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The impact of high and volatile commodity prices on public finances: Evidence from developing countries

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Abstract

The recent boom and bust in commodity prices has renewed the policymakers' interest in three complementary issues: i) characteristics and determinants of commodity price instability, ii) its macroeconomic effects and, iii) the optimal policy responses to this instability. This work falls within the scope of studies dedicated to the macroeconomic effects of commodity price instability, but focuses on the impact on public finance, while existing works were concentrated on growth. This paper also differs from the few previous studies on two aspects. First, we test the impact of commodity price volatility rather than focusing only on price levels. Second, we use disaggregated data on tax revenues (income tax, consumption tax and international trade tax) and on commodity prices (agricultural products, minerals and energy) in order to identify transmission channels between world prices and public finance variables. Our empirical analysis is carried out on 90 developing countries over 1980-2008. We compute an index which measures the volatility of the international price of 41 commodities in the sectors of agriculture, minerals and energy. We find robust evidence that tax revenues in developing countries increase with the rise of commodity prices but that they are hurt by the volatility of these prices. More specifically, increased prices on imported commodities, lead to increased trade taxes and (to a smaller extent) consumption taxes being collected. Export prices are also positively associated with tax revenue collection but the channel is through income taxes and non-tax revenues rather than international trade taxes and consumption taxes. However, the volatility of commodity prices, both of imported and exported commodities, is robustly negatively affecting tax revenues. These findings point at the detrimental effect of commodity price volatility on developing countries public finances and highlight further the importance of finding ways to limit this price volatility and to implement policy measures to mitigate its adverse effects.

JEL Classification: E62, O13, F10

Key Words: Price Volatility, Public Finance, Primary Commodities

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1. Introduction

The recent boom and bust in commodity prices has renewed the policymakers' interest in causes and consequences of commodity price instability. This concern is of particular importance for developing countries (DCs), which are frequently vulnerable to this instability. Hence, it is also a central issue for OECD countries to design their aid policy in G8 and G20 forums where a better world economic regulation is targeted. High vulnerability of DCs to commodity price instability comes from combination of: a) a large share of exports earnings is drawn from commodities, b) a significant share of imports bill consists in food and oil products, c) a large share of public revenues relies on external trade (tariffs and VAT on imports). Therefore DCs frequently face sharp drops in their exports earnings, sudden rise in their import bill, and sometimes food crises. This vulnerability is reinforced by the weakness of the tools available to DCs to smooth revenues fluctuations (low resilience to shocks).

Existing literature on commodity prices studies three issues: i) characteristics and determinants of commodity price instability, ii) its macroeconomic effects and, iii) the optimal policy responses to this instability. The first stream of literature (i) has identified some stylized facts about real commodity prices (Cashin et al., 2002, Deaton, 1999): a strong asymmetry of prices cycle (a long-lasting downward trend is followed by a sharp upward) (Deaton and Laroque, 1992), a high persistence of shocks (Cashin et al., 2004), and a strong correlation between commodity prices theoretically unrelated (Pyndick and Rotemberg, 1990). Supply and demand constraints as well as commodity markets mechanisms have been explored to explain these characteristics (Deaton and Miller, 1996, Akiyama et al., 2003). The third stream of literature (iii), dedicated to the appropriate policy responses to commodity price instability, has highlighted the difficulty to either tackle the causes of instability or to offset its impact: buffer stocks, buffer funds, international commodity agreements to stabilize prices, government intervention in commodity markets, use of commodity derivative instruments (Guillaumont, 1987, Larson et al., 1998, Varangis and Larson, 1996).

This work falls within the scope of studies dedicated to the macroeconomic effects of commodity price instability (ii), but focuses on the impact on public finance, while existing works were concentrated on growth[1]. The extensive existing literature has produced controversial conclusion. Basically, most papers found that commodity prices shocks (and more generally trade shocks) have significant detrimental effect on growth through the investment channel (Blattman et al., 2007, Bleaney and Greenaway, 2001, Collier and Goderis, 2007, Kose and Riezman, 2001), while others argue that the impact on investment and growth is either small (Raddatz, 2007) or highly conditional to national institutions (Deaton and Miller, 1996). Few studies explored sectoral effects of commodity prices: agricultural production (Subervie, 2008), public finance (Kumah and Matovu, 2007, Medina, 2010).

This paper aims at analyzing the impact of commodity price volatility on tax revenues. It differs from the few previous studies dedicated to this issue on two main aspects: i) we test the impact of commodity price *volatility* rather than focusing only on price *levels*; ii) we use disaggregated

[1] Therefore, other macroeconomic effects of commodity prices volatility (impact on aggregate savings, on production structure, etc…) as well as socio-economic consequences are beyond the scope of this study.

data on tax revenues (income tax, value added tax and trade tax) and on commodity prices (agricultural products, minerals and energy) in order to identify transmission channels between world prices and public finance variables (meso-analysis). Our empirical analysis is carried out on 90 developing countries over 1980-2008. We compute an index which measures the volatility of the international price of 41 commodities in the sectors of agriculture, minerals and energy.

We find robust evidence that tax revenues in developing countries increase with the rise of commodity prices but that they are hurt by the volatility of these prices. More specifically, increased prices on imported commodities, lead to increased trade taxes and (to a smaller extent) consumption taxes being collected. Export prices are also positively associated with tax revenue collection, in large commodity-exporting countries, but the channel is through income taxes and non-tax revenues rather than international trade taxes. However, the volatility of commodity prices, both of imported and exported commodities, is negatively affecting tax revenues. These findings point at the detrimental effect of commodity price volatility on developing countries public finance and highlight further the importance of finding ways to limit this price volatility and its adverse effects.

The remainder of the paper is organized as follows. Section 2 gives an analytical overview of the potential effects of commodity price instability on public finance. Section 3 deals with methodology, volatility measurement and data. Section 4 presents our results. Section 5 summarizes our empirical findings and discusses the policy implications of the study.

2. The effects of commodity prices on public finance

2.1 Commodity price levels and public revenues

The impact of commodity price instability on public finances is expected to be different for imports and exports. In addition, it is useful to consider both microeconomic and macroeconomic effects. Microeconomic impact may be broken up into 3 analytical mechanisms: i) the direct price effect (incidence effect), ii) the tax rate effect and iii) the volume effect.

The incidence effect relies on taxes collected on tradable goods whose value has changed. It depends upon the initial structure of commodity production and consumption and the initial tax structure on commodities. Higher prices of import commodities should have a positive incidence on taxes levied on imports, but may also affect public expenditures if some commodities are subsidized. This "price effect" may be supplemented by a "tax rate effect". The government may react to the price shock by implementing some policy changes, typically by providing temporary tariffs or VAT exemptions on food products and oil[2]. Governments in developing countries have widely used this tool since 2007 (annex 1, taken from IMF, 2008, and annex 2 f or a country-by country description of the measures). Lastly, the rise in food prices could induce a reallocation of food consumption towards cheaper goods; either imported or domestically produced, and this would reduce tax base (negative volume effect). The magnitude of the latter effect will be small if there are few substitutes to commodities

[2] Another way to mitigate the price shock is to provide subsidies on food commodities.

whose price has risen (this is particularly true for gas). Hence, the overall microeconomic effect is ambiguous, since the price effect may be offset by a tax rate effect and a (probably smaller) volume effect.

If the price increase is significant, it will also induce some macroeconomic effects. Typically, the country which is a net importer of the commodities whose price has risen will face a drop in its national revenue and aggregate expenditure. Direct taxes (profit taxes and income taxes) will therefore decrease. Theoretically, the drop in national revenue may produce a real exchange rate depreciation, but this effect seems small enough to be ignored. The overall impact (microeconomic and macroeconomic) of a rise in the commodity import prices is therefore ambiguous (see annex 3 for a synthesis of the different effects).

