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Abstract

Fiscal indicators for resource-rich and resource-poor low- and middle-income countries are compared using annual data from 1996 to 2012. Resource richness is defined by export composition: fuel greater than a 25 percent share and/or ores and metals greater than a 10 percent share. Fuel exporters have a significantly better general government fiscal balance than the rest of the sample, and higher revenues and expenditures, which are approximately evenly split between extra consumption expenditure and extra capital expenditure. Only about a quarter of their extra revenue goes into extra consumption expenditure, and this proportion has been lower since 2005. Fuel exporters' expenditure reacts with a lag to oil price fluctuations. There are no significant differences between ores and metals exporters and resource-poor countries, or between new and old resource exporters, in aggregate expenditures and revenues. Ores and metals exporters spend more on investment and less on government consumption. Some individual country cases are briefly discussed.

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Do Resource-Rich Countries Suffer from a Lack of Fiscal Discipline?

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1. Introduction

In the 1980s and 1990s it became quite fashionable to regard natural resources as a curse whose potential benefits were entirely wasted. Perhaps this view reached its high point with the research on cross-country growth by Sachs and Warner (1997, 2001), in which a measure of specialization in natural resource exports entered the growth equation with a strongly negative coefficient. Bleaney and Nishiyama (2002) confirmed this result. Since then, it has been recognized that some countries, such as Botswana, seem to have managed their natural resources quite well and achieved rapid growth, and that, despite particular examples of gross mismanagement, the overall experience is varied (e.g. IMF, 2012). Authors such as Brunnschweiler and Bulte (2008) questioned whether natural resources were in fact associated with slower growth after all; in part the debate turned on how natural resource endowment was measured. Mehlum, Moene, and Torvik (2006) showed that the quality of institutions was critical to the correlation between natural resource endowments and growth; they added an interaction term between natural resources and institutional quality to their cross-country growth regression and found that it had a significant positive coefficient. The magnitudes were such that natural resources were estimated to be bad for growth in the presence of poor institutions, but good for growth where there were good institutions. Variations across regions also must be recognized: resource-rich Latin America and Africa have grown far more slowly in recent decades than resource-poor East and South Asia, so natural resource effects may sometimes be confounded with unobserved regional factors. Moreover, institutional quality measures tend to be based on human judgment rather than hard data, so they may be somewhat endogenous to macroeconomic performance.

Nevertheless, it is clear that in some cases natural resource endowments are wasted. But why? Van der Ploeg (2011) provides a recent extensive survey. There is some evidence that the natural resource curse is worse in presidential than in parliamentary political systems. Price volatility of natural resource exports may also be a negative factor. Resources may induce voracious rent-seeking and civil conflict. Van der Ploeg (2011) discusses the empirical evidence in relation to these hypotheses in some detail. But when he comes to "unsustainable government policies," which, presumably, refer primarily to fiscal policy, he seems to find very little empirical evidence to draw on.

Providing such evidence is the main aim of this paper. We compare fiscal performance in resource-rich and resource-poor countries in a way that, as far as we are aware, has not been done in previous research.

2. Some Theory

According to the permanent income hypothesis (PIH), a resource discovery should lead to an increase in consumption that is smoothed over all future periods. Because the increase is smoothed, consumption will not be correlated with the flow of income from resource extraction. In the period between resource discovery and the start of extraction, there will be dis-saving, since consumption increases from the moment of discovery. Savings will be high during the extraction period, and then there will be dis-saving again after extraction ends, when consumption is sustained by the flow of income from and the gradual depletion of other assets acquired during the extraction period.

An alternative model allows for the possibility that, in developing countries, there may be high returns to domestic investment projects that remain unexploited—for example, because of the expropriation risk for foreign investors. Resource extraction provides the means to invest in these projects, which offer a higher return than the world market. It then pays to divert some of the additional consumption that would occur before extraction begins to investment, and to allow consumption to be higher during the extraction period, relative to the PIH path; nevertheless there is still a considerable degree of consumption smoothing (Collier and others 2010, figure 3).

For simplicity, these models assume that the value of the resource stock in terms of other goods is known. That assumption abstracts from uncertainty about the true quantity of reserves, future extraction technology, and future relative price of resources. Commodity prices are known to be volatile, and there has been a long debate about whether or not they exhibit a downward trend. Harvey and others (2010) find that many of them do, and also that there tend to be long cycles of 20 to 40 years' duration. Volatility is enhanced by the fact that the price depends on past investment decisions, which in turn reflect expectations of the future price. In the Appendix a simple model is used to show that, in the absence of producer collusion, in these circumstances the time series properties of the price are likely to be time varying, which makes forecasting particularly difficult. All these uncertainties suggest a cautious approach to the spending of resource revenues, so as not to overestimate the permanent increase in wealth.

Government revenues may be affected by resource wealth, particularly if the assets are state owned or generate considerable royalties. Smoothing consumption requires that extra revenues are largely saved, either as an improved fiscal balance or as capital expenditure. If revenues are sensitive to commodity prices, then the appropriate response to price fluctuations depends very much on the perceived dynamics of prices. If prices are perceived to be nonstationary, then the estimated value of unextracted resources moves with the current price, and so does planned consumption in every period. As the model in the Appendix suggests, there is a strong case that, in the long run, supply

and demand will respond to price changes—even if the short-run elasticities are low, which would make prices stationary. If prices are stationary, however, it is optimal to maximize extraction when prices are high and to minimize it when prices are low. This would cause government revenues to be more volatile than price; if at the same time consumption is to stay largely unaffected, in accordance with the PIH, fluctuations in revenues should be absorbed largely by capital expenditure and the fiscal balance.

The theory of optimal resource abstraction assumes that the resources in the ground are finite and known. This is very much a matter of debate, particularly in relation to oil, where new technology such as fracking has made more reserves accessible.

In terms of assessing fiscal performance, a natural test is whether resource wealth is associated with higher government saving or, in other words, whether there is less government consumption expenditure relative to revenue, and whether the saving takes the form of a stronger fiscal balance or higher capital expenditure. This is the issue that we address here. A second aspect of the resource curse issue, which we do not discuss here, is the possibility that even when the revenues are largely saved, they may nevertheless be wasted—for example, in ill-conceived or inefficiently implemented investment projects.

