INTERNATIONAL MONETARY FUND

October 2015 Fiscal Monitor

Background Notes

Prepared by the Fiscal Affairs Department

In consultation with the other departments

Approved by Vitor Gaspar

September 1, 2015

Contents Page

EMPIRICAL ANALYSIS

Relationship between Oil Prices, Government Spending, and Economic Activity

The role of government spending in the transmission of oil price changes on the non-oil economy is assessed, following Husain, Tazhibayeva, and Ter-Martirosyan (2008). The analysis draws on panel regressions:

$$\Delta \log(RY\_NC_{it}) = \alpha_i + \beta\Delta \log(P\_N_{it}) + \gamma \frac{EXP_{it}}{NY\_NC_{it}} + \eta\Delta \log(RY\_WORLD_{it}) + \varepsilon_{it}, \quad (1.1)$$

in which *RY_NC* is the real non-oil GDP, *P_N* is the nominal oil price, *EXP* is government spending, *NY_NC* is the nominal non-oil GDP, *RY_WORLD* is the real world GDP, and *i* and *t* indexes denote country and year. As shown in Table 1.1, the coefficient on the nominal oil price changes is positive and significant when the government spending ratio is not included. However, inclusion of the government spending ratio washes out the significance of the oil price coefficient. The coefficient on government spending ratio is positive and significant, suggesting that oil price changes affect non-oil GDP through government spending.[1]

Table 1.1. Oil Price Shocks Are Transmitted through Public Spending

	(1)	(2)	(3)	(4)
Change in log of oil price (nominal, lagged)	0.042***	0.012	0.046***	0.013
	[0.010]	[0.011]	[0.009]	[0.011]
Change in (public spending/non-commodity GDP, lagged)		0.134***		0.140***
		[0.025]		[0.023]
Percentage change in world GDP (real)			0.454*	0.667***
			[0.250]	[0.191]
Constant	5.012***	5.028***	3.319***	2.554***
	[0.150]	[0.120]	[0.846]	[0.797]
Observations	732	437	732	437
Number of countries	20	20	20	20

Source: IMF staff estimates.
Note: The sample period is 1972–2014.
Estimations are performed using the fixed effects estimator. Robust standard errors are in brackets.
* p < 0.10; ** p < 0.05; *** p < 0.01. Results remain qualitatively unchanged when share of mining GDP in total GDP is used as an additional control.

[1] Husain, Tazhibayeva, and Ter-Martirosyan (2008) and Arezki, Hamilton, and Kazimov (2011) confirm the importance of government spending for growth in a panel VAR setting; they find that the impact is stronger for countries with greater commodity dependence.

Fiscal Cyclicality in Resource-Rich Countries

1. Measuring the impact of commodity prices on government spending

A positive association between the commodity prices and government spending would indicate procyclicality, as government spending would increase in periods of economic expansion fueled by growing commodity prices. The advantage of this approach is that commodity prices are exogenous to spending policies, which alleviates endogeneity issues. The empirical specification takes the following form:

$$\Delta \log(RG_{it}) = \alpha_i + \beta \Delta \log(P_{it}) + \varepsilon_{it}, \qquad (1.2)$$

in which *RG* is real government spending. *P* is the country-specific commodity price index, measured as:

$$P_i = \sum_{j \in J} P_{ij} * w_{ij}, \qquad (1.3)$$

in which *i* is the country, *j* is the commodity type (oil, gas, gold, tin, zinc, lead, aluminum, nickel, copper, silver), *P* is the real commodity price (deflated by the U.S. consumer price index, CPI), and *w* is the commodity weight (commodity export share in GDP). Results appear in Table 1.2.

By using changes of government spending and commodity price variables, the analysis is abstracting from the long-run association of their levels, which according to the Permanent Income Hypothesis (PIH) should be positive. Changes of these variables proxy their cyclical movements. A positive association between changes is an indication of procyclicality, in which government spending expands (contracts) aggregate non-commodity demand in good (bad) times, exacerbating the non-commodity business cycles in a procyclical fashion.

Table 1.2. Procyclicality to Commodity Prices
(Country-Specific Regressions)

