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One Rule Fits All? Heterogeneous Fiscal Rules for Commodity Exporters When Price Shocks Can Be Persistent

Theory and Evidence

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Abstract

Commodity-exporting developing economies are often characterized as having needlessly procyclical fiscal policy: spending when commodity prices are high and cutting back when prices fall. The standard policy advice is instead to save during price windfalls and maintain spending during price busts. This paper questions this characterization and policy advice. Using a New Keynesian model, it finds that optimal fiscal policy is heterogeneous depending on the commodity exported and exchange rate regime. Optimal fiscal policy is often procyclical in countries with floating exchange rates because many commodity price shocks are highly persistent, and so they should be spent according to the permanent income hypothesis. In contrast, in countries with fixed exchange rates, optimal fiscal policy becomes countercyclical to smooth the business cycle. Empirically, the paper introduces a new measure of fiscal cyclicality, the marginal propensity to spend (MPS) an extra dollar of commodity revenues, and shows that it is moderately procyclical overall but highly heterogeneous across countries depending on their characteristics. Consistent with theory, the MPS is more procyclical in countries with floating exchange rates than those with fixed exchange rates. Moreover, in countries with floating exchange rates, the MPS is higher in countries facing more persistent commodity price shocks.

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One Rule Fits All? Heterogeneous Fiscal Rules for Commodity Exporters When Price Shocks Can Be Persistent: Theory and Evidence

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Introduction

Commodity-exporting developing economies are often characterized as having needlessly procyclical fiscal policy: increasing government expenditure when commodity prices are high and then cutting back when commodity prices fall. A consensus in the literature is that these countries should instead adopt acyclical structural surplus rules (SSRs) that save resource windfalls when prices are high, and maintain spending when prices are low (e.g., Kumhof and Laxton 2013, Pieschacon 2012).[1] The rationale for such advice is twofold. First, procyclical fiscal policy tends to reinforce the business cycle, exacerbating booms and aggravating busts (the "economic stabilization motivation"). Second, the permanent income hypothesis (PIH) suggests that agents should smooth consumption by only spending the permanent component of their income (the "consumption smoothing motivation").

This paper questions the consensus views that SSRs are always optimal policy for commodity exporters and that fiscal policy for commodity-exporting developing countries is always a long way from optimal. Instead, we find that the optimal fiscal rule is heterogeneous: it can be countercyclical or procyclical depending on the persistence of the country's commodity price shocks and on its exchange rate (ER) regime—there is no "one-size-fits-all" optimal fiscal rule. While no country's fiscal policy is likely to be optimal, we do find empirical evidence that procyclicality varies with the ER regime and commodity price shock persistence in the way suggested by theory.

Our point of departure from the theoretical literature is simple but important: we recognize that most commodity price shocks are highly persistent (whereas the literature mostly analyzes the effects of temporary shocks). We calculate the

[1] Chile's fiscal rule targets a primary structural balance calculated based on a long-run "reference" price of copper, saving extra revenues when the price of copper is high (relative to the reference) and running a deficit when the price is low. Norway's fiscal rule, which is also often cited as best practice, achieves the same goal of smoothing commodity prices by saving all oil revenues offshore in a sovereign wealth fund and spending only the long-run rate of return (Gonzalez et al. 2013) (which also helps to address intergenerational equity, which is beyond the scope of this paper).

marginal propensity to spend (MPS) commodity revenues—the fraction spent of an extra dollar of resource revenue due to a price shock—in a relatively standard open economy New Keynesian (NK) model with a share of financially constrained households, as in Kumhof and Laxton (2013). If price shocks are temporary, the NK model suggests both consumption smoothing and economic stabilization motivations imply that an acyclical SSR is optimal, regardless of the ER regime, rationalizing the conventional wisdom.

However, if commodity price shocks are persistent, the ER regime becomes a crucial determinant of optimal fiscal policy. When the ER is floating, fiscal policy is less important for economic stabilization (which is achieved by monetary policy), and so the fiscal authorities can focus on consumption smoothing on behalf of financially constrained households. As revenue shocks are persistent, the PIH suggests a large fraction should be spent, leading fiscal policy to be procyclical.[2]

On the other hand, when the ER is fixed, monetary policy is impotent and so optimal fiscal policy in a NK model must also try to stabilize the economy. Unlike with temporary shocks, persistent shocks generate large output gaps as forward-looking households start to consume today based on tomorrow's economic windfalls. In this environment, fiscal policy faces a trade-off: countercyclical spending to close the output gap or procyclical spending to smooth consumption. Our model suggests that optimal fiscal policy turns out to be countercyclical in the short run (less than one year), acyclical in the medium run (one year), and procyclical in the long run (two-plus years) as prices adjust and the output gap closes.

To produce quantitative estimates of the optimal MPS, we calibrate our NK model to a typical commodity-exporting country in Sub-Saharan Africa (SSA), where commodity price shocks are very persistent, with a half-life of 6.7 years. For the typical country in SSA with a floating ER, the optimal MPS is about 0.5: around 50 cents of every 1 dollar in cyclical commodity revenues should be spent (procyclical). In contrast, the typical country in SSA with a fixed ER should *cut*

[2] This is the result of Mendes and Pennings (2017), but in a NK model rather than an RBC model.

spending by 20 cents for every extra 1 dollar of revenues in the short term (countercyclical). However, these summary figures mask substantial heterogeneity across individual countries in SSA, depending on the persistence of the price shocks of the commodities they export.[3]

These results are calculated assuming that governments receive all commodity export revenues. But increasingly, governments are implementing local content restrictions, which can be modeled as a fraction γ of government commodity revenues accruing directly to domestic households (as foreign producers need government incentives for local production). Local content restrictions in our model make the optimal rule less procyclical (more countercyclical) because fiscal policy must work against the extra procyclical spending of domestic workers. There are no good data on degree of local content, but, for example, with $\gamma = 20\%$, an MPS of 0.5 is reduced to 0.375 and an MPS of -0.2 is reduced to -0.3.[4]

Empirically, our methodological contribution is to estimate the MPS consistent with our theoretical model, which allows us to *quantitatively* compare the empirical procyclicality with that predicted by the model. To our knowledge, we are the first to do that in the literature on fiscal procyclicality in developing countries, which has otherwise relied on atheoretical correlations or reduced-form estimates as procyclicality measures. We show that these atheoretical measures can be misleading as to how procyclicality varies quantitatively across countries. Specifically, a reduced-form regression of changes in spending variables on changes in log commodity price indices makes countries with smaller commodity revenues appear more acyclical. In addition, usual correlation-based measures of cyclicality in the literature are even more concerning, as they also depend on the relative variances of commodity and non-commodity revenues.

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[3] For example, Botswana (floating ER) should only spend one-third of revenue windfalls (and save two-thirds), as shocks to diamond prices are moderately persistent (three-year half-life), which is much lower than the MPS of 0.6 for oil exporters like Angola and Sudan, which experience more persistent price shocks (nine-year half-life, also with floating ER). See Appendix Table 3 for a list of model-generated MPS for individual countries, noting that price shock persistence, on which these are based, is estimated with noise.

[4] In fact, an economy with local content (LC) fraction γ is isomorphic to an economy with no local content (NOLC) if $MPS_{LC} = (MPS_{NOLC} - \gamma)/(1-\gamma)$.

Our empirical specification involves regressing the change in spending (as a share of GDP) on the change in commodity revenues (also as a share of GDP) for a panel of 54 emerging market developing economies (EMDEs) (including 22 countries in SSA) over 1980–2016. As commodity revenues can be endogenous, we instrument them by the percentage change in a country-specific commodity price index scaled by commodity revenues as a share of GDP. The scaling removes the dependence of procyclicality estimates on the size of commodity revenues and allows us to consistently estimate the MPS. Motivated by our theoretical results, we estimate a flexible specification where the MPS can vary with the ER regime and the persistence of commodity price shocks. We also control for other determinants of procyclicality in the literature, such as institutional quality, financial depth, and real GDP per capita.

Empirically, we find that EMDEs spend 25c of every extra dollar of commodity revenue on average (MPS=0.25). Countries in SSA spend 0.3c for every dollar leading fiscal policy to be more procyclical in Africa than in other developing countries. Splitting by ER regime, the MPS is more procyclical for floating ERs (0.3) than for fixed ERs (0.15) for a typical commodity exporter in the EMDE sample.[5] The MPS displays the same pattern in SSA: 0.5 for the typical country with a floating ER and 0.15 for countries with a fixed ER.

These empirical results suggest that, on average, actual fiscal policy in EMDEs may not be suboptimal as is often claimed, at least qualitatively. First, fiscal policy is more procyclical in countries with floating than fixed ERs, as predicted by the NK model. Second, both the optimal and estimated MPS diverge for fixed and floating ER regimes as persistence increases. For example, as the half-life of commodity price shocks increases from five to twenty years, the predicted MPS increases substantially for countries with floating ERs, but is fairly flat for countries with fixed ERs—with a similar pattern observed for the optimal MPS.

However, we do find some quantitative differences between the model's predictions and the data. Across EMDEs as a whole, fiscal policy is too acyclical:

[5] A typical country is one with average half-life of commodity price shocks, institutional quality, financial depth, and per capita income.

not countercyclical enough for fixed ER countries and not procyclical enough for floating ER countries. For SSA countries, fiscal policy is generally too procyclical for countries in both regimes. Moreover, the divergence in the MPS by ER regimes as persistence increases is more extreme than suggested by the model, especially for SSA. In summary, there is some evidence the fiscal policy is needlessly procyclical but only in SSA and not in developing countries in general.

The remainder of the paper is organized as follows. Section II relates the paper to the literature. Section III presents the NK model and shows how the optimal MPS changes with the ER regime and the persistence of commodity price shocks in a version of the model calibrated to SSA. Section IV discusses the existing measures of cyclicality in the literature and describes the data and the methodology applied to estimate the MPS. Section V estimates the cross-country MPS for EMDEs and SSA in the data and compares the empirical results with the NK model's predictions. This section also provides a battery of robustness tests. Section VI concludes.

I. Related Literature

The closest papers to ours are Kumhof and Laxton (2013) on theory and Cespedes and Velasco (2014) on the empirics. Kumhof and Laxton (2013) use a similar NK model to ours to argue that the SSR is the optimal rule for Chile.[6] In contrast, our optimal MPS for Chile (see Panel A of Figure 2) is procyclical, with an MPS of around 0.5. The difference between these results is driven by the assumptions about the persistence of copper prices. Based on a sample from 1850 to 2017, we estimate the half-life of copper price to be five years, while Kumhof and Laxton (2013) estimate a half-life of two years based on a shorter sample from 1999 to 2007.

[6] Our paper also relates to other literature on the cyclicality of fiscal policy for commodity-exporting countries, which identifies four key roles for fiscal policy: smoothing the business cycle, smoothing tax rates (Barro 1979), Dutch disease (Pieschacon 2012) and smoothing the consumption of hand-to-mouth households (Medina and Soto 2007 and Kumhof and Laxton 2013).

Cespedes and Velasco (2014) argue that procyclicality for commodity exporters is lower for the 2000s commodity boom relative to earlier booms, due in part to better institutions. The empirical part of our paper is similar in spirit to Cespedes and Velasco (2014), but we seek to explain cross-country variation in cyclicality based on the persistence of commodity price shocks and ER regime rather than due to institutional quality (which for us is a control). While we also construct country-specific commodity price indices in a similar way as Cespedes and Velasco (2014), we estimate the MPS consistent with our theoretical model rather than estimating a reduced form, which we argue below improves the accuracy of the estimates.

Our paper also relates to the literature on the persistence of commodity price shocks. Although most papers in this literature recognize that the persistence of commodity prices is a key variable for policymaking in commodity-rich countries, they generally do not calculate optimal fiscal policy as we do.[7] Using a median-unbiased estimator on commodity price data for 60 commodities from 1957 to 1998, Cashin et al. (2000) find that the majority of individual commodities have a half-life above 5 years. Using a maximum likelihood approach, Borensztein et al. (2013) find that 7 of 9 important commodities have a half-life of 5 years or higher. Fornero and Kirchner (2014) estimate an unobserved components model for the copper price and find a half-life of the persistent component of 24 years. Fernández et al. (2020) decompose the dynamics of commodity prices into transitory shocks and a permanent global component (the "commodity super cycle"), and find the latter is an important driver of country-level business cycles (but not a dominant one). As an input into our calculations, we estimate the persistence of 61 commodity prices using around a century of data taken from Jacks (2013) and find wide variation in the persistence of shocks across commodities, with many being highly persistent (though still stationary).[8]

[7] For example, Cashin et al. (2000) argue that highly persistent commodity price shocks will undermine commodity price stabilization schemes, but they make this argument descriptively.

[8] The long sample is important to reduce the well-known attenuation bias on the estimation of persistence in short samples. Appendix Table 2 lists the estimated persistence of 61 individual commodity prices.

II. Optimal Fiscal Rules in a New Keynesian Model

In this section, we present a New Keynesian (NK) model of a small open economy (subsection A) which we calibrate to a typical commodity exporter in SSA (subsection B). We use the NK model to calculate the optimal response to a persistent commodity price shock in countries with floating and fixed ERs, and compare it to common "real world" fiscal rules (subsection C). Subsection D shows the dynamic (impulse) response to a commodity price shock which illustrates how with a fixed ER, fiscal policy is countercyclical in the short term, but becomes procyclical over time. Subsection E recalculates the optimal rule for exporters of commodities with price shocks of different degrees of persistence, and shows that shock persistence drives the difference between our results and others in the literature. Finally, subsection G presents a robustness test when we allow some commodity revenues to accrue directly to households through local content.

