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Tax Revenue Performance and Vulnerability in Developing Countries

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ABSTRACT *This paper addresses vulnerability of revenue to external shocks using export composition to capture economic structure and differentiating countries according to income levels, resource endowments and political regimes. This gives a richer characterisation than previous studies. Lower income countries are vulnerable to shocks, especially in terms of trade (associated with the greatest revenue loss): democratic regimes seem to be less vulnerable to revenue losses due to shocks than non-democracies whereas revenue in resource rich countries is more vulnerable to shocks (except natural disasters) than non-resource rich countries. We find a negative relationship between manufacturing exports and revenue in lower income countries.*

1. Introduction

The literature on tax performance of developing countries largely comprises cross-country regression analysis to identify determinants, with some papers specifically considering if aid affects performance (Morrissey & Torrance, 2015). There are also studies aiming to assess the effects of reforms, such as in public financial management or revenue authorities, taking a case study approach (Moore, 2014). Ahlerup, Baskaran, and Bigsten (2015) is an exception including both approaches, using cross-country panel data for sub-Saharan African countries to explore the revenue impact of introducing VAT (no effect) and semi-Autonomous Revenue Authorities (increase revenue). The findings from cross-country studies are rather limited; usually robust results only confirm that tax/GDP ratios are related to broad proxies for the tax base such as shares of agriculture, industry and international trade in the economy. This paper revisits and contributes to that literature in two ways. First, with a richer set of tax base indicators based on export composition we allow for the effect of shocks to address vulnerability of revenue as an additional dimension of tax performance. Second, we allow for country heterogeneity in various ways by considering how determinants of revenue/GDP ratios including shocks vary according to income levels, resource endowments and political regimes. This gives us a richer characterisation of tax performance by economic structure than previous studies and highlights particular challenges facing low-income countries in sustaining increased tax revenue.

Financing for development requires developing countries to improve their domestic revenue mobilisation, but many low and lower-middle income countries may be failing to tap their full revenue potential (International Monetary Fund, 2011). One issue not sufficiently addressed in this context is

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the vulnerability of public revenue in developing countries to exogenous shocks. It has been conventional wisdom for some time that a narrow tax base combined with an excessive reliance on a few commodity exports exposes countries to the risk of increased economic and revenue volatility and, ultimately, lower levels of tax collection. Beyond this general statement there is a knowledge gap regarding the relationship between exogenous shocks and public revenue in a broad and diverse range of low and lower-middle income countries.

In addition to the general impact of shocks on the economy there are specific effects of shocks on revenue systems that may affect the capacity of governments to react to adverse external events and sustain development expenditure. These effects vary not only with the kinds of shock affecting the economies, but also with the characteristics of these economies (for example, level of development, dependence on natural resources), the political and administrative capacity of states to react to changing situations, and the structure of the tax systems. Shocks do not only affect the level of tax collection, but also (perhaps even more importantly) the stability and predictability of revenue. It can be argued that the latter is critical for adaptation to exogenous changes and the ability of public revenue to recover from adverse external events.

Following existing literature, we begin with a standard tax performance specification representing the structure, openness and level of development of the economy but include a richer range of indicators than most studies: the shares of agricultural, mining, manufacturing and fuel exports to GDP along with imports to GDP rather than a single combined measure of trade to GDP. Measures of exposure to three exogenous shocks (exchange rate pressure, terms of trade and intensity of natural catastrophes) are then added, allowing these to be non-linear in order to test if large shocks have a particularly strong impact. Following baseline fixed effects estimates for the full sample classified by income levels and allowing for time trends across countries, the particular features of lower income countries are explored further according to natural resource endowments and political regime type.

Section 2 provides a brief review of the existing literature to set the context. Section 3 outlines the empirical approach and discusses the data, covering up to 152 countries over 1980–2010. The main results are presented and discussed in Section 4, and Section 5 concludes by discussing the characteristics of lower income countries associated with tax revenue performance and vulnerability.

2. Literature Review

With regard to tax systems, the concepts of vulnerability and resilience refer to different functions, such as revenue generation, distribution, stabilisation of income and legitimacy. Apart from affecting the amount of revenue collected, external shocks influence above all the *stability* of revenues and, hence, their predictability with regard to budgeting and public service delivery. Vulnerability is interpreted in terms of sensitivity and capacity to recover; resilient tax systems are those that are not vulnerable to shocks (low sensitivity) or are able to recover quickly; tax systems that are not resilient are very sensitive to shocks and revenue recovers slowly. Further, external shocks may alter the distributive effects of existing tax systems, thus undermining (or strengthening) their legitimacy.

The standard approach in the literature (Gupta, 2007; Le, Moreno-Dodson, & Bayraktar, 2012; Profeta & Scabrosetti, 2010; Tanzi, 1992; Teera & Hudson, 2004) is to model the revenue to GDP ratio as determined by variables chosen to proxy for the tax base and structure of the economy. The proxy indicators most commonly used in developing countries are: (i) agriculture and industry value added as a percentage of GDP; (ii) openness to international trade; and (iii) GDP per capita. Studies sometimes include aid, demographic features such as urbanisation, or indicators of governance and institutions. A broad summary of the literature suggests:

- Tax performance is lower the larger the share of agriculture in GDP and the smaller the share of industry or manufacturing. A large agricultural sector reduces taxable capacity as in low income countries agriculture is largely a subsistence activity which is difficult to tax directly. A large industrial sector is easier to monitor and tax, and a larger share of manufacturing in GDP captures economic development and a larger formal (taxable) sector.