Let us explore the consequences of a shock on export prices, using the breakdown of mechanisms previously used for import prices. The price effect relies on taxes levied on the export sector; which structure is more complex than that of imports. First, export taxes have been widely removed since the eighties, but still exist (Droit Unique de Sortie (DUS) used for cocoa and other commodities in Cote d'Ivoire, DUS and registration tax on cocoa in Cameroon). Second, the export sector is taxed through the profit tax. Third, the main contribution of oil and minerals sectors is drawn from non-tax revenues (royalties, production sharing contracts (PSC), …). The impact on public revenues will also be positive if production is made by State-Owned Enterprises (SOE) (through dividends), or if marketization is managed through a public body. This positive price effect may be enhanced by a tax rate effect if an *ad hoc* taxation is implemented to deal with the exports boom (windfall gain taxation)[3]. Many countries have implemented stabilizing taxation when they experienced trade booms, as suggested widely by international institutions (Bevan et al., 1993). The rationale behind this taxation is to allow a high saving rate on the windfall gains, which would otherwise be consumed by the private sector. The medium-run price and tax-rate effects may be magnified by a volume effect, since there is a strong incentive to increase production when the world price is high. The smaller is the price elasticity of supply (a frequent feature of agricultural production in developing countries), the smaller will also be this volume effect. The microeconomic impact of a rise in the commodity export prices is thus clearly positive.

The impact incidence is inevitably supplemented by macroeconomic effects when the country is highly dependent from its exports. First, the positive shock on exporter's revenues will spread over the economy and eventually lead to a change in the tax base of profit taxes and personal income taxes. Second, the trade shock induces a variation in the relative prices of tradable and non-tradable goods. Typically, a positive trade shock will eventually lead to a real exchange rate appreciation (Dutch disease), which usually reduces taxes actually collected for any given level of the overall tax base. The relative price effect may partly offset the positive revenue effect, but a full offsetting is unlikely. Therefore the overall impact (microeconomic and macroeconomic) of a rise in the price of exported commodities is unambiguously positive.

[3] A positive export shock may also lead to variations in public expenditures. Typically, a positive export shock may be partially transferred to the private sector through an increase in social expenditures or public employment.

2.2 Commodity price instability and public revenues

The implications of commodity price instability may be explored using the three microeconomic mechanisms and the macroeconomic one detailed above. Firstly, since taxes on imports are mainly *ad valorem* taxes, the relationship between any commodity price and tax proceeds drawn from this commodity is linear; hence price instability will have no impact on average tax revenues (gains during high price phases are strictly offset by losses when prices are low). Secondly, contrary to the price effect, the tax rate effect is not expected to be null: tax exemptions on food and oil imports granted in times of high prices are not compensated by increased tax rates during periods of low prices and these asymmetries therefore lead to a net loss of tax proceeds when the price of imports is volatile. Thirdly, volatility may also have some negative volume effect, since a strong volatility of prices gives an incentive to substitute the goods imported by less price volatile goods to dampen uncertainty on import bill. On the macroeconomic side, volatility of commodity prices has also effects (extensively studied, as mentioned in introduction). Indeed, price volatility (of either imports or exports) leads to GDP volatility, which decreases GDP (Ramey and Ramey, 1995) and therefore reduces the tax base and lowers tax revenues. Volatility of commodity prices is thus expected to have a negative impact for both imports and exports through the macroeconomic channel. Therefore the overall effect (microeconomic and macroeconomic) of commodity import price volatility is clearly negative.

The differences in microeconomic effects between import and export price variations induce differences in the impact of volatility. A common feature of profit tax and non-tax revenue is to be a "margin taxation". Therefore, proceeds from this kind of taxation will be strongly non-linear with respect to the price of commodities, i.e. the proceeds will be very small – or even null - when commodity price is weak, but will grow faster than the commodity price when the price is high. Oil taxes, either through a conventional profit tax or through a production sharing contract (PCS), typically rise more than proportionally when price goes up (Leenhardt, 2005). Therefore, we can expect the price volatility effect to be null (exports with ad valorem taxes or with almost no taxation) or positive (oil and minerals). Volatility is also expected to have a positive impact through the tax rate effect: tax rate increases in response to export price spikes lead a net gain when price is volatile. Volatility may however have some negative volume effect, since a strong volatility of prices gives an incentive to substitute the goods exported by less volatile goods to dampen uncertainty on profits. The macroeconomic effects of export price volatility are expected to be similar to that of import prices but, in large commodity-exporting countries, the price volatility is also inducing lower foreign investment (Blattman et al., 2007) which can in turn result in lower tax collection. Therefore, the positive effects of export price volatility (through the price and tax rate effects) may be offset – probably with some delay - by negative effects through volume and macroeconomic effects.

To sum up, the high prices of imported commodities have an ambiguous impact on public revenues while the volatility of these prices has a clear negative effect. Conversely, the high prices of exported commodities have a clear positive impact on public revenues while volatility has an ambiguous effect. This survey of the various effects of commodity price level and instability shows the need to investigate empirically the impact of commodity price volatility (and not only of price levels) and to distinguish import and export prices.

2.3 Existing empirical literature

Among the scarce existing studies dedicated to a statistical analysis of the relationship between commodity prices and public finance, most of them focused on the incidence of a shock in the prices of commodities on overall tax revenues or fiscal balance rather than the incidence of the volatility of these prices. Using descriptive statistics Talvi and Vegh (2005) show that fiscal policy tends to be procyclical in developing countries. They argue that exogenous shocks on the tax base (of which commodity price variations are the main factor) lead to an optimal procyclical fiscal policy that aims at avoiding the misuse of budget surpluses during booms. Medina (2010) - using a VAR methodology on Latin American and high income commodity-dependent countries - shows that there is a significant heterogeneity of fiscal responses between countries. The pattern of the fiscal response to commodity price shocks is similar to high income countries in Chile (small impact on total revenues and almost no impact on primary expenditures) while both revenues and expenditures react strongly to shocks in Venezuela and Ecuador (more dependent from exports of commodities) *i.e.* both revenues and expenditures increase in case of a positive shock. Kumah and Matovu (2007), using the same methodology on Russia and three central Asian countries, find a significant response of revenues and expenditures to variations in commodity prices, thus indicating a "commodity-dependent" pattern.

A more disaggregated analysis that distinguishes different tax categories (meso-analysis) and/or identifies policy changes is made only in case studies. The goal of Collier and Gunning (1999) is clearly broader than fiscal policy, since it aims at analyzing the impact of trade shocks on aggregate savings, investment and productivity. The study of public finance is thus an instrument to understand the ultimate effects of trade shocks, but it gives valuable and rich information on fiscal responses. Their main finding is the strong heterogeneity of both initial tax structure on commodities and fiscal responses to commodity price shocks. Despite the heterogeneity of the initial taxing structure in various countries, governments share a strong capacity to capture the financial gains (or losses) induced by a commodity price shock. This capacity relied on stabilization mechanisms in many countries: a marketing board in Ghana during the 1976-77 cocoa boom, the Caisstab in Cote d'Ivoire during the 1976-79 cocoa and coffee boom, the CPSP (*Caisse de Péréquation et de Stabilisation des Prix*) in Senegal during the 1974-77 groundnut and phosphates boom, etc... When no stabilization mechanism was in place, indirect taxes have been the main channel of tax revenue changes (as in Kenya during the 1976-79 coffee boom). The heterogeneity is even larger as far as policy reactions are concerned. Some countries raised significantly their effective tax rate (Kenya, Bolivia), while others kept it unchanged (Colombia, Bostwana) or decreased it (Cameroon, Senegal) during price spikes[4].