Country	Coefficient	st. error	t-statistic	p-value
Norway	-0.007	0.01	-0.74	0.47
Canada	-0.027	0.03	-0.87	0.39
Australia	-0.072	0.04	-2.01	0.05
South Africa	0.011	0.04	0.25	0.80
Bolivia	-0.196	0.07	-2.79	0.01
Chile	-0.019	0.02	-0.80	0.43
Colombia	-0.005	0.15	-0.03	0.97
Ecuador	0.497	0.36	1.38	0.18
Mexico	0.086	0.06	1.39	0.18
Peru	0.141	0.06	2.42	0.03
Venezuela	0.673	0.15	4.43	0.00
Guyana	-0.014	0.14	-0.10	0.92
Trinidad and Tobago	0.191	0.11	1.68	0.11
Bahrain	0.024	0.12	0.20	0.85
Iran	0.087	0.13	0.66	0.52
Kuwait	0.353	0.13	2.68	0.01
Oman	0.194	0.10	1.86	0.08
Qatar	0.143	0.16	0.88	0.39
Saudi Arabia	0.195	0.10	1.97	0.06
Syria	0.064	0.16	0.40	0.69
United Arab Emirates	-0.002	0.16	-0.01	0.99
Yemen	0.585	0.27	2.15	0.04
Brunei Darussalam	0.282	0.24	1.16	0.26
Indonesia	-0.051	0.19	-0.26	0.80
Algeria	0.210	0.11	1.87	0.08
Angola	1.020	0.34	3.03	0.01
Botswana	0.081	0.07	1.17	0.25
Cameroon	-0.168	0.09	-1.97	0.06
Congo, Republic of	0.284	0.22	1.30	0.21
Gabon	-0.108	0.17	-0.64	0.53
Guinea	0.064	0.23	0.28	0.78
Côte d'Ivoire	0.032	0.08	0.39	0.70
Mali	-0.142	0.16	-0.91	0.38
Nigeria	0.065	0.33	0.19	0.85
Papua New Guinea	0.010	0.07	0.14	0.89
Azerbaijan	-0.313	0.34	-0.93	0.36

Source: IMF staff estimates and calculations.
Note: Estimations are performed using ordinary least squares with AR(1) residuals. The sample period 1972–2014, but length varies across countries; the minimum sample length is set to 10 observations for each country.

2. *Measuring the impact of the non-commodity output gap on the cyclically adjusted non-commodity balance*

To alleviate the positive bias when measuring fiscal cyclicality, Villafuerte, Lopez-Murphy, and Ossowski (2010), among others, suggest removing the impact of commodity prices from output and the overall balance. The empirical specification takes the following form:

$$\frac{CA\_BAL\_NC_{it}}{GDP\_NC_{it}} = \alpha_i + \beta GAP\_NC_{it} + \varepsilon_{it}, \tag{1.4}$$

in which *CA_BAL_NC* is the cyclically adjusted non-commodity balance (assume elasticities of 1 for revenues and 0 for expenditures), *GDP_NC* is the non-commodity GDP, and *GAP_NC* is the non-commodity GDP gap. Coefficient β captures the extent of fiscal cyclicality (a negative coefficient implies procyclicality). The equation is estimated by the panel fixed effects estimator. As a robustness check, non-commodity GDP growth is used instead of the non-commodity output gap, given the high uncertainty with measuring output cycles in commodity-exporting countries.

3. *Measuring the impact of institutional variables and fiscal rules*

To analyze the impact of institutional characteristics and fiscal rules, the commodity price index is interacted with respective measures of institutional quality and fiscal rules. The empirical specification takes the following form:

$$\Delta \log(RG_{it}) = \alpha_i + \beta\Delta \log(P_{it}) + \gamma\Delta \log(P_{it}) * I_{it} + \varepsilon_{it}, \quad (1.5)$$

in which I stands for the index of institutional quality (a continuous variable) and the existence of a fiscal rule in place (a dummy variable). Coefficient γ measures the extent to which institutions and rules can affect procyclicality (a negative coefficient would imply a reduction in procyclicality in countries with better institutions and fiscal rules). Results are shown in Tables 1.3 and 1.4. Table 1.5 lists fiscal rules and Table 1.6 lists oil funds for selected commodity-exporting countries.

Table 1.3. Impact of Institutions on Fiscal Procyclicality

	(1)	(2)	(3)	(4)	(5)	(6)
Δ log(commodity Price)	0.123**	0.173**	0.365***	0.231**	0.650***	0.286**
	[0.054]	[0.083]	[0.094]	[0.099]	[0.180]	[0.118]
Δ log(commodity Price) * Polity		-0.01				
		[0.007]				
Δ log(commodity Price) * Bureacratic quality			-0.094***			
			[0.029]			
Δ log(commodity Price) * Corruption				-0.031		
				[0.025]		
Δ log(commodity Price) * Political risk					-0.007***	
					[0.002]	
Δ log(commodity Price) * Institutions and legal setting						-0.003*
						[0.001]
Constant	0.052*	-1.102	0.037	0.038	0.043	0.133**
	[0.028]	[2.299]	[0.029]	[0.057]	[0.029]	[0.062]
Observations	834	411	741	741	740	651
Number of countries	37	19	37	37	37	29

Source: IMF staff estimates and calculations.
Note: The sample period is 1972–2014.
Estimations are performed using panel fixed effects estimator with AR(1) residuals. Dependent variable is real government expenditure growth. Robust standard errors are in brackets. *** < 0.01.