A. Model Overview

We set up an NK model of a small open economy consisting of a small country (home) and the rest of the world (foreign). As the model is relatively standard, we present the main features of the model in this section and provide a full description in the online Technical Appendix. The model's structure is taken from the canonical NK small open economy from Galí and Monacelli (2005). However, we depart from their setup by assuming incomplete markets, a share of hand-to-mouth households, a government, and a commodity resource sector.[9]

As in Galí and Monacelli (2005), households supply labor to domestic firms at competitive wages, and consume a bundle of home and foreign goods (which they can substitute with constant elasticity η). There is a preference for home goods captured by the parameter $1-\alpha \in [0,1]$. The home good is a composite index of a continuum of varieties, with each variety produced by a single monopolist domestic

[9] Galí and Monacelli (2005) model a continuum of small open economies, whereas we group these into a small home country and foreign ($\star$) country that represents the rest of the world combined.

firm. Each domestic firm produces a variety using one unit of labor and, each period, can reset their prices with probability $1-\xi$, as in Calvo (1983).[10]

Households. The home economy is inhabited by two types of households: a share ω of households cannot borrow or save and consume their entire income (wages and transfers) hand-to-mouth each period, and the remaining fraction $1-\omega$ are Ricardian households. The Ricardian households also receive wages transfers but can save and borrow through non-contingent government bonds (domestic and foreign), and also own domestic firms. Both types of households maximize their expected utility (standard CRRA) over a stream of hours worked and consumption.

The resource sector and the government. Each period, the economy produces a fixed amount of the resource good Q_{ss} that is exported at price P_t. We make the simplifying assumption that the resource does not run out during the simulation period (discussed further below) and that all proceeds from the resource activity accrue to the government.[11] The price of the resource good follows a simple autoregressive process with annual autocorrelation (persistence) ρ and error standard deviation σ_p. The half-life of the shock, i.e., the required time for the shock to decay by half of its initial value, is given by $\ln(0.5)\,/\ln(\rho)$. The government collects commodity revenues, pays out transfers to households, and borrows/saves internationally through a non-contingent bond issued by the foreign government.[12]

The untargeted transfers to households follow the simple fiscal rule:

$$Tr_t - Tr_{ss} = \theta_P v_t Q_{ss}(P_t - P_{ss}) + \theta_A v_t (A_t - A_{ss}), \qquad (1)$$

where $Tr, Q, P,$ and A denote transfers, units of the resource good, price of the resource good, and public assets, respectively. The subscript ss denotes the long-

[10] Households substitute across different varieties at the constant elasticity ϵ. As a monopolist, each firm will set their prices to minimize the expected deviations from their optimal mark-up: $\epsilon/(\epsilon-1)$.
[11] In Section III.E, we assume that a share of the resource income accrues to households (local content).
[12] As is standard in NK models, the government also pays a fixed employment subsidy τ for the domestic firms. The subsidy is such that it offsets the monopoly power of domestic producers and the country as a whole. The subsidy renders the flexible price economy efficient.

run (steady-state) value of each variable. While commodity prices and public assets are denominated in foreign currency (dollars), transfers are denominated in home currency (e.g., pesos). To express all variables in the home currency, we multiply the right-hand side of equation (1) by the nominal ER, υ_t, pesos per dollar.

The parameter θ_P is the *one-quarter MPS resource revenue* (1q-MPS): the fraction spent of an extra dollar of commodity revenue in the quarter of the shock. We also report the j-year MPS as the average fraction spent of extra resource revenue over the first j-years from the shock. The one-year MPS is comparable to the empirical MPS estimated in Section V with annual data.[13] The parameter θ_A is the MPS accumulated assets: the fraction spent of an extra dollar of public assets (above their target value) every quarter.

Fiscal rules. We consider three types of fiscal rules. The *optimal simple rule* (OSR) chooses θ_p and θ_A to minimize the household's welfare loss. The welfare loss is a linear function of the variance each household's consumption and hours worked plus the variance of inflation.

The *balanced budget rule* (BBR) involves minimizing the volatility of public assets around the long-term level by spending all extra commodity revenues ($\theta_p = 1$).[14] The BBR is a procyclical fiscal rule since expenditure (transfers) increase during times of high commodity prices and decrease in times of low commodity prices.

The *structural surplus rule* (SSR) involves minimizing the volatility of fiscal instruments (transfers in our case). To achieve this, government saves revenues in excess of their long-run level and draws down from their sovereign wealth fund (i.e., public foreign assets) when revenues fall below the long-run level. The value of the parameters that accomplish that are $\theta_p = 0$ (saves all extra resource revenue) and $\theta_A > r_W$ (spends at least the net interest rate on excess public assets). The SSR is acyclical since transfers are nearly constant over the commodity cycle.

[13] Note that the j-year MPS is a non-linear increasing function of θ_P and θ_A and converges to one as $j \to \infty$.

[14] The government must also spend at least the net interest rate on public assets ($\theta_A > r_W$), where r_W denotes the world's net interest rate, which is assumed to be constant at 4% per year.

Financial markets and monetary policy. There are two assets in this economy. One is a bond denominated in domestic currency that is issued by the home government and pays gross nominal interest rate R_t. The other is a bond issued by the foreign government denominated in foreign currency with nominal interest rate R_t^*, which is the sum of the constant "world" interest rate, r_W, plus a debt-elastic country spread, ψ. The central bank sets the gross domestic nominal interest rate, R_t, according to an inflation-targeting regime (floating ER) or a peg to the foreign currency (fixed ER). Uncovered interest rate parity (UIP) holds so that either bond provides the same expected return when converted to the same currency.[15]

Constant natural resource production and precautionary savings. An assumption in our NK model worth highlighting is that the production of the natural resource good is constant at Q_{ss}, which allow us to abstract from concerns about intergenerational equity. On the surface, this simplification may seem unrealistic—almost by definition—for producers of *non-renewable* natural resources.[16] But historical data suggest it is actually a good approximation for countries with large reserves relative to current production, and active mineral exploration. Indeed, since 2000, the largest 10–20 producers of key commodities have shown *increased* reserves and production, likely due to technological progress and new discoveries (see Appendix Figures 3 and 4).[17] For example, BP argues that "over the last 35

[15] We define the Consumer Price Index (CPI) as the price index of a unit of consumption in the home country (basket of the home and foreign goods) and the Producer Price Index (PPI) as the price index of a unit of the home good (basket of all good varieties). The real ER (RER) is defined as the price of the foreign good (converted to the home currency) over the CPI. The terms of trade is defined as the price of the foreign good (converted to the home currency) over the PPI. As in Galí and Monacelli (2005), the law of one price holds at the variety level: the price of a given variety in different countries is identical once expressed in the same currency. In the presence of home bias, the law of one price carries over to the PPI level but not to the CPI level. Note that the UIP implies that, in the linearized model, the return of the domestic bond is equal to the world interest rate plus the debt-elastic spread plus the expected devaluation of the nominal ER.

[16] Naturally, agricultural commodities are renewable, and so a constant Q_{ss} is less controversial.

[17] Appendix Figure 3 shows an index of the evolution of the reserves of the main natural resource produced in 13 large commodity exporters from 2000 to 2017. The index is equal to 100 in 2000 and is built with data from the BP-Energy dataset and the US Geological Survey. One can see that reserves increased from 2000 to 2017 in 10 of 13 commodity exporters. For some countries, such as Peru, Venezuela, and Brazil, the increase is quite remarkable, with reserves tripling over 2000–

years or so, for every barrel of oil consumed, two have been added to estimates of proved oil reserves" (Dale and Fattouh 2018).

Nonetheless, the conventional logic of declining production may apply for many countries, especially those with small reserves relative to current production and limited scope for new discoveries. In these countries, intergeneration equity is a first order issue for the PIH, meaning that a fraction of revenue should be saved (or invested), reducing the optimal MPS in response to permanent shocks.[18] The predictions of our NK model are less applicable for these countries.

B. Calibration to Sub-Saharan African Countries

Generic parameters. Panel A of Table 1 displays the generic parameters (not country-specific) that are calibrated to international data or are taken from the literature. Most important, we assume 50% of the population is hand-to-mouth ($\omega = 0.5$, following Galí et al. 2015); prices can be adjusted once a year, on average (ξ = 0.25); and time is quarterly, so the discount rate is set to achieve an interest rate of 4% ($\beta = 0.99$). We also set the debt-elastic interest spread so that a 100% of non-resource GDP increase in net debt increases the annual interest rate by one percentage point ($\psi = 0.01/4^2$).[19] When the ER is floating, the central bank responds to home Producer Price Inflation (PPI) with coefficient $\phi_{\pi_H} = 1.5$.

2017. Only Mexico registered a significant fall in reserves during the period in consideration, likely due to underinvestment in exploration. Appendix Figure 4 displays an index of reserves in 2017 for oil (Panel A), natural gas (Panel B), copper (Panel C), and gold (Panel D) in the world's top producers of each commodity (relative to reserves in 2000). It also shows the average annual growth rate of production in 2000–2017. One can see that, for most countries, both production and reserves of natural resources increased from 2000 to 2017.

[18] Precautionary saving motives can undermine the predictions of the PIH (Mirzoev and Zhu 2019).

[19] Schmitt-Grohe and Uribe (2003) set $\psi = 0.001/4^2$ to match the volatility of the observed current-account-to-GDP ratio for Canada. Schmitt-Grohe and Uribe (2016) estimate $\psi = 1/4^2$ for Argentina. As in Mendes and Pennings (2017), we take $\psi = 0.01/4^2$ as a compromise between these two approaches. Most papers in the literature adopt annual frequency, where $\psi = 0.01$ implies that a 100% of non-resource GDP increase in debt increases the annual interest rate by one percentage point. Because our model is expressed in quarterly frequency, we divide by four to convert annual interest rates to quarterly and divide by four again as the debt-to-non-resource GDP ratio is a share of quarterly rather than annual non-resource GDP.

Table 1: Calibration of the NK Model to a Typical Commodity Exporter in Sub-Saharan Africa

Parameters	(1) Symbol	(2) Value	(3) Source/Target
Panel A. General parameters			
Quarterly discount factor	β	0.99	1% interest rate at qtly frequency
Risk aversion	$1/\sigma$	1	Nakamura & Steinsson (2014)
Frisch elasticity	$1/\varphi$	1	Nakamura & Steinsson (2014)
Elasticity of subst. across varieties	ϵ	7	Nakamura & Steinsson (2014)
Elasticity of subst. btw H and F	η	2	Nakamura & Steinsson (2014)
Price rigidity parameter	$1-\iota$	0.25	Galí & Monacelli (2008)
Taylor rule reaction to PPI	π_H	1.5	Galí & Monacelli (2008)
Debt-elasticity of country premia	ψ	0.007	Schmitt-Grohe & Uribe (2016)
Payroll subsidy rate	τ	-0.5%	Farhi & Werning (2012)
Share of hand-to mouth HHs	ω	0.5	Galí et. al (2007)
Panel B. Sub-Saharan Africa			
AR(1) Commodity Price (Quarterly):			
AR coefficient of price	ρ	0.975	Match half-life of 6.7 years
Error % STD of price	σ_p	0.09	Match annual STD of 22%
Structural Parameters:			
Size of H economy/rest of the world	n	1%	Small SSA country
Degree of openness	α	0.4	2000-16 SSA imports 40% GDP
Steady State (% Qtly Non-Res GDP)			
Resource GDP	Y_{ss}^R	20%	2008-12 comm. exports in SSA
Public assets	A_{ss}	-244%	2000-18 external debt in SSA
Private assets (Ricardian HHs)	B_{ss}	0%	No asset revaluation effects
Transfers to Hand-to-mouth HHs	Tr_{ss}''	16%	Equal S.S. cons. across HHs
Transfers to Ricardian HHs	Tr_{ss}''	2%	Equal S.S. cons. across HHs
Profits	D_{ss}	14%	(Endogenously determined)

SSA-specific parameters. Panel B of Table 1 displays parameters calibrated to match key features of a typical country in SSA.[20] On average in SSA, commodity exports represented 15.2% of GDP in 2008–2012, so we normalize the steady-state non-resource quarterly GDP (Y_{ss}^Z) to 1 and set resource GDP (Y_{ss}^R) to 0.2 such that $Y_{ss}^R/(Y_{ss}^R + Y_{ss}^Z) \approx 15\%$. The degree of openness is calibrated so that steady-state consumption of foreign goods is equivalent to 40% of GDP ($\alpha = 0.4$), based on the median imports-to-GDP ratio in SSA during in 2000–2018 (see Appendix

[20] Panel B of Appendix Table 1 displays the list of countries in SSA with available export data from the UN Comtrade Database. Column (1) shows the average commodity exports in 2008–2012 as a percent of GDP. Columns (3)–(8) display the two main commodities exported by each country and their respective shares of GDP.