3. Resource Wealth and Fiscal Performance

In this section we examine the correlation between resource wealth and a number of fiscal variables, using annual data for low- and middle-income countries back to 1996. Fiscal data are scarce before that date, so the sample can be extended further back for only a very few countries.

We capture resource wealth by the share of exports represented by fuel or ores and metals, transformed into dummy variables that are equal to 1 if the export share is above a threshold level. For fuels, we use a threshold of 25 percent; for ores and metals, the threshold is 10 percent. Each of these dummy variables is equal to 1 for just over 20 percent of the sample, but it is rare for both of these dummies to be 1 (2.5 percent of the sample). Using dummy variables for export shares exceeding a certain threshold rather than the export shares themselves focuses the analysis on the differences between resource-rich and resource-poor countries, rather than on the degree of resource richness. This binary approach eliminates the variation among resource-rich countries, but it has the important advantage that it prevents the results from being dominated by a few extreme cases where practically 100% of exports consist of fuel.

Other variables included in the regression are: a measure of political stability (to be discussed below), a dummy for a hard-peg exchange-rate regime (a currency union, currency board, or with no separate legal tender), and a time trend. The governments of less stable countries are more likely to focus on the short term and to ignore longer-term issues like fiscal sustainability, so one would expect them to have worse fiscal balances. A hard-peg regime constrains the government's ability to raise seigniorage revenue, so the fiscal balance needs to compensate for this. Of course the exchange-rate regime is a policy choice, so there is an issue of endogeneity here: countries that have difficulty in closing their fiscal deficits might be more reluctant to adopt a hard peg. There are counterexamples to this argument, however. Argentina adopted a currency board system in 1991 out of despair over its persistent history of high inflation, and precisely to wean itself off repeated resort to seigniorage revenue. Ecuador adopted the U.S. dollar as its currency for similar reasons. Moreover the Sub-Saharan African countries that have adopted hard pegs have mostly done so by historical accident: they were formerly colonies of France rather than of some other European power. Thus a case can certainly be made for the exogeneity of the hard-peg dummy. A time trend is included to capture significant shifts in the relationship over time.

A country's measure of political stability is the political risk rating supplied by the International Country Risk Guide (ICRG), which is measured on a scale of 0 (most risky) to 100 (least risky). It is based on 12 risk indicators, as judged by ICRG staff. Government stability, socioeconomic tensions, risks to investments, internal conflict, and external conflict count for a maximum of 12 points each. Less important factors are: corruption, involvement of the military in politics, religious tensions, law and order, ethnic tensions, democratic accountability (all six points maximum), and the quality of the bureaucracy (four points maximum). In this sample the political risk rating has a mean of 62, with a standard deviation of 10.3.

Hard pegs are identified using the annual exchange-rate regime classification of Bleaney and Tian (2014), mainly because the data run to 2012. It is well known that different exchange-rate classification schemes do not agree with one another, so in principle choosing a classification scheme might make a difference (Tavlas, Dellas, and Stockman 2008), but this seems unlikely in this case since the disagreements between classification schemes do not lie in the identification of hard pegs. As Bleaney and Tian (2014) show, this classification scheme, which is based on purely statistical criteria, is quite similar to the International Monetary Fund's (IMF's) de facto classifications.

Table 1 shows regressions for the general government fiscal balance, total revenues, and total expenditures, all as a percentage of gross domestic product (GDP). There are more than 1,360

observations. The fiscal balance shows no particular time trend, but it is significantly better in hard-peg regimes, politically stable countries, and fuel-exporting countries, but not in countries that export ores and metals. The estimated coefficients suggest that being on a hard peg is associated with an improvement in the fiscal balance of 1.4 percent of GDP, while the effect of being a fuel exporter is much greater: 4.8 percent of GDP. The coefficient of the ICRG political risks measure implies that a ten-point improvement in this measure (which is approximately equal to one standard deviation) adds about 0.6 percent of GDP to the fiscal balance.

Columns 2 and 3 of table 1 show that there is a highly statistically significant upward trend to both revenues and expenditures, of about 0.3 percent of GDP per annum in each case. In fact every coefficient has the same sign in column 3 as in column 2, which shows that in every case the estimated effect on the fiscal balance is the result of offsetting effects on revenues and expenditures. In the case of hard pegs, both revenues and expenditures are significantly lower than under other exchange-rate regimes, but the fiscal balance is better because the expenditure effect is larger. For fuel exporters, the estimated revenue effect of 9.5 percent of GDP is nearly twice as large as the estimated expenditure effect. Politically stable countries have considerably higher revenues and expenditures than unstable ones.

The finding that fuel exporters have higher revenues and expenditures is consistent with the view that developing countries find taxes costly and difficult to collect, which limits the size of their government sector. This argument is often used to explain these countries' tendency to rely on trade taxes (Keen and Mansour 2010). The oil and gas sector is relatively easy to tax, which enables fuel exporters to finance higher government expenditure. Nevertheless, the fact that their fiscal balances tend to be better shows that not all of the extra revenue is spent.

Table 2 contains a similar regression analysis of different components of expenditure as a share of GDP: consumption expenditure, capital expenditure, and expenditure on wages. The additional expenditure of fuel exporters seems to be fairly evenly split between consumption and capital expenditure, and the extra expenditure on wages is only just significant at the 5 percent level. Although exports of ores and metals are not associated with higher expenditure overall, they are associated with significantly higher capital expenditure and lower consumption expenditure. Hard-peg regimes have considerably lower consumption expenditure, by 4.4 percent of GDP, and lower wage expenditure, but not lower capital expenditure. Political stability is associated overwhelmingly with higher consumption and wage expenditure, but slightly lower capital expenditure.