Table 1.4. Impact of Fiscal Rules on Fiscal Procyclicality

	(1)	(2)	(3)	(4)	(5)
Δ log(CommodityPrice)	0.123**	0.151**	0.166**	0.158**	0.177**
	[0.054]	[0.069]	[0.072]	[0.066]	[0.073]
Δ log(CommodityPrice)*Saving fund		-0.04			
		[0.075]			
Δ log(CommodityPrice)*Stabilization fund			-0.057		
			[0.067]		
Δ log(CommodityPrice)*Fiscal rule				-0.121	
				[0.098]	
Δ log(CommodityPrice)*Fiscal rule OR Savings/Stabilization fund					-0.073
					[0.066]
Constant	0.052*	0.023	0.024	0.024	0.024
	[0.028]	[0.033]	[0.033]	[0.032]	[0.033]
Observations	834	650	650	650	650
Number of countries	37	30	30	30	30

Source: IMF staff calculations and estimates.
Note: The sample period is 1972–2014.
Estimations are performed using panel fixed effects estimator with AR(1) residuals. Dependent variable is real government expenditure growth. Robust standard errors are in brackets. *** < 0.01.

Table 1.5. Fiscal Rules

Country	Description	Date established
Botswana	Expenditure rule (2003)	2003
Cameroon	Supranational rules - Central African Economic and Monetary Community (CEMAC) (2002, 2008) Budget balance rules (2002, 2008), Debt rule (2002)	2002, 2008
Chad	Supranational rules - Central African Economic and Monetary Community (CEMAC) (2002, 2008)	2002, 2008
Chile	Budget balance rule (2001)	2001
Colombia	Budget balance rule (2012), Expenditure rule (2000)	2000, 2012
Congo, Rep. of	Supranational rules - Central African Economic and Monetary Community (CEMAC) (2002, 2008)	2002, 2008
Côte d'Ivoire	Supranational rules - West African Economic and Monetary Union (WAEMU), Budget balance rule (2000), Debt rule (2000)	2000
Ecuador	Expenditure rule (2010), Budget balance rule (2003), Debt rule (2003)	2003, 2010
Equatorial Guinea	Supranational rules - Central African Economic and Monetary Community (CEMAC) (2002, 2008)	2002, 2008
Gabon	Supranational rules - Central African Economic and Monetary Community (CEMAC) (2002, 2008)	2002, 2008
Indonesia	Budget balance rule (1967), Debt rule (2004)	1967, 2004
Mali	Supranational rules - West African Economic and Monetary Union (WAEMU) (2000)	2000
Mexico	Budget balance rule (2006), Expenditure rule (2013)	2006, 2013
Mongolia	Expenditure rule (2013), Budget balance rule (2013), Debt rule (2014)	2013, 2014
Niger	Supranational rules - West African Economic and Monetary Union (WAEMU) (2000)	2000
Nigeria	Budget balance rule (2007)	2007
Norway	Budget balance rule (2001)	2001
Peru	Budget balance rule (2000, 2003, 2009), Expenditure rule (2000, 2003, 2009, 2013)	2000, 2003, 2009, 2013
Russian Federation	Expenditure rule (2013)	2013
Venezuela	Fiscal rules embedded in Organic Law for the Public Finances (2000)	2000

Source: IMF staff etsimates and calculations.

