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Commodity price volatility and tax revenue: Evidence from developing countries

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Résumé. Dans cet article nous analysons l'impact de la volatilité des prix des matières premières sur les recettes fiscales des pays en développement, alors que la littérature s'est principalement concentrée sur son effet sur la croissance économique. Notre analyse quantitative porte sur 80 pays en développement sur la période 1980-2008. Nous construisons des indices spécifiques à chaque pays mesurant la volatilité des prix internationaux de 41 matières premières agricoles, minérales et énergétiques. Nos résultats indiquent que la volatilité des prix des matières premières a un effet négatif sur les recettes fiscales des pays en développement. Plus spécifiquement, la volatilité des prix des matières premières importées réduit les recettes issues des taxes sur le commerce international alors que celle des matières premières exportées diminue les recettes de l'imposition directe. Cet impact négatif de la volatilité sur les recettes fiscales n'est cependant pas homogène pour tous les pays. D'une part, l'impact sur les recettes fiscales de la volatilité des prix des matières premières exportées est négatif sauf pour les pays pétroliers pour lesquels l'effet est nul. D'autre part, l'importance de l'effet dépend de la structure des tarifs douaniers de chaque pays *id est* est plus fort dans les pays avec une forte dispersion des tarifs.

Mots-clés : Volatilité des prix, Recettes fiscales, Matières premières, Pays en développement.
Codes JEL : E62, O13, F10

Abstract. In this paper we assess the impact of commodity price volatility on tax revenues, while existing works were concentrated on its effect on economic growth. Our empirical analysis is carried out on 80 developing countries over 1980-2008. We compute country-specific indices which measure 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 are hurt by the volatility of commodity prices. More specifically, the volatility of import prices decreases revenues from international trade tax while the volatility of export prices reduces revenues from income tax. We also show that this negative effect on tax revenues is not homogenous between countries. First, the export price volatility impact is negative except for oil exporters for whom it is null. Second, the magnitude of the negative impact of import price volatility on tax revenues depends on the tariff structure, i.e. is greater in countries where tariff dispersion is high.

***Keywords*:** Price Volatility, Tax revenues, Commodities, Developing economies.
***JEL Classification*:** E62, O13, F10

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 a combination of three aspects: 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 studied three issues: i) the 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 (Pindyck 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 but proposed several instruments such as 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. This paper aims at analyzing the impact of commodity price volatility on tax revenues in developing countries. It differs from the few previous studies dedicated to this issue on four main aspects. First, we test the impact of commodity price *volatility* rather than focusing only on price *levels.* Second, we break up export and import prices, rather than using terms of trade indices. Third, we disaggregate tax revenues into its different components and lastly we assess on which economic features the impact of commodity price volatility depends on, rather than assuming a homogeneous marginal impact. Our empirical analysis is carried out on 80 developing countries over 1980-2008. We compute country-specific indices of commodity prices that geometrically weight together the international prices of 41 commodities from the sectors of agriculture, minerals and energy.

We find robust evidence that tax revenues in developing countries are hurt by the volatility of commodity prices (once controlled for the positive effect of price levels). More specifically, the price volatility of imported commodities decreases revenues from international trade taxes while the volatility of export commodity prices reduces proceeds from income taxes. We also show that this negative effect is not homogenous between countries. First, the export price volatility impact on tax revenue is negative for non-oil exporters but is null for oil exporters. Second, the magnitude of the negative impact of import price volatility on tax revenues depends on the tariff structure, i.e. is greater in countries where tariff dispersion is high. These findings not only point at the detrimental effect of commodity price volatility on developing countries tax revenues, but also identify the most vulnerable countries (non-oil exporters with highly dispersed tariffs).

The remainder of the paper is organized as follows. Section 2 gives an analytical overview of the potential effects of commodity price instability on tax revenues and an empirical literature review on this issue. 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.

2. The effects of commodity prices on tax revenues

2.1. Commodity price instability and public revenues

Let us first analyze the impact of commodity price levels on tax revenues, which is expected to be different for imports and exports and is needed to understand the effect of commodity price volatility on tax revenues.

Higher prices of imported commodities should have a positive incidence on taxes levied on imports. This "price effect" may be partially offset by a "tax rate effect" and a "tax evasion effect". Firstly, 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[1]. Governments in developing countries use widely this tool. For instance, the policy measures implemented by governments during the food prices surge in 2008 are described in Annex 1 and Annex 2. In addition, importers may react to price jumps by magnifying their tax evasion strategies (under-recording of imports value or misclassification i.e. shift to a less taxed tariff line). The higher and more dispersed the trade taxes, the larger the incentive and the easiness of tax evasion. Other potential effects (reallocation of internal consumption, contractionary effect for net importers) are expected to be weak. The overall impact of high prices of imported commodities on tax revenues is thus expected to be positive or null.

Let us explore the consequences of a positive shock on export prices. Export taxes have been widely removed since the eighties[2], thus the exporting sector produces public revenue through the profit tax and non-tax revenues (royalties, production sharing contracts (PSC)) drawn from oil and minerals sectors. 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). Many countries have implemented stabilizing taxation when they experienced trade booms, as suggested widely by international institutions (Bevan et al.,

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

[2] These export tax however 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, for instance.