Table 1. Fiscal Balances, Tax Revenues, and Expenditures

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-7.34***	-7.06***	-0.099
	(-8.04)	(-4.79)	(-0.06)
Dummy fuel > 25% exports	4.74***	9.45***	5.05***
	(10.52)	(14.87)	(9.07)
Dummy ores and metals > 10% exports	0.384	0.404	0.359
	(1.30)	(0.83)	(0.71)
Hard peg dummy	1.43***	-2.69***	-4.15***
	(2.96)	(-4.53)	(-8.17)
Political stability	0.0620***	0.469***	0.412***
(0 to 100)	(4.66)	(20.72)	(17.64)
Time trend	0.0185	0.315***	0.278***
(=0 in 2000)	(0.74)	(7.05)	(5.91)
n	1,378	1,392	1,378
R-squared	0.134	0.299	0.231
RMSE	4.75	8.03	7.97

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2012 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

There is a question of whether these results are unduly influenced by outliers. Robust regression is a technique that minimizes the weighted sum of squares of residuals, with observations weighted between zero and one based on Cook's distance statistic, which measures the effect on the fitted values of deleting a particular observation. Outliers tend to have low (sometimes even zero)

weights. A zero weight is of course equivalent to omission of that observation from the sample. An iterative procedure is required because the weights affect the estimated coefficients and therefore the residuals on which the weighting formula is based. Table 3 shows the results of reestimating the regressions in table 1 by robust regression.

Table 2. A Breakdown of Expenditures

Dependent variable:	Consumption expenditure/GDP (%)	Capital expenditure/GDP (%)	Wage expenditure/GDP (%)
Constant	-7.21***	6.17***	0.749
	(-4.75)	(8.05)	(1.32)
Dummy fuel > 25% exports	2.87***	2.37***	0.387*
	(5.47)	(7.21)	(1.78)
Dummy ores and metals > 10% exports	-1.50***	0.896***	-0.312
	(-2.91)	(3.51)	(-1.49)
Hard peg dummy	-4.46***	0.597*	-1.00***
	(-8.82)	(1.78)	(-6.70)
Political stability	0.452***	-0.0266**	0.0977***
(0 to 100)	(19.15)	(-2.37)	(11.45)
Time trend	0.274***	0.0273	0.0280
(=0 in 2000)	(5.61)	(1.17)	(1.37)
n	1,286	1,232	1,128
R-squared	0.279	0.080	0.102
RMSE	7.73	3.90	3.05

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

The general conclusion from table 3 is that the ordinary least squares results shown in table 1 are pleasingly robust. Fuel exports are always highly significant, with coefficients fairly close to those of table 1, and ores and metals exports are always insignificant with a positive coefficient, as in table 1. All the significant coefficients in the fiscal balance regression get smaller when robust methods are used; this effect is smaller for the revenue and expenditure regressions. There is no obvious explanation for this, but it must be remembered that the weights are different for each regression. In the fiscal balance regression, there are 24 observations with a zero weight, of which Libya contributes six, the Republic of Congo five, and Lebanon four. Lebanon has a large deficit in those years, and the other two countries have large surpluses.

Table 3. Fiscal Balances, Tax Revenues, and Expenditures—Robust Regression Results

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-4.81***	-7.89***	-1.23
	(-7.27)	(-5.00)	(-0.76)
Dummy fuel > 25% exports	3.36***	9.11***	5.24***
	(14.36)	(16.49)	(9.09)
Dummy ores and metals > 10% exports	0.244	0.469	0.488
	(1.12)	(0.91)	(0.91)
Hard peg dummy	0.459*	-2.81***	-4.03***
	(1.66)	(-4.24)	(-5.90)
Political stability	0.0301***	0.475***	0.424***
(0 to 100)	(3.06)	(20.28)	(17.52)
Time trend	-0.027	0.318***	0.291***
(=0 in 2000)	(-1.41)	(6.88)	(6.08)
n	1,378	1,392	1,378

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data for 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Any device that is effective in reducing inflation, and therefore seigniorage revenue, might have the effect of improving the fiscal balance in the same way as hard pegs. Table 4 shows the effect of adding a dummy for an inflation-targeting regime to the table 1 regression. This variable is never significant, however.

Do countries behave differently when they first become commodity exporters? To examine this issue, we construct a dummy variable that is equal to one in the five years after a country first exceeds the 25 percent threshold for fuel exports, or the 10 percent threshold for ores and metals (even if the other threshold is already exceeded). Thus this dummy is zero for countries that do not specialize in natural resource exports and also for those that have been exporting resources of the specified type for more than five years. In table 5 this dummy is added to the regressions in table 1, together with an interaction term between this dummy and political stability, which is designed to test whether political stability affects the behavior of new commodity exporters. Neither of these new variables is significant, even at the 10 percent level, for total revenues or total expenditures, but they are each significant at 10 percent level for the fiscal balance. The interaction term has a positive coefficient, and the new commodity exporter dummy has a negative one. This suggests that with low political stability (below 11.91/0.176 = 68) new commodity exporters have somewhat worse fiscal balances, whereas those with high political stability have slightly better ones.

These results imply that new fuel exporters shift to the higher revenue and expenditure patterns of fuel exporters as soon as they become significant fuel exporters. We have also investigated whether there is an anticipation effect whereby new fuel exporters start to take on the fiscal characteristics of fuel exporters in the three years before extraction begins, but we found no evidence of it (results not shown).

Table 4. Controlling for Inflation Targeting

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-7.31***	-7.22***	-0.309
	(-7.95)	(-4.86)	(-0.20)
Dummy fuel > 25% exports	4.74***	9.41***	5.00***
	(10.57)	(14.87)	(8.99)
Dummy ores and metals > 10% exports	0.383	0.412	0.371
	(1.29)	(0.84)	(0.73)
Hard peg dummy	1.44***	-2.77***	-4.26***
	(2.96)	(-4.63)	(-8.33)
Political stability (0 to 100)	0.0615***	0.472***	0.417***
	(4.55)	(20.57)	(17.95)
Inflation targeting dummy	0.091	-0.565	-0.722
	(0.33)	(-0.85)	(-0.99)
Time trend (=0 in 2000)	0.0172	0.323***	0.288***
	(0.68)	(7.19)	(6.11)
n	1,378	1,392	1,378
R-squared	0.134	0.300	0.232
RMSE	4.75	8.03	7.97

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 5. New Commodity Exporters

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-7.26***	-7.14***	-0.276
	(-7.98)	(-4.81)	(-0.18)
Dummy fuel > 25% exports	4.80***	9.51***	5.06***
	(10.53)	(14.93)	(9.07)
Dummy ores and metals > 10% exports	0.414	0.507	0.462
	(1.36)	(0.98)	(0.86)
Hard peg dummy	1.40***	-2.72**	-4.17***
	(2.91)	(-4.57)	(-8.19)
Political stability	0.0609***	0.470***	0.416***
(0 to 100)	(4.59)	(20.62)	(17.63)
New commodity exporter dummy	-11.91*	2.17	13.83
	(-1.93)	(0.23)	(1.35)
Political stability * NCE dummy	0.176*	-0.0551	-0.232
	(1.77)	(-0.42)	(-1.59)
Time trend	0.0184	0.316***	0.279***
(=0 in 2000)	(0.74)	(7.09)	(5.94)
n	1,378	1,392	1,378
R-squared	0.136	0.300	0.232
RMSE	4.74	8.03	7.97

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. The dummy for being a new commodity exporter is equal to one in the first five years of fuel exceeding 25 percent

of exports or ores and metals exceeding 10 percent of exports. RMSE = root mean square error, or sample standard deviation.