Table 1.6. Oil Funds

Country	Name	Date established	Objective
Algeria	Revenue Regulation Fund	2000	Stabilization
Angola	Fundo Soberano de Angol (FSDEA)	2012	Investment and development
Azerbaijan	State Oil Fund of Azerbaijan Republic (SOFAZ)	1999	Stabilization and saving
Bahrain	Reserve Fund for Strategic Projects	2000	Stabilization
	Mumtalakat Holding Company	2006	Investment
Botswana	Revenue Stabilization Fund	1972	Stabilization
	Pula Fund	1994	Saving
Brunei Darussalam	Brunei Investment Agency	1986	Saving
	General Consolidated Fund	1984	Saving
Chad	Stabilization Account	1999	Stabilization
Chile	ES Fund	2007	Stabilization
	PRF	2006	Pension
Colombia	Oil Stabilization Fund (FAEP)	1995	Stabilization
Equatorial Guinea	Fund for Future Generations	2002	Saving
	Special Reserve Fund (SRF)	2002	Saving and stabilization
Gabon	Fund for Future Generations	1998	Saving
Ghana	Ghana Stabilization Fund	2011	Stabilization
Indonesia	Government Investment Unit	2006	Stabilization and development
Iran	National Development Fund	1999	Oil stabilization and development
Kazakhstan	National Fund of the Republic of Kazakhstan (NFRK)	2000	Stabilization and saving
Kuwait	General Reserve Fund	1960	Stabilization and saving
	Reserve Fund for Future Generations	1976	Saving
Libya	Oil Reserve Fund (ORF)	1995	Stabilization and saving
	Libyan Investment Authority	2006	Saving
Mauritania	National Fund for Hydrocarbon Reserves	2000	Stabilization
Mexico	Oil Revenues Stabilization Fund of Mexico	2000	Stabilization and saving
Mongolia	Fiscal Stabilization Fund	2011	Stabilization
Nigeria	Nigeria Sovereign Investment Authority	2004, 2011	Stabilization and saving
Norway	Government Pension Fund	1990	Stabilization and saving
Oman	State General Reserve Fund	1980	Saving
	Oman Investment Fund	2006	Investment
Papua New Guinea	Sovereign Wealth Fund	2011	Stabilization and development
Peru	Fiscal Stabilization Fund	1999	Stabilization
Qatar	Stabilization Fund (2000)/Qatar Investment Authority (since 2005)	2000	Stabilization/saving
Russian Federation	Reserve Fund (Former Oil Stabilization Fund)	2004	Stabilization
	National Wealth Fund		Saving
Sudan	Oil Revenue Stabilization Account	2002	Stabilization
Timor-Leste	Petroleum Fund	2005	Stabilization and saving
Trinidad & Tobago	Heritage and Stabilization Fund	2000	Stabilization and saving
United Arab Emirates	Several funds		
Venezuela	Macroeconomic Stabilization Fund (FIEM)	1998	Stabilization

Source: IMF staff estimates and calculations.
Note: For Iran, the National Development Fund was previously called the Oil Stabilization Fund. For Norway, although the Government Pension Fund was established in 1990, it was activated only in 1995. For Trinidad and Tobago, the Heritage and Stabilization Fund was previously known as the Interim Revenue Stabilization Fund. The funds for United Arab Emirates include the Abu Dhabi Investment Authority, Abu Dhabi Investment Council, Emirates Investment Authority, IPIC, Investment Corporation of Dubai, Mubadala Development Company, and RAK Investment Authority.

Table 1.7. Noncommodity Revenues Respond to Persistent Commodity Shocks, but the Response to Temporary Changes Is Muted

	(1)	(2)	(3)
Long-run coefficients			
Commodity revenue/non-commodity GDP (lagged)	-0.036***	-0.037***	-0.042***
	[0.007]	[0.007]	[0.007]
Constant	19.494***	19.593***	20.009***
	[0.421]	[0.454]	[0.390]
Short-run coefficients			
Speed of adjustment	-0.141***	-0.149***	-0.153***
	[0.043]	[0.044]	[0.046]
Δ Commodity revenue/non-commodity GDP	-0.067	-0.047	-0.066
	[0.080]	[0.098]	[0.157]
Δ Commodity revenue/non-commodity GDP (1 lag)		-0.045	-0.044
		[0.110]	[0.200]
Δ Commodity revenue/non-commodity GDP (2 lags)			-0.147
			[0.177]
Observations	711	675	639
Log likelihood	-1498.6	-1387.6	-1267.7
Half life (years)	4.6	4.3	4.2

Source: IMF staff calculations and estimates.
Note: The sample period is 1991–2014.
Dependent variable is the change in non-commodity revenue ratio. Estimations are performed using the Pooled Mean Group (PMG) estimator.

Response of Non-Commodity Revenues to Commodity Revenue Shocks

The Pooled Mean Group (PMG) estimator of Pesaran, Shin, and Smith (1999) was applied; this is a panel data version of the error-correction model. The empirical specification is:

$$\Delta\left(\frac{R_{it}^{NC}}{Y_{it}}\right) = \phi_i\left[\frac{R_{it}^{NC}}{Y_{it}} - \alpha - \beta\frac{R_{it}^{C}}{Y_{it}}\right] + \delta_i\Delta\left(\frac{R_{it}^{C}}{Y_{it}}\right) + \mu_i + \varepsilon_{it}, \tag{1.6}$$

in which i and t indexes denote country and time, Y is the nominal GDP (total or non-commodity), R is government non-commodity (NC) revenues and commodity (C) revenues, μ is the country-specific fixed effect, and ε is an *i.i.d.* error term. The term in the squared bracket is the error-correction term measuring the extent of the deviation of the non-commodity revenue from its long-run equilibrium value determined by the commodity revenue. β measures the *long-run* effect of non-commodity revenue in response to a permanent change in commodity revenue and corresponds to the coefficient estimates in the literature (such as Bornhorst, Gupta, and Thornton 2009; Crivelli and Gupta 2014). Similarly, δ measures the *short-term* effect of non-commodity revenue to a temporary change in non-commodity revenue. ϕ is the speed of adjustment of non-commodity revenue to its long-run equilibrium defined by commodity revenue: the larger the absolute value of this coefficient, the faster is the adjustment of non-commodity revenues to their long-run equilibrium level. Finally, the specification includes country-specific fixed effects, μ_i, to capture unobserved heterogeneity of non-commodity revenue across different countries.

