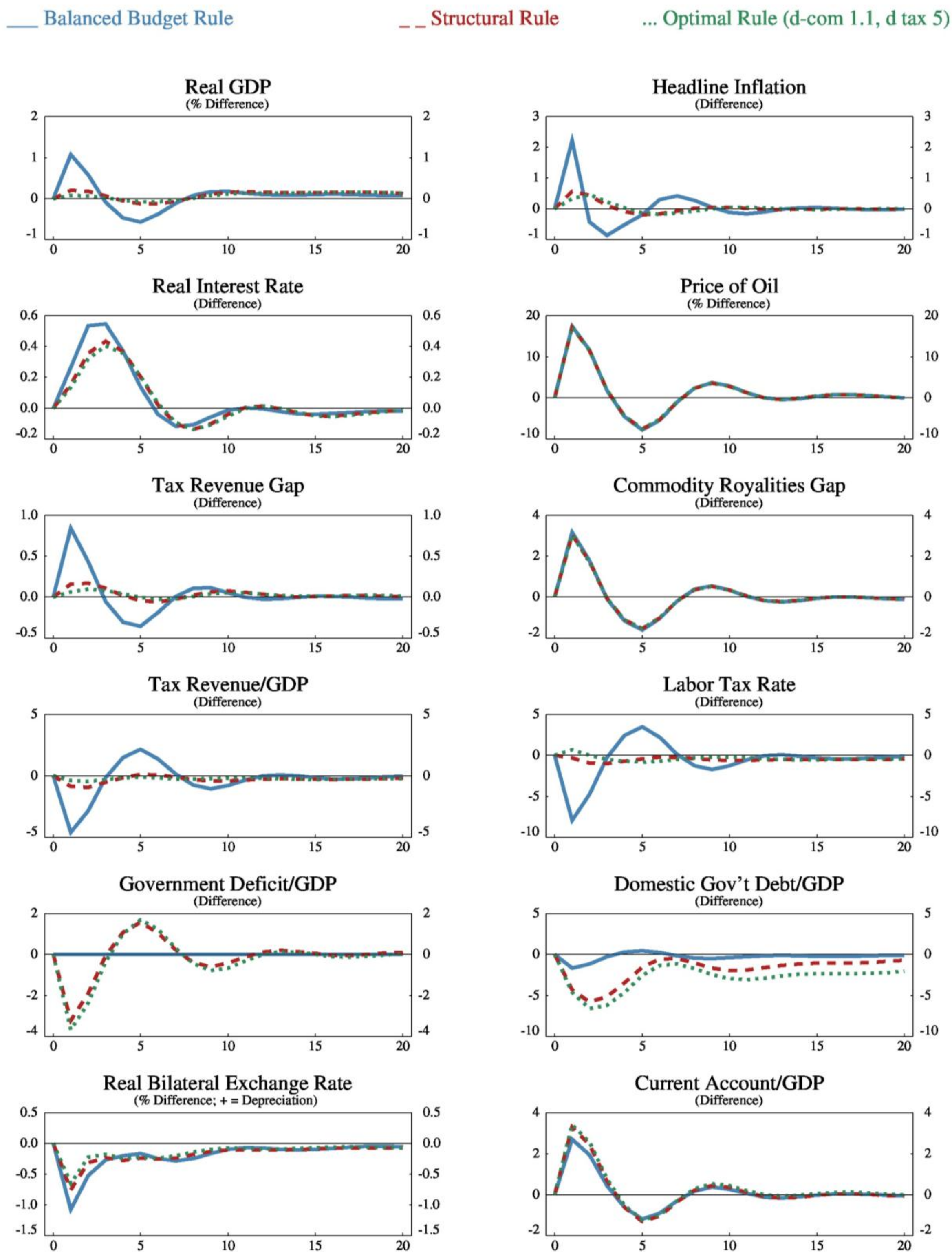
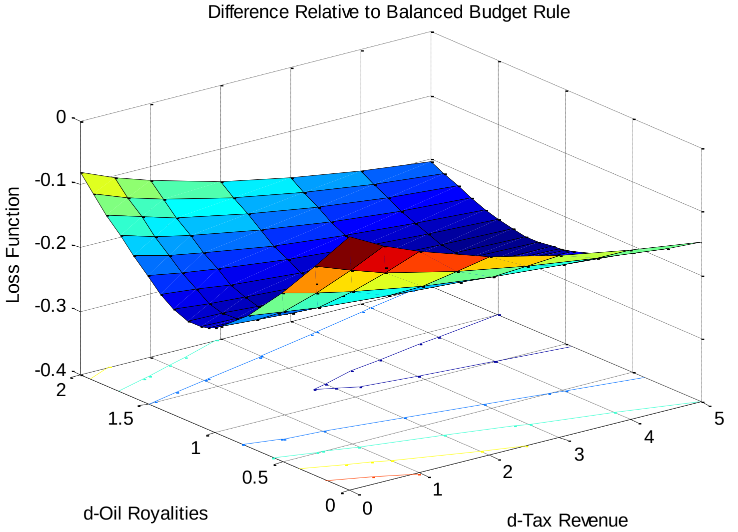