While the effect of variations in the level of commodity prices on public finance has been studied, there is however -to our knowledge- a lack of analysis of the impact of commodity price instability on public finance. This study aims at filling this gap by testing the impact of various measures of this instability on tax revenues and by identifying the various channels of transmission.

[4] Collier and Gunning (1999), table 1.6, p.44.

3. Methodology and Empirical Framework

Our analysis stretches over the 1980-2008 period and covers 90 developing countries (see Annex 4 for the list of countries and annex 5 for descriptive statistics). Over this period, several episodes of high volatility of the commodity prices occurred. For instance, in the 1980s, the price of silver declined of 50% between the years 1980 and 1981, from 2080 dollars to 1052 dollars, decreased further of 25% in 1982 to reach 793 dollars and on year later, in 1983, bounced back to 1143 dollars. In the 1990s, the international price of cocoa more than doubled between 1993 and 1994, rising from 70 dollars to 148 dollars. One additional example of an instability episode is when the price of coal doubled in 2004 from 28 dollars to 57 dollars and then strongly increased to reach 136 dollars in 2008.

From Table 1, we can notice that the export and import dependence on commodities of these countries decreased over time but, in 2008, commodities were still accounting for more than 31.8% of the exports and 17.9% of the imports. Huge differences can be highlighted across regions, Sub-Saharan African countries and Latin American countries being significantly more concentrated on commodity exports than Asian countries. Regarding imports, Asian countries are however importing a larger share of commodities in their total imports than the other developing countries.

Table 1.Descriptive statistics on the full sample

		Mean	Min	Max	Mean 1980	Mean 1992	Mean 2008
Commodities Exports / Total Exports	Developing countries	38.6%	0.0%	99.9%	49.0%	37.0%	31.8%
	Sub Saharan Africa	46.7%	0.0%	99.7%	55.7%	38.6%	43.7%
	Latin America	46.3%	0.4%	97.9%	57.4%	46.8%	37.1%
	South Asia	20.1%	0.1%	68.5%	42.3%	15.2%	15.3%
	East Asia	29.4%	0.0%	99.9%	35.4%	36.7%	17.1%
Commodities Imports / Total Imports	Developing countries	19.9%	0.62%	62.4%	27.7%	21.5%	17.9%
	SSA	18.0%	2.27%	55.4%	25.0%	19.5%	16.3%
	Latin America	17.4%	0.6%	62.4%	21.0%	19.3%	14.1%
	South Asia	29.2%	6.6%	62.0%	41.1%	26.6%	24.4%
	East Asia	20.5%	2.5%	49.5%	33.8%	20.0%	20.9%

The price level and volatility of imported commodities should affect all the developing countries given that the degree of reliance on commodities of the imports is relatively homogeneous across countries. However, the degree of dependence of exports on commodities ranges between almost zero and 100% according to the country and therefore, the incidence of variations in commodity export prices might be mostly interesting to study in large commodity exporter countries. For the analysis of the export commodity side, we therefore follow Bleaney and Greenaway (2001) and focus on a sub-sample of developing countries where primary products account largely in their exports. On average over the period 2000-2008, primary products accounted for more than 60% of the exports of

these countries. The 34 countries retained are listed in Annex 6 and the corresponding descriptive statistics are provided in Annex 7.

Following Deaton and Miller (1999) and Dehn (2000), we construct, for each developing country in our sample, a country-specific index of commodity prices that geometrically weight together the international prices of 41 commodities, using common international prices but fixed individual country weights. The country-specific commodity import price indices are therefore calculated such that:

$$I_{i,t} = \prod_{c=1}^{41} p_{c,t}^{\,w_{i,c}}$$

where $p_{c,t}$ is the international price of commodity c in year t. The weight $w_{i,c}$ is an average over the period 2000 to 2008 of the share of commodity c imports in total commodity imports of country i. The weight of each commodity is then held constant over time. The country-specific commodity export price indices are calculated in a similar way, the weight w being for exports instead of imports. Forty-one commodities are distinguished and their international prices are drawn from IMF data. Among agricultural commodities, we consider: bananas, barley, beef, cocoa, coffee, cotton, groundnuts, hides, lamb, maize, olive oil, orange, palm oil, pork, poultry, rice, rubber, salmon, sawnwood, shrimp, soybean oil, soybean, sugar, sunflower oil, tea, wheat, wool corse, wool fine; among minerals: aluminium, copper, iron ore, lead, nickel, tin, uranium, zinc, gold, silver and among energetic commodities: coal, gas and oil. The share of these commodities in the imports and exports of each country are obtained from WITS with the SITC 2 classification disaggregated over 4 digits. Table 2 gives some illustrative examples of countries largely dependent on one given commodity.

Table 2. Examples of countries highly dependent on one commodity in 2008

Exports			Imports		
Country	Commodity	Share in exports	Country	Commodity	Share in Imports
Iraq	Oil	99.9%	Côte d'Ivoire	Oil	35.4%
Sao Tomé and Principe	Cocoa	89.4%	India	Oil	29.8%
Mali	Gold	74.3%	Sudan	Wheat	28.8%

The country-specific price indices are then deflated by the unit value index of advanced economies exports, taken from the International Financial Statistics of the IMF. As first evidence, the relationships between these country-specific commodities price indices and our variable of interest, namely tax revenue are depicted graphically in Annex 8. According to these correlations, the prices of both imported and exported commodities are positively associated with tax revenue.

The volatility of commodity prices is assessed through two distinct measures. The standard deviation is the most common indicator of variability (Mendoza, 1997, for terms of trade volatility or Aghion et al., 2009, for exchange rate volatility, among others). We therefore firstly measure commodity price volatility as the standard deviation of the first-difference of the deflated country-specific price indices. The volatility of the composite price indices which is calculated can however under-estimate the volatility really faced by a country. Indeed, the variations of two commodity prices in opposite directions can be neutralized within the price index, resulting in only a low volatility of the price index. To avoid this compensation mechanism and asses the total volatility which is affecting

countries, we propose a second measure of volatility. We compute the volatility of each of the 41 commodity prices by taking the standard deviation of the first-difference of the deflated prices. We then compute the country-specific commodity price volatility as the weighted average of these 41 price volatilities. The weights for each commodity are those used to construct the country-specific price indices.
We followed the advice of Bekaert et al. (2006) and measured all the standard deviations over five-year rolling windows.

To assess the impact on fiscal revenues of variations in both the levels of commodity prices and the volatility of these prices, the basic estimated equation, for the import side, is of the following form:

$$T_{i,t} = \alpha + \beta_1 \log(I^M_{i,t}) + \beta_2 \log(\sigma^M_{i,t}) + X'_{i,t}\,\beta_3 + \mu_i + \varepsilon_{i,t}$$

This equation will be also estimated separately for each commodity category (agriculture, minerals and energy).[5]
And for the sub-sample of large commodity exporting countries, it will be:

$$T_{i,t} = \alpha + \delta_1 \log(I^X_{i,t}) + \delta_2 \log(\sigma^X_{i,t}) + X'_{i,t}\,\delta_3 + \mu_i + \varepsilon_{i,t}$$

where *i* and *t* are country and time period indicators respectively, the dependent variable *T* is the tax revenue as part of GDP and will be either total government revenue, excluding grants, or one of the disaggregated tax revenue category (income taxes, domestic indirect taxes, trade taxes). $I^M_{i,t}$ and $I^X_{i,t}$ are the commodity price indices for imports and exports respectively whereas $\sigma^M_{i,t}$ and $\sigma^X_{i,t}$ represent the commodity price volatility. Following Collier and Goderis (2007), to allow the effect of import and export price volatility to be larger for countries with higher imports and exports, the country-specific volatility of imported and exported commodities were weighted respectively by the share of imports and exports in the countries' GDP.