The results, presented in Table 1.7, suggest that a permanent increase in commodity revenues by 1 percent of non-commodity GDP reduces non-commodity revenues by 0.04 percent of non-commodity GDP. Temporary changes in commodity revenues do not have a significant impact on non-commodity revenues.

THE PERMANENT INCOME HYPOTHESIS MODEL

Models of intertemporal consumption constitute the reference framework to establish long-term fiscal benchmarks in resource-rich countries.[2] For illustrative purposes, this section considers the simplest version of such models, in which a government, at every period *t*, receives resource income y_t and chooses spending c_t to maximize the total utility $u(.)$ of a representative agent, a standard concave utility function. Without loss of generality, all variables are expressed in percent of nonresource GDP and assume that nonresource GDP (hereafter, GDP for simplicity) grows each year by a known and constant rate n. Formally, the analysis considers a government that at every period *t* chooses a plan $\{c_{t+\tau}\}_{\tau=0}^{\infty}$ to maximize

$$E\left[\sum_{\tau=0}^{\infty}\frac{u(c_{t+\tau})}{(1+\beta)^{\tau}}\middle| I_t\right], \tag{1.7}$$

in which the expectation is conditional on information available at time *t* (I_t). The government is subjected to an ex post budget constraint:

$$a_t = \left(\frac{1+i}{1+n}\right)a_{t-1} + y_t - c_t, \tag{1.8}$$

in which a_t is net financial wealth at the end of period *t*, and i is the constant and known interest rate. Let $1 + r = (1 + i)/(1 + n)$. Then the ex post budget constraint becomes:

$$a_t = (1 + r)a_{t-1} + y_t - c_t. \tag{1.9}$$

It is assumed that future resource income is random and it is the only source of uncertainty. However, y_t is known by the time the government must choose $\{c_{t+\tau}\}_{\tau=0}^{\infty}$ and the natural resource will be depleted at the known period T. The usual transversality condition holds:

$$\lim_{\tau\to\infty}\frac{a_{t+\tau}}{(1+r)^{\tau}} = 0. \tag{1.10}$$

This benchmark model can be extended in many directions: for example, by distinguishing between public consumption and public investment, thus allowing the government to use resource revenues to increase the capital stock of the economy.

The solution to the simple model must satisfy the following conditions:

[2] See Engel and Valdes (2000).

- The first order conditions (Euler equations). The government equates the marginal benefit of consumption across time:

$$u'(c_t) = \frac{1+r}{1+\beta} E[u'(c_{t+1})|I_t], \tag{1.11}$$

$$E[u'(c_{t+\tau})|I_t] = \frac{1+r}{1+\beta} E[u'(c_{t+\tau+1})|I_t]. \tag{1.12}$$

- The ex ante budget constraint. The fact that the budget constraint must hold *ex post*, under *all possible realized income paths*, implies that the intertemporal budget constraint must hold ex ante in conditional expectation. That is:

$$\frac{c_t}{1+r} + \sum_{\tau=1}^{\infty} \frac{E[c_{t+\tau}|I_t]}{(1+r)^{\tau+1}} = \frac{y_t}{1+r} + \sum_{\tau=1}^{\infty} \frac{E[y_{t+\tau}|I_t]}{(1+r)^{\tau+1}} + a_{t-1}. \tag{1.13}$$

From these conditions, a few standard results emerge:

- Consumption depends on the expected value of total wealth. The first-order conditions imply that $E[c_{t+\tau}|I_t]$ is a function of c_t (and, of course, of other parameters such as r and β), the current level of wealth, as well as the moments of the distribution of income shocks (for simplicity, it is assumed that income is the only source of uncertainty). Noticing that the right-hand side of the ex ante budget constraint is the expected net present value of total current and future income (which is called $NPV[W_t|I_t]$), then it is clear that optimal consumption c_t is a function of $NPV[W_t|I_t]$.

- Precautionary savings emerge in the model. If the utility function of the representative agent has a positive third derivative (which is the case if the agent displays constant relative risk aversion), then it is possible to show that

$$\mathrm{E}[\mathrm{u}'(\mathrm{c}_{\mathrm{t}+\tau})|\mathrm{I}_{\mathrm{t}}] > \mathrm{u}'(\mathrm{E}[\mathrm{c}_{\mathrm{t}+\tau}|\mathrm{I}_{\mathrm{t}}]). \tag{1.14}$$

  If $r = \beta$, it follows from the Euler equations that

$$\mathrm{c}_{\mathrm{t}} < E[\mathrm{c}_{\mathrm{t}+\tau}|\mathrm{I}_{\mathrm{t}}]. \tag{1.15}$$

  Under the ex ante budget constraints, this implies the following result:

$$\mathrm{c}_{\mathrm{t}} < r\mathrm{NPV}[\mathrm{W}_{\mathrm{t}}|\mathrm{I}_{\mathrm{t}}]. \tag{1.16}$$

That is, optimal consumption is lower than the annuity that derives from the expected value of wealth. The government saves part of this annuity.