Figure 5 and 5.A: Temporary Reduction in Oil Supply in the Rest of the World, Evaluated Loss Function and Policy Efficiency Frontier

(Optimal Rule at λ_Y = 1: d^{com} = 1.2, d^{tax} = 5)



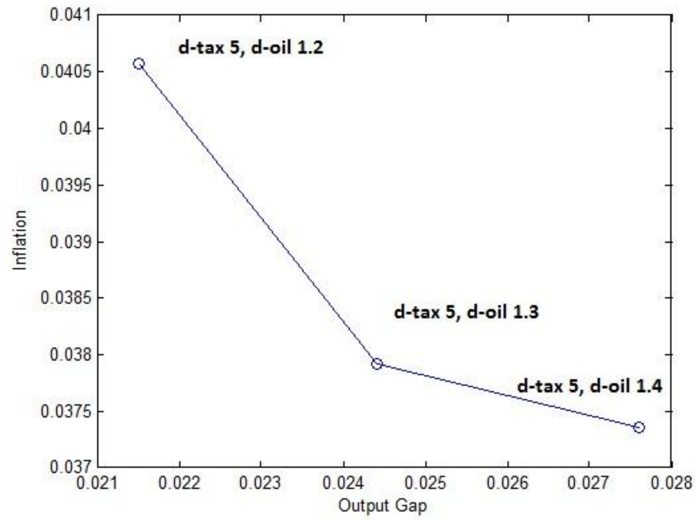
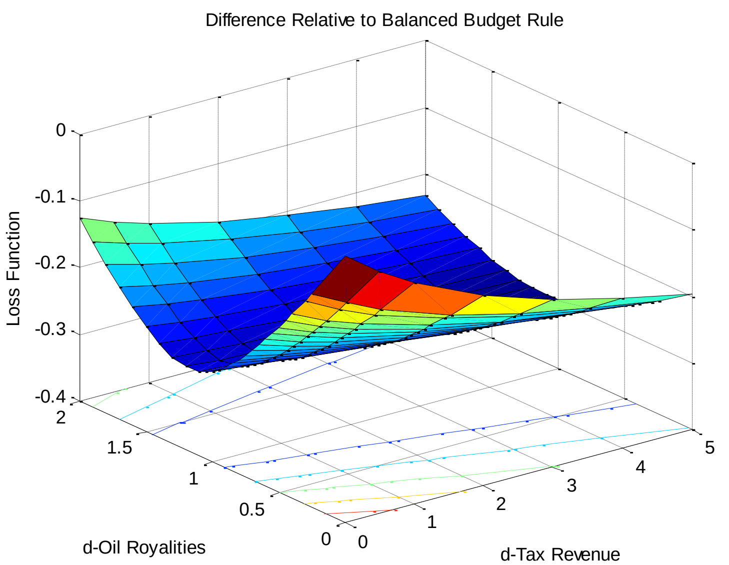


Figure 6 and 6.A: Temporary Increase in Liquidity in the Rest of the World, Evaluated Loss Function

(Optimal Rule at λ_Y = 1: d^{com} = 1.1, d^{tax} = 5)