Figure 1). Finally, the home economy is 1% of the world economy, representing a small SSA country ($n = 0.01$).[21]

Persistence and volatility of commodity prices. The most important parameter is the persistence of commodity price shocks, ρ. To calibrate this parameter, we first construct a commodity price index for SSA. The index is a weighted average of prices of commodities that countries in SSA export. Each commodity is assigned a weight based on its average share of export value out of total goods exports in 2008–2012.[22] We consider 61 commodities for which price data is available either at the World Bank Commodity Price Database (The Pink Sheet) or from Jacks (2013). Export trade data is taken from the UN Comtrade Database (four-digit HS 2002 code). Column (1) of Appendix Table 2 provides the list of 61 commodities we consider.

For each commodity price, we estimate an AR(1) process with OLS using the longest time series available at an annual frequency.[23] Appendix Table 2 reports the implied half-life, which is our baseline measure of persistence, and the price standard deviation. The table shows that commodity prices are highly volatile and shocks are persistent: the median half-life is 5.4 years, and the price annual standard deviation is 42%.[24] Next, we simulate 1,000 observations from the estimated AR(1) process for each commodity price and compute the implied trajectory of the SSA commodity price index. We then use this time series to estimate the autocorrelation and standard deviation of the SSA commodity price index—by OLS with an AR(1) model. Panel B of Table 1 reports the results. The quarterly autocorrelation of the commodity price in the NK model is set to 0.975 (which implies a half-life of 6.7

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[21] There is a larger steady state transfer to the hand-to-mouth households to equalize steady state consumption across households, given that the Ricardian households also profit from firms.

[22] Appendix Table 1 lists the two most important commodities for each country.

[23] As is well known, estimates of persistence are biased on finite samples. However, usually a long time series of commodity price data—typically more than a century—minimizes the size of the bias and hence the severity of the problem.

[24] Appendix Table 2 also reports the data source and the length of each time series in columns (2) and (3), respectively. Columns (4) and (5) report the OLS point estimate of the autocorrelation and error standard deviation (σ_p), respectively.

years), and the quarterly error standard deviation is set to 9% (which implies an annual standard deviation of 22%).

C. The Optimal Marginal Propensity to Spend Commodity Revenues

In this subsection, we show how procyclical the optimal simple fiscal rule should be based on consumption smoothing and economic stabilization, and how it depends on the ER regime and the persistence of commodity price shocks. We also compare the optimal fiscal rule to common real world fiscal rules: BBR and SSRs.

Fiscal policy has one instrument—transfers—but two goals: consumption smoothing and economic stabilization. We first discuss the goals of fiscal policy and then show that, under some circumstances, these goals are conflicting, and the government faces a trade-off between being procyclical to smooth the consumption of the hand-to-mouth households or being countercyclical to stabilize the economy.

Consumption smoothing. The PIH says that as risk-averse households prefer a steady stream of consumption to a volatile one, they should consume based on the permanent annuity value of income rather than current income. A corollary of the PIH is that households should (mostly) save transitory income shocks and (mostly) spend persistent income shocks. In our model, Ricardian households can smooth consumption by borrowing/saving, but hand-to-mouth households cannot, creating a role for fiscal policy to use transfers to smooth consumption on their behalf. Consequently, the persistence of commodity price shocks determines the fiscal response in resource-rich countries: when the shock persistence is low, most of the windfall from commodity price shocks must be saved and fiscal policy should be acyclical (only spending the interest rate). But when the persistence is high, most of the windfall must be spent and fiscal policy should be procyclical.

Economic stabilization. Sticky prices in the NK model mean that the terms of trade between home and foreign goods do not adjust quickly to shocks, which can result in output and employment that depart from those in the (efficient) flexible price allocation. For example, a fall in commodity prices would lead to a fall in the prices of home goods if prices were flexible, shifting demand toward home goods that would stabilize domestic employment. But when prices are sticky (and the ER is fixed), domestic prices do not fall quickly enough, resulting in inefficiently low domestic employment.[25] This creates a role for fiscal policy to "lean against the wind" by providing countercyclical transfers, which will help inflation, output, employment, and consumption to remain close to their efficient counterparts.

Table 2 summarizes the welfare properties of the OSR and two popular fiscal rules, BBR and SSR, under three frameworks: a flexible price economy (Panel A), a sticky price economy with a floating ER and domestic inflation targeting (Panel B, which is very similar), and a sticky price economy with a fixed ER (Panel C).

Table 2 MPS and the Welfare of Fiscal Rules

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	A. Flexible Price			**B. Floating ER**			**C. Fixed ER**		
	BBR	**SSR**	**OSR**	**BBR**	**SSR**	**OSR**	**BBR**	**SSR**	**OSR**
$\boldsymbol{\theta_A}$	.025	.025	.025	.025	.025	.025	.025	.025	.089
$\boldsymbol{\theta_P}$	1	0	0.54	1	0	0.55	1	0	-0.35
1-year MPS	1	0.04	0.55	1	0.04	0.56	1	0.04	-0.18
3-year MPS	1	0.13	0.60	1	0.13	0.61	1	0.13	0.18
5-year MPS	1	0.23	0.64	1	0.23	0.64	1	0.23	0.43
$\%\boldsymbol{SD(\tilde{a}_t^y)}$	23%	333%	141%	23%	333%	138%	22%	334%	125%
$\%\boldsymbol{SD(\tilde{b}_t^y)}$	293%	338%	15%	293%	338%	17%	287%	341%	133%
Welfare loss (OSR Flex=100)	109	115	100	110	118	101	189	140	128
	D. Welfare Loss Decomposition (% of total loss)								
$\boldsymbol{SD(\hat{C}_t')}$	36	38	40	36	37	40	21	31	31
$\boldsymbol{SD(\hat{C}_t'')}$	43	41	41	42	40	41	38	37	40
$\boldsymbol{SD(\hat{l}_t')}$	9	10	9	9	10	9	9	7	6
$\boldsymbol{SD(\hat{l}_t'')}$	12	11	10	12	11	10	6	9	11
$\boldsymbol{SD(\pi_t^H)}$	0	0	0	1	2	1	21	11	10

Notes: BBR = Balanced budget rule, SSR = structural surplus rules, and OSR = optimal simple rule. $SD(.)$ denotes standard deviation. The variables $\tilde{a}_t^y, \tilde{b}_t^y, \hat{c}_t', \hat{c}_t'', \hat{l}_t', \hat{l}_t''$, and, π_t^H denote public assets, private assets, consumption of the Ricardian HH, consumption of the hand-to-mouth HH, hours worked of the Ricardian HH, hours worked of the hand-to-mouth HH, and home inflation (PPI), respectively.

The flexible price economy—pure consumption smoothing. In the flexible price economy, there is no need for economic stabilization and so provides a

[25] Staggered price setting also means that as prices adjust, there will be inefficient price and markup dispersion across goods at the micro level. These distortions are eliminated when prices are fully stabilized (Galí 2015), which is what monetary and fiscal policy try to achieve.

benchmark when the only goal of fiscal policy is to smooth the consumption of hand-to-mouth households. Surprisingly, columns (1) and (2) of Table 2 show that the BBR outperforms the SSR. Moreover, the difference in welfare is significant: the welfare loss is 6% larger under the SSR. This result is in line with Mendes and Pennings (2017), where BBR outperforms SSR in RBC models (which are similar to the flexible price economy here). Still, it is at odds with the literature that finds substantial welfare gains from adopting structural rules over balanced budget rules for commodity exporters.

The OSR is shown in column (3). The 1q-MPS suggests that a 1 dollar increase in commodity revenues should lead to an increase of 54 cents in transfers, which is about halfway in between the BBR and SSR. The 1q-MPS is procyclical because shocks to commodity prices are highly persistent in SSA (6.7 years of half-life) and should be partly spent, according to the PIH. Acyclical rules such as the SSR over-save windfall revenues (and over-spend when commodity prices are low), which means that in the short term, consumption of the hand-to-mouth households under-responds to changes in commodity prices.

The optimal θ_A prescribes that 2.5% of the sovereign wealth fund (SWF) should be spent each quarter, which is greater than the 1% quarterly interest rate.[26] This implies that the j-year MPS increases slowly as j increases (saved revenues are spent at a 10% (4 x 2.5%) annual rate). A related problem is that the SSR leads to an excessively high standard deviation of public and private assets. In the model, the country spread responds to net public assets (SWF). The rate of return on the SWF will decrease as the SWF increases in size, or alternatively, the interest rate increases when the SWF is small. Therefore, a highly volatile SWF under the SSR makes it harder for Ricardian households to smooth consumption by themselves, as the country's interest rate also becomes very volatile. In practice, the volatility of

[26] We also assume that $\theta_A = 0.025$ for the BBR and SSR. For the BBR that choice is not important, as net public assets does not deviate substantially from steady state. For the SSR, a (locally) higher value of θ_A will increase welfare, as it makes transfers more procyclical (closer to OSR).

public assets would create solvency concerns, and the government may eventually reach a debt limit, undermining its ability to provide acyclical transfers.[27]

Sticky price economy with floating ER regime. Panel B of Table 2 shows that optimal policy, welfare losses, and the ranking of simple rules in a sticky price economy with floating ERs are very similar to those in a flexible price economy. Specifically, the optimal rule prescribes that transfers should increase by 55 cents when resource revenues increase by 1 dollar, and transfers should increase by 2.5 cents when public SWF assets increase by 1 dollar (column (6)). In addition, the welfare loss is 7% lower under the BBR than under SSR (columns (4) and (5)). These results are not surprising, as it is well known that monetary policy can absorb demand shocks (such as commodity price shocks) almost perfectly when operating under a Taylor rule under floating ERs (see Galí and Monacelli 2005). Because the central bank provides the necessary countercyclical stimuli to mitigate the inflationary implications of commodity price shocks, the fiscal authority can concentrate on its goal of consumption smoothing, and the resulting optimal transfer is procyclical, as in the flexible price economy.

Sticky price economy with fixed ER regime. Under a fixed ER, monetary policy is set to maintain the peg to the foreign currency and cannot "lean against the wind." The absence of an active monetary policy generates a need for countercyclical fiscal policy that stabilizes the economy over the commodity cycle. Fiscal policy then faces a trade-off between being either countercyclical to control inflation and the output gap or procyclical to smooth the consumption of the hand-to-mouth household. Column (9) in Panel C of Table 2 shows that the optimal transfer rule is countercyclical for fixed ERs. It prescribes a cut in transfers of 35 cents on each dollar increase of commodity revenues in the first quarter. Correspondingly, the BBR yields a welfare loss 35% *larger* than the SSR. Note that

[27] A related literature discusses the effects of commodity prices on the country's borrowing terms. Hamann et al. (2018) argue that being a large oil producer decreases the sovereign risk because it increases a country's capacity to repay. However, large oil discoveries increase the country spread because it makes autarky more attractive. Drechsel and Tenreyro (2018) also find that commodity price fluctuations affect the country spread.

while the welfare costs of price dispersion are negligible for the floating ER, they account for 21% of the total welfare loss under the BBR (Panel D in Table 2).

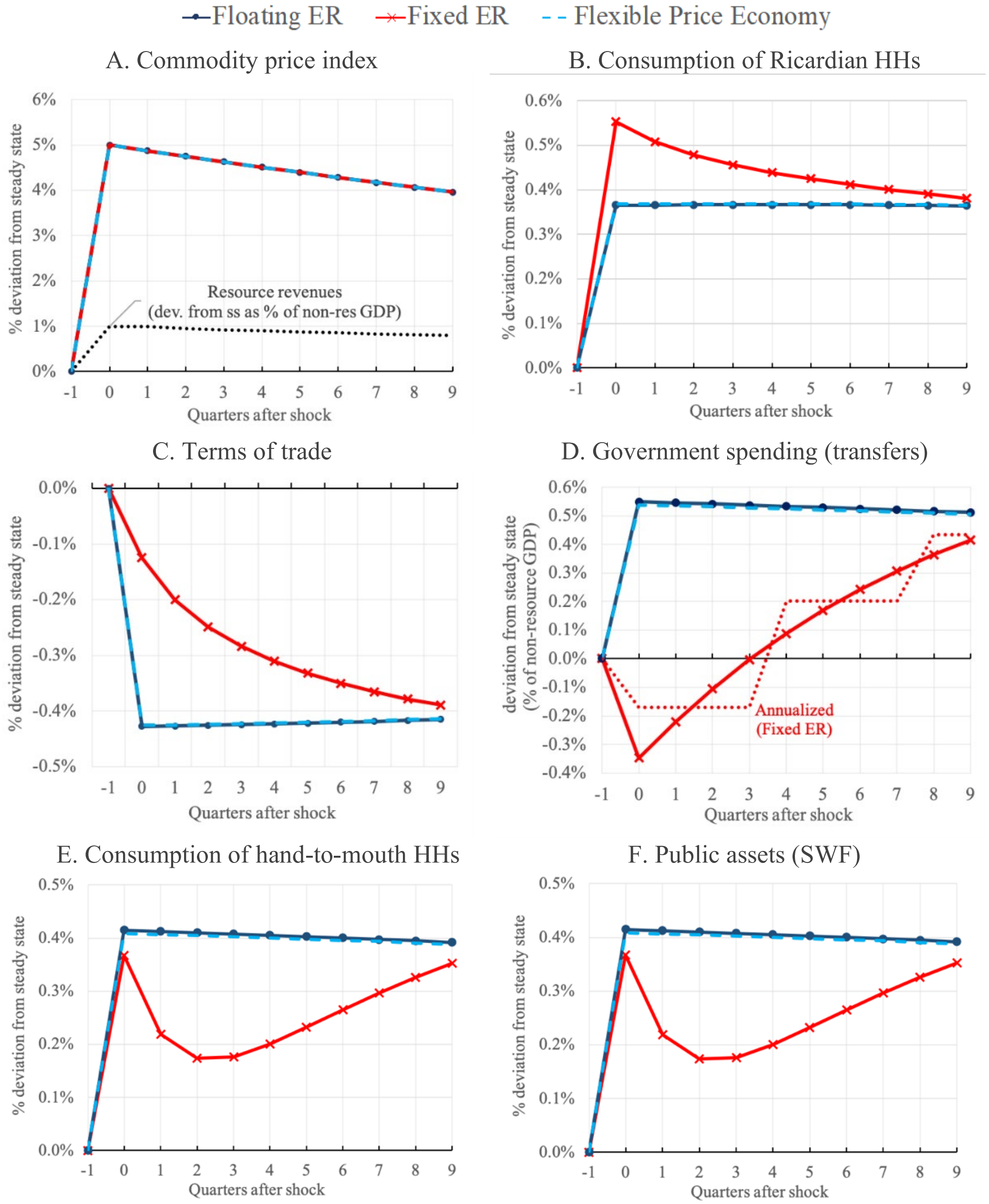
An interesting feature of the OSR for fixed ERs is that it is countercyclical in the short term but is procyclical in the long term. Note that the optimal MPS public assets for the fixed ER ($\theta_a = 0.089$) is 3.5 times higher than for the floating ER, implying that 35 cents of each dollar of saved revenue in the SWF is spent after one year. This implies that the j-year MPS increases sharply with j. Five years after the shock, the government is spending around 70% (0.43/0.64) of what is spent under the floating ER.