The simulations in the main text assume that the resource revenues are determined by:

$$y_t = k\frac{Q_t P_t}{GDP_t}, \tag{1.17}$$

in which Q_t is the quantity of the resource extracted at period t, and k is the effective rate of resource taxation. For simplicity, it is assumed that Q_t can change from one year to the next, but that $E[Q_{t+\tau}|I_t] = Q_t$, and that Q_t does not depend on P_t or any of its past values. Assuming that production shocks are positively correlated to price shocks would result in greater precautionary savings. It is also assumed that P_t follows the following process:

$$p_{t+1} = max\left\{\mu_{t+1} + \phi(p_t - \mu_t) + \varepsilon_{t+1}, \underline{p}\right\}, \tag{1.18}$$

in which ε_{t+1} is independent across time and normally distributed with a mean of zero and a standard deviation $\sigma_t^2 = c\mu_t$ (with c constant); $\underline{p}$ is a lower bound on prices; and μ_{t+1} is the long-run price trend, which is assumed to follow:

$$\mu_{t+1} = \mu_t(1+\pi). \tag{1.19}$$

(This further assumes that $\underline{p} < \mu_0$.)

Under this formulation,

$$E[P_{t+\tau}|I_t] = \mu_t(1+\pi)^\tau + \phi^\tau(p_t - \mu_t). \tag{1.20}$$

This formulation is used because it allows $NPV[W_t|I_t]$ to be expressed in a conveniently compact way. Notice that this formulation encompasses a random walk if one sets $\pi = 0$ and $\phi = 1$. Under the prevailing assumptions on prices and quantities in this analysis:

$$E[y_{t+\tau}|I_t] = k\frac{Q_t}{GDP_t}\left[\mu_t\left(\frac{1+\pi}{1+n}\right)^\tau + \left(\frac{\phi}{1+n}\right)^\tau (p_t - \mu_t)\right]. \tag{1.21}$$

$NPV[W_t|I_t]$ simplifies to:

$$NPV[W_t|I_t] = \frac{Q_t}{GDP_t}\frac{1}{1+r}\left[\mu_t\frac{1-\psi^{T-t+1}}{1-\psi} + \frac{1-\varphi^{T-t+1}}{1-\varphi}(p_t - \mu_t)\right], \tag{1.22}$$

in which

$$\psi = \frac{1+\pi}{(1+n)(1+r)} \text{ and } \varphi = \frac{\phi}{(1+n)(1+r)}. \tag{1.23}$$

To simulate the Precautionary Permanent Income Hypothesis (PPIH) and standard PIH (that is, PIH under certainty), we assume the standard constant relative risk aversion (CRRA) utility function $(c_t) = \frac{c_t^{1-\rho}}{1-\rho}$, where ρ is the coefficient of risk aversion, and we simulate the model numerically adapting Carroll's endogenous gridpoint solution method to the model illustrated above (Carroll 2006).

Finally, because the CRRA utility function does not allow one to determine precautionary savings in close form, to illustrate what precautionary savings depend upon, following Caballero (1990), the rest of the analysis will rely on a specific example for the utility function. This will allow to compute in closed form the amount of precautionary saving at each period *t* for an exponential utility function, $u(c_t) = -\frac{e^{-\rho c_t}}{\rho}$, keeping the termination period (when resources are exhausted) fixed. It turns out that:

$$c_t = rNPV(W_t|I_t) - \Gamma_t. \tag{1.24}$$

Precautionary savings $\Gamma_t = 0$ for $t \geq T$ and they are determined recursively for $t < T$,

$$\Gamma_{t-1} = \frac{\theta}{1+r}\left(\frac{r}{1+r}\right)^2 \frac{var_{t-1}}{2} + \frac{\Gamma_t}{1+r}, \tag{1.25}$$

in which (by letting $\psi = \frac{\phi}{(1+n)(1+r)}$ and with σ_t^2 being the variance of the price shocks ε_t):

$$var_{t-1} = \left(\kappa \frac{Q_t}{GDP_t}\right)^2 \left(1 + \psi \frac{1-\psi^{T-t}}{1-\psi}\right)^2 \sigma_t^2. \tag{1.26}$$

The formula suggests that precautionary savings increase with the extraction horizon $T - t$, the variance σ_t^2 , the persistence ϕ of price shocks, the dependence on resource revenues $\kappa \frac{Q_t}{GDP_t}$, and the risk aversion ρ.