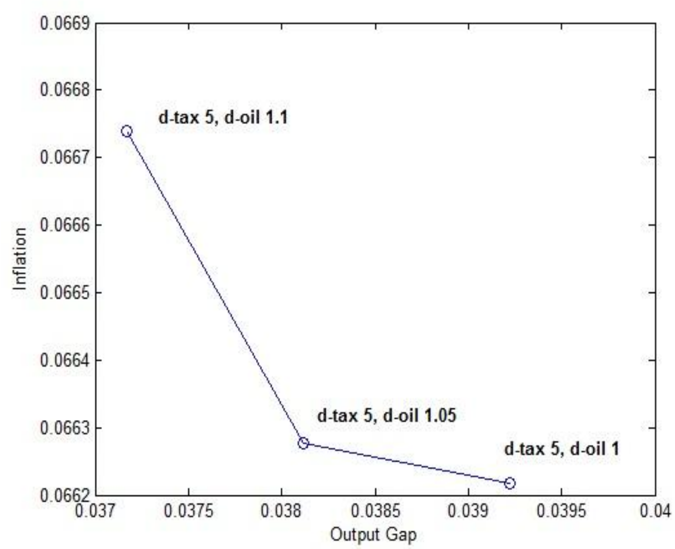


Figure 7: Temporary Reduction in Oil Supply in the Rest of the World, Effects on the SOE: Fixed Exchange Rates
(x-axis in years)