The divergence between optimal short- and long-run fiscal policy occurs because prices are only sticky in the short term (firms' expected duration of fixed prices is one year). The government wants to provide some countercyclical stimuli when firms have not yet adjusted their prices to the commodity price shock. But as time passes, an increasing fraction of firms have been able to change their prices, so the welfare losses from insufficient consumption smoothing become more important relative to the gains from economic stabilization, causing fiscal policy to become more procyclical.

D. Impulse Response to a Commodity Price Shock with Optimal Fiscal Rules

Figure 1 displays the impulse response to a persistent 5% increase in the commodity price index, which generates a 1% of non-resource GDP increase in government commodity revenues (Panel A). The half-life of the shock is 6.7 years ($\rho = 0.975$), which matches the persistence of the SSA commodity price index. Variables in the flexible price economy (light blue dotted line), floating ER (dark blue line), and fixed ER (red line) are shown assuming the transfer rule is optimal (columns (3), (6), and (9) of Table 2 , respectively). The most striking feature of Figure 1 is that under a floating ER, the economy replicates almost exactly the path of the flexible price economy, so we discuss these two cases together.

Figure 1: Impulse Response to a Commodity Price Shock under Optimal Fiscal Rules



Notes: The commodity price shock is normalized so that commodity revenues increase by 1% of the non-resource GDP on impact. The annual standard deviation of commodity price shocks in SSA is 9%, and the half-life is 6.7 years. The resource sector accounts for 15% of GDP (20% of non-resource GDP). A +0.5 standard deviation shock is required to increase revenues by 1% of the non-resource GDP.

The persistent increase in commodity revenues boosts the Ricardian household's consumption (Panel B). The behavior of the Ricardian household is independent of the transfer rule in place, as they can borrow (save) to anticipate higher (lower) transfers in the future (i.e., Ricardian equivalence).[28]

A key difference between the flexible price/floating ER and fixed ER is due to the behavior of the terms of trade. In the (efficient) flexible price economy, the terms of trade appreciate on impact, almost to the new long-run value. With sticky prices and a floating ER, the same allocation is achieved by an appreciation of the nominal ER. But under a fixed ER, the terms of trade's initial response is more muted and follows a hump-shaped dynamic. The intuition is as follows. Domestic firms want to respond to the increase in demand by raising their prices, which would normally appreciate the terms of trade. But as prices are sticky, the desired increase in prices can only partly (and gradually) be achieved, meaning that the appreciation of the terms of trade takes 2.5 years, rather than one quarter (Panel C of Figure 1).[29]

The adjustment of the terms of trade has important implications for the dynamics of consumption and the optimal fiscal rule. Under a floating ER/flexible prices, the improvement in the terms of trade drive the excess demand of the Ricardian household toward foreign goods.[30] In this case, the fiscal policy focuses on smoothing the hand-to-mouth household's consumption, and because the shock is highly persistent, the optimal transfer is procyclical. Panel D shows that transfers increase by 0.55% of steady-state non-resource GDP (1q-MPS of 0.55) and remain high for several periods. Panel E shows that the procyclical transfer smooths the hand-to-mouth household's consumption: it increases 0.42% on impact and

[28] Regardless of the fiscal rule, at some point, the government will transfer to households the extra revenue generated by the higher commodity price (recall that the *j*-year MPS converges to one). The Ricardian household anticipates future transfers and responds by increasing current consumption, in line with the PIH.

[29] Under floating ER, the initial rise in PPI leads to a contractionary monetary policy (i.e., higher interest rate), resulting in an appreciation of the nominal ER and the terms of trade. Under fixed ER, the monetary authority cannot raise the interest rate because of its commitment to keep the peg to the foreign currency.

[30] With a floating ER, the nominal ER adjusts, allowing the terms of trade to appreciate at almost zero PPI inflation, and hence achieve efficient production and employment.

remains almost constant over time, as the PIH would suggest.[31] In contrast, under a fixed ER, transfers are countercyclical in the short term to constrain aggregate demand (before prices have adjusted) but support consumption smoothing of the hand-to-mouth household in the long run (after prices have adjusted), consistent with its new higher permanent income. Specifically, Panel D shows that transfers fall by 0.35% of steady-state non-resource GDP in the first period (1q-MPS of -0.35) and increase slowly thereafter.[32] After three quarters, transfer are back to steady state, and after three years, transfers are as high as with floating ERs/flexible prices. This dynamic path is accomplished through a high MPS accumulated public assets (θ_a), as assets increases rapidly (Panel F) in response to the fall in transfers and higher commodity revenue. Overall, the optimal transfer can partially stabilize the economy in the short term, but this implies a volatile (hump-shaped) consumption path of the hand-to-mouth households, resulting in a welfare loss 28% higher than with a floating ER.

E. The Role of Shock Persistence

In this subsection, we show how the procyclicality of the optimal fiscal rule changes with the persistence of commodity price shocks.

The MPS, half-life, and ER in the short run. Panel A of Figure 2 shows the relation between the optimal one-year MPS (y-axis) and the half-life of the commodity price shock (x-axis) in the flexible price economy (light blue line), with a floating ER (dark blue solid line), or fixed ER (solid red line).[33] As before, the lines for the flexible price economy and the floating ER are almost identical. In these two cases, the one-year MPS increases substantially with the half-life of the commodity price shock. When the shock is purely transitory (a zero half-life), the

[31] Note that the consumption of the hand-to-mouth household increases less than the change in transfers (0.42% versus 0.55% of non-resource GDP) due to the negative wealth effect on labor supply. This mechanism is highlighted in Giambattista and Pennings (2017).

[32] Despite the lower transfers from the government, the consumption of the hand-to-mouth household increases due higher wages and hours worked.

[33] To isolate the effect of shock persistence as the half-life varies, when calculating the optimal MPS, we adjust the error standard deviation to keep constant the variance of the commodity price.

government should transfer only 10 cents of each dollar of windfall commodity revenues over the first year in times of high prices. However, when the shock is highly persistent (half-life of ten years), the government should transfer 65 cents of the dollar, implying that commodity-exporting countries in SSA with a floating ER can have significantly different optimal fiscal rules depending on shock persistence. For example, for large oil-exporting countries, such as Angola and Sudan (half-life of eight years), the government should transfer 60 cents of the dollar of windfall revenues. But for large diamond exporters such as Botswana (half-life of three years), the government should transfer only 35 cents. Note that the one-year MPS is an increasing *and concave* function of the price shock's half-life, implying that even commodities with intermediary persistence, such as copper or lead, have procyclical transfers with a one-year MPS above 50 cents.

The MPS in the medium run. Panel B of Appendix Figure 2 displays the relation between the three-year MPS and the half-life of the commodity price shock. While the three-year MPS is almost identical to the one-year MPS for floating ER/flexible price economy, for fixed ER economies, the three-year MPS is now procyclical because after three years, prices have adjusted sufficiently for consumption smoothing to dominate economic stabilization.[34]

Testable predictions. In sum, the NK model provides three predictions that we can (and do) test empirically in Section V:

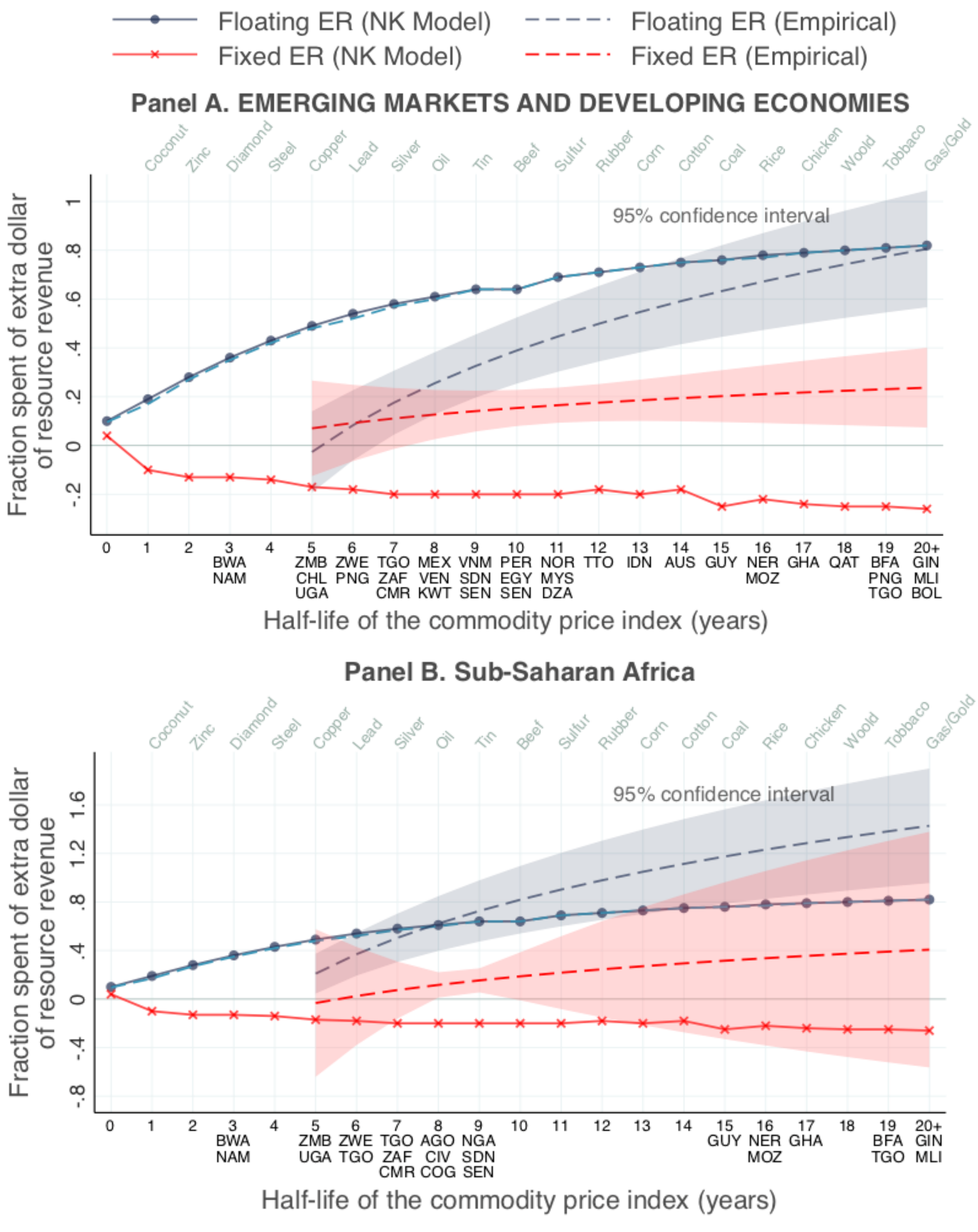
(**Prediction 1**) The one-year MPS is lower for countries with fixed ER;

(**Prediction 2**) The one-year MPS is increasing in the half-life of commodity price shocks for countries with floating ER;

(**Prediction 3**) The slope of the one-year MPS with respect to the half-life of commodity price shocks is flatter for countries with a fixed ER.

[34] The three-year MPS increases slightly with shock persistence. Panel B of Appendix Figure 2 shows this is implemented by increasing θ_A from 0.025 for one-off shocks to 0.11 for a 10-year half-life. The latter implies 50% of any increase in public assets is spent within the first year.