- Trade taxes are relatively easy to collect and have historically been a major share of tax revenue in low-income countries (Aizenman & Jinjarak, 2009; Greenaway & Milner, 1991). As agriculture itself is difficult to tax developing countries often levied taxes on commodity (cash crop) exports as a way of taxing the sector, and also tended to impose high tariffs on imports. Thus, many studies include the trade volume measure of openness (the sum of exports and imports as a percentage of GDP) and it is usually significant (with a positive effect).
- GDP per capita is included as a proxy for the level of economic development to capture increased tax buoyancy (the responsiveness of revenue to income growth) and collection efficiency (Tanzi, 1992). Results are quite mixed and the variable is often insignificant, and sometimes significant but negative. The latter suggests that country differences may be important; for example, many East Asian countries have lower revenue than would be predicted by their economic structure, whereas the low revenue of poor African countries is captured by their high share of agriculture. Furthermore, multi-collinearity of variables such as GDP per capita and agriculture share leads to an imprecise estimation of coefficients (von Haldenwang & Ivanyna, 2012).
- There are no consistent findings for other variables that are often included, for example, Gupta (2007) tests for political variables such as government stability, political stability, law and order, and democracy but fails to find robust results.

Many governance variables have been included to account for societal choices regarding the role of the state, but few are consistently significant: Gupta (2007) and Le et al. (2012) use International Country Risk Guide (ICRG) data on institutional quality; Mkandawire (2010) uses indicators of colonial experience; and Ehrhart (2012) relies on World Bank Governance Indicators. Nevertheless, it seems likely that institutional features shape the capacity of governments to collect taxes. A growing body of research explores the relation between political regimes and tax collection (for example, Ehrhart, 2012; Moore, 2008); Garcia and von Haldenwang (2016) find a U-shaped relation between political regimes and tax ratio, with full autocracies and full democracies collecting significantly higher shares than political regimes located between both margins. Baskaran and Bigsten (2013) find a positive association with democracy in some specifications for 31 sub-Saharan African countries over 1990–2005.

It is likely that the features discussed so far with reference to the level of revenue are also relevant for the vulnerability of tax revenues facing external shocks, although there are few clear guidelines regarding the choice of variables to include. External shocks refer to ‘a sudden event beyond the control of the authorities that has a significant negative impact on the economy’ (IMF, 2003, p. 4). Empirical studies covering the impact of shocks on public revenue in developing countries are scarce. The most commonly employed measure for external shocks is changes in the terms of trade (Rodrik, 1998). Raddatz (2007) argues that changes in commodity prices are the most important external source of GDP fluctuations in low-income countries, and GDP instability is a good proxy for exposure to shocks (Ebeke & Ehrhart, 2012; Lledó & Poplawski-Ribeiro, 2013). Natural disasters affect entire societies, countries or regions and the severe economic impacts can be expected to affect fiscal revenues in developing countries: ‘between 1997 and 2001, the average damage per natural disaster was over 5 per cent of GDP in low-income countries [and] 97 per cent of disaster-related deaths were in developing countries [between 1990 and 1998]’ (IMF, 2003, pp. 4–6).

Many studies exploring the impact of different variables on tax effort or tax performance assume that there are sub-sets in the sample characterised by specific properties. The literature provides us with some initial clues regarding the identification and tax performance behaviour of specific country groups. Level of income is a plausible criterion; Le et al. (2012) observe that the world-wide increase in tax revenue between 1998 and 2009 was particularly pronounced in low income countries. Resource endowment is likely to be important as extractive industries are a potential source of revenue. The nature of the political regime may affect revenue by influencing the formulation of tax policies and shaping the capacity of states to enact tax legislation and manage tax systems (von Haldenwang & Ivanyna, 2010).

Current knowledge regarding the relationship of tax revenue and exogenous shocks in developing countries is limited to a handful of rather basic insights, such as, for instance, high revenue volatility originating from taxing commodity exports. The two most relevant debates in this context – on developing countries' tax effort and performance on the one hand, and on growth volatility and exposure to shocks on the other hand – have not been brought together in a systematic manner. The empirical analysis that follows aims to provide a systematic approach.

3. Research Design

The short literature review sketched out above helps to identify the variables to include for incorporating shocks into the analysis of revenue performance. Research in this area has been hampered by a lack of reliable data, in particular from low and lower-middle income countries, henceforth termed lower income countries to distinguish from higher income (upper-middle and high) developing countries. Almost all studies use the revenue/GDP data provided by the IMF and we follow that practice for comparability (Ahlerup et al. (2015) use the recent independently compiled Government Revenue Dataset). In addition to basic problems in the accuracy of tax data for lower income countries, definitional problems arise: there are differences between central and general government revenue, between tax and total revenue and in how resource rents are treated. It is not evident that the data are based on a consistent definition across countries and over time. Nevertheless, using the same data source as previous studies allows for comparability with the literature, but any conclusions must be cautious.

We follow the standard approach reviewed in Section 2, with some adjustments in variables used, introducing measures of different types of shocks and presenting results for different groups of countries. Definitions and sources for the data can be found in Appendix Table A1. The analysis is conducted on a sample of annual observations covering 1980 to 2010. Exceptions for the length of the observation period for certain countries arising from data limitations and classification changes are indicated in the lists of sample countries in the Online Appendix.

While sector shares of agriculture and industry and the trade volume measure of openness are suitable for cross-country analysis with period averages, especially for reasonably long periods, results are not robust. These measures are less suitable for panel studies with annual data or short period averaged data because shares of agriculture and industry in GDP will tend to change only slowly over time (typically following a clear trend) and shares themselves are poor measures of sector performance (as an indicator of the tax base). The trade volume measure of openness is also of questionable relevance as it combines imports and exports; both are taxed but the applicable tax rates vary and have been changed in different ways. We consider it more helpful to distinguish the import/GDP ratio, as an indicator of the tax base for tariffs, from the export/GDP ratio that can be interpreted more as an indicator of the performance of major sectors in the economy (as many countries eliminated direct export taxes from the 1980s). It is also useful to allow for the composition of exports (which reflects the structure of the economy) so we aim to distinguish agriculture (soft commodities), minerals ('hard' commodities), fuels and manufactured exports, all measured as shares of GDP. The basic specification is:

$$Rev = f(agri\_x, min\_x, fuel\_x, man\_x, M, Y) + \varepsilon \tag{1}$$

Total revenue (*Rev*) is measured as a ratio of GDP and ε is a standard error term. Agricultural exports (*agri_x*), mineral exports (*min_x*), fuel exports (*fuel_x*), manufactured exports (*man_x*) and imports (*M*) are also measured relative to GDP. Treating each type of export separately allows for differential performance of separate parts of the economy, which may be related to external shocks and the tax structure. For example, climatic shocks are most likely to affect agricultural exports; product-specific world price or demand shocks may affect exports of particular commodities; and manufactured exports should be the most resilient to the external shocks analysed here. GDP per capita (*Y*) is included as a measure of the level of development that is expected to reflect administrative capacity and tax collection efficiency.