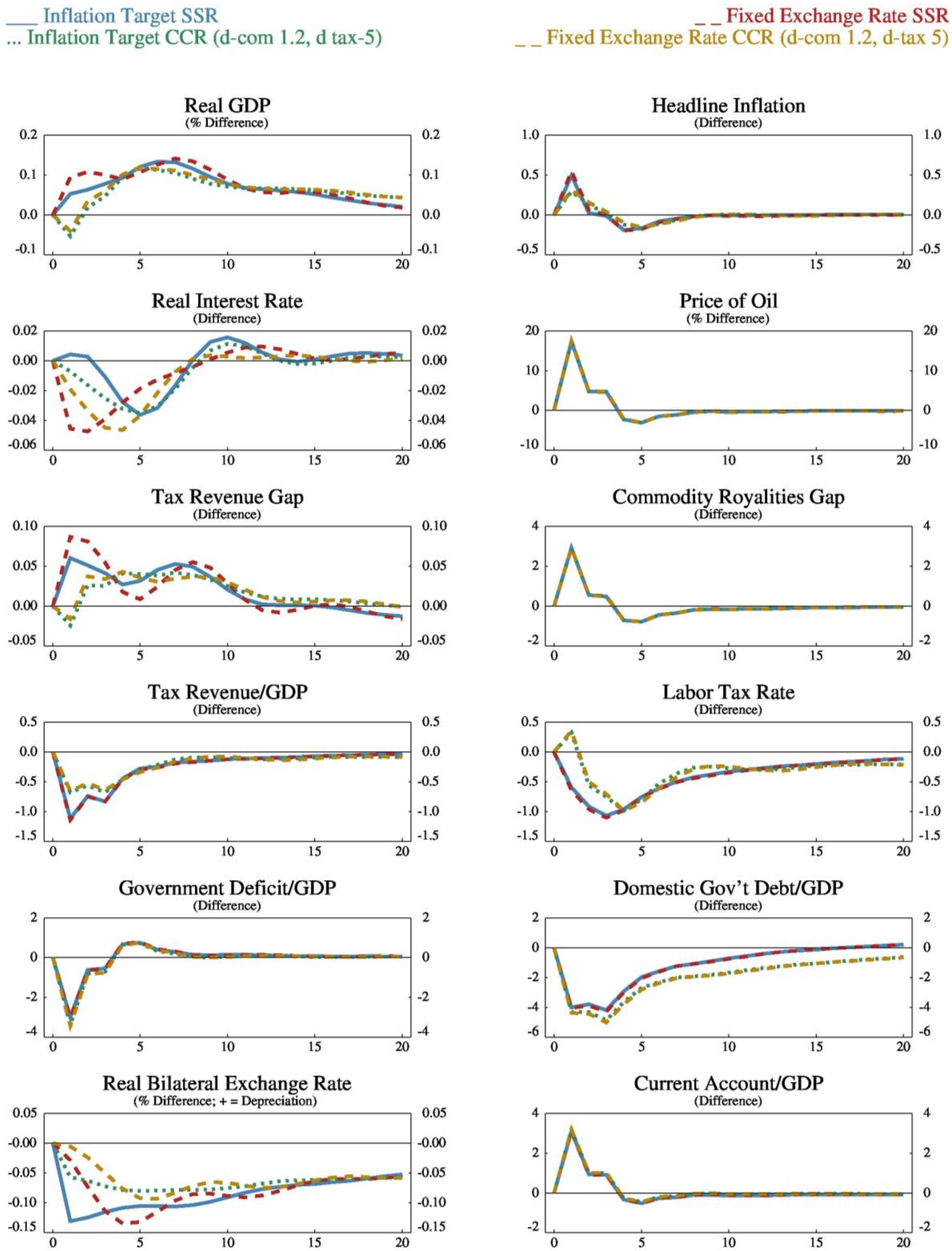


Figure 8: Temporary Increase in Liquidity in the Rest of the World, Effects on the SOE: Fixed Exchange Rates
(x-axis in years)

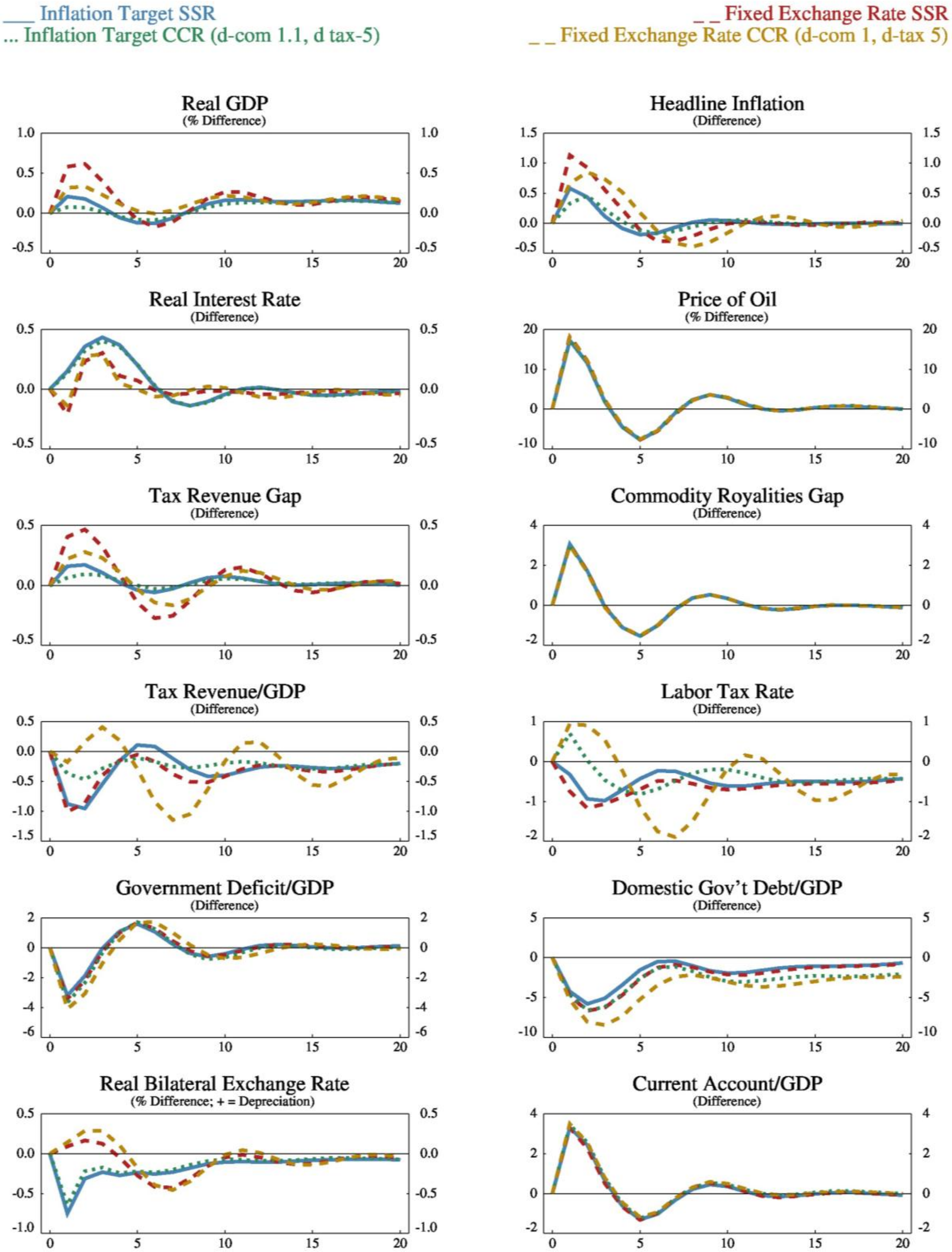
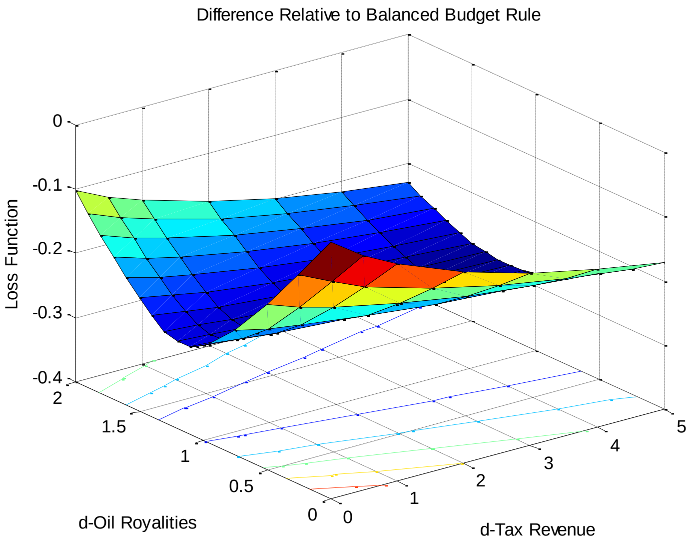