Figure 2: Empirical One-Year MPS —Model Versus Data



Notes: The NK model is calibrated to SSA (Section III.B) assuming zero local content. The empirical MPS is taken from the 2SLS baseline regression, columns (3) and (6) of Table 3, for EMDEs and SSA, respectively. The blue dashed line represents the theoretical MPS implied by the flexible-price economy. The shaded areas represent the 95% confidence interval of the empirical MPS.

F. Local Content (LC)

The baseline calibration of the NK model assumes that all resource income accrues to the government. This simplifying assumption is motivated by the lack of reliable data on the distribution of the resource income shares at the sectoral level. In practice, the resource income is split between the government (taxes, royalties, profits from state-owned companies), local workers (wages and other forms of labor compensation), and international investors (dividends on equity). Since one of the government's goals is to smooth commodity revenues on behalf of financially constrained households, the share of resource income that accrues to local workers affects the optimal cyclicality of fiscal policy.

In this subsection, we relax the assumption that all resource income accrues to the government and instead assume that a fixed share $1-\gamma$ accrues to the government and the remaining γ accrues to households (proportionately distributed across the Ricardian and hand-to-mouth households).[35] γ represents the local content (LC) restrictions. We find that this economy with LC of γ is isomorphic to an economy with no local content (NOLC) if $MPS_{LC} = (MPC_{NOLC} - \gamma)/(1-\gamma)$. This is because the government can achieve the same quarterly income profile of the hand-to-mouth households by reducing transfers in response to a commodity price increase (Ricardian households are unaffected by this, as it only affects the time path of transfers and not their present value).[36]

Figure 3 illustrates this relationship when γ, the local content share, is equal to 0, 0.1, 0.2, or 0.3. When $MPS_{NOLC} = 1$, the corresponding $MPS(\gamma)$ is also equal to 1 for all γ. For $MPS_{NOLC} < 1$, higher values of LC require a lower (less procyclical) MPS because fiscal policy must work against the extra procyclical spending of the

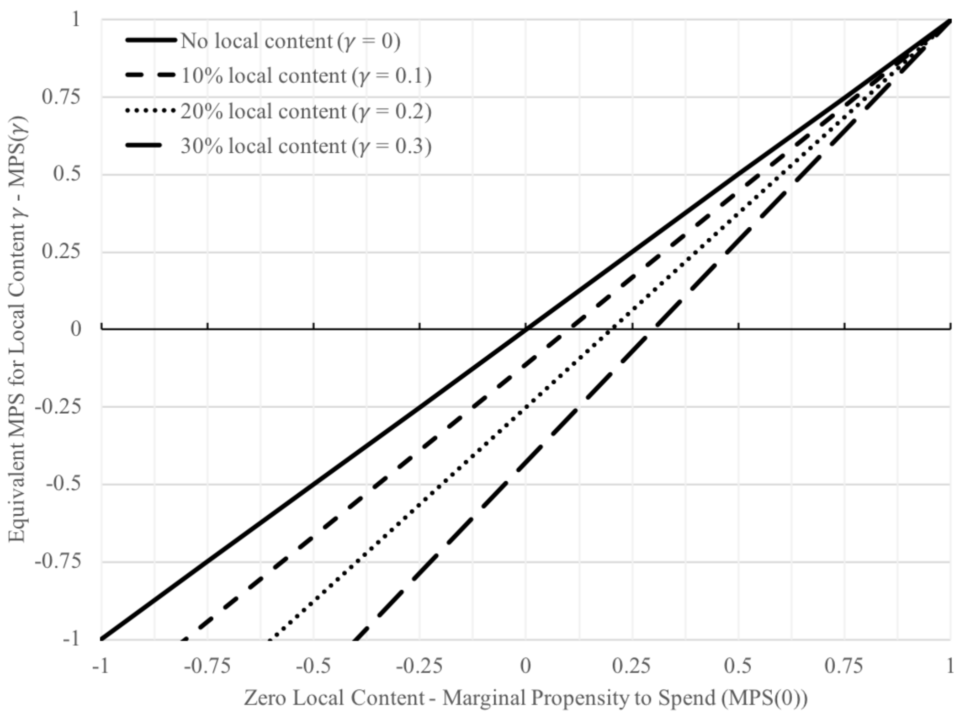
[35] The share of the resource sector sent abroad to remunerate foreign capital is irrelevant for fiscal policy, which is defined in terms of the income that the government (or domestic sector) receives. Without loss of generality, we assume that the share is zero.

[36] To see this, note that the marginal propensity to consume (MPC) of a hand-to-mouth household with local content fraction γ can be written as $MPC''(\gamma) = \gamma + (1-\gamma)MPS_{LC}(\gamma)$, where $MPS_{LC}(\gamma)$ is the government's 1q-MPS when the local content is γ. In an economy without local content, $MPC''_{NOLC} = MPS_{NOLC}$. So to derive the equation in the main text, set $MPC''(\gamma) = MPS_{NOLC}$ and solve for $MPS_{LC}(\gamma)$.

hand-to-mouth households. For example, to achieve no response in hand-to-mouth household consumption, fiscal policy should be acyclical when LC is zero, i.e., $MPS_{NOLC} = 0$, but if LC is 20% $MPS(0.2) = -0.25$ (countercyclical).

Appendix Table 3 provides a list of optimal one-year MPS for each country in SSA when LC is equal to 0%, 10%, and 20%. In addition, Appendix Figure 5 plots the optimal one-year MPS generated numerically by the NK model against the half-life of the commodity price index under the floating (Panel A) and fixed ER (Panel B), conditional to different degrees of local content. As in Figure 3, a higher degree of local content is associated with a less procyclical MPS.

Figure 3: Mapping from $\boldsymbol{MPS(0)}$ to $\boldsymbol{MPS(\gamma)}$



Notes: For a given $MPS(0)$ and local content γ, there is a corresponding $MPS(\gamma)$ such as the consumption of the hand-to-mouth household and other equilibrium prices and allocations are equal across the two scenarios.

III. Empirical Methodology

This section discusses the existing measures of cyclicality in the literature (IV.A), describes the methodology applied to estimate the MPS (IV.B) and the data used in the empirical analysis (IV.C).

A. Measures of Procyclicality in the Literature

There is a large and growing literature on the cyclical patterns of fiscal policy in advanced and developing countries. A number of articles in this literature use correlations between fiscal outcomes and the business cycle as their measure of procyclicality.[37] The influential work of Frankel et al. (2013) uses a measure of procyclicality based on the correlation between the cyclical components of government spending and GDP. Cespedes and Velasco (2014) is another important article closely related to our paper, where the cyclicality of fiscal policy *over the commodity cycle* is measured by a regression of the log change in expenditure (or other fiscal variables) on an index of commodity prices (e.g., their equation (26)). This literature focuses mostly on the sign of the relation rather than on its quantitative size. However, it is the quantitative size that determines how close fiscal policy is from being optimal, and consequently, simple correlations or elasticities can be misleading in several ways.

Relation between the MPS and existing measures of cyclicality. In this section, we use a simple framework of fiscal policy—consistent with the model of Section III—to illustrate how existing measures of procyclicality may fail to capture the MPS.

Consider a simple economy where, each period, the government exports a fixed quantity of Q units of a resource good at price P_t and receives non-resource revenues, Z_t. Assume that P_t and Z_t are jointly normally distributed with a mean

[37] Some of the leading articles in that field are Gavin and Perotti (1997), Tornell and Lane (1999), Kaminsky et al. (2004), Talvi and Vegh (2005), Mendoza and Oviedo (2006), Alesina and Tabellini (2005), Alesina et al. (2008), and Ilzetzki and Vegh (2008).

of one, standard deviations σ_R and σ_Z, and covariance σ_{RZ}. Consider the simple fiscal rule:

$$G_t = \bar{G} + MPS_R Q(P_t - 1) + MPS_z(Z_t - 1), \qquad (2)$$

where G_t is the government expenditure in period t, $\bar{G}$ is the long-run expenditure (equal to $1 + Q$), and MPS_R and MPS_z are the MPS commodity resource (R) and non-resource (Z) revenues, respectively. Note that, by construction, the MPS_R is the structural measure of cyclicality over the commodity cycle.

Simple regression measure of cyclicality. Can an OLS regression of log changes in expenditure on log changes in price (similar to Cespedes and Velasco 2014) recover the underlying procyclicality of fiscal policy? If we take the first difference of equation (2), divide by $\bar{G} = (1 + Q)$, and rearrange terms so that

$$\Delta G_t/\bar{G} = MPS_R(Q\bar{P}/\bar{G})\Delta P_t/\bar{P} + u_{t,} \qquad (3)$$

where $u_t \equiv MPS_z \Delta Z_t/\bar{G}$ is the error term and $Q\bar{P}/\bar{G}$ is the steady-state commodity revenues as a share of total spending (i.e., the long-run share of spending financed by commodity revenues).

With the conservative assumption that resource and non-resource revenues are uncorrelated in large samples ($\sigma_{RZ} = 0$), the OLS regression of $\Delta G_t/\bar{G}$ on $\Delta P_t/\bar{P}$––similar to a regression of $\Delta \log G_t$ on $\Delta \log P_t$ as in Cespedes and Velasco (2014)—recovers the reduced-form parameter $\alpha \equiv MPS_R(Q\bar{P}/\bar{G})$. Hence, this OLS measure of cyclicality has no clear economic interpretation because the regression coefficient measures two objects: the true MPS_R and the size of resource revenues relative to total spending, $Q\bar{P}/\bar{G}$. Moreover, it cannot be used for cross-country comparisons, as it tends to overestimate the procyclicality of countries where commodity revenues are relatively more important. In other words, using the reduced-form OLS measure to rank two countries with the *same* MPS_R, one will incorrectly conclude that the country with the highest dependence on commodity revenues (highest $Q\bar{P}/\bar{G}$) is the most procyclical. Within-country comparison over time can also be misleading if $Q\bar{P}/\bar{G}$ varies across commodity price regimes.[38]

A second concern about the reduced-form OLS measure is omitted variable bias if $\sigma_{RZ} \neq 0$. A number of papers argue that commodity price shocks have large effects on the non-resource sector, which suggests $\sigma_{RZ} \neq 0$.[39] We would expect $\sigma_{RZ} > 0$, as commodity price booms stimulate the rest of the economy and so generate extra non-resource tax revenues. In this case, a failure in controlling for non-resource revenues results in an upward biased estimator of procyclicality.

Correlation-based measures of procyclicality. Another common measure of procyclicality in the literature is the simple correlation between $\Delta \log G_t$ and $\Delta \log P_t$ ($\equiv \rho_{GP}$). However, correlation-based measures suffer from the same problem as the regression-based measures: they depend on the size of commodity revenues. When commodity revenues are large (high $Q\bar{P}/\bar{G}$), the measure of procyclicality can be high even when the MPS_R is small. Moreover, ρ_{GP} depends on the relative variance of commodity prices and non-resource revenue shocks: as commodity prices become relatively more volatile, the correlation coefficient increases, regardless of the size of MPS_R.[40]

The correlation-based measure can result as a misclassification of the cyclicality of well-known fiscal rules. For example, an acyclical fiscal rule that only spends the interest rate on excess resource revenue (e.g., Norway's fiscal rule) would be classified as procyclical if either (i) commodity revenues are important in the budget (high $Q\bar{P}/\bar{G}$) or (ii) the volatility of the commodity price is high relative to the volatility of the business cycle (low σ_z/σ_p). Alternatively, a procyclical rule that spends all excess resource revenue each period ($MPS_R = 1$) is classified as

[38] Cespedes and Velasco (2014) also estimate a number of other specifications, including one where the left-hand side variable is the change in expenditure as a share of GDP. This regression has a similar problem but where resources revenues are measured as a share of GDP rather than as a share of total revenues (or spending).
[39] See, for example, Kose (2002), Schmitt-Grohé and Uribe (2018), Drechsel and Tenreyro (2018), and Shousha (2015).
[40] More specifically, $|\rho_{GP}|$ is increasing in the share of the variance of total revenue explained by resource revenue, regardless of the underlying MPS_R. Moreover, $|\rho_{GP}|$ becomes arbitrarily close to one as $\sigma_z/(Q_R\sigma_p) \to 0$, even when MPS_R is arbitrarily close to zero.

acyclical if either (i) commodity revenues are not important in the budget (low $Q\bar{P}/\bar{G}$) or (ii) the volatility of the commodity price is low relative to the business cycle's volatility (high σ_z/σ_p).[41]

Motivated by these concerns, we now introduce a new empirical specification where estimates of procyclicality do not depend on the relative size and volatility of commodity revenues.

B. Empirical Specification of the MPS

Our empirical specification is:

$$\Delta G_{it}^{y} = \left(MPS_{it}^{FLOAT} \text{ x } FLOAT_{it} + MPS_{it}^{PEG} \text{ x } PEG_{it}\right) \text{ x } \Delta CRev_{it}^{y} + \\ + \eta \Delta NCRev_{it}^{y} + \zeta_i + \delta_t + \epsilon_{it} \qquad (4)$$

where ΔG_{it}^{y} , $\Delta CRev_{it}^{y}$, and $\Delta NCRev_{it}^{y}$ are the annual change in expenditure, commodity resource revenue, and non-resource revenue in the country i in year t, respectively, each as a share of three-year moving average GDP (MAGDP).[42] Variables ζ_i and δ_t represent country and year fixed effects, respectively. The country fixed effect captures country-specific time trends in expenditure growth. By including year fixed effects, we control for the global level of commodity prices, as well as aggregate shocks that affect all countries at a particular year, such as the financial crisis of 2008–2009. The dummy variable PEG_{it} is equal to one if country i adopted a fixed ER regime in period t (otherwise $PEG_{it} = 0$ if the ER is floating). $FLOAT_{it}$ indicates a floating regime: $FLOAT_{it} \equiv 1 - PEG_{it}$. The parameter MPS_{it}^{j} is the MPS commodity revenues for countries with floating ($j = FLOAT$) or fixed

[41] A similar argument applies to measures of cyclicality over the business cycle based on correlations between expenditure and GDP.