The vector *X* captures other explanatory variables affecting tax revenue. Drawing on the empirical literature that models the share of tax revenues in GDP (Adam et al., 2001; Khattry and Rao, 2002; Keen and Lockwood, 2010), we include the following variables as control. The lagged dependent variable controls for the persistence of tax revenues. The GDP per capita is a proxy for the tax base and the tax administration capacity, higher level of per capita income is usually found to be positively related to domestic tax revenues. The structure of the economy is proxied by the share of agriculture in GDP usually negatively associated with the domestic tax revenues over GDP ratio (agriculture, in particular the subsistence sector is less easily taxed than industry and services). The degree of openness should be positively associated with domestic tax performance given that, in developing countries, a large part of the taxes are collected at the borders. Higher inflation is supposed to reduce domestic tax yields according to the Tanzi Olivera effect. Theory suggests that foreign aid may

[5] A more disaggregated approach (product by product) is theoretically appealing, but unfortunately not feasible for two main reasons: ii) individual commodity prices variations correspond to a common shock for all countries, already captured by time fixed effects, ii) a simultaneous test of the different product prices would imply too many right hand side variables (with strong correlations between them).

have some impact on public revenues; recent evidence shows that foreign aid (especially grants) has been associated with increases in tax revenues (Brun et al., 2007, Clist and Morrissey, 2011). We also include the proportion of the population under 14 years, the tax ratio usually being increasing with the number of dependent in the population. All these variables are from the World Development Indicator (WDI) database.

The OLS estimator becomes inconsistent because the lagged level of tax instability is correlated with the error term due to the presence of country fixed effects (Nickell, 1981). One way to handle these issues is to use the Generalized Method of Moments (GMM) technique (Blundell and Bond, 1998). The System-GMM estimator combines, in a system, first-difference equations, where the right-hand-side variables are instrumented by lagged levels of the series with an additional set of equations in levels, using lagged first differences of the series as instruments. We will also present the AR(1), AR(2) and Hansen tests to ascertain that the econometric results are consistent.

4. Results

4.1. The effect of commodity import price level and volatility

The results with the GMM-System estimator are presented in Table 3 (volatility measure 1) and Table 4 (volatility measure 2). The first two columns present the results for the total government revenue, excluding foreign aid, whereas in the six subsequent columns, the results represent the three different categories of taxes, namely income taxes, domestic indirect taxes and taxes on international trade. For each dependent variable, we use successively the aggregated price index (columns 1, 3, 5 and 7) and disaggregated price indexes (columns 2, 4, 6 and 8)

Increased prices on the imported commodities appear to lead to more taxes being collected. The effect is non-negligible, an increase of 10% in the price index leading to a rise of 0.35 percentage points in the total revenue ratio over GDP. The channel of this positive impact is difficult to identify since none of the categories of taxes appear to be significantly positively affected by increased import prices. This weakly significant effect can be explained by the presence of tax exemptions (either tariff rate decreases or indirect consumption tax rate decreases) in times of high prices and therefore even though the tax base is higher (because of the increased price of imports) it does not necessarily translate into higher taxes being collected. Looking at the disaggregated effects by category of commodities (agricultural, minerals and energy), we can notice a strong heterogeneity of results. The price of minerals has a positive impact on total tax revenues, and this impact comes from both consumption and trade taxes. Trade taxes also seem positively affected by energy prices, but the impact on total revenues is not significant. Lastly, agricultural prices exhibit no impact on total revenues or on any specific tax component, most probably because of the tax exemptions that these imported products are often granted in period of price spikes.

Regarding the volatility of the prices of these imported commodities, we can see that it is leading to decreased tax revenues. The result originates from domestic consumption taxes and taxes on international trade which are negatively affected by the volatility of the commodity import prices.

We may notice that international trade taxes are more vulnerable than consumption taxes to price volatility (the negative marginal impact being roughly twice as large, see columns 5 and 7). This negative effect of volatility can be explained by the existence of asymmetries where tax exemptions on imported goods are granted in times of price spikes resulting in lower taxes being collected but during times of low prices, tax rates are not increased and thus do not result in more taxes being collected. This mechanism may have been supplemented by a substitution effect between products (shift toward cheaper or less taxed products) and a macroeconomic effect (if volatility of import prices is translated into growth volatility). The negative impact of volatility on tax revenues is clearly confirmed when commodities are disaggregated. This impact is channeled by consumption taxes (agriculture and minerals) and trade taxes (energy and minerals). The negative impact of agricultural price volatility is however not significant on total tax revenue.[6]

[6] The fact that a negative impact of agricultural price volatility is identified on consumption taxes and that the marginal impact on total tax revenues has roughly the same magnitude (although not significant) suggests that the impact on total tax revenues is actually negative, but difficult to identify due to aggregation biases between the different tax categories.

Table 3. Impact of imported commodities price level and volatility (System-GMM – 1st indicator of volatility)

VARIABLES	Tax Revenue (%GDP)	Tax Revenue (%GDP)	Income Tax (%GDP)	Income Tax (%GDP)	Consumption Taxes (%GDP)	Consumption Taxes (%GDP)	International Trade Taxes (%GDP)	International Trade Taxes (%GDP)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Commodity import price index	3.658*		-0.287		0.139		0.639	
	(2.022)		(0.762)		(0.668)		(0.590)	
Commodity import price volatility	-0.363**		-0.0519		-0.160**		-0.310***	
	(0.175)		(0.097)		(0.076)		(0.112)	
Agricultural import price index		1.739		-1.144		0.0583		-0.334
		(1.898)		(0.953)		(0.826)		(0.532)
Agricultural import price volatility		-0.235		0.0303		-0.153**		-0.108
		(0.202)		(0.082)		(0.065)		(0.096)
Energy import price index		0.783		-0.0380		-0.192		0.527**
		(0.650)		(0.259)		(0.250)		(0.209)
Energy import price volatility		-0.123***		-0.00535		-0.0175		-0.117***
		(0.040)		(0.027)		(0.020)		(0.041)
Minerals import price index		3.609**		0.457		1.833**		2.279*
		(1.537)		(1.003)		(0.769)		(1.207)
Minerals import price volatility		-0.221**		0.0117		-0.107**		-0.167**
		(0.093)		(0.056)		(0.046)		(0.078)
Lagged dependent variable	0.646***	0.626***	0.842***	0.843***	0.899***	0.928***	0.944***	0.944***
	(0.080)	(0.086)	(0.055)	(0.055)	(0.062)	(0.051)	(0.059)	(0.075)
Imports (%GDP)	0.0884***	0.112***	0.0260**	0.0126	0.0230**	0.0315**	0.0416***	0.0559***
	(0.029)	(0.031)	(0.012)	(0.015)	(0.011)	(0.015)	(0.014)	(0.019)
Population below 14	-0.0676	-0.0382	0.0379	0.0568	-0.100**	-0.0771**	-0.0583	-0.0238
	(0.114)	(0.097)	(0.057)	(0.049)	(0.045)	(0.030)	(0.061)	(0.044)
Aid per capita	-0.00213	0.00893	0.00293	-0.00181	0.000752	1.57e-07	0.0132	0.0118
	(0.008)	(0.009)	(0.0042)	(0.004)	(0.005)	(0.004)	(0.008)	(0.007)
GDP (log)	-0.776	-0.156	1.236	1.275	-1.375*	-1.570***	-0.713	-0.427
	(2.173)	(2.077)	(0.931)	(0.984)	(0.712)	(0.590)	(1.036)	(0.816)
Agriculture (%GDP)	-0.114	-0.0904	0.0498	0.0418	-0.0562*	-0.0660**	-0.0180	-0.00649
	(0.101)	(0.010)	(0.04)	(0.044)	(0.030)	(0.027)	(0.041)	(0.033)
Observations / Nb countries	1,770 / 90	1,770 / 90	1,483 / 88	1,483 / 88	1,608 / 88	1,608 / 88	1,610 / 88	1,610 / 88
Nb of instruments	23	27	23	27	19	23	15	19
AR(1) Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) Test p-value	0.480	0.618	0.424	0.407	0.139	0.119	0.706	0.469
Hansen Test p-val.	0.333	0.490	0.673	0.326	0.393	0.317	0.196	0.277