Figure 9 and 9.A: Temporary Reduction in Oil Supply in the Rest of the World, Evaluated Loss Function and Policy Efficiency Frontier: Fixed Exchange Rates
(Optimal Rule at $\lambda_Y = 1$: $d^{com} = 1.2$, $d^{tax} = 5$)



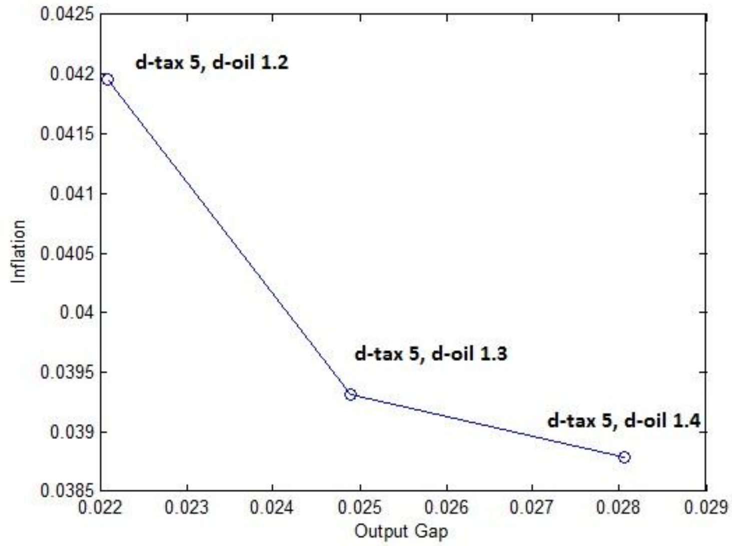


Figure 10 and 10.A: Temporary Increase in Liquidity in the Rest of the World, Evaluated Loss Function and Policy Efficiency Frontier: Fixed FX Rate
(Optimal Rule at $\lambda_Y = 1$: $d^{com} = 1$, $d^{tax} = 5$)