Three exogenous shocks are considered (definitions are in Appendix Table A1). The exchange rate pressure index (*ER_p*) is a proxy for export demand and foreign capital flow shocks, widely used in international finance literature (Aizenman & Hutchison, 2012; Kaminsky, Lizondo, & Reinhart, 1998). It is generally defined as a weighted average of percentage changes of policy variables in response to current account or financial account shocks. We use the following definition:

$$PI_{it} = w_{E,i}\frac{\Delta E_{it}}{E_{i,t-1}} - w_{RES,i}\frac{\Delta RES_{it}}{RES_{i,t-1}} \tag{2}$$

where i identifies the country, t is the year, E is the exchange rate in local currency units per USD, RES is the size of reserves, $w_{E,i}$ and $w_{RES,i}$ are country-specific weights: $w_{E,i} = \frac{\sigma_{RES,i}}{\sigma_{RES,i}+\sigma_{E,i}}$, $w_{RES,i} = \frac{\sigma_{E,i}}{\sigma_{RES,i}+\sigma_{E,i}}$. Here $\sigma_{RES,i}$ is the standard deviation of $\frac{\Delta RES_{it}}{RES_{i,t-1}}$ in country i in 1980–2012, $\sigma_{E,i}$ is the same for $\frac{\Delta E_{it}}{E_{i,t-1}}$. The logic behind the index is that in response to an adverse balance of payment shock a country could employ different strategies: the government could devalue the currency, but it could also use its international reserves to defend the exchange rate. Both policy variables should be considered in measuring the magnitude of external shocks. The weights in Equation (2) are country-specific and chosen so that the more volatile series gets a smaller weight. To reduce the impact of outliers, the ER pressure index is transformed so:

$$ER\_p_{it} = sign(PI)^{*}\log(1 + |PI|) \tag{3}$$

We assume tax revenue in countries with developed capital and financial markets to be more vulnerable to ER pressure. Capital outflows affect above all the financial sector and those companies that are able to borrow abroad. These sectors typically pay larger shares of personal and corporate income taxes. At the same time, countries with sound and credible policies (for example, countries with political regimes that enjoy more trust from the markets) are expected to be less vulnerable to ER pressure. For instance, the effect of capital outflows on the economy, and on financial intermediation in particular, is much stronger if a country's financial markets are not properly regulated.

The second shock that we use is the terms of trade (*ToT*) index, scaled as the unit price of imports divided by unit price of exports, the factor most likely to increase vulnerability of government revenue to ToT shock is the reliance on trade taxes. Economies that are not sufficiently diversified and unable to quickly reorient their exports according to price changes are expected to be more vulnerable. Some countries may reduce their vulnerability to ToT shocks by establishing insurance mechanisms against these shocks. For instance, a number of resource-rich countries follow a fiscal rule, by which they save extra revenue in a stabilisation fund when times are good and then use revenue from the fund when times are bad. Countries with access to (and trust of) international capital markets may protect themselves against ToT shocks by adjusting their borrowing needs.

The third shock we explore is the intensity (in terms of people killed and affected) of natural catastrophes (*NC*). We assume that natural disasters negatively impact on government revenue by damaging public infrastructure and affecting economic activity. Countries with larger shares of agriculture are expected to be more vulnerable. The measure of intensity of natural disasters follows Fomby, Ikeda, and Loayza (2009) by calculating the approximate magnitude of impact for each type of disaster (drought, earthquake, flood and storm) relative to the population size as the ratio of the sum of the number of casualties plus 30 per cent of the total number of people affected to the population size (a ratio greater than 1% is indicative for a severe impact).

The exogenous shocks are measured as continuous variables and ordered so that higher values mean worse outcomes. For instance, the 90th percentile of ER pressure is 2.86, which roughly corresponds to a weighted average of currency devaluation and decline in reserves of 16.5 per cent. In order to identify the sign and the magnitude of the effect that a shock has on tax revenue, we first fit the following linear regression:

$$rev_{\{i,t\}} = \alpha + \beta w_{\{i,t\}} + \Gamma X_{\{i,t\}} + \epsilon_{\{i,t\}} \tag{4}$$

where i is the country index, and t is the year index; *rev* is total revenue (as percentage to GDP); w is external shock (*ToT, ER_p, NC), X* is the vector of our controls as in Equation (1) and ε is a random error. Our interest is the estimate of β.