Note: Robust standard errors in brackets. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Constant and country fixed effects included but not reported. Two-step GMM using the Windmeijer (2005) correction with collapsed instruments. The price indices and volatility, the population below 14 and the agricultural value-added are treated as exogenous whereas imports and the lagged dependent variable are considered as predetermined and the level of GDP per capita and of aid per capita as endogenous. The number of lags used to instrument variables varies from one dependent variable to another. In the four first columns, predetermined variables are instrumented with their 1st to 4th-order lagged values and endogenous variables by 2nd to 4th-order lagged values. In columns 5 and 6, predetermined variables instrumented with 1st to 3rd-order lags and endogenous variables with 2nd to 3rd-order lags. In columns 7 and 8, predetermined variables instrumented with 1st-order lags and endogenous variables with 2nd to 3rd-order lags.

The control variables included in the model exhibit the expected sign. The lagged dependent variables and imports are significantly positively associated with tax revenues. The value added in the agriculture sector is inducing decreased consumption taxes being collected and so does the GDP. The remaining control variables are non-significant. AR(1), AR(2) and Hansen tests confirm the adequacy and the validity of our instruments.

With this first measure of volatility, the variations in the price of different commodities can be compensated, the commodities price volatility being therefore lower that what is really faced by governments. Estimations using an alternative measure of the commodity price volatility are given in Table 4.

The results presented in Table 4 exhibit only few differences compared to those obtained using the conventional measure of volatility. The main difference is the size and the significance of the price and volatility effects when no tax disaggregation is used (see column 1 and 7), which suggests that there is a real value-added of our alternative measure on volatility[7]. The negative impact of import price volatility on tax revenues is significant at the 1% level and originates from consumption and international trade taxes, confirming our previous result. Again, the detrimental effect of volatility is larger for international trade taxes than for consumption taxes. Differences on estimations using disaggregation of tax revenues price indexes are only minor. The negative impact of agricultural price volatility is stronger than previously (significant for total tax revenues) while the impact of mineral price volatility is weaker (no longer significant for total tax revenues and trade taxes). From these disaggregated measures of volatility we can also remark that the largest marginal negative impact of import price volatility appears to originate from agricultural products.

Results regarding the import prices may be sum up as follows: first, a positive impact of the price level on tax revenues; second a negative impact of volatility, channeled by consumption and trade taxes; third, a larger vulnerability of international trade taxes to price volatility (compared to consumption taxes).

[7] With disaggregated measures of the volatility of the different categories of products, the result does not appear sensibly different from those obtained with the first indicator of volatility. This is not surprising since the compensation effect that we want to avoid is mainly present in the computation of the price index of the 41 commodities and is present in a smaller extent in the agricultural, metals or energy price indexes.

Table 4. Impact of imported commodity price level and volatility (System-GMM – 2nd indicator of volatility)

VARIABLES	Total Revenue (%GDP) (1)	Total Revenue (%GDP) (2)	Income Tax (%GDP) (3)	Income Tax (%GDP) (4)	Consumption Taxes (%GDP) (5)	Consumption Taxes (%GDP) (6)	International Trade Taxes (%GDP) (7)	International Trade Taxes (%GDP) (8)
Commodity import price index	6.182***		-0.0133		1.020		2.941***	
	(2.298)		(1.155)		(0.859)		(0.977)	
Commodity import price volatility	-0.521***		-0.0224		-0.173*		-0.488***	
	(0.196)		(0.101)		(0.095)		(0.155)	
Agricultural import price index		2.933		-1.282		0.815		0.373
		(2.023)		(1.022)		(0.697)		(0.558)
Agricultural import price volatility		-0.346*		0.0498		-0.184**		-0.210*
		(0.209)		(0.098)		(0.083)		(0.115)
Energy import price index		0.807		-0.0751		-0.113		0.616**
		(0.749)		(0.308)		(0.257)		(0.299)
Energy import price volatility		-0.117***		-0.00421		-0.00927		-0.0982**
		(0.041)		(0.024)		(0.018)		(0.042)
Minerals import price index		2.238*		0.190		1.343**		1.275
		(1.297)		(0.782)		(0.564)		(0.934)
Minerals import price volatility		-0.104		0.0252		-0.0671**		-0.0767
		(0.070)		(0.030)		(0.027)		(0.050)
Lagged dependent variable	0.614***	0.629***						
	(0.087)	(0.090)						
Imports (%GDP)	0.131***	0.121***	0.0201	0.00696	0.0285*	0.0326*	0.0821***	0.0614***
	(0.039)	(0.037)	(0.016)	(0.016)	(0.015)	(0.017)	(0.024)	(0.024)
Population below 14	-0.0808	-0.0182	0.0537	0.0647	-0.089***	-0.0761***	-0.0778*	-0.0149
	(0.104)	(0.079)	(0.046)	(0.049)	(0.034)	(0.026)	(0.040)	(0.039)
Aid per capita	0.00148	0.00784	0.00166	-0.00181	0.00263	0.000287	0.0151***	0.00910
	(0.008)	(0.010)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.007)
GDP (log)	-0.744	0.534	1.438*	1.440	-1.157**	-1.394***	-0.945	-0.261
	(2.011)	(1.793)	(0.770)	(0.988)	(0.521)	(0.512)	(0.718)	(0.759)
Agriculture (%GDP)	-0.124	-0.0645	0.0535	0.0486	-0.0501**	-0.0609**	-0.0322	-0.00467
	(0.094)	(0.088)	(0.037)	(0.045)	(0.023)	(0.024)	(0.031)	(0.032)
Observations / Nb countries	1,770 / 90	1,770 / 90	1,483 / 88	1,483 / 88	1,608 / 88	1,608 / 88	1,610 / 88	1,610 / 88
Nb of instruments	23	27	23	27	19	23	15	19
AR(1) Test p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
AR(2) Test p-val	0.438	0.578	0.420	0.397	0.112	0.180	0.666	0.674
Hansen Test	0.534	0.441	0.575	0.298	0.235	0.229	0.440	0.174

Note: See Notes of Table…

4.2. The effect of exported commodity price level and volatility

Turning now to the export side, Table 5 reports the estimation results with the System-GMM estimator and our first measure of commodity export price volatility. Both the level and the volatility of commodity export prices appear to significantly influence total fiscal revenue (column 1). Higher prices for exported commodities have significantly large positive impacts on the total revenue collected in exporting countries. Indeed, an increase of 10% in the price index will lead to a rise of 0.63 percentage points in the total revenue ratio over GDP. For the mean level of total revenue in our sample of exporting countries (18.3% of GDP), this 10% increase in the commodity export prices could lead to a rise of 3.4% of total revenue.

However, increased volatility of these international prices moves significantly the revenue ratio in the opposite direction. Therefore, a country with a one standard deviation greater level of volatility than the mean, which corresponds to a rise of 79.5%, will mobilize 0.47 percentage point less tax revenue over GDP than the sample average. We therefore provide evidence that volatile prices for exported commodities are negatively affecting tax revenues.

The control variables exhibit the expected signs with a larger dependent population and a higher level of GDP per capita being positively and significantly associated with total government revenue over GDP. Moreover, the AR(1), AR(2) and Hansen Tests confirm that our estimation results are reliable.