Table 6 examines whether political stability has different effects in fuel-exporting countries, by adding an interaction term between these two variables to the regressions in table 1. For the fiscal balance, this makes no difference: the coefficient of the interaction term, although positive, is statistically insignificant. However, this is the result of counteracting effects on expenditures and revenues. For both of these, the coefficient of the interaction term is significantly negative at the 1 percent level. Since this coefficient is about half the size of the positive political stability coefficient for both revenues and expenditures, the effect is to reduce the estimated political stability coefficient for fuel exporters to about half that for the rest of the sample. Thus political stability is not so strongly associated with higher government revenues and expenditures in fuel exporters as it is in other countries.

Table 7 investigates what happens if we control for real per capita GDP, together with its interaction with the fuel exporter dummy. The results show that for the fiscal balance, real per capita GDP is insignificant for the cases where the fuel exporter dummy is zero, but significantly positive when the dummy is one, implying that for fuel exporters only the fiscal balance improves with per capita GDP. The other columns of table 7 show that for countries that are not fuel exporters, per capita GDP has a highly significant positive coefficient that is almost exactly the same for revenues and expenditures. For fuel exporters, the estimated revenue coefficient (2.19 + 1.22 = 3.41) is more than twice as great as the estimated expenditure coefficient (2.21 – 0.52 = 1.69). Results are similar using robust regression methods (not shown).

Table 8 has the same regression specification as table 6, but the dependent variables are various types of expenditure. Recall that in table 2 political stability was associated with less capital expenditure, and more consumption and wage expenditure. In table 8 we allow the political stability effect to be different for fuel exporters. This makes a significant difference to the results. Political stability is associated with less capital expenditure only in nonfuel exporters; in fuel exporters the correlation is positive. For consumption expenditure and wage expenditure, the positive association with political stability is much weaker in fuel exporters. Indeed, for wage expenditure for fuel exporters the coefficient (0.125 – 0.117 = 0.008) is virtually zero, and for consumption expenditure it is only about one-third as great as for the rest of the sample (0.547 – 0.367 = 0.180 compared with 0.547).

Table 6. Political Stability Effects in Fuel Exporters

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-6.3***	-11.05***	-4.50***
	(-7.26)	(-7.44)	(-2.66)
Dummy fuel > 25% exports	1.24	23.48***	20.75***
	(0.55)	(7.01)	(6.90)
Dummy ores and metals > 10% exports	0.334	0.645	0.582
	(1.11)	(1.36)	(1.18)
Hard peg dummy	1.38***	-2.51**	-3.95***
	(2.89)	(-4.15)	(-7.78)
Political stability	0.0475***	0.528***	0.478***
(0 to 100)	(3.80)	(22.86)	(18.23)
Political stability * fuel exporter dummy	0.0594	-0.237***	-0.267***
	(1.46)	(-4.05)	(-5.21)
Time trend	0.0155	0.324***	0.291***
(=0 in 2000)	(0.62)	(7.32)	(6.24)
n	1,378	1,392	1,378
R-squared	0.136	0.309	0.244
RMSE	4.74	7.98	7.91

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 7. Controlling for Real Per Capita GDP

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-6.44***	-11.23***	-5.01***
	(-7.46)	(-7.42)	(-2.98)
Dummy fuel > 25% exports	-8.81**	-1.92	7.15*
	(-2.31)	(-0.38)	(1.74)
Dummy ores and metals > 10% exports	0.447	1.35***	1.24**
	(1.50)	(2.75)	(2.42)
Hard peg dummy	1.36***	-2.11***	-3.52***
	(2.89)	(-3.71)	(-7.19)
Political stability	0.0540***	0.282***	0.234***
(0 to 100)	(2.67)	(10.29)	(8.36)
Ln (real per capita GDP)	-0.0454	2.19***	2.21***
	(-0.29)	(9.19)	(8.86)
Fuel exporter dummy * ln (real per capita GDP)	1.74***	1.22*	-0.515
	(3.43)	(1.83)	(-0.96)
Time trend	0.0177	0.223***	0.189***
(=0 in 2000)	(0.65)	(4.93)	(3.93)
n	1,352	1,366	1,352
R-squared	0.151	0.345	0.270
RMSE	4.71	7.81	7.82

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 8. Political Stability and the Breakdown of Expenditures for Fuel Exporters

Dependent variable:	Consumption expenditure/GDP (%)	Capital expenditure/GDP (%)	Wage expenditure/GDP (%)
Constant	-13.57***	8.39***	-1.09*
	(-7.62)	(9.86)	(-1.76)
Dummy fuel > 25% exports	2.45***	-5.85***	7.31***
	(9.05)	(-3.44)	(6.93)
Dummy ores and metals > 10% exports	-1.10**	0.765***	-0.209
	(-2.20)	(2.89)	(-1.03)
Hard peg dummy	-4.16***	0.466	-0.930***
	(-8.39)	(1.40)	(-6.39)
Political stability	0.547***	-0.0593***	0.125***
(0 to 100)	(19.69)	(-4.82)	(13.16)
Political stability * fuel exporters dummy	-0.367***	1.42***	-0.117***
	(-7.98)	(4.59)	(-6.48)
Time trend	0.289***	0.0189	0.0334*
(=0 in 2000)	(6.04)	(0.82)	(1.65)
n	1,286	1,232	1,128
R-squared	0.305	0.098	0.121
RMSE	7.59	3.87	3.02

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

4. Oil Price Effects

Oil prices have fluctuated quite markedly over the period, as have the prices of other commodities. In particular, oil prices were nearly three times as high in real terms on average over the period 2005–13 as in the years 1996–2005. In tables 9 and 10, we explore whether the relationship between fiscal aggregates and fuel exporting is different in the two halves of the data period, by including a dummy variable that is equal to one from 2005 onward, and equal to zero in the early years, together with an interaction term between this dummy and the fuel exporter dummy. The time trend that was included in earlier tables is omitted.