The OLS estimator of β may not be consistent because of the relationship between historical averages of *rev* and w. To control for this we will use fixed effects panel estimation, similar to the approach to climate shocks in Deschênes and Greenstone (2007, 2011):

$$r\ddot{e}v_{\{i,t\}} = \alpha + \beta\ \ddot{w}_{\{i,t\}} + \Gamma\ \ddot{X}_{\{i,t\}} + \ddot{\epsilon}_{\{i,t\}} \tag{5}$$

Here for any variable a, $\ddot{a}$ denotes its time-demeaned value:

$$\ddot{a}_{\{i,t\}} = a_{\{i,t\}} - 1/T \sum_t a_{\{i,t\}} = a_{\{i,t\}} - \bar{a} \tag{6}$$

Fixed effects (FE) panel estimation tests the relationship between random deviations of an external factor from its historical mean and deviations of revenue from its historical mean – exactly what we mean by identifying the effect of a random shock. Applying FE to level data is equivalent to demeaning the data and running OLS; this is what is shown in Equations (5) and (6) so FE regression is exactly what we need to identify revenue volatility. Note that with some shocks FE would still be insufficient to identify the causal effect. For instance, a shock to international capital flows may arise due to both exogenous push factors (for example, US interest rate) and endogenous pull factors (for example, misalignment of real exchange rate). Nevertheless, the FE method would still provide for a more robust estimation of associations in the data. To control for time-invariant variables, as well as for country-specific time trends common to all variables, we also estimate fixed effects with individual slopes (FEIS) using a country-specific quadratic time trend.

4. Results

After presenting baseline results for the full sample we restrict focus to the core estimates for lower income countries (further details are available on request). Initial results on the determinants of revenue performance are presented in Table 1. The dependent variable in all regressions is general government total revenue without grants as a share of GDP, including tax and other revenue (from property income, interest payments, sales of goods and services, and so forth). This broader category accounts for the often considerable non-tax revenue accruing from natural resource endowments. Three estimation methods are employed: pooled OLS, fixed effects (FE), and fixed effects with country-specific quadratic time trend (FEIS) to allow for within heterogeneity. All specifications include year dummies; standard errors are robust to arbitrary heteroscedasticity and serial correlation within country. The final column excludes countries with the largest export/import figures (see notes to Table 1). Standard errors are clustered by country to control for any heteroscedasticity and serial correlation within a country; with up to 30 time periods for each country this generates quite large standard errors so we are using conservative significance levels.

The results vary according to the methods used, especially comparing OLS with the more reliable FE or FEIS. Mineral and fuel exports are most consistently associated with higher revenue (and in all FE specifications), and fuel exports are positive and statistically significant in all specifications. Manufacturing exports and share of agriculture in GDP have negative signs in all specifications, but

Table 1. Base specification: determinants of revenue performance

	Full sample			
	OLS	FE	FEIS	FE
	All	All	All	No outliers
Agri_x	0.233***	−0.006	0.023	−0.042
	(0.079)	(0.051)	(0.032)	(0.050)
Min_x	−0.000408	0.224**	0.116**	0.209*
	(0.081)	(0.112)	(0.050)	(0.118)
Fuel_x	0.209***	0.255***	0.168***	0.286***
	(0.056)	(0.095)	(0.050)	(0.072)
Man_x	−0.089	−0.080**	−0.052*	−0.122**
	(0.055)	(0.040)	(0.028)	(0.061)
M	0.007	0.007	−0.011	0.055*
	(0.048)	(0.034)	(0.020)	(0.029)
Agri_VA	−0.174**	−0.089	−0.090***	−0.081
	(0.082)	(0.060)	(0.019)	(0.058)
Y	3.757***	1.536	0.937	0.741
	(0.750)	−1.730	−1.187	−1.658
Constant	1.973	16.59	−0.440*	21.73
	−7.891	(14.21)	(0.253)	(13.52)
R^2	0.663	0.189	0.085	0.219
Observations	2,332	2,332	2,330	2,192
N	152	152	150	148

Notes: All export variables (_x), imports (*M*) and agriculture value added (*Agri_VA*) are measured as a ratio of GDP; GDP per capita (*Y*) is in logs; N refers to number of countries. Under FEIS Mexico and Tajikistan are dropped because each have only one observation (one year with all variables). Robust standard errors in parentheses: *** p < 0.01, ** p < 0.05, * p < 0.1. OLS – ordinary least squares (pooled); FE – fixed effects; FEIS – fixed effects with individual slopes (linear and quadratic). No outliers: excluding countries with Manuf. Exp/GDP > 45 per cent or Imports/GDP > 100 per cent or Fuel Exp/GDP > 60 per cent; four countries are omitted completely (as compared to FE): Hong Kong, Libya, Lesotho and Singapore. We also excluded countries with a population of less than 300,000 to control for specific patterns of small states without observing major changes to our results (available on request).

are not consistently significant. The contribution of imports is very small, and as with agricultural exports is positive in the one case where it is significant. The exclusion of outliers does not seem to matter much for our results except that imports are significant and *Agri_VA* becomes insignificant; otherwise neither magnitudes nor significance change substantially. This suggests that the low statistical significance of the coefficients and small magnitude for some may stem from overall heterogeneity of countries that we pool together in these regressions.

Heterogeneity between countries is demonstrated in Table 2 where we include shocks and divide the sample into lower (low and lower-middle) and higher (high and upper-middle) income groups, which transpire to be quite different (as could be anticipated). The near zero effect of imports/GDP in our pooled regressions is explained by the opposite ways this variable acts in countries with different income: it is negative and mostly insignificant in higher income countries (HICs), perhaps reflecting relatively low tariffs given import levels, whereas in lower income countries (LICs) it is positive, large and statistically significant (consistent with the importance of tariff revenues). The positive relationship between mineral exports and revenue seems to be driven by HICs, significant for *ER* and *NC* shocks, whereas the negative relationship between manufacturing exports and revenue is due to LICs (significant for *ToT* and *NC* shocks). The coefficient on fuel exports is always positive but only significant for LICs (and in the case of *NC* shocks for HICs). The share of agriculture in GDP is never significant.