The subsequent columns (2 to 4) present the effects on the different components of government revenue. In column 2, the dependent variable is the sum between the non-tax revenue and the income tax revenue. Indeed, a substantial effect of export prices on revenue can happen either through the non-tax revenue or through the income tax revenue according to which arrangement countries set in their mining or petroleum investment codes (payments through dividends with a state participation in the companies, through royalties or only through profit taxes). Given the large variety of systems across countries, we retain as dependent variable the sum of non-tax and income tax revenues to include any situation prevalent in our sample of countries.

The identified positive effect of commodity export prices on tax revenues seem to originate in the joint category income and non-tax revenue. A rise in the commodity export prices increases the collection of these revenues whereas export price volatility negatively affects them. An enhancement of export prices leads to higher tax revenues, as developed in section 2.1, through both the price and tax rate effects and the macroeconomic effects of increased growth and investments. The volatility of terms of trade has been however found to induce less foreign investment (Blattman, 2007) and therefore this adverse macroeconomic effect can lead to less tax revenues being collected. As expected, there is no evidence of significant impact of the level and volatility of exported commodity prices neither on consumption tax nor on international trade tax revenues. These taxes might be affected only indirectly and probably with some delay.

Table 5. Impact of exported commodity price level and volatility (System-GMM – 1st indicator of volatility)

VARIABLES	Total Revenue (%GDP)	Income Taxes and Non Tax Revenue (%GDP)	Consumption Taxes (%GDP)	International Trade Taxes (%GDP)
	(1)	(2)	(3)	(4)
Commodity export price index (log)	6.628**	4.352*	0.828	0.0632
	(3.063)	(2.275)	(0.896)	(0.973)
Commodity export price volatility (log)	-0.796*	-0.584*	-0.112	-0.171
	(0.447)	(0.340)	(0.156)	(0.133)
Lagged dependent variable	0.636***	0.705***	0.827***	0.862***
	(0.113)	(0.114)	(0.081)	(0.077)
Exports (%GDP)	0.205	0.149*	0.00176	0.0370
	(0.135)	(0.077)	(0.028)	(0.037)
Population below 14	0.392*	0.0283	0.0862	-0.0251
	(0.230)	(0.214)	(0.059)	(0.090)
Aid per capita	0.0211	0.00840	-0.00509	0.00492
	(0.027)	(0.021)	(0.007)	(0.008)
Imports (%GDP)	0.0218	-0.0283	0.0216	0.0109
	(0.038)	(0.032)	(0.015)	(0.012)
GDP (log)	6.465*	1.271	0.998	-0.846
	(3.850)	(2.002)	(0.612)	(1.239)
Agriculture (%GDP)	0.262	0.0434	0.0293	-0.0305
	(0.168)	(0.081)	(0.027)	(0.047)
Observations	711	604	664	656
Nb of countries	34	33	33	33
Nb of instruments	15	25	23	17
AR(1) p-val	0.001	0.004	0.000	0.000
AR(2) p-val	0.248	0.904	0.342	0.959
Hansen Test	0.442	0.349	0.558	0.628

Note: Robust standard errors in brackets. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Constant and country fixed effects included but not reported. Two-step GMM using the Windmeijer (2005) correction with collapsed instruments. The price indices and volatility, the population below 14 and the agricultural value-added are treated as exogenous whereas imports, exports and the lagged dependent variable are considered as predetermined and the level of GDP per capita and of aid per capita as endogenous. The number of lags used to instrument variables varies from one dependent variable to another. In the first column, predetermined variables are instrumented with their 1st-order lagged values and endogenous variables by their 2nd-order lagged values. In column 2, predetermined variables instrumented with 1st to 3rd-order lags and endogenous variables with 2nd to 4th-order lags. In column 3, predetermined variables instrumented with 1st to 3rd-order lags and endogenous variables with 2nd to 3rd-order lags. In column 4, predetermined variables instrumented with 1st-order lags and endogenous variables with 2nd to 3rd-order lags.

In Table 6, we test the robustness of these results by using our alternative measure of commodity export price volatility. The first column of the Table reports the estimation for total government revenue as a share of GDP, confirming our previous result that the price volatility of export commodities is detrimental for tax revenue collection. The effect appears to be even larger with this second indicator of the price volatility than with the previous one given that, as explained previously, there is no compensation between the volatilities of different commodities in this second indicator. The marginal impact stands at -1.119, which corresponds to a loss of 0.65 percentage point of revenue when the price volatility increases of one standard deviation.

Table 6. Impact of exported commodity price level and volatility (System-GMM –2nd indicator of volatility)

VARIABLES	Total Revenue (%GDP)	Income Taxes and Non Tax Revenue (%GDP)	Consumption Taxes (%GDP)	International Trade Taxes (%GDP)
	(1)	(2)	(3)	(4)
Commodity export price index (log)	9.694**	5.994*	0.620	0.718
	(4.485)	(3.234)	(1.287)	(1.601)
Commodity export price volatility (log)	-1.119**	-0.806*	-0.0453	-0.218
	(0.568)	(0.432)	(0.194)	(0.267)
Lagged dependent variable	0.652***	0.666***	0.826***	0.862***
	(0.108)	(0.109)	(0.081)	(0.079)
Exports (%GDP)	0.236*	0.191*	-0.00653	0.0423
	(0.129)	(0.098)	(0.034)	(0.052)
Population below 14	0.453*	0.0202	0.0807	0.00655
	(0.263)	(0.178)	(0.071)	(0.103)
Aid per capita	0.0180	0.00614	-0.00648	0.00578
	(0.025)	(0.018)	(0.007)	(0.009)
Imports (%GDP)	0.0213	-0.0434	0.0224	0.0111
	(0.038)	(0.038)	(0.015)	(0.014)
GDP (log)	7.438*	1.492	0.949	-0.343
	(4.237)	(1.626)	(0.756)	(1.417)
Agriculture (%GDP)	0.290	0.0390	0.0259	-0.00969
	(0.180)	(0.070)	(0.033)	(0.062)
Observations	711	604	664	656
Nb of countries	34	33	33	33
Nb of instruments	15	25	23	17
AR(1) p-val	0.001	0.006	0.000	0.000
AR(2) p-val	0.261	0.973	0.352	0.811
Hansen Test	0.464	0.256	0.614	0.623

Note: See the notes of Table 5.

The positive relationship between commodity export prices and revenue also holds, which is consistent with the results established by Medina (2010) with time-series analyses for Latin American and high-income commodity-exporting countries and by Kumah and Matovu (2007) for Russia and three central Asian countries. These effects robustly arise from one component of government revenue, namely income taxes and non-tax revenues.

Globally, the results displayed in Table 5 and 6 illustrate an additional important aspect of the impact of the commodity export price volatility that has never (to our knowledge) received attention: price volatility of exported commodities leads to decreased tax revenues.

5. Conclusion and policy implications

In this paper we estimated, on a sample of 90 developing countries over the period 1980-2008, the impact on fiscal revenues of commodity price volatility rather than focusing only on price levels. We used disaggregated data on tax revenues (income tax, consumption tax and international trade tax)

and on commodity prices (agricultural products, minerals and energy) in order to identify the transmission channels between world commodity prices and public finance variables.

Our analysis suggests that tax revenues in developing countries increase with the prices' rise of either imported or exported commodities. For imported commodities this increase in fiscal revenue is due to more tariffs being collected but, because of the numerous tax exemptions granted in times of high prices, the positive impact on tax revenue may not always happen. In our sub-sample of large commodity-exporting economies, the effect is more straightforward: the tax revenue increases due to an export price spike are originating in more profit tax and non-tax revenues, such as dividends or royalties, being collected on companies which are producing primary products.

We find however robust evidence that international commodity price instability, both for imported and exported products has an adverse effect on tax revenues in developing countries. Import price volatility hurts indirect tax revenues while, export price volatility affects direct taxes (income tax and non-tax revenues). Among indirect tax revenues, international trade taxes are more vulnerable than consumption taxes to price volatility.