In table 9 the coefficient of the 2005-13 dummy indicates that resource-poor countries are estimated to have received significantly more tax revenue and also to have spent significantly more in 2005-13, with the revenue effect being larger, so their fiscal balance improved on average by 0.8 percent of GDP. The coefficients of the fuel exporter dummy are similar to those in table 1, except that expenditures of fuel exporters are estimated not to have increased in the second period as expenditures of resource-poor countries have. The revenues of fuel exporters have also increased less than the revenues of resource-poor countries, although not significantly so.

Table 10 suggests that fuel exporters spent 4.9 percent of GDP more on government consumption and 1.7 percent of GDP more on government investment than resource-poor countries in the years 1996–2004, but there was a shift in the second period, when fuel exporters spent only 1.3 percent (= 4.9 – 3.6) of GDP more on consumption and 2.8 percent (= 1.7 + 1.1) more on investment. This implies that in 2005–12 the extra revenues of fuel exporters (+9.0 percent of GDP) were overwhelmingly saved (fiscal balance +5.0 percent of GDP and investment +2.8 percent of GDP).

An interesting question is how fiscal variables in fuel-exporting countries react in the short term to changes in the real price of oil. Table 11 shows that revenue is strongly correlated with the real oil price, as one might expect, but that expenditure reacts only with a lag. Consequently the fiscal balance improves in the first year when the oil price rises. Table 12 looks at oil price effects on different types of expenditure. Both capital and consumption expenditure increase significantly in the year after an oil price increase. A second lag of the oil price is not significant (results not shown). These results are consistent with the analysis of surges in natural resource revenues in IMF (2012), which reports that savings increase more than investment, particularly for short-lived surges. If investment can be undertaken efficiently in developing countries, it is likely to have a high return, and a substantial increase in public investment may be an optimal response to a resource boom (Berg *et al.*, 2013).

Table 9. Differences in Fuel Exporter Effects, 1996–2004 and 2005–13

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-7.52***	-7.08	-0.107
	(-8.31)	(-4.84)	(-0.07)
Dummy 2005–13	0.786***	3.11***	2.26***
	(3.39)	(6.76)	(4.55)
Dummy fuel > 25% exports	4.25***	10.19***	6.60***
	(8.56)	(11.86)	(8.19)
Dummy fuel > 25% exports * Dummy 2005–13	0.730	-1.31	-2.59**
	(0.94)	(-1.13)	(-2.51)
Dummy ores and metals > 10% exports	0.320	0.385	0.400
	(1.11)	(0.79)	(0.79)
Hard peg dummy	1.38***	-2.63***	-4.05***
	(2.89)	(-4.50)	(-7.93)
Political stability (0 to 100)	0.0605***	0.467***	0.414***
	(4.60)	(20.77)	(17.66)
n	1,378	1,392	1,378
R-squared	0.143	0.299	0.224
RMSE	4.72	8.04	8.02

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996-2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 10. Differences in Fuel Exporter Effects on the Breakdown of Expenditures

Dependent variable:	Consumption expenditure/GDP (%)	Capital expenditure/GDP (%)	Wage expenditure/GDP (%)
Constant	-7.40***	6.49***	0.611
	(-4.89)	(8.45)	(1.09)
Dummy 2005–13	2.48***	-0.086	0.291
	(4.87)	(-0.35)	(1.34)
Dummy fuel > 25% exports	4.90***	1.72***	1.12***
	(6.91)	(4.50)	(3.37)
Dummy fuel > 25% exports * Dummy 2005–13	-3.56***	1.13**	-1.24***
	(-3.72)	(2.08)	(-3.11)
Dummy ores and metals > 10% exports	-1.52***	0.920***	-0.308
	(-2.98)	(3.62)	(-1.48)
Hard peg dummy	-4.34***	0.593*	-0.978***
	(-8.60)	(1.76)	(-6.44)
Political stability (0 to 100)	0.455***	-0.0290**	0.0994***
	(19.36)	(-2.58)	(11.80)
n	1,286	1,232	1,128
R-squared	0.275	0.083	0.107
RMSE	7.75	3.90	3.04

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 11. Oil Prices and Fiscal Balances of Fuel Exporters

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-9.17	-10.70	-9.70
	(-1.19)	(-1.51)	(-1.63)
Lagged dependent variable	0.699***	0.886***	0.814***
	(10.64)	(24.36)	(16.81)
Ln (real $ oil price)	14.8***	11.45***	-2.90
	(8.08)	(6.96)	(-1.63)
Lagged ln (real $ oil price)	-12.9***	-8.47***	6.56***
	(-7.14)	(-5.37)	(3.97)
Hard peg dummy	0.258	-0.0968	-1.55
	(0.22)	(-0.76)	(-1.55)
Political stability	0.0369	0.0662***	0.0661**
(0 to 100)	(1.44)	(2.64)	(2.27)
Time trend	-0.257	-0.377	-0.392*
(=0 in 2000)	(-1.00)	(-1.63)	(-1.93)
n	297	305	297
R-squared	0.564	0.811	0.749
RMSE	4.65	4.36	4.08

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries with fuel > 25 percent of total exports. RMSE = root mean square error, or sample standard deviation.

Table 12. Oil Prices and the Breakdown of Expenditures among Fuel Exporters

Dependent variable:	Consumption expenditure/GDP (%)	Capital expenditure/GDP (%)	Wage expenditure/GDP (%)
Constant	-1.39	-9.05***	0.0097
	(-0.26)	(-3.01)	(0.76)
Lagged dependent variable	0.814***	0.950***	0.936***
	(19.16)	(20.66)	(26.47)
Ln (real $ oil price)	-3.50**	0.186	-2.57***
	(-2.21)	(0.30)	(-6.69)
Lagged ln (real $ oil price)	4.51***	2.43***	2.41***
	(3.18)	(3.17)	(6.53)
Hard peg dummy	-1.26**	-0.0030	-0.131
	(-1.99)	(-0.01)	(-1.36)
Political stability	0.0444**	0.00206*	0.00589
(0 to 100)	(2.06)	(1.69)	(0.94)
Time trend	-0.0794	-0.314***	0.0053
(=0 in 2000)	(-0.43)	(-3.15)	(0.11)
n	288	265	254
R-squared	0.741	0.809	0.884
RMSE	3.60	1.88	0.891

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries with fuel > 25 percent of total exports. RMSE = root mean square error, or sample standard deviation.