[42] The variables in levels used to calculate ΔG_{it}^{y}, $\Delta CRev_{it}^{y}$, and $\Delta NCRev_{it}^{y}$ are denominated in current local currency. Nominal series are deflated using the national CPI, from the IMF World Economic Outlook Database.

($j = PEG$) ER regimes. We also allow the MPS^{j}_{it} to be conditional on the persistence of commodity price shocks and other controls:

$$MPS^{j}_{it} \equiv \beta^{j}_{0} + \beta^{j}_{1}\, ln(HL_i/\overline{HL}) + \gamma \tilde{X}'_{it} \;,\;\; j \in \{FLOAT, PEG\}, \qquad (5)$$

where HL_i is the half-life of the commodity price index of country i and $\overline{HL}$ is the cross-panel average. The vector of controls, $\tilde{X}_{it}$, includes variables that measure the country's (i) institutional quality, (ii) financial depth, and (iii) level of development.[43] See Appendix Table 7 for descriptive statistics.

The parameters β^{FLOAT}_{0} and β^{PEG}_{0} represent the MPS for the typical floating and fixed ER commodity exporter (i.e., a country with average half-life, institutional quality, financial depth, and level of development), whereas β^{FLOAT}_{1} and β^{PEG}_{1} capture the relation between the half-life and the MPS for floating and fixed ERs, respectively. More specifically, β^{j}_{1} is the semi-elasticity of the MPS: the predicted increase in the MPS given a 1% increase in the half-life relative to the cross-panel average, $\overline{HL}$. This linear-log specification allows for a decreasing impact of the half-life on the MPS, as suggested by the theory (see Figure 2).

Testable Predictions. Translated into restrictions on estimated coefficients in equations (4) and (5), the three predictions of the NK model in Section III become:

(Empirical Prediction 1) Typical commodity exporters with a fixed ER have a lower MPS than those with a floating ER: $\beta^{PEG}_{0} < \beta^{FLOAT}_{0}$;

(Empirical Prediction 2) The MPS is increasing in the half-life for commodity exporters with floating ER: $\beta^{FLOAT}_{1} > 0$; and

(Empirical Prediction 3) The slope of the MPS is flatter for commodity exporters with fixed ERs than for those with floating ERs: $\beta^{PEG}_{1} < \beta^{FLOAT}_{1}$.

Our benchmark approach to estimating equations (4)–(5) is to instrument the change in resource revenue as a share of MAGDP ($\Delta CRev^{y}_{it}$) using the country-

[43] The "tilde" indicates that all variables in $\tilde{X}_{it}$ are calculated as deviation from their cross-panel averages. Note that γ does not depend on the country's ER regime, so that the controls have the same impact on the MPS in both countries with a floating or fixed exchange rate.

specific commodity price index (ΔlnP_{it}) scaled by the 2008–2012 average of commodity revenue as a share of 2010 GDP.[44]

There are two reasons to instrument $\Delta CRev_{it}^{y}$ rather than estimating equation (4) by OLS. First, and most importantly, we want to estimate the propensity to spend an extra dollar of resource revenue *driven* by an exogenous change in commodity prices, *not* driven by shocks to commodity production. Second, a challenge in identifying the MPS is that resource revenue is potentially endogenous. For instance, reverse causality may arise if an unexpected expansion of public investment (part of government expenditure) in the energy or mining sectors also increases commodity revenues. Instrumenting resource commodity revenues with the commodity price index eliminates this potential bias since commodity prices are arguably exogenous to domestic fiscal developments.

We then estimate the cross-country MPS with a two-stage least square (2SLS) estimator. The first stage of the two-step approach is to estimate the following equation[45]:

$$\Delta CRev_{it}^{y} = \delta_0 + \delta_1 \times \overline{CRev}_{i}^{y} \times \Delta lnP_{it} + \varepsilon_{it}, \qquad (6)$$

where ΔlnP_{it} is the log change in the commodity price index of country i in period t and $\overline{CRev}_{i}^{y}$ is the 2008–2012 average of commodity revenue as a share of 2010 GDP in country i. The expression $\delta_1 \times \overline{CRev}_{i}^{y}$ is the predicted change in resource revenue (as share of MAGDP) given a 1% change in the commodity price index in country i. Note that equation (6) allows $\overline{CRev}_{i}^{y}$ to vary across countries, allowing the change in commodity revenues (as a share of MAGDP) to be more sensitive to commodity prices in countries with larger commodity sectors (as highlighted in Section IV.A).

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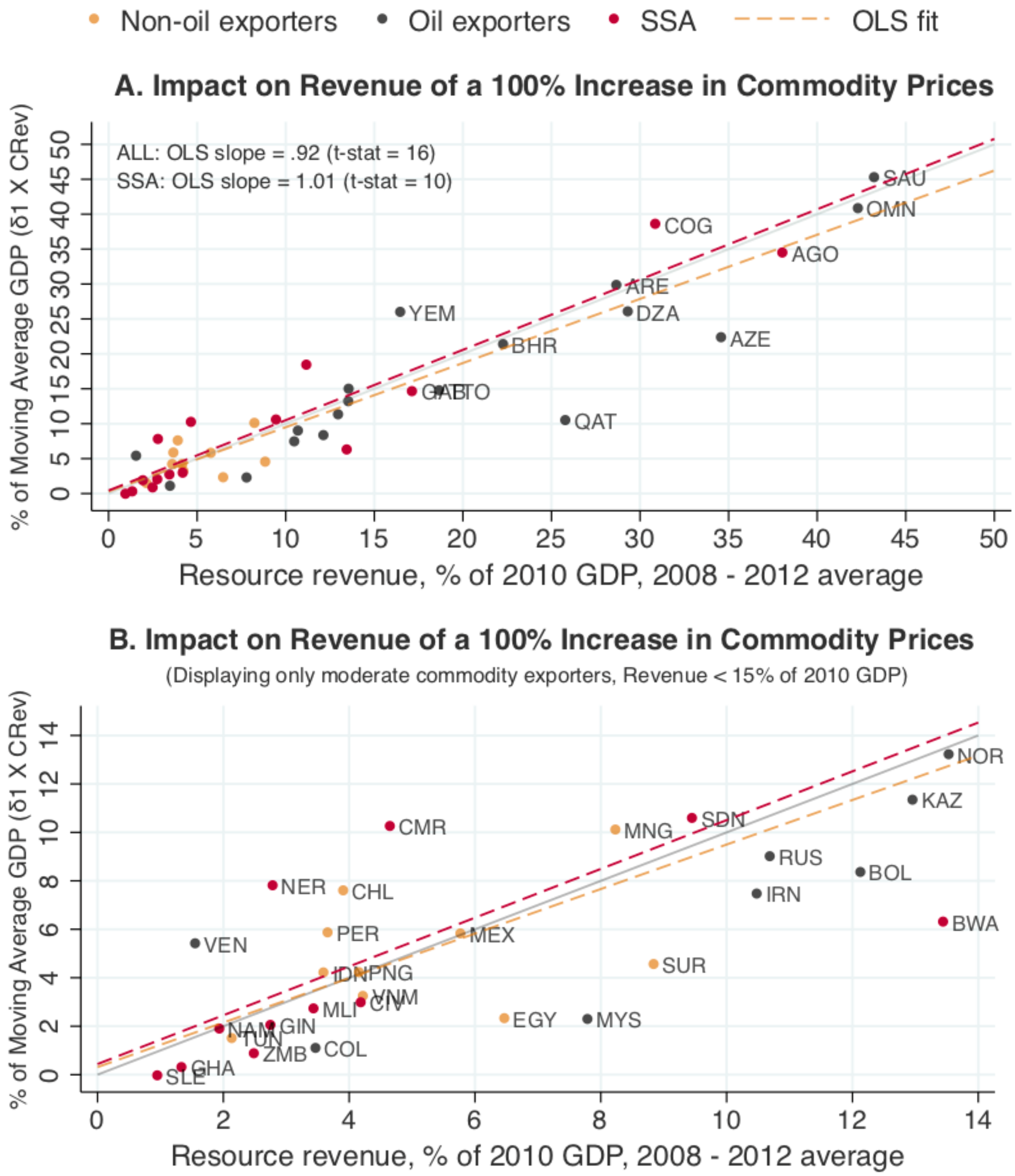
[44] The country-specific commodity price index is calculated using the same methodology used to generate the commodity price index for SSA in Section III.

[45] In practice, we instrument all interactions with $\Delta CRev_{it}^{y}$ with the corresponding interaction with $\overline{CRev}_{i}^{y} \times \Delta lnP_{it}$ as a GMM optimization problem.

Figure 4: How Resource Revenues Change with Commodity Prices – 1st Stage of the 2SLS

(The importance of controlling for the size of commodity revenues)



Notes: The y-axis displays, for each commodity exporter, the fitted values from a country-by-country regression of the change in commodity revenues (as a percent of MAGDP) on the change in the country-specific commodity price index, as in Equation (6). The x-axis is the 2008-2012 average of commodity revenues as a share of 2010 GDP. Panels A and B depict the same graph, but with different scales: while panel A displays all commodity exporters, panel B zooms in on countries where commodity revenues accounted for less than 15% of GDP, on average, in 2008–2012. The grey line is the 45-degree line. The red and yellow dotted lines are the best (OLS) linear fit for all commodity exporters and for SSA, respectively. The slopes are 0.92 and 1.01, respectively, and they are both significant at 1%. Countries with less than nine observations are not reported. Outliers Libya and Kuwait are dropped from the graph.

To illustrate the importance of allowing the effect of commodity prices on revenue to vary across countries, Figure 4 displays on the vertical axis the point estimates of an univariate regression of the change in commodity revenues (as a share of MAGDP) on the log change in the commodity price index. The predicted impact on resource revenue of a 100% increase in the commodity price index ranges from 0% to 45% of MAGDP. This range is also wide within SSA countries (0% to 40%). On the x-axis, we plot the 2008–2012 average commodity revenues as percent of 2010 GDP, $\overline{CRev}_i^y$. The estimates are almost proportional, suggesting that δ_1 is close to 1 and is stable across countries (0.92, on average; 1.01 for SSA). We get a very similar estimate of δ_1 in our first-stage estimates.

C. Data

To estimate equations (4)–(6), we use annual panel data on government expenditure and commodity resource revenues over 1980–2016 for 56 commodity exporters (22 in SSA). The criteria to add a country in the panel is to have sizable commodity exports (more than 5% of GDP or one-third of total exports, on average, in 2008–2012) and to have at least two consecutive years of data for all of the variables included in the regression.[46] Appendix Table 5 displays the list of countries included in the panel as well as the data sources, and the sample period for each variable. Appendix Table 7 provides summary statistics of all variables in the regressions.

To construct our spending variable (LHS of equation (4)) we obtain data on "General Government Total Expenditure, Percent of GDP" (GGEY), "Gross Domestic Product, Current National Prices" (NGDP), and "Inflation, Average Consumer Prices" (CPI) from the International Monetary Fund (IMF) World

[46] Commodity export data are taken from the UN Comtrade Database. See Appendix Table 1 for details on commodity exports for each of the 56 countries included in the sample.

Economic Outlook (WEO) (available since 1980).[47] We then compute our spending variable as follows:

$$\Delta G_{it}^{y} \equiv [GGEY_{it} \text{ x } NGDP_{it}/(1+\pi_t) - GGEY_{it-1} \text{ x } NGDP_{it-1}]/MANGDP_{it}$$

where $MANGDP_{it}$ is the 3-year moving average of NGDP and $\pi_t = CPI_t/CPI_{t-1} - 1$ is the inflation rate.

The primary data source to construct the commodity resource revenue variable, $\Delta CRev_{it}^{y}$, is the ICTD/UNU-WIDER Government Revenue Dataset 2018 (GRD), which provides data on "Total Natural Resource Revenue, General Government, Percent of GDP" (CREVY), from 1980 to 2016. We also use data from the IMF World Commodity Exporters Dataset (WCED), which provides data on general government resource revenues (% of GDP) from 1980 to 2013.[48] In both datasets, resource revenue includes tax and non-tax receipts from natural resources that include a significant component of economic rent, primarily from oil, natural gas, and mining activities. For each country in the panel, we use the dataset (GRD or WCED) that provides the longest time series.[49] Like for the spending variable, we define the resource revenue variable as,

$$\Delta CRev_{it}^{y} \equiv [CREVY_{it} \text{ x} NGDP_{it}/(1+\pi_t) - CREVY_{it-1} \text{ x } NGDP_{it-1}]/MANGDP_{it}$$

[47] GGEY consists of general government total expenses and the net acquisition of nonfinancial assets (public investment). Conceptually, the measure should exclude public investment, but this decomposition is not available for many country-years in the WEO database.