The negative coefficient on manufacturing exports for LICs is counter-intuitive at first glance. Higher shares of manufacturing in the economy are expected to indicate a relatively larger formal

Table 2. Shocks and revenue performance by income groups (fixed effects estimates)

	Exchange Rate (*ER_p*)		Terms of Trade (*ToT*)		Natural Disaster (NC)	
	Higher	Lower	Higher	Lower	Higher	Lower
Shock	−0.193***	−0.077	−4.387**	−4.327***	−5.916	−7.868**
	(0.069)	(0.059)	(2.069)	(1.453)	(9.147)	(3.721)
Large Shock	−0.364	−0.989*	1.930**	−0.279	0.215	0.376
	(0.749)	(0.525)	(0.850)	(0.636)	(0.924)	(0.250)
Agri_x	−0.004	0.030	0.002	−0.002	0.024	0.046
	(0.090)	(0.060)	(0.101)	(0.063)	(0.091)	(0.063)
Min_x	0.390***	0.004	0.115	−0.137*	0.281*	−0.005
	(0.080)	(0.105)	(0.171)	(0.082)	(0.158)	(0.096)
Fuel_x	0.162	0.309***	0.155	0.299***	0.334**	0.323***
	(0.117)	(0.064)	(0.169)	(0.091)	(0.163)	(0.064)
Man_x	−0.069	−0.063	−0.033	−0.083*	−0.071	−0.081*
	(0.058)	(0.042)	(0.051)	(0.047)	(0.061)	(0.045)
M	−0.058	0.120***	−0.025	0.116***	−0.095**	0.107***
	(0.035)	(0.029)	(0.041)	(0.033)	(0.045)	(0.032)
Agri_VA	−0.372	−0.095	−0.245	−0.057	−0.292	−0.098
	(0.250)	(0.068)	(0.269)	(0.048)	(0.237)	(0.067)
Y	−3.768**	3.800**	−2.870	2.814	−0.592	4.326**
	−1.881	−1.796	−2.180	−1.815	(2.696)	(1.767)
Constant	74.42***	−7.938	59.38***	−0.876	45.46*	−11.13
	(17.28)	(13.12)	(21.55)	(12.97)	(25.00)	(12.79)
R^2	0.301	0.253	0.311	0.280	0.301	0.256
Obs	1,082	1,112	706	1,029	1,091	1,173
N	83	92	76	92	81	96

Notes: As for Table 1. The sample classified into Higher (HIC and UMIC) and Lower (LMIC and LIC) income countries is listed in the Online Appendix. The number of observations depends on data availability for shocks and revenue. Large Shock: equal to 1 if *ER_p, ToT* or *NC* is above 90th percentile of the general distribution of the shock (similar results were obtained for definitions on the income group specific distribution of shocks, available on request). We also estimated further model specifications including the shock variables at two different thresholds for large/largest shocks, above the 75th and 90th percentile or above the 75th and 95th percentile in the income group specific distribution of shocks; results remain substantially the same (available on request).

sector that is easier to tax than the informal sector, and so is expected to be associated with higher tax revenue. It is also the case that formal firms, in contrast to informal microenterprises, are more likely to export. The coefficient ceases to be significant for LICs with *ToT* shocks only if the imports/GDP variable is omitted (results available on request). Controlling for country openness to trade, manufacturing (and mineral) exports are more vulnerable to *ToT* shocks than other exports in LICs. A plausible interpretation is that for manufacturing in poorer countries to be globally (export) competitive they need to restrain labour costs and margins; wages and profits are low so the sector makes no significant contribution to the tax base. The results are also consistent with global fragmentation of production: manufacturing exports of poor countries are based on adding a small amount of value added to imported intermediate inputs, hence they do not contribute much to domestic tax revenue (although any tariffs on the imports do contribute). To the extent that greater manufacturing exports are associated with the presence of foreign investment this may also reflect difficulties in taxing multinationals. The significant negative coefficient on *man_x* for LICs under *NC* shocks suggests that manufacturing is vulnerable to the disruption associated with natural disasters (perhaps due to effects on transport and energy supply).

There are differences in the importance of shocks between the two groups of countries. Exchange rates shocks only have a significant adverse effect on revenue in HICs; for LICs the significance is weak and only for large shocks. However, large *ER* shocks imply a greater revenue loss for LICs than HICs. In both groups *ToT* shocks have an adverse impact; the significance is greater for LICs and in

HICs larger shocks appear to reduce this adverse effect. Note that as LICs have lower revenue/GDP ratios on average, similar coefficients imply a larger proportional revenue loss for LICs. The economic importance of shocks is greater for LICs.

In the remainder of the analysis we focus on the lower income sample only and chose FE without exclusion of outliers as our benchmark specification. Compared to FE, FEIS generally produces smaller coefficient estimates, which are also less statistically significant (results available on request). The reason is that the inclusion of country-specific time trends wipes out more variation than simply allowing for country-specific intercepts (as is the case for FE). Wiping out this variation may not always be reasonable. For instance, an increase in a country's fuel exports to GDP may very well cause an increase in its tax ratio. This is the relationship that we want to capture. If we track that country from the onset of fuel production and export, FEIS may not be able to capture this relationship as both increases in tax ratio and fuel exports would be accounted for by the time trend. Unlike FE, OLS does not control for omitted variables that are time-invariant or change only slowly with time. For instance, within a relatively stable institutional environment of a particular country, an increase in mining exports to GDP is likely to cause an increase in tax ratio, and this is the effect we want to estimate. However, institutional environments – and hence tax regimes in the mining industry – between the countries vary a lot: some countries manage to extract a large share of rents from the mining companies, whereas other countries do not. As a result, OLS would estimate no empirical relationship between mining exports and tax ratio, whereas FE would (see Table 1).

We further divide LICs into two groups to check for heterogeneity in the effects of shocks and run FE regressions with the three shocks. First, LICs are classified as resource rich (RR) and non-resource rich (NRR) by their natural resource endowment (as classified in IMF, 2012). Second, LICs are classified as democratic (D) and non-democratic (ND) according to their political regime characteristics, based on their Polity IV score: on a scale ranging from 10 to −10, a country is considered a democracy if its Polity IV score is higher than 6 and a non-democracy otherwise (see Marshall, Gurr, & Jaggers, 2010). Results are presented in Tables 3 and 4.