5. Discussion

Laxity of fiscal policy has always been suspected as being a significant dimension of the natural resource curse. Previously, lack of sufficient data had inhibited empirical work on this issue. We have investigated the fiscal balance and total revenues and expenditures of general governments, as a proportion of GDP, in low- and middle-income countries from 1996 to 2012. Specialization in the exports of ores and metals, defined by the share of ores and metals exceeding 10 percent of exports, shows no particular correlation with total revenues or expenditures. Specialization in fuel exports, defined as fuel representing more than 25 percent of exports, is strongly and robustly associated with higher government revenues and expenditures. This difference may reflect the fact that, in the case of fuel, the rents from extraction are more likely to accrue to the government. Nevertheless, the estimated expenditure effect of being a fuel exporter is only about half the estimated revenue effect, so that the fiscal balance is estimated to be better among fuel exporters than in the rest of the sample. The extra expenditure of fuel exporters appears to be about evenly split between consumption and capital expenditure; since capital expenditure is typically much smaller than consumption expenditure, this implies a larger proportionate increase for capital expenditure. The proportion of fuel exporters' extra revenue that is saved rather than spent on extra government consumption has increased from about 60 percent in 1996–2004 to about 85 percent from 2005 onward.

It is also the case that ores and metals exporters have significantly higher capital expenditure and lower consumption expenditure than countries that do not specialize in exporting minerals or fuel. This implies that government saving is higher in ores and metals exporters than in resource-poor countries, given that there is no significant difference between them in total revenues and expenditures.

There is little evidence that countries that have recently (within five years) become specialists in exporting fuel or minerals are any different from established specialists. Other features of the data are that more politically stable countries and those on a hard-peg exchange-rate regime tend to have better fiscal balances. In the case of hard pegs, this is because both revenues and expenditures are smaller, but the expenditure effect is bigger. Political stability, on the other hand, is associated with higher revenues and, to a lesser extent, expenditures. The political stability effect is somewhat weaker for fuel exporters than for the rest of the sample. There is also a clear upward trend over time in the size of government, as measured by total expenditure and revenue. On the expenditure side, the upward trend is concentrated on consumption expenditure rather than capital expenditure.

The revenues of fuel exporters respond immediately to changes in the real price of oil, as one might expect, and expenditures respond with a lag of approximately one year. There is no evidence of asymmetry between rises and falls in oil prices, or that the effect varies with political instability.

6. Country Studies

In this section we briefly consider some individual resource-rich countries whose recent fiscal performance might be of interest. After a foreign investment boom in the mining sector, Mongolia relies heavily (more than 50 percent) on the export of ores and metals, but its fiscal position has recently deteriorated. Ghana has been a major exporter of oil only since 2010, but has seen a rapidly expanding fiscal deficit in that time. We also discuss three countries with a relatively sound fiscal position: Paraguay, which like Ghana exported oil in large quantities since 2010 only; Bolivia, which for many years relied on exports of gas (about 50 percent) and ores and metals (30 percent); and Tanzania, where the share of ores and metals has increased to about 30 percent of total exports in recent years.

In Mongolia total revenues have fluctuated between 30 percent and 40 percent of GDP in recent years. They reached a peak of 40.3 percent in 2011, but fell to 35.5 percent of GDP in 2012 and 33.7 percent in 2013. Meanwhile total expenditure has grown rapidly from 26.2 percent of GDP in 2006 to 45.1 percent in 2011, 46.3 percent in 2012, and 43.8 percent in 2013. Mongolia moved from a budget surplus in four out of the six years between 2005 and 2010, to a deficit of over 10 percent of GDP in 2012 and 2013. The 2014 IMF Country Report characterizes both fiscal and monetary policy in Mongolia as extremely expansionary (IMF 2014c); however, a breakdown of expenditure is not available. The model does not explain these developments: the residual for 2012 is -8.2 percent of GDP, after being -2.2 percent in 2011 (the model is not estimated for 2013).

Ghana has had a fiscal deficit of over 4.0 percent of GDP every year since 2006. From 2010 to 2013 revenue was in the range 16 to 20 percent of GDP, and expenditure between 25 percent and 31 percent of GDP. As a percentage of GDP, the fiscal deficit was 9.4 percent in 2010, 6.5 percent in 2011, 11.8 percent in 2012, and 10.0 percent in 2013. General government capital expenditure actually fell from 7.6 percent of GDP in 2010 to 4.6 percent in 2013, but in the same period consumption expenditure increased from 18.5 percent of GDP to 22.2 percent. The 2014 IMF Country Report attributes this to the public sector wage bill and energy subsidies (IMF 2014b). Ghana's negative residual in every year since 2005 shows a consistently worsening fiscal position than the model predicts. The negative residuals have gotten larger in every year except 2009—they reached -6.6 percent of GDP in 2010, -8.1 percent in 2011, and -13.5 percent in 2012. As was the

case with Mongolia, the model does not explain the widening fiscal deficit (which has improved since 2012).

Paraguay jumped from exporting effectively no fuel in 2009, to fuel representing 30 percent of its exports from 2010 onward. Nevertheless, it has had an altogether less dramatic fiscal experience than Mongolia or Ghana in recent years. Tax revenue has grown modestly from roughly 19 percent of GDP in 2005–08, to 21 percent in 2009–13. Expenditure has grown faster, from 17 percent to 21 percent of GDP, but from a fairly low base. The overall fiscal position has shifted from a small surplus (< 2 percent of GDP) to a slight deficit (also < 2 percent of GDP). Some of the extra expenditure has gone into capital projects, but consumption expenditure has also increased, with higher expenditure on wages and salaries (IMF 2014d). Public debt is low at about 14 percent of GDP, and a Fiscal Responsibility Law that came into effect in 2015 restricts the growth of public spending, the rate of increase of public sector wages, and the size of the budget deficit (IMF 2014d). Overall, Paraguay has strong economic fundamentals and appears to be addressing the modest trend deterioration in its fiscal position. From 2005 to 2009 its residual in the fiscal balance model was over +4 percent of GDP each year, but it fell to virtually zero in 2010 and 2011, and to -2.4 percent of GDP in 2012.