These results suggest several policy recommendations. First, this highlights further the importance of finding ways to both limit this international price volatility (through world markets regulation for instance) and manage the macroeconomic effects of the price instability (through national policies). Second, the shift from trade tax to consumption taxes could be expected to reduce the vulnerability of tax revenues to commodity price level and volatility. Third, the negative effect of import price volatility being partly due to the frequent use of tariff or tax exemptions on some primary products, the adequacy of these temporary tax exemptions should deserve further examination.

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7. Annexes

Annex 1: Food Tax decreases (IMF, 2008)

Table 12. Pattern of Food Tax Decreases by Tax and Country Characteristics

		Tax reductions				Year of reduction			
	Number of Countries	Import	VAT	Sales	Excise	2007	2008	Countries w/changes	Percent of countries
Income group									
High-income OECD	18	17	0	0	0	16	1	17	94
High-income non-OECD	15	5	1	0	0	4	1	5	33
Upper-middle income	49	20	10	2	0	7	19	23	47
Lower-middle income	43	19	4	1	1	10	14	19	44
Low-income	34	15	7	0	0	12	10	20	59
Net total food trade balance									
Large importer	19	10	5	1	1	4	9	12	63
Small importer	99	47	12	1	0	32	24	28	28
Small exporter	28	15	4	0	0	11	7	9	32
Large exporter	13	4	1	1	0	2	5	6	46
Net cereal trade balance									
Large importer	104	46	16	3	1	21	37	51	49
Small importer	38	20	3	0	0	21	2	22	58
Exporter	17	10	3	0	0	7	6	11	65
All Countries	159	76	22	3	1	49	45	84	53

Sources: IMF (2008a).

Note: Large food importer: net imports greater than 3 percent of GDP; large food exporter: net exports greater than 4 percent of GDP; large cereal importer: net imports greater than 0.2 percnt of GDP.
The count for total changes may differ from the sum of 2007 and 2008 because the same country may have tax changes in both years.

Annex 2: Trade based policy measures (FAO, 2009)

Table 1: Trade based policy measures commonly adopted (as of 1 December 2008)

	Domestic market based measures			Trade policy measures	
	Release stock (public or imported) at subsidized price	**Suspension/ reduction VAT and other taxes**	**Admin. price control or restrict private trade**	**Reduction of tariffs and customs fees on imports**	**Restricted or banned export**
Asia (26 countries)	Bangladesh Cambodia China India* Iraq Jordan Lebanon Malaysia Nepal Pakistan Philippines Republic of Korea Thailand Viet Nam Yemen	Azerbaijan China Indonesia Jordan Mongolia	Bangladesh Jordan Malaysia Pakistan Republic of Korea Sri Lanka	Azerbaijan Cambodia China Indonesia Iran Jordan Lebanon Pakistan Philippines Republic of Korea Saudi Arabia Turkey Yemen	Bangladesh Cambodia China India Iran Jordan Kazakhstan Lebanon Myanmar Nepal Pakistan Syria Vietnam
	15	5	6	13	13
Africa (33 countries)	Algeria Benin Cameroon Egypt Eritrea Ethiopia Kenya Malawi Mauritania Nigeria Senegal Sierra Leone Togo	Burkina Faso Congo Djibouti Ethiopia Ivory Coast Kenya Lesotho Madagascar Morocco Mozambique Senegal Sudan Uganda	Benin Cape Verde Djibouti Ethiopia Ivory Coast Malawi Morocco Senegal Sudan Togo	Benin Burkina Faso Cameroon Cape Verde Gambia Ghana Guinea Côte d'Ivoire Kenya Liberia Libya Madagascar Mauritania Morocco Niger Nigeria Rwanda Senegal	Cameroon Egypt Ethiopia Guinea Kenya Malawi Tanzania Zambia
	13	14	10	18	8
Latin America & Caribbean (22 countries)	Bolivia Brazil Costa Rica Dominican Republic Guatemala Guyana Honduras	Brazil Dominican Rep Guyana Suriname	Belize Costa Rica El Salvador Mexico Saint Lucia	Argentina Bahamas Belize Bolivia Brazil Ecuador El Salvador Guatemala Mexico Nicaragua Peru Trinidad & Tobago	Argentina Bolivia Brazil Ecuador
	7	4	5	12	4
Total	35	23	21	43	25

Annex 3: Synthesis of commodity price effects on public revenues

Theoretical mechanisms on import prices

	High commodity prices (Effect: < or > 0 ?)	**Volatile commodity prices (Effect: < 0)**
Microeconomic effects	**Trade and consumption taxes (<> 0 ?)** Price effect: > 0 Tax rate effect: < 0 (Tax exemptions on food and oil imports) Volume effect: < 0 / = 0 (if non traded substitutes, less taxed)	**Trade and consumption taxes (< 0)** Price effect: = 0 (ad valorem tax) Tax rate effect: < 0 (asymmetry of tax exemptions) Volume effect: < 0 = 0 (if less volatile substitutes, partly non tradable, less taxed)
Macroeconomic effects	**Income taxes (< 0) Indirect taxes (< 0)** Revenue effect: < 0 < 0 Real exchange rate effect = 0 = 0	**Income taxes (< 0) Indirect taxes (< 0)** Growth volatility effect < 0 (GDP growth volatility – lower GDP growth)

Theoretical mechanisms on export prices

	High commodity prices (Effect: > 0)	**Volatile commodity prices (Effect: <> 0 ?)**
Microeconomic effects	**Trade and profit taxes, royalties (> 0)** Price effect: > 0 Tax rate effect: > 0 (taxation of windfall gains) Volume effect: > 0 / = 0 (if supply response)	**Trade and profit taxes, royalties (> 0)** Price effect: = 0 (ad valorem tax) > 0 (progressive / margin tax) Tax rate effect: > 0 (asymmetry of ad hoc taxes) Volume effect: < 0 / = 0 (if non traded & less volatile substitutes, less taxed)
Macroeconomic effects	**Income taxes (> 0) Indirect taxes (> 0)** Revenue effect: > 0 > 0 Real exchange rate effect < 0 > 0	**Income taxes (< 0) Indirect taxes (< 0)** Growth volatility effect < 0 (GDP growth volatility – lower GDP growth)

Annex 4. The 90 developing countries in the sample

Afghanistan, Albania, Algeria, Argentina, Armenia, Azerbaijan, Bangladesh, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chile, China, Colombia, Comoros, Cote d'Ivoire, Egypt. Arab Rep., El Salvador, Eritrea, Ethiopia, Fiji, Gabon, Gambia. The, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Honduras, India, Indonesia, Iran. Islamic Rep., Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Lebanon, Lesotho, Madagascar, Malawi, Maldives, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Samoa, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Thailand, Togo, Tonga, Tunisia, Turkey, Uganda, Ukraine, Uruguay, Venezuela, Vietnam, Yemen, Zambia.