[48] GRP is a comprehensive dataset that contains data on resource revenue for 69 countries from five different sources: OECD Revenue Statistics, OECD Latin American Tax Statistics, IMF Government Finance Statistics, IMF Article IV Staff Reports, and CEPALSTAT Revenue Statistics in Latin America. The WCED is a collection of key macro-fiscal indicators covering 51 countries that are exporters of oil, gas, and metals (such as copper, gold, iron, and silver), where these commodities represent a large share of exports (20% or more of total exports) or fiscal revenues. The dataset is compiled from the following sources: International Financial Statistics (IFS), Balance of Payments Statistics, Direction of Trade Statistics, World Economic Outlook, and FAD's fiscal rules database. The resource revenue data from the WCED is broadly consistent with GRD, although there are substantially divergent information for specific years and countries. Appendix Figure 9 displays the dispersion of resource revenues data across the WCED and GRD. In subsection I.B, we discuss the robustness of our main results to potential measurement errors present in the revenue dataset.

[49] Columns (6)–(8) in Appendix Table 5 summarize the data source and sample size for expenditure and resource revenue. For nine countries, mixed data from the GRD and WCED are used.

To compute our measure of non-resource revenue, we use data on "General Government Revenue, Percent of GDP" from WEO and GRD from 1980–2016. For each country, we choose the dataset with the longest time series available. Non-resource revenue is computed as the difference between total revenue and resource revenue (columns (9) and (10) of Appendix Table 5). The annual change in non-resource revenue as a share of MAGDP, $\Delta NCRev_{it}^{y}$, is computed as above (for ΔG_{it}^{y} and $\Delta CRev_{it}^{y}$).

The country-specific commodity price index and the half-life are estimated using the same methodology applied in Section III.B for SSA. Appendix Table 4 provides the OLS estimates of the half-life of the commodity price index for the 56 commodity exporters included in the sample.

The dummy variable PEG_{it} is calculated based on the ER index constructed in Ilzetzki et al. (2019), using the "Hard Peg" classification of Eichengreen and Razo-Garcia (2011). Ilzetzki et al. (2019) provide a time series covering 1940–2016 for 191 countries of an index that ranges from 1 (currency union, the least flexible) to 13 (freely floating, the most flexible) (see Appendix Table 6 for a more detailed description of the ER index). A country *i* is classified as having a fixed ER regime in period *t* ($PEG_{it} = 1,\ FLOAT_{it} = 0$) if the ER index is equal to or less than 3 (pre-announced narrow band), and as floating ER otherwise ($PEG_{it} = 0, FLOAT_{it} = 1$).[50] Under this metric, about one-third of the observations in the sample are associated with a fixed ER, and 24 out of 56 countries have at least one year in this regime (see Appendix Table 6 for details). For robustness, in Section V.I.B we report the results using a different classification where a country is classified as having a fixed ER when the ER index is equal to or less than 7 (De

[50] We depart from Ilzetzki et al. (2019) and classify Algeria as having a fixed ER in 2000–15. This adjustment is based on Achouche and Allaoua (2018) that identify a "fear of floating" in Algeria during the same period: "(…) throughout the study period, volatility of exchange rates is lower than that of foreign reserves: relatively, the ratio remains less than unity (…) This is consistent with the results of Hausmann et al. (2000) on de jure floating countries but de facto fixed. This finding supports the idea that foreign exchange reserves are used to defund exchange rate and the Algerian economy depend on external relations; exports and imports and its exchange rate is not defined by internal inputs."

Facto Crawling Peg). In this case, 59% of the observations in the sample are classified as fixed ER, and 52 countries have at least one year in this regime.

Control variables. Our specification in equation (5) allows the MPS to vary with other covariates. In addition to a generic control for the level of development, measured as the log of Gross Domestic Product Per Capita (GDPPC; constant dollars, from World Development Indicators (WDI)), we include two other controls from the literature.

The first control variable is motivated by Calderón and Schmidt-Hebbel (2008), Frankel et al. (2013), Cespedes and Velasco (2014), and Carneiro and Garrido (2016) who argue that the ability of countries to conduct countercyclical fiscal policy depends on the quality of their institutions. Following this literature, we construct a country-specific institutional quality (IQ) index as the average of four indicators: (i) government effectiveness, (ii) rule of law, (iii) regulatory quality, and (iv) control of corruption. The indicators are provided by the International Country Risk Guide for 146 countries from 1984–2016. The IQ index ranges from zero (lowest institutional quality) to one (highest institutional quality).

Second, Gavin and Perotti (1997), Riascos and Vegh (2003), and Caballero and Krishnamurthy (2004) argue that imperfect credit markets prevent developing countries from borrowing during economic downturns and hence affect their ability to conduct countercyclical fiscal policy. To assess the development of domestic financial markets, we use Loayza and Ranciere's (2006) measure of financial depth as liquid liabilities as a share of GDP (data from the World Bank WDI).

Outliers. As commodity prices and fiscal policy in developing countries are volatile, we need to be careful to make sure that our results are not being driven by a small number of influential observations. We check for the presence of outliers and influential observations by calculating the Cook's distance from simple OLS regressions of the first stage (similar to equation (6)) and second stage (similar to equation (4)). We run these regressions by splitting the sample between fixed and floating ERs and classify the five observations with the highest Cook's distance in each regression as outliers.[51] For robustness, we also report results without dropping the outliers in Section V.B.

IV. Empirical Results

This section estimates the cross-country MPS in the data, compares the empirical results with the NK model's predictions (Section V.A), and provides a battery of robustness tests (Section V.B).

A. Main Cross-Country MPS Estimates

Panel A of Table 3 reports the 2SLS estimates of the MPS for the EMDE sample (54 countries) using a parsimonious specification without controls (which are added later in subsection B). Standard errors are in parentheses and are clustered by country.[52] Column (1) imposes a pooled specification where the MPS does not vary with persistence or the ER regime (i.e., imposing $\beta_0^{FLOAT} = \beta_0^{PEG}$ and $\beta_1^{FLOAT} = \beta_1^{PEG} = 0$ in equation (5)). For the typical EMDE commodity exporter, a 1 dollar increase in commodity revenues leads to an increase of 25 cents in expenditure in the first year. Column (2) allows the MPS to be conditional on the ER regime (now allowing $\beta_0^{FLOAT} \neq \beta_0^{PEG}$ but keeping $\beta_1^{FLOAT} = \beta_1^{PEG} = 0$). While EMDE commodity exporters with a floating ER spend, on average, 30 cents on the dollar of resource windfall, fixed ER countries spend only 15 cents. We reject the equality of these coefficients (a null hypothesis that $\beta_0^{FLOAT} = \beta_0^{PEG}$) at the 5% significance level, providing evidence in favor of the NK model's first prediction (the MPS is higher for countries with floating than fixed ER regimes).

[51] Panels A and B of Appendix Figure 6 plot the first stage (resource revenues against scaled commodity prices) for floating and fixed ERs, respectively, and panels C and D plot the second stage (expenditure against predicted commodity revenues). Appendix Table 8 displays the estimated Cook's distance and the list of outliers. The estimated Cook's distance of each outliers is substantially above the usual cutoff used in the literature of 4 x (sample size).

[52] Clustering standard errors by country allows for arbitrary correlation over time in the error term for a given country.

Table 3 Main Results: Estimated MPS Commodity Revenues

Two-Stage Least Squares, Parsimonious Specification

Dependent variable: Annual change in expenditure as a share of 3-year MAGDP

ITERACTIONS WITH	A. EMDEs			B. SUB-SAHARAN AFRICA		
$\Delta CRev_{it}^{y}$:	(1)	(2)	(3)	(4)	(5)	(6)
$\boldsymbol{\beta_0^{pool}}$	0.25***			0.31*		
(Overall MPS)	(0.05)			(0.18)		
$\boldsymbol{\beta_0^{FLOAT}}$ **x** $\mathbf{FLOAT_{it}}$		0.30***	0.39***		0.52**	0.82***
(MPS of Floating ER)		(0.07)	(0.07)		(0.23)	(0.14)
$\boldsymbol{\beta_0^{PEG}}$ **x** $\mathbf{PEG_{it}}$		0.15***	0.15***		0.15***	0.19*
(MPS of Fixed ER)		(0.04)	(0.04)		(0.04)	(0.10)
$\boldsymbol{\beta_1^{FLOAT}}$ **x ln** $(\mathbf{HL_i}/\overline{\mathbf{HL}})$ **x** $\mathbf{FLOAT_{it}}$			0.60***			0.88***
(MPS slope of Floating ER)			(0.11)			(0.16)
$\boldsymbol{\beta_1^{PEG}}$ **x ln** $(\mathbf{HL_i}/\overline{\mathbf{HL}})$ **x** $\mathbf{PEG_{it}}$			0.12			0.32
(MPS slope of Fixed ER)			(0.12)			(0.58)
Controls	NO	NO	NO	NO	NO	NO
(Interactions with IQ, LLY, GNI)						
P-VALUE (Prob > F)						
H0: MPS Float = MPS Fixed		0.02**	0.00***		0.07*	0.00***
H0: [Slope] MPS Float = MPS Fixed			0.00***			0.32
First stage F-statistic	91.7	28.7	18.6	40.6	19.8	8.8
Control for non-res revenue	YES	YES	YES	YES	YES	YES
Country & year fixed effects	YES	YES	YES	YES	YES	YES
Observations	917	917	917	322	322	322
R-squared	0.20	0.20	0.21	0.16	0.17	0.20
Number of countries	54	54	54	22	22	22

Notes: Standard errors are in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors are clustered at the country level. In the first stage, commodity revenues are instrumented with the country-specific commodity price index scaled with the average commodity revenues as a share of GDP in 2008–2012.

Column (3) of Table 3 reports the full specification, which allows the MPS to vary with the ER regime and the half-life of the commodity price shock. For a typical developing commodity exporter (with average half-life), the MPS is 0.39 for floating ERs and 0.15 for fixed ERs, and we reject the null hypothesis that $\beta_0^{FLOAT} = \beta_0^{PEG}$ at the 1% significance level (also in line with the NK model's first prediction). The point estimate of the semi-elasticity of the MPS to years of half-life, $\hat{\beta}_1^{j}$, is 0.6 for floating ER and 0.12 for fixed ER. Moreover, $\hat{\beta}_1^{FLOAT}$ is statistically greater than zero at the 1% level, supporting the NK model's second prediction (the MPS increases with persistence for countries with a floating ER). We also reject the null hypothesis that $\beta_1^{FLOAT} = \beta_1^{PEG}$ at 1% significance level, providing empirical support for the NK model's third prediction (the MPS increases more with persistence in countries with floating rather than fixed ER regimes).

To visualize how the empirical estimates compare with the NK model's predictions, Panel A of Figure 2 plots the 2SLS fitted values of the MPS for EMDEs (column (3) of Table 3) against the half-life of the commodity price index for floating (blue dotted line) and fixed ERs regimes (red dotted line). The blue and red shaded areas represent the 95% confidence interval around the fitted MPS for floating and fixed ERs, respectively. The MPS implied by the NK model (Section III) is shown for a fixed ER (solid red line) and a floating ER (solid blue line).

At 6 years of half-life, which is one of the lowest persistence in the sample, the empirical MPS is 0.1 regardless of the ER regime. For floating ERs, the MPS increases with half-life, reaching 0.4 and 0.8 when the half-life is 10 and 20 years, respectively. For fixed ERs, the MPS is almost flat, reaching only 0.2 when the half-life is 20 years.[53]

Comparing the dotted and solid lines, one can see that the empirical estimates of the MPS are broadly consistent with those produced in the NK model, as expected from the results in Table 3. However, the empirical estimates of the MPS are less procyclical for floating ER and less countercyclical for fixed ERs. These differences might be explained by other frictions (like budget rigidities) not included in the NK model. However, one can see that countries with floating ERs that face highly persistent shocks tend to have procyclical fiscal spending, as in the NK model.

Empirical MPS in SSA. Panel B of Table 3 reports estimates of the MPS for the SSA sample. Column (4) shows that the overall procyclicality of a typical commodity exporter in SSA is higher than in EMDEs. In SSA, a 1 dollar increase in commodity revenue leads to a 31 cent increase in government expenditure in the first year (versus 25 cents in EMDEs, shown in column (1)). Allowing the MPS to be conditional on the ER regime, we find that while the typical country with a

[53] For a half-life equal or above 10 years, the confidence intervals of the MPS for floating and fixed ERs do not overlap, providing further evidence that the MPS for floating ERs is higher than fixed ERs at high persistence – although not necessarily at lower persistence levels.

floating ER in Africa spends 52 cents on the dollar of the resource windfall, the typical fixed ER country spends only 15 cents (same as the typical EMDE). Moreover, we reject the null hypothesis that the MPS is equal across the two ER regimes at the 10% level (column (5)) and 1% (column (6)) (Testable Prediction 1). The semi-elasticity of the MPS to years of half-life is 0.88 for floating ERs and is significantly positive at the 1% level (Testable Prediction 2). For countries with a fixed ER, even though the point estimate is somewhat high, $\beta_1^{PEG} = 0.32$; it is not statistically significant. Contrary to Testable Prediction 3, we fail to reject the null hypothesis that $\beta_1^{PEG} = \beta_1^{FLOAT}$ at conventional levels of significance.