For interpreting the shock coefficients recall that the FE estimation uses an unbalanced panel of annual observations so coefficients can be interpreted in accordance with deviations from the mean. The results suggest significant heterogeneity within LICs. First, consider differences between RR and NRR lower income countries (Table 3):

- *ER* pressure is negative and weakly significant only for RR countries. Fuel exports are a positive and highly significant determinant of revenue for RR countries, as would be expected (and consistent with the large positive coefficient on GDP per capita). Exchange rate shocks do reduce revenues in RR countries, on average by about 0.5 percentage points (a one standard deviation adverse *ER*_p is 2.4, corresponding to a 10% currency depreciation or loss of reserves). Mineral and manufacturing exports have weakly significant negative coefficients only for NRR countries, but exchange rate shocks are insignificant. Countries more reliant on fuel exports (RR) are more susceptible to exchange rate shocks. However, relatively richer RR countries have higher revenue (*Y* is positive and significant) so may be more resilient.
- The coefficient on terms-of-trade shocks is negative and statistically significant in both groups of countries, but smaller and less significant in NRR countries. Most other results are similar to those for *ER*: fuel exports are positive and the more significant for RR countries, whereas manufacturing exports have significant negative coefficients only for NRR countries. Thus, *ToT* shocks have a significant negative impact on revenue irrespective of endowments: a one standard deviation *ToT* shock is 0.3 (about a 25% reduction in relative prices) and would reduce revenue by between 1.1 (NRR) and 1.4 (RR) percentage points. Again, RR countries are more susceptible to the shocks.
- The negative effect of natural disasters intensity seems to be driven entirely by NRR countries (it is insignificant for RR). It appears to be that the extractive industries – the main sources of tax revenue in RR countries – are less affected by natural catastrophes than other types of economic activity; fuel exports are positive and significant for both groups. A one standard deviation *NC* shock would reduce revenues in NRR countries by about 0.2 percentage points, so far less severe

Table 3. Effects of shocks on revenues of lower income countries, resource-rich vs. non-resource-rich countries, fixed effects estimation

	Exchange rate pressure (*ER_p*)		Terms of trade (in logs) (*ToT*)		Intensity of natural disasters (*NC*)	
Shocks:	RR	NRR	RR	NRR	RR	NRR
Shock Level	−0.221*	−0.082	−4.54***	−3.608**	−3.373	−7.986**
	(0.110)	(0.062)	(1.234)	(1.499)	(7.401)	(3.383)
Agri_x	0.200	−0.0461	0.168	−0.054	0.162	0.002
	(0.139)	(0.056)	(0.142)	(0.074)	(0.146)	(0.059)
Min_x	0.028	−0.587*	−0.071	−0.573**	0.003	−0.578*
	(0.091)	(0.297)	(0.083)	(0.280)	(0.095)	(0.292)
Fuel_x	0.289***	0.258*	0.264***	0.373**	0.273***	0.357**
	(0.056)	(0.130)	(0.096)	(0.166)	(0.059)	(0.152)
Man_x	0.002	−0.085**	−0.048	−0.089*	−0.061	−0.093**
	(0.087)	(0.038)	(0.098)	(0.048)	(0.075)	(0.042)
M	0.064*	0.160***	0.063	0.148***	0.049	0.136***
	(0.034)	(0.032)	(0.038)	(0.038)	(0.033)	(0.039)
Agri_VA	−0.202**	−0.056	−0.088	−0.054	−0.210**	−0.062
	(0.093)	(0.055)	(0.066)	(0.053)	(0.087)	(0.057)
Y	6.389**	2.299	4.436	1.485	5.206**	3.362*
	(2.404)	(1.905)	(2.911)	(2.161)	(2.134)	(1.857)
Constant	−23.68	2.331	−12.06	8.457	−13.90	−4.740
	(16.95)	(13.89)	(20.01)	(15.93)	(15.02)	(13.56)
R^2	0.436	0.234	0.425	0.261	0.441	0.230
Observations	346	766	331	698	385	788
Number of countries	29	63	32	60	32	64
Chow tests:						
a. Only shocks						
t-statistic	−1.13		0.629		1.43	
p-value	0.26		0.48		0.16	
b. Shocks and structural variables						
F-statistic	2.53		1.35		1.60	
p-value	0.02		0.23		0.13	

Notes: As for Table 1. RR refers to resource-rich and NRR to non-resource-rich countries. The number of observations varies according to data availability.

than *ToT* shocks. Furthermore, relatively richer countries appear to have more resilient revenue under *NC* shocks (*Y* is positive and significant for both groups).

- It may seem surprising that fuel exports are usually positive and significant for NRR as well as RR countries. The threshold for the RR classification used is that the value of fuel exports exceeds 30 per cent of GDP. The majority of NRR have some hydrocarbon exports: the median value is 2.2 per cent of GDP, perhaps due to low production or processing, although for some the value exceeds 25 per cent (suggesting re-exports). We conducted sensitivity analysis (available on request) and qualitative results were largely unchanged (the same variables were significant with similar coefficients). If we set *fuel_x* = 0 for NRR, the only notable differences are that the *ToT* shock coefficient is larger and *min_x* is insignificant in the NC regression. If we only include NRR countries for which *fuel_x* < 10 per cent (or < 5%), *fuel_x* is significant and other significant coefficients tend to be a little smaller (except for *NC* there is a larger negative coefficient on the shock). At any level, fuel exports are a significant contributor to revenue.