Bolivia is very different from Paraguay in that it has exported natural resources in large quantities for a long time; in that respect it is more similar to Mongolia. Both revenue and expenditure are high, fluctuating between 30 and 39 percent of GDP in the years 2005 to 2013. It ran a small fiscal surplus (usually less than 2 percent of GDP) in every year from 2006 to 2013, although in 2014 there was a deficit of 3.4 percent of GDP. Partly as a result of debt relief, public debt has fallen from 95.7 percent of GDP in 2003 to 33.4 percent in 2012 (IMF 2014a). Bolivia's fiscal balance in the years 2010 to 2012 is very much in line with the model's predictions, with residuals close to zero, and the authorities seem committed to maintaining fiscal discipline.

Tanzania is another country with rather stable ratios, but its fiscal position is weaker than that of Bolivia or Paraguay. Since 2009 the fiscal deficit has been between 5.0 percent and 6.5 percent of GDP in each year, with tax revenue of roughly 21 percent of GDP and expenditure of 26–27 percent of GDP. Capital expenditure is quite high, at about 8 percent of GDP. Growth has been strong over the past decade, but financial management could be improved (IMF 2014e). The residuals from the fiscal balance equation were small up until 2008; however, in the four years 2009 to 2012 they were -3.2, -3.6, -2.2, and -2.2 percent of GDP, respectively, which indicates a somewhat worse performance than predicted by the model.

7. Some Robustness Tests

In this section we report the results of some additional regressions. It is likely that fiscal variables exhibit strong serial correlation. Accordingly, in tables 13 and 14 a lagged dependent variable is added to the regressions shown in tables 1 and 2. It is always extremely significant, with a coefficient of more than 0.8 for revenue and all types of expenditure and of slightly less than 0.6 for the fiscal balance. Its inclusion improves the R-squared dramatically, but it tends to make the other variables rather less significant.

Table 15 repeats table 11 except that country fixed effects are included, which tends to reduce the coefficient of the lagged dependent variable. Otherwise the results are similar, though there is a significant negative time trend to revenues and the fiscal balance.

Table 16 is a first-difference specification for fuel exporters with country fixed effects. It also considers the possibility of asymmetry between price rises and price falls, but the difference is not statistically significant. The main result is that the change in the fiscal balance and the change in total revenues are both positively correlated with changes in the real price of oil. This result is not surprising, in view of the previous tables. Changes in total expenditures are never positively correlated with changes in the real oil price, even with a one-year lag.

Table 17 uses the first-difference specification to investigate interactions between political stability and oil price changes; the interaction variable is never statistically significant.

Table 13. Allowing for Persistence

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Constant	-3.13	-0.725	0.076
	(-4.03)	(-1.04)	(0.12)
Lagged dependent variable	0.571***	0.881***	0.905***
	(10.44)	(33.84)	(55.02)
Dummy fuel > 25% exports	2.19***	1.28***	0.447
	(5.42)	(3.17)	(1.63)
Dummy ores and metals > 10% exports	0.203	0.240	0.167
	(0.78)	(0.96)	(0.83)
Hard peg dummy	0.533	-0.313	-0.280
	(1.07)	(-0.54)	(-0.99)
Political stability	0.0271**	0.0565***	0.0397***
(0 to 100)	(2.51)	(3.35)	(3.41)
Time trend	-0.0097	0.0231	0.0377*
(=0 in 2000)	(-0.50)	(1.27)	(1.75)
n	1,342	1,358	1,344
R-squared	0.423	0.846	0.874
RMSE	3.88	3.76	3.21

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 14. Allowing for Persistence in the Breakdown of Expenditures

Dependent variable:	Consumption expenditure/GDP (%)	Capital expenditure/GDP (%)	Wage expenditure/GDP (%)
Constant	-0.368	0.768*	0.167
	(-0.68)	(1.75)	(1.02)
Lagged dependent variable	0.925***	0.888***	0.922***
	(77.59)	(20.92)	(23.98)
Dummy fuel > 25% exports	0.0067	0.429**	-0.0044
	(0.03)	(2.45)	(-0.06)
Dummy ores and metals > 10% exports	-0.148	0.296**	0.0609
	(-0.98)	(2.25)	(0.93)
Hard peg dummy	-0.394*	0.271*	-0.0953*
	(-1.94)	(1.83)	(-1.66)
Political stability	0.0336***	-0.0046	0.0061*
(0 to 100)	(3.58)	(-0.89)	(1.64)
Time trend	0.0316*	0.0007	0.0042
(=0 in 2000)	(1.69)	(0.07)	(0.60)
n	1,244	1,186	1,082
R-squared	0.915	0.812	0.903
RMSE	2.64	1.74	0.982

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries. RMSE = root mean square error, or sample standard deviation.

Table 15. Oil Prices and Fiscal Balances of Fuel Exporters—Country Fixed Effects

Dependent variable:	Fiscal balance/GDP (%)	Total revenues/GDP (%)	Total expenditures/GDP (%)
Lagged dependent variable	0.379***	0.539***	0.498***
	(4.87)	(4.76)	(7.25)
Ln (real $ oil price)	16.01***	11.92***	-3.44
	(6.31)	(6.28)	(-1.39)
Lagged ln (real $ oil price)	-9.62***	-4.92**	6.31***
	(-4.08)	(-2.18)	(3.96)
Political stability	0.182**	0.133**	-0.0135
(0 to 100)	(2.18)	(2.16)	(-0.23)
Time trend	-0.644**	-0.661***	-0.223
(=0 in 2000)	(-2.39)	(-3.40)	(-0.99)
n	297	305	297
No. of countries	30	30	30
RMSE	4.29	4.02	3.85

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries with fuel > 25 percent of total exports. Country fixed effects are included in the regression. RMSE = root mean square error, or sample standard deviation.