Panel B of Figure 2 shows the relation between the MPS, half-life, and the ER regime for the sample of SSA countries and compares it to the NK model. Although the results for SSA are similar to EMDEs in terms of direction and statistical significance, the coefficients differ substantially in magnitude. Specifically, for both fixed and floating ER countries, fiscal policy is too procyclical for SSA commodity exporters, relative to the predictions of the NK model. For floating ER countries, the MPS is around 0.4 for countries with less persistent shocks. For countries with half-life above 12 years, the predicted MPS is above one, and the 95% coefficient interval lies above the optimal MPS implied by the NK model, suggesting that fiscal policy is also too procyclical. For fixed ERs, the MPS is close to 0.2 at 10 years of half-life and increases to almost 0.4 as the half-life approaches 20 years. While this is also above the MPS of the NK model—suggesting fiscal policy is too procyclical—the confidence interval widens sharply at extreme half-lives, suggesting the point estimates are imprecisely estimated, and should be interpreted with caution.

B. Robustness

In this section, we present a range of extra results in Table 4 to check the robustness of our main results for EMDEs. For comparison, Panel A repeats the results from the benchmark regressions (Columns (1) – (3) of Table 3).

Table 4: Robustness Tests for EMDEs: Two-Stage Least Squares

Dependent variable: Annual change in government expenditure as a share of the three-year MA GDP

INTERACTIONS WITH $\Delta CRev_{it}^{y}$:	A. BENCHMARK			B. ADD CONTROLS			C. EXTENDED FIXED ER (Index <= 7)			D. ADVANCED CEs (AUS & NOR)			E. INCLUDE OUTLIERS			F. DROP INFLUENCIAL (DZA & QAT)			G. MEASUR. ERROR IN RES. REVENUES		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(13)	(14)	(15)	(10)	(11)	(12)	(16)	(17)	(18)	(19)	(20)	(21)
$\boldsymbol{\beta_0^{pool}}$	0.25***			0.31***			0.31***			0.31***			0.33**			0.37***			0.31***		
(Overall MPS)	(0.05)			(0.08)			(0.08)			(0.08)			(0.15)			(0.09)			(0.08)		
$\boldsymbol{\beta_0^{FLEX} \text{x } FLOAT_{it}}$		0.30***	0.39***		0.36***	0.46***		0.52***	0.69***		0.36***	0.45***		0.40**	0.51***		0.39***	0.48***		0.35***	0.44***
$(Floating\ ER, MPS)$		(0.07)	(0.07)		(0.08)	(0.09)		(0.18)	(0.20)		(0.08)	(0.09)		(0.17)	(0.17)		(0.08)	(0.09)		(0.06)	(0.07)
$\boldsymbol{\beta_0^{PEG} \text{x } PEG_{it}}$		0.15***	0.15***		0.21***	0.21***		0.27***	0.29***		0.22***	0.23***		0.16	0.16		0.26**	0.25		0.21***	0.21***
$(Fixed\ ER, MPS)$		(0.04)	(0.04)		(0.07)	(0.07)		(0.07)	(0.08)		(0.07)	(0.07)		(0.10)	(0.11)		(0.12)	(0.16)		(0.08)	(0.08)
$\boldsymbol{\beta_1^{FLEX} \text{x } ln(HL_i/\overline{HL}) \text{ x } FLOAT_{it}}$			0.60***			0.62***			0.79***			0.52***			0.65***			0.61***			0.57***
$(Floating\ ER, MPS\ slope)$			(0.11)			(0.20)			(0.28)			(0.19)			(0.19)			(0.23)			(0.20)
$\boldsymbol{\beta_1^{PEG} \text{x } ln(HL_i/\overline{HL}) \text{ x } PEG_{it}}$			0.12			0.19			0.23			0.17			0.08			-0.03			0.34
$(Fixed\ ER, MPS\ slope)$			(0.12)			(0.21)			(0.17)			(0.26)			(0.18)			(0.77)			(0.27)
CONTROLS (IQ, LLY, GDPPC)	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
P-VALUE (Prob > F)																					
H0: MPS Float = MPS Fixed		0.02**	0***		0.05**	0.01***		0.18	0.05**		0.06*	0.02**		0.02**	0.01***		0.20	0.20		0.05*	0***
H0: [Slope] MPS Float = MPS Fixed			0***			0.1*			0.04**			0.24			0.07*			0.47			0.50
First-stage F-statistics	91.7	28.7	18.6	59.4	26.0	11.8	59.4	13.0	22.2	63.2	24.9	13.0	33.7	16.5	8.5	38.5	22.2	13.6	55.4	28.0	7.6
Control for non-res revenue	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country & year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	917	917	917	917	917	917	917	917	917	949	949	949	937	937	937	878	878	878	737	737	737
R-squared	0.20	0.20	0.21	0.20	0.19	0.20	0.20	0.22	0.24	0.20	0.19	0.20	0.33	0.34	0.34	0.17	0.18	0.19	0.24	0.25	0.26
Number of countries	54	54	54	54	54	54	54	54	54	56	56	56	54	54	54	52	52	52	49	49	49

Notes: Standard errors are in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors are clustered at the country level. In the first stage, commodity revenues are instrumented with the country-specific commodity price index scaled with the average commodity revenues as a share of GDP in 2008–2012. The control variables are the IQ index, liquid liabilities as a share of GDP, and the natural log of per capita gross national income. All controls are added in the equation interacting with changes in the commodity price index scaled with the average commodity revenues as a share of GDP in 2008–2012.

Our first concern is that the MPS might be driven by other economic variables that are correlated with the ER regime or shock persistence. In particular, the literature stresses that low institutional quality and financial frictions can lead to procyclicality. In addition, we include the log of real GDP per capita to control for the level of income and development. Results with all three controls are shown in Panel B of Table 4, and we keep these controls for all other robustness tests.[54] The main results remain unchanged, except that all MPS coefficients are slightly higher (more pro-cyclical). In addition, β_1^{PEG} in column (6) increases from 0.12 to 0.19 and is estimated less precisely so that we can only reject the null hypothesis that $\beta_1^{PEG} = \beta_1^{FLOAT}$ at the 10% level (versus 1% in the benchmark).

A second concern involves the classification of ER regimes, as many countries lie close to the benchmark cutoff, and the ER regime might be classified with error. In Panel C of Table 4, we classify countries as having a fixed ER if the ER index is equal to or less than seven (versus three in the benchmark).[55] Results are generally similar, though the size and significance of some coefficients increase.

Although our paper focuses on EMDEs, some commodity exporters are developed economies. Panel D of Table 4 tests whether our results generalize to all commodity exporters by added Australia and Norway to the sample. The results remain generally similar, except we fail to reject $\beta_1^{FLOAT} = \beta_1^{PEG}$ at conventional levels.

The third concern is that the results might be driven by influential observations, countries, or years and do not reflect a general relationship. To test this, Panel E adds the extreme outliers that we dropped from the benchmark regressions (see Appendix Table 8 for a list of outliers). The results are generally similar, except that the estimates are less precise – with higher standard deviation of coefficients – and the first-stage F-statistics fall substantially.

Appendix Figures 7 and 8 test the sensitivity of the results to individual countries or years by dropping them one by one from the fully specified regression for EMDEs (column (6) of Table 4). While there is little evidence that specific years

[54] Appendix Table 9 shows results when controls are added one by one.

[55] See Appendix Table 6 for details about the ER classification.

are important, some results are sensitive to specific countries. Specifically, no individual country is highly influential for β_0^{FLOAT} or β_0^{PEG} except for Algeria (discussed further below). β_1^{FLOAT} is fairly robust to the exclusions of individual countries, though estimates of β_1^{PEG} are sensitive to Qatar: excluding this country makes β_1^{PEG} negative, although still insignificant.[56]

Given that Appendix Figure 7 identifies Algeria and Qatar as potentially influential, in Panel F of Table 4 we re-estimate excluding these two countries.[57] The coefficients β_0^{FLOAT} and β_1^{FLOAT} are mostly unchanged (including $\beta_1^{FLOAT} > 0$, as in in the model's second prediction). But the standard deviation of β_0^{PEG} and β_1^{PEG} are much higher relative to our main results. Even though the point estimates still suggest $\beta_0^{FLOAT} > \beta_0^{PEG}$ and $\beta_1^{FLOAT} > \beta_1^{PEG}$, we now cannot reject $\beta_0^{PEG} = \beta_0^{FLOAT}$ or $\beta_1^{PEG} = \beta_1^{FLOAT}$ at conventional levels.

A final concern is on the quality of the commodity revenue data. Appendix Figure 9 shows that there is some disagreement with respect to the size of resource revenues for some countries across the GRD and WCE datasets. This disagreement raises the concern that our main results may be sensitive to measurement error. To test that possibility, panel G reports the estimates dropping all observations if the reported change in resource revenue from GRD differs from the WCE by more than 3% of MAGDP (in absolute value). The results are very similar to those in panel B, except that β_1^{PEG} is higher relative to benchmark – although still insignificant – and we fail to reject $\beta_1^{PEG} = \beta_1^{FLOAT}$.

Our final robustness test is of the 2SLS specification itself. As the coefficient on the first-stage regression is close to one, an alternative specification is a reduced-

[56] Although Botswana, Kuwait and Trinidad and Tobago are influential for β_1^{FLOAT}, the coefficient remains positive and statistically significant at 5% or 10% when dropping either of these countries. Dropping Botswana from the sample increases significantly the standard deviation of β_1^{FLOAT}. The precision of the estimation falls because Botswana is a large diamond exporter with the lowest persistence in the sample. By dropping that country, the variance of the half-life across countries with floating ERs reduces significantly, increasing the standard deviation of $\hat{\beta}_1^{FLOAT}$.

[57] Recall there is some disagreement in the literature regarding the type of ER regime in Algeria. We depart from Ilzetzki et al. (2019) and classify Algeria as having a fixed ER in 2000–2015. This adjustment is based on Achouche and Allaoua (2018) who identify a "fear of floating" in Algeria during this period.

form OLS regression of the change in government spending ΔG_{it}^{y} on the scaled change in the commodity price index $\overline{CRev}_i^y \times \Delta lnP_{it}$.[58] The results are reported in Appendix Table 10 and are broadly similar to the main 2SLS results, with the full regression providing support for all of the NK model's three predictions.[59]

V. Conclusion

In this paper, we develop an NK model of a small commodity-exporting economy and calculate the optimal marginal propensity to spend (MPS) commodity revenues, which we then compare with the same measure calculated in the data for a panel of developing countries.

Our key theoretical finding is that as the persistence of commodity price shocks increases, optimal fiscal policy diverges for countries with different ER regimes. For countries with floating ERs, fiscal policy becomes more procyclical, motivated by the desire to smooth consumption of financially constrained households (by the PIH). But for countries with fixed ERs, fiscal policy becomes countercyclical in order to smooth the business cycle (as monetary policy is constrained to maintaining the fixed ER). For a typical commodity exporter, price shocks are sufficiently persistent that the difference is large: for every extra dollar in revenues, the NK model predicts spending should increase by 50 cents if the ER is floating but should be cut by 20 cents if it is fixed.

In the data, we find support for the key qualitative predictions of the model in terms of how procyclicality should change with commodity price shock persistence and ER regime, but also find some quantitative differences. Overall, the MPS is estimated to be moderately procyclical in EMDEs (0.25) but is more procyclical in SSA countries (0.31). Comparing the optimal and empirical MPS for EMDEs, we find that actual fiscal policy is too acyclical: it is less procyclical than predicted by

[58] $\Delta G_{it}^{y} = \alpha_i + \delta_t + (MPS_{it}^{FLOAT} \text{ x } FLEX_{it} + MPS_{it}^{PEG} \text{ x } PEG_{it}) \text{ x } \overline{CRev}_i^y \times \Delta lnP_{it} + \eta \Delta NCRev_{it}^{y}$

[59] The only two differences are that (i) we fail to reject $\beta_0^{PEG} = \beta_0^{FLOAT}$ in the intermediate specification in columns (3)–(4), though it is rejected in the full specifications in columns (5)+; and (ii) in column (9) we can only reject $\beta_1^{PEG} = \beta_1^{FLOAT}$ at the 15% level of significance.

the NK model for floating ER countries but more procyclical than predicted for fixed ER countries. In SSA countries, the empirical MPS is more procyclical than optimal for both types of ER.

In closing, it is worth mentioning several caveats to our results. Empirically, a key challenge is estimating the persistence of commodity price shocks when they are close to a random walk. Some of the results for specific commodities, or the countries producing them, may be estimated less precisely, which is why we focus on the cross-country results. Theoretically, our model abstracts from three important real-world features: political economy, finite reserves, and non-linearities. First, raising expenditure in booms is politically easier than cutting it in busts, which can lead to a suboptimal "ratcheting-up" of expenditure. Second, our results also apply most directly to countries with many years of commodity production ahead of them. We show that over the past 20 years, stable or increasing reserves and production are actually very common. But in countries whose reserves will soon expire, intergenerational equity is a primary concern, which we abstract from. Third, non-linearities can introduce precautionary savings motives that undermine the simple predictions of the PIH. Relaxing these assumptions provides interesting areas for future research.

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