Despite the visible difference between the estimated coefficients for RR and NRR countries, the Chow tests show no statistical significance: p-values get close to commonly accepted levels when only coefficients on shocks are tested, except for *ToT* shocks. This finding is driven by the high standard

Table 4. Effects of shocks on revenues of lower income countries, democratic vs. non-democratic countries, fixed effects estimation

	Exchange rate pressure (*ER_p*)		Terms of trade (in logs) (*ToT*)		Intensity of natural disasters (*NC*)	
Shocks:	D	ND	D	ND	D	ND
Shock Level	−0.022	−0.201***	0.691	−5.231***	−7.248	−5.183
	(0.075)	(0.068)	(2.007)	(1.268)	(8.877)	(4.268)
Agri_x	−0.050	0.016	0.037	−0.120	−0.001	0.002
	(0.075)	(0.106)	(0.084)	(0.091)	(0.086)	(0.107)
Min_x	−0.229	0.034	−0.202	−0.117	−0.242	0.019
	(0.162)	(0.111)	(0.139)	(0.108)	(0.148)	(0.110)
Fuel_x	0.492***	0.315***	0.498***	0.250**	0.481***	0.326***
	(0.115)	(0.068)	(0.129)	(0.108)	(0.113)	(0.067)
Man_x	−0.149***	−0.066	−0.143***	−0.108*	−0.145***	−0.105
	(0.052)	(0.069)	(0.053)	(0.064)	(0.051)	(0.075)
M	0.114*	0.137***	0.049	0.133***	0.073	0.135***
	(0.064)	(0.035)	(0.093)	(0.029)	(0.084)	(0.035)
Agri_VA	−0.007	−0.192**	0.003	−0.111	−0.013	−0.187**
	(0.031)	(0.096)	(0.020)	(0.080)	(0.033)	(0.090)
Y	−0.210	3.488*	−0.514	3.606*	0.192	4.180**
	(−3.010)	(−1.972)	(−2.859)	(−2.001)	(−2.959)	(−1.933)
Constant	20.52	−4.290	23.61	−4.771	19.14	−8.737
	(22.30)	(13.65)	(21.08)	(13.91)	(21.92)	(13.20)
R^2	0.366	0.322	0.370	0.368	0.360	0.328
Observations	383	651	360	631	386	707
Number of countries	37	66	37	69	37	70
Chow tests:						
a. Only shocks						
t-statistic	1.10		2.19		−0.26	
p-value	0.28		0.03		0.80	
b. Shocks & structural variables						
F-statistic	2.17		2.09		1.95	
p-value	0.03		0.04		0.06	

Notes: As for Table 1; D denotes Democracies and ND Non-democracies. The number of observations varies according to data availability.

error of a coefficient in at least one of the groups. Chow tests are even less significant when we jointly test coefficients on shocks and structural variables, suggesting that within the group of LICs RR and NRR countries are not dramatically different. Thus, one should not over-emphasise the differences found between the two groups for each shock.

Table 4 reports differences between democratic (D) and non-democratic (ND) lower income countries:

- *ER* pressure has a negative effect in both D and ND countries, but is only statistically significant (and greater) for the ND group. As *fuel_x* and *M* are positive and significant for both groups, the main endowment difference is in *man_x* which is negative and significant for D only (but *ER_p* is insignificant); it may be that democracies are better able to support manufacturing export although it does not appear to generate revenue. It is the ND regimes that are more susceptible to revenue loss during *ER_p* shocks: the magnitude of the effect corresponds to a 0.5 percentage point revenue loss (similar to RR).
- The coefficient on *ToT* shocks is also negative and significant for ND countries only, and again is closer in magnitude to that for RR than NRR countries. A one standard deviation ToT shock would reduce revenue on average by 1.6 per cent in ND countries. Democratic regimes do appear better

able to extract and sustain public revenue from the oil sector (the coefficient on *fuel_x* is larger), and appear far more resilient to *ToT* shocks. In both groups *man_x* is negative and significant, albeit more so in democracies.

- Natural disasters (*NC*) are not significant for either group of countries, perhaps because the incidence of disasters is unrelated to the level of democracy.

Democratic LICs fare better than non-democracies in their revenue resilience to shocks (coefficients are insignificant). For non-democratic LICs, the effects of shocks are negative and statistically significant (except for NC), varying in impact from 0.1 (*NC*) to 1.6 (*ToT*) percentage points loss in revenue. Chow tests show that many of the differences are significant. Interestingly, imports are more important (positive and significant) for ND (mostly insignificant for D), whereas the negative coefficient on manufacturing exports is mostly only significant for D. Whilst acknowledging the many caveats that apply, democracies do appear to out-perform non-democracies in revenue resilience to shocks for lower income countries.

The Online Appendix reports sensitivity analysis using interaction terms rather than separate regressions for two groups. Significance levels are generally low but the core inferences are consistent with the conclusions above: LICs are more vulnerable to revenue losses from shocks than HICs, especially for *ToT* shocks; within LICs democracies are significantly less vulnerable to revenue losses from shocks than non-democracies and resource rich countries tend to be more vulnerable although differences are not statistically significant. The results above show that coefficients on explanatory variables often differ notably between the two groups, so the use of interaction terms is limited: as including interaction terms for all variables is too demanding of the data separate regressions for groups are more informative.

5. Conclusions

The main purpose of the analysis is to provide empirical evidence on the vulnerability or resilience of government revenue under exogenous shocks, especially for lower income countries. The approach chosen, given the limited quality of the data, is parsimonious estimation methods and conservative standard errors. This necessarily raises the bar for achieving statistical significance and may lead to less appealing results in some instances, but it increases the robustness of findings as well as the credibility of the inferences presented in the following paragraphs. Concerns about endogeneity are certainly an issue although mitigated by the focus on shocks (unlikely to be influenced by revenue/GDP) and export composition variables. The results should be read as identifying statistical relationships and not any causal link. Where causal relationships are suggested, they are theoretically plausible.