Annex 5. Descriptive Statistics

Variable	Obs	Mean	Std Dev.	Min	Max
Revenue (%GDP)	1770	19.16	7.962	2.228	54.4
Income Taxes (%GDP)	1483	4.395	2.852	0.105	23.9
Consumption Taxes (%GDP)	1608	5.696	3.169	0.021	21.962
International Trade Taxes (%GDP)	1610	3.813	3.651	0.054	37.1
Commodity import price index (log)	1770	0.536	0.117	0.311	1.168
Agricultural import price index (log)	1770	0.507	0.0622	0.332	0.767
Energy import price index (log)	1770	0.604	0.240	0.270	1.474
Minerals import price index (log)	1770	0.592	0.135	0.288	1.410
Volatility of commodity import prices (log)[a]	1770	2.605	2.247	0.104	20.880
Volatility of commodity import prices (log)[b]	1770	4.816	3.465	0.524	31.182
Volatility of agricultural import prices (log)[a]	1770	2.367	1.699	0.257	16.520
Volatility of agricultural import prices (log)[b]	1770	3.891	2.457	0.503	20.464
Volatility of energy import prices (log)[a]	1770	5.955	5.215	0.133	36.840
Volatility of energy import prices (log)[b]	1770	6.796	5.735	0.143	39.053
Volatility of minerals import prices (log)[a]	1770	4.709	3.624	0.233	30.203
Volatility of minerals import prices (log)[b]	1770	5.719	4.498	0.480	45.573
Population below 14	1770	38.918	7.242	13.942	51.771
Aid per capita	1770	47.540	53.263	-40.38	438.24
Imports	1770	39.941	21.710	4.631	147.65
GDP (log)	1770	7.550	0.966	5.227	9.636
Agriculture (%GDP)	1770	23.489	13.999	1.833	68.879

Notes: [a] Volatility based on the first measure; [b] Volatility based on the first measure

Annex 6. The 34 exporting developing countries

Algeria, Azerbaijan, Belize, Benin, Bolivia, Burkina Faso, Burundi, Cameroon, Costa Rica, Cote d'Ivoire, Ethiopia, Gabon, The Gambia, Ghana, Iran. Islamic Rep., Kazakhstan, Kyrgyz Republic, Mali, Mauritania, Mozambique, Nicaragua, Nigeria, Papua New Guinea, Paraguay, Rwanda, Sierra Leone, Vincent and the Grenadines, Sudan, Syrian Arab Republic, Tajikistan, Uganda, Venezuela, Yemen, Zambia

Note: Angola, Libya, Chad and DRC are excluded from the sample due to the lack of tax revenue data. Botswana is also excluded since diamonds are not included in the IMF International commodity price database.

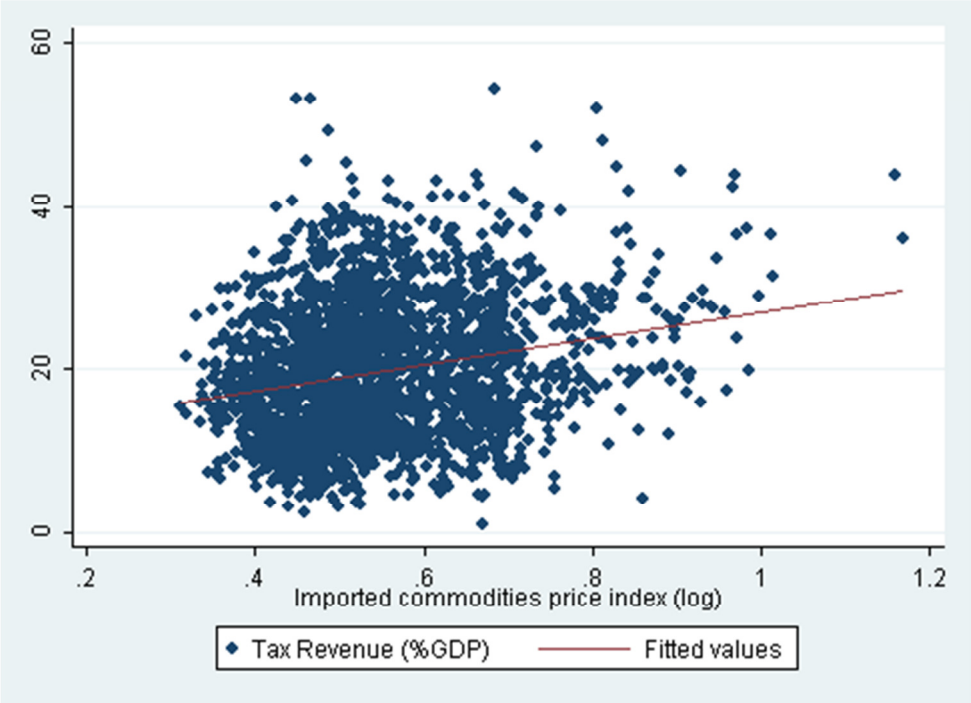
Annex 7. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Revenue (%GDP)	711	18.335	7.446	2.228	47.193
Income Tax and Non-Tax Revenue (%GDP)	604	9.403	7.266	0.247	37.328
Consumption Taxes (%GDP)	664	5.030	2.598	0.502	17.500
International Trade Taxes (%GDP)	656	3.449	2.441	0.386	16.126
Commodity export price index (log)	711	0.517	0.142	0.274	1.176
Volatility of commodity export price (log)[a]	711	2.762	2.196	0.090	11.989
Volatility of commodity export price (log)[b]	711	3.517	2.611	0.159	14.502
Population below 14	711	41.604	5.454	23.671	51.771
Aid per capita	711	48.040	41.638	-8.032	440.874
Exports (%GDP)	711	30.116	17.514	2.525	98.762
Imports (%GDP)	711	36.857	17.112	7.066	100.913
GDP per capita (log)	711	7.317	0.999	5.227	9.595
Agriculture (%GDP)	711	28.281	13.840	4.023	68.879

Notes: [a] Volatility based on the first measure; [b] Volatility based on the first measure

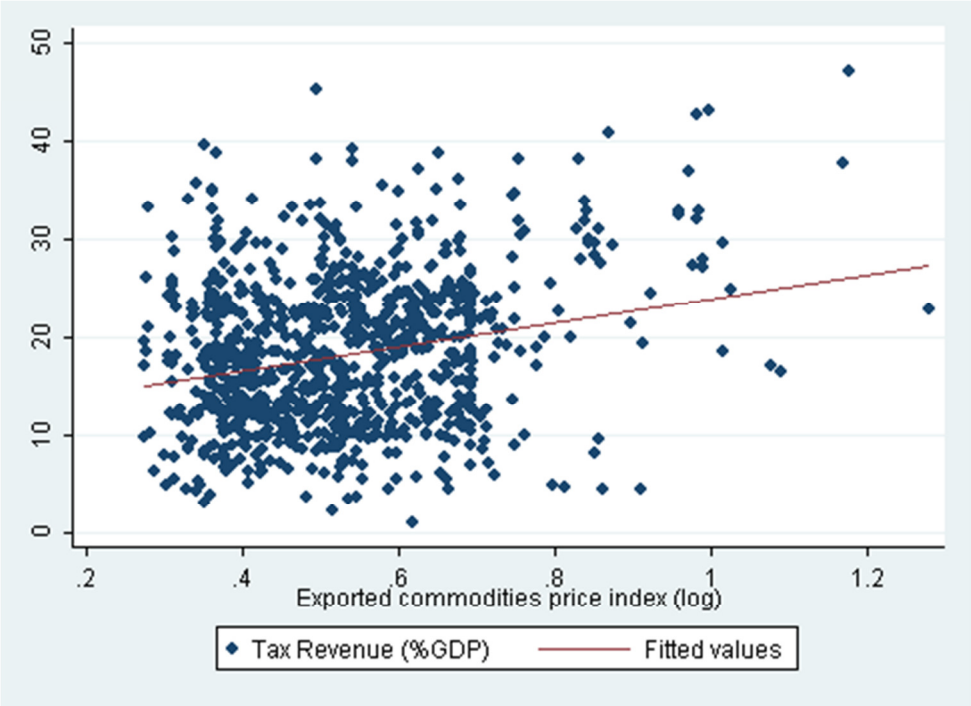
Annex 8. Correlation between tax revenue and commodity price indices

8.A. Correlation for imported commodities



Source: authors' calculations

8.B. Correlation for exported commodities in the sub-sample of large commodities exporting countries



Source: authors' calculations