FISCAL REGIMES FOR EXTRACTIVE INDUSTRIES AND REVENUE VOLATILITY[3]

Countries use a wide range of fiscal instruments to collect revenue from extractive industries (EI). These vary significantly among jurisdictions, and multiple instruments are commonly applied within a single regime. This makes it difficult to make a comprehensive assessment of all fiscal instruments currently in use. Nonetheless, this Background Note presents a brief evaluation of the implication for the volatility of receipts of tax and nontax instruments most commonly found in resource-rich countries, such as ad valorem royalties, the corporate income tax (CIT), the resource rent tax (RRT), the production sharing contract (PSC), and state participation.

[3] This section was prepared by Diego Mesa Puyo.

Five fiscal regimes, each using a different fiscal instrument to collect the government share, were evaluated using IMF's Fiscal Analysis of Resource Industries (FARI) model.[4] To make the different instruments somewhat comparable, each fiscal regime was calibrated to yield an average effective tax rate (AETR) of 50 percent.[5] Panel 1 of Figure 1.1 shows that, for the specific project circumstances being assumed there, an ad valorem royalty at a rate of 35 percent yields the same government take as a corporate income tax with a 45 percent rate;[6] or a resource rent tax with a rate of 52 percent when the project reaches an internal rate of return (IRR) of 15 percent or higher; or a paid-up state participation of 50 percent (the government shares in both revenue and costs, and is responsible for financing its equity in the project); or an R-factor–based production sharing contract (the government starts to receive its share of production only once all costs have been recovered) with a maximum government share of 55 percent.[7]

The progressivity of each instrument is first assessed by evaluating the government share of total benefits[8] at different prices (constant over time) and their corresponding project pretax IRR. The share of total benefits from the ad valorem royalty is relatively stable (panel 2). However, a very high royalty could make a project uneconomical. The resource rent tax, on the other hand, appears to be the most progressive instrument. The government does not receive any revenue when the pretax IRR of the project is below 15 percent. The state participation and production sharing mechanisms also exhibit significant progressivity. Finally, while the corporate income tax is less stable than the royalty, it is not as progressive as the other three profit-related instruments (because it includes in the tax base a normal return to equity).

The implications of the volatility of revenue of each instrument are evaluated under explicit uncertainty (through simulated stochastic oil price paths using an AR(1) process) in Figure 1.1., panel 3 shows the probability distribution of expected government revenue under each regime. Panel 4 shows their minimum, mean, and maximum expected revenue. The results

[4] The analysis uses a stylized large petroleum project, with total production of approximately 950 million barrels of oil, a price assumption of $75 a barrel over the entire life of the project, and a pretax IRR of 27 percent.

[5] The AETR is the ratio of government revenue to project pretax cash flows. The 50 percent AETR is calculated using a discount rate of 10 percent. Results in undiscounted terms are also shown.