Looking at tax performance, it is evident that splitting the sample into lower and higher income groups is relevant, especially for addressing the differentiated impact of imports and various kinds of exports. Typically, research on tax effort in developing countries uses one single trade openness measure (lumping exports and imports) combined with several sector value-added variables (at least agriculture and industry). Our findings indicate that at least regarding manufacturing and mineral exports as well as imports the effects on tax performance are quite different, sometimes even opposite in different groups. It is particularly striking to see that manufacturing exports are associated with less revenue in the lower income group, especially NRR or democracies. This could be due to low value-added and productivity of manufacturing so profits (the corporate tax base) are low (and/or difficult to tax, especially if earned by multinationals) or because wages (the income tax base) are low to maintain international competitiveness, in either case leading to lower revenues at given tax rates. While promoting manufacturing exports may be an economically desirable strategy it should not be assumed to generate increased tax revenues. However, it is only for the non-resource rich lower income countries that the negative effect of manufacturing exports on revenue is significant.

The three shocks considered – exchange rate (*ER*) pressure, terms of trade and the intensity of natural disasters – have a negative effect on revenue (implying a greater revenue loss for lower than higher income countries), although it is not always statistically significant. Terms of trade shocks tend to have the greatest impact, reducing revenues on average by about 1.5 percentage points for lower income countries (except for democracies where the effect is insignificant), and this is associated with manufacturing and mineral exports. In lower income countries, *ER* shocks are only significant for non-democracies and resource rich countries, in both cases reducing revenue by 0.5 percentage points on average. Natural disasters have a much lower impact on revenues, with losses less than 0.2 percentage points on average and only significant for non-resource rich lower income countries.

The analysis focusses on differences within lower income countries according to endowments and political regime. A striking result is that democracies do appear to outperform non-democracies in revenue resilience to shocks for lower income countries (and the differences are statistically significant). For non-democratic countries, the effects of *ER* and *ToT* shocks are negative and significant, whereas for democracies the shocks are insignificant. This difference could be connected to a larger capacity of democratic regimes to avoid or compensate revenue losses through public policies and political bargaining, both on the revenue and expenditure side. Democratic countries seem to benefit more from fuel exports (coefficients being much bigger than for non-democratic countries), that is a given ratio of fuel exports translates into more revenue. The positive effect of fuel exports could be related to more common-interest oriented policies under democratic rule – something several papers in this special issue discuss in case-specific analyses.

Although resources (mineral and fuel exports) are associated with higher revenue, revenue in resource rich lower income countries appears more susceptible to exchange rate and ToT shocks than in non-resource rich countries, seemingly reflecting their greater reliance on fuel exports. The differences are not statistically significant, perhaps because non-resource rich countries do benefit from fuel and mineral exports. In contrast, revenue in resource rich countries is unaffected by natural disaster shocks, unlike in non-resource rich countries (although the magnitude of the effect is small), suggesting resource sectors are less vulnerable to disasters. Both groups of lower income countries are adversely affected by terms of trade shocks, and the effects appear quite large in terms of revenue losses; dependence on commodity exports to a volatile world market increases revenue vulnerability.

All in all, we observe a democracy rent in the sense of lower vulnerability to shocks being associated with democratic rule in lower income countries. It should be noted, however, that causality is particularly difficult to establish in this context. Reflecting the focus of this study, we have been inclined to interpret the findings as outcomes of democratic rule (for instance, assuming a higher ability of democratic governments to impose short-term hardships on their citizens). Several contributions gathered in this special issue show how different institutional and organisational settings influence the outcomes of tax reform. There is also evidence in the literature pointing from higher and more stable revenue to sustained democratic rule, as governments can spend more on public services. Still, reforms aiming at accountability, transparency and rule of law could have an important positive effect on revenue resilience, as governments may have more legitimacy to build broad-based revenue systems, as well as additional short-term manoeuvring space to respond to adverse external events.

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Appendix Table A1: Data (1980–2010) Sources and Definitions

Total Revenue	Total revenue (per cent of GDP)	"Revenue Data for IMF Member Countries as of 2011" Fiscal Affairs Department, Tax Policy Division, IMF (IMF Tax-database)
Total Tax Revenue	Total tax revenue (per cent of GDP)	IMF Tax- database
GDP per capita	GDP per capita	World Development Indicators 2012 ("WDI 2012"). Available online: http://data.worldbank.org/data-catalog/world-development-indicators
Agricultural exports	Exports of agricultural commodities and food (per cent of GDP)	Own construction based on data from WDI 2012
Mineral Exports	Exports of mineral (non-fuel) commodities (per cent of GDP)	Own construction based on data from WDI 2012
Fuel Exports	Export of fuels (per cent of GDP)	Own construction based on data from WDI 2012
Manufacturing Exports	Exports of manufactured commodities (per cent of GDP)	Own construction based on data from WDI 2012
Imports	Merchandise imports (per cent of GDP)	Own construction based on Merchandise imports in current USD and GDP in current USD (WDI 2012)
Terms of trade	Terms of trade	Net barter terms of trade index (2000 = 100), export/import (WDI 2012)
Intensity of Natural Disaster	Measure of intensity of natural disaster based on people killed and affected by natural disaster in every year t and every country j. Formula: $Intensity_{j,t} = \frac{people\ killed_{j,t} + 0.3 * Total\ affected_{j,t}}{population_{j,t}}$	Own construction based on Fomby / Ikeda / Loayza 2009, 12–14. Data from the EM-DAT Database (http://www.emdat.be/)
Income groups	Income groups. 4 groups: low income, lower-middle income, upper-middle income and high income	Period 1980 to 95 - classification as of 1990; period 1996 to 2005 - classification as of 2000; period 2006 to 2010 - classification as of 2011.) Classifications are available online: http://data.worldbank.org/about/country-classifications/country-and-lending-groups
Resource rich	Resource-rich country dummy	IMF (2012)
Democracy	1= democracy 0 =non democratic	Based on Polity II Dataset. Values above 6 are considered democracieshttp://www.systemicpeace.org/polity/polity4.htm
Exchange rate pressure	Defined in text	Own calculation. Source: IMF WEO

Note: The correlations between variables are very low, the highest being 0.5 for *agri_x* and imports, and −0.76 for *agric_VA* and GDP per capita (details available on request).