Table 16. Oil Prices and Fiscal Balances of Fuel Exporters in First Differences with Country Fixed Effects

Dependent variable:	Change in fiscal balance/GDP (%)	Change in total revenues/GDP (%)	Change in total expenditures/GDP (%)
Change in ln (real $ oil price)	15.90*** (5.18)	12.17*** (4.72)	-3.36 (-1.67)
Change in ln (real $ oil price) if > 0	-0.407 (-0.24)	-0.918 (-0.79)	-0.358 (-0.25)
Political stability (0 to 100)	0.0212 (0.52)	0.0272 (0.82)	0.0099 (0.22)
Time trend (=0 in 2000)	-0.0.0673 (-1.12)	-0.0180 (-0.38)	0.0503 (0.93)
n	328	336	328
No. of countries	33	33	33
RMSE	5.07	4.50	4.38

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries with fuel >25 percent of total exports. Country fixed effects are included in the regression. RMSE = root mean square error, or sample standard deviation.

Table 17. Interaction between Oil Prices and Political Stability for Fuel Exporters

Dependent variable:	Change in fiscal balance/GDP (%)	Change in total revenues/GDP (%)	Change in total expenditures/GDP (%)
Change in ln (real $ oil price)	0.364 (0.04)	11.65 (1.58)	7.04 (0.85)
Political stability (0 to 100)	-0.0180 (-0.37)	0.0296 (0.69)	0.0384 (0.71)
Political stability * change in ln (real $ oil price)	0.265 (1.39)	-0.016 (-0.12)	-0.195 (-1.18)
Time trend (=0 in 2000)	-0.0.0771** (-2.06)	-0.0436 (-1.31)	0.0395 (0.96)
n	328	336	328
No. of countries	33	33	33
RMSE	5.05	4.50	4.36

Note: Figures in parentheses are robust t-statistics. *, **, ***: significant at 10, 5, and 1 percent respectively. Annual data from 1996–2013 for low- and middle-income countries with fuel >25 percent of total exports. Country fixed effects are included in the regression. RMSE = root mean square error, or sample standard deviation.

8. Conclusions

The evidence does not support the notion that natural resource wealth promotes fiscal indiscipline in general. The permanent income theory suggests that the appropriate response to a resource windfall should depend on how long it lasts. A temporary windfall should be largely saved since the permanent increase in consumption will be small compared with the windfall. The less temporary the windfall is, the larger the proportion that it is appropriate to take in increased consumption.

Our results suggest that fuel exporters save about half of the government revenue gains in the form of a stronger fiscal balance, and about half of the remainder in the form of investment, so that only about a quarter is consumed. Moreover, the proportion saved has increased from about 60 percent in 1996–2004 to about 85 percent in 2005–12. Although ores and metals exporters' fiscal balances are on average similar to those of resource-poor countries, the composition of their government expenditure is different. They have significantly higher capital expenditure and significantly lower consumption expenditure. The difference between exporters of oil and exporters of ores and minerals may reflect differences in the higher average level and volatility of rents for fuel exporters, but we have not explicitly investigated this.

A significant caveat is that our data mostly cover a period of relatively high commodity prices. The recent fall in commodity prices may lead to lower government saving in resource-rich countries relative to resource-poor ones.

The response of fuel exporters to fluctuations in the real price of oil was also examined. Revenue is immediately affected, and expenditure reacts with a lag of one year. Consumption as well as capital expenditures are positively correlated with the lagged oil price.

The case studies show that the diverse fiscal experiences of resource-rich countries are largely unexplained by the model. Countries such as Ghana and Mongolia, which have run large fiscal deficits in recent years, display large negative residuals, while other more disciplined countries, such as Bolivia and Paraguay, do not.

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Appendix. A Theoretical Model

This model shows that the price dynamics in a commodity market depends on what each supplier thinks other suppliers will do, and are therefore likely to be unstable.

Let demand (D) be a decreasing function of price (p), plus an intercept that follows a random walk:

$$D_t = a - bp_t + \sum_{T=0}^{t} u_T \quad \text{(A1)}$$

Supply (S) is an increasing function of the capital invested in the last period (K):

$$S_t = c + dK_{t-1} \quad \text{(A2)}$$

The solution for the price is then:

$$p_t = \left(\frac{1}{b}\right)(f_{t-1} - dK_{t-1} + u_t) \quad \text{(A3)}$$

where $f = a - c + \sum_{T=0}^{t-1} u_T$

Capital lasts one period, and different projects vary in cost, so that the amount of capital invested increases with the expectation of the future price:

$$K_{t-1} = gp_t^e \quad \text{(A4)}$$

Substituting from (A4) into (A3) and taking expectations gives the rational expectations solution:

$$p_t^e = \left(\frac{f_{t-1}}{b+dg}\right) = p_t^*; p_t = p_t^* + \left(\frac{u_t}{b+dg}\right) \quad \text{(A5)}$$

Note that p^* is not a constant but contains a random walk element. If suppliers expect a price of p^* and set their supply accordingly, p will deviate from p^* only by a random term. If, however, suppliers expect a higher price, they will supply more, and the actual price will be *below* p^*, not above it as they expected.

Now assume that there are *n* separate suppliers with identical production functions that make independent investment choices and cannot observe the investment decisions of others. Investor *j* understands the model and decides her investment k_{jt-1}on the basis of the expected price determined by others' investment decisions. Suppose that $p_{t-1} > p_t^*$ and that she expects other producers to think incorrectly that prices are only slowly mean-reverting, then she will expect them to supply too much and will depress the price. Therefore she will expect a price below p_t^*, and she will supply accordingly. She is what in financial markets is termed a contrarian investor, betting on the opposite outcome to that expected by the crowd. But if every other investor is like her, believing that others will overinvest, they will all underinvest and the realized price will indeed tend to be above p_t^*.

A relevant case is where historical data support a simple time series model of prices such as:

$$p_t = hp_{t-1} + (1-h)p_t^* + u_t \qquad 0 < h < 1 \qquad \text{(A6)}$$

Suppose that $p_{t-1} > p^*$. If suppliers believe that this will continue to hold in period *t*, they will overinvest and the actual likely outcome will be that $p_t < p^*$. If instead they decide that others will believe this, then we get the case discussed above, with the opposite result. The actual dynamics of prices will depend on how expectations are formed.