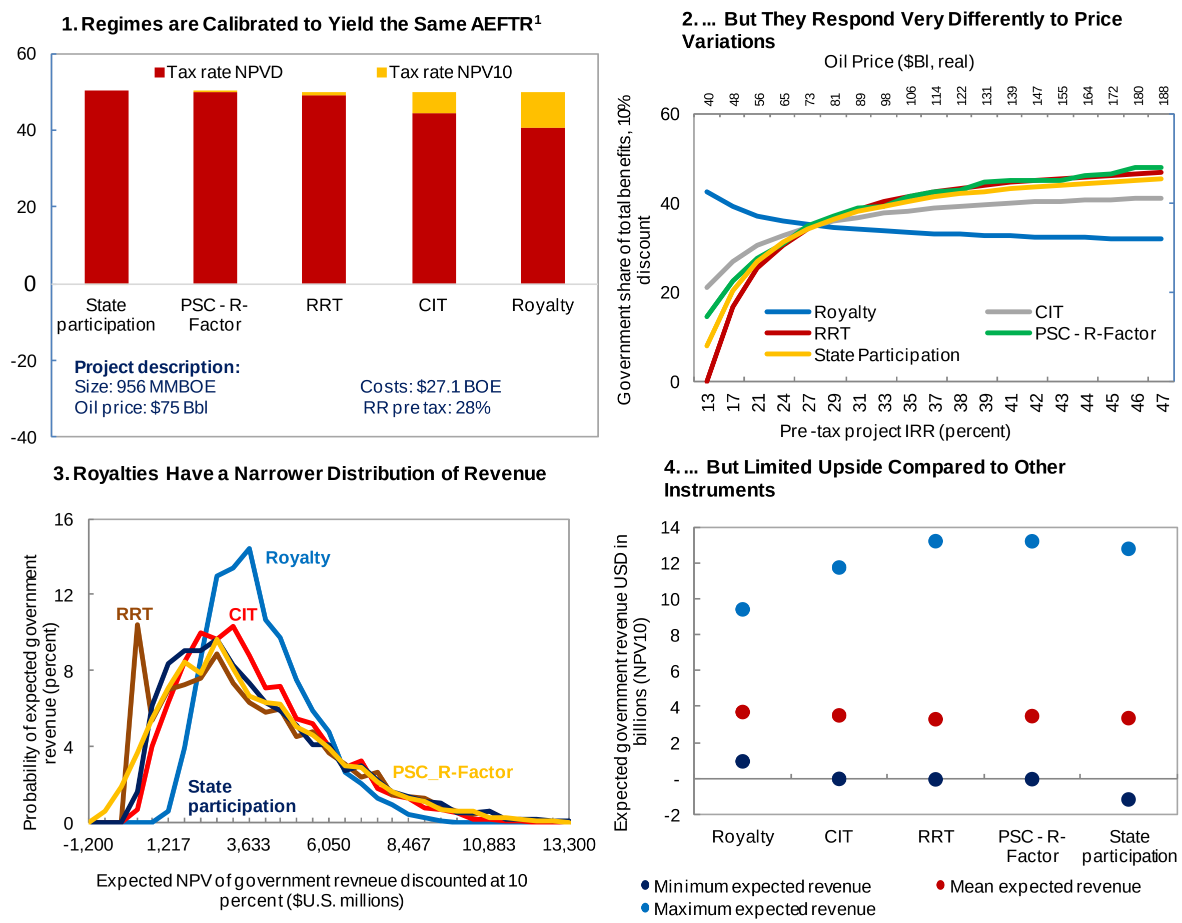
[6] The CIT regime assumes that exploration costs are immediately expensed, while development costs are depreciated over five years using the straight line method

[7] Under the R-factor system, the government's share of production increases with the ratio of the contractor's cumulative revenues to the contractor's cumulative costs (the R-factor). In this case, the government share is 30 percent when the R-factor is between 1 and 2, and increases to 55 percent when the R-factor is above 2.

[8] Total benefits is defined as revenue minus operating costs and replacement capital investment.

are presented in net present value (NPV) terms, using a discount rate of 10 percent. The volatility of the distribution of expected government revenue for the royalty is relatively low compared to other instruments. The state participation option, on the other hand, appears to be the most volatile instrument—since the government can suffer net losses when prices are very low. The corporate income tax, resource rent tax, and production sharing contract options are more volatile than the royalty, but these regimes usually do not result in losses for the government.

Figure 1.1. Fiscal Instrument Progressivity and Revenue Volatility



Source: IMF staff calculations and estimates.
Note: NPV = Net present value, CIT = Corporate income tax, RRT = Resource rent tax, PSC-R-Factor = R- factor based production sharing contact.
¹Tax rates are average effective tax rates.

References

Arezki, R., K. Hamilton, and K. Kazimov. 2011. "Resource Windfalls, Macroeconomic Stability and Growth: The Role of Political Institutions." IMF Working Paper 11/142, International Monetary Fund, Washington.

Bornhorst, F., S. Gupta, and J. Thornton. 2009. "Natural Resource Endowments and the Domestic Revenue Effort." *European Journal of Political Economy* 25: 439–46.

Caballero, R. 1990. "Consumption Puzzles and Precautionary Savings." *Journal of Monetary Economics* 25 (1): 113–36.

Carroll, C. 2006. "The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems."*Economics Letters* 91 (3): 312–20.

Crivelli, E., and S. Gupta. 2014. "Resource Blessing, Revenue Curse? Domestic Revenue Effort in Resource-Rich Countries." *European Journal of Political Economy* 35 (C): 88–101.

Engel, E., and R. Valdes. 2000. "Optimal Fiscal Strategy for Oil-Exporting Countries." IMF Working Paper 00/118, International Monetary Fund, Washington.

Husain, A., K. Tazhibayeva, and A. Ter-Martirosyan. 2008. "Fiscal Policy and Economic Cycles in Oil-Exporting Economies." IMF Working Paper 08/253, International Monetary Fund, Washington.

Pesaran, H., Y. Shin, and R. Smith. 1999. "Pooled Mean Group Estimation of Dynamic Heterogeneous Panels." *Journal of the American Statistical Association* 94 (446): 621–34.

Villafuerte, M., P. Lopez-Murphy, and R. Ossowski. 2010. "Riding the Roller Coaster: Fiscal Policies of Nonrenewable Resource Exporters in Latin America and the Caribbean." IMF Working Paper 10/251, International Monetary Fund, Washington.