1993).[3] These direct effects may be supplemented by macroeconomic effects when the country is highly dependent from its exports: 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.[4] The overall impact of a rise in export prices on tax revenues is then positive.

Regarding price volatility more specifically, the relationship between commodity price volatility and public revenues will depend mainly on the mechanisms mentioned above, i.e. tax and tariff structure, trade structure and government's response to shocks.

On the imports side, three mechanisms can be identified. 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). [5] 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, commodity price instability may spur tax evasion, the possibility of tax evasion being greater when tariff dispersion is high (Ebrill et al. 2002 ; Fisman and Wei, 2004). In total, the effect of commodity import price volatility is expected to be negative on tax revenue and to be stronger when there is a large use of tax exemptions and a high dispersion of tariffs (i.e. resilience of tax revenue is weaker).

The impact of export price volatility on public revenue depends on the taxation characteristics. A common feature of profit tax and non-tax revenue is to be "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

[3] 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.

[4] The latter effect may be partially offset by real exchange rate appreciation (Dutch disease).

[5] Volatility may also have some negative volume effect, since a strong volatility of prices gives an incentive to substitute the goods imported by domestic goods. Given the weak substitutability of imported goods, this effect is expected to be small.

up (Leenhardt, 2005). Therefore, we can expect the price volatility effect to be null for exports with ad valorem taxes or with almost no taxation or positive in the case of oil and mineral exports. Nevertheless, commodity price volatility of exports leads to GDP volatility, which may decrease GDP (Ramey and Ramey, 1995, Blattman et al., 2007) and therefore may reduce the tax base and lower tax revenues. Therefore, the average impact of export price volatility on tax revenues is ambiguous, but should be positive or null for oil and minerals exporters (thanks to margin taxation) and negative for other countries (due to GDP volatility).

2.2. 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 balances rather than the incidence of the volatility of these prices. Medina (2010) - using a VAR methodology on Latin American and high income commodity-dependent countries - shows that there is a significant heterogeneity of tax responses between countries. The tax response to commodity price shocks is small in high income countries and Chile while it is high in Venezuela and Ecuador which are more dependent from exports of commodities. Kumah and Matovu (2007), using the same methodology on Russia and three central Asian countries, find a significant response of revenues to variations in commodity prices, thus indicating a "commodity-dependent" pattern.[6] Spatafora and Samake (2012), using a panel of 116 countries on 1990-2010, found a rise in tax revenues in response to commodity (import or export) price increases, this effect being smaller in floating exchange rate regimes. A more disaggregated analysis that distinguishes different tax categories and/or identifies policy changes is made only in case studies. Analyzing the commodity boom in the late 1970s, Collier and Gunning (1999) show strong heterogeneity in tax rate response to positive price shocks (increase in Kenya and Bolivia, stability in Colombia and Bostwana, decrease in Cameroon and Senegal).[7] They although point out a

[6] In addition, these studies find a pro-cyclical behavior of public expenditure which increases with commodity prices. This behavior is also highlighted by Talvi and Vegh (2005).

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

strong capacity of governments to capture the financial gains (or losses) induced by a commodity price shock, either by stabilization mechanisms[8] or by indirect taxes (levied notably on consumption imports, as in Kenya).

A second strand of empirical literature relevant for our study tests the impact of commodity prices instability on economic growth. Most of studies use terms of trade indices, a synthetic measure of commodity price evolution, but some of them use separate price indices for exports and imports – as Dehn (2000) and Collier and Goderis (2007).[9] The main result drawn from this literature is the negative impact of terms of trade volatility on economic growth in developing countries. Mendoza (1997) interprets this negative impact (using a sample of 40 industrial and developing countries over the period 1970-1991) as an effect of risk that reduces savings. Bleaney and Greenaway (2001) found the same negative effect of terms of trade instability on a panel of 14 sub-Saharan African countries over 1980–1995. Subervie (2008) also found a negative impact of commodity price instability on agricultural production in developing countries.

Several papers point out that vulnerability to commodity price instability is different between high income economies and developing economies. Using a very long sample (1870-1939), Blattman et al. (2007) found that the detrimental effect is significant only for periphery commodity-dependent economies while it is not significant for US and western economies (labeled "core economies"). The main channel seems to be the adverse effect of volatility on foreign investment. Bahattacharyya and Williamson (2009) shows that the great commodity price volatility experienced by Australia during the 20th century did not cause the negative effects on growth observed in most developing countries, and argue that the main explanation is the diversification of the Australian economy. Deaton and Miller (1996), Hoffmaister et al. (1998) and Raddatz (2007), using a variance decomposition based on a VAR methodology, show that terms-of-trade shocks account for only a small fraction of the volatility of these countries' real GDP, and conclude that the negative impact of commodity price instability on growth should not be overstated. Crossing case studies evidence, Deaton and Miller

[8] Among these stabilization mechanisms: the 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...

[9] Collier and Goderis (2007) test the impact of price levels on economic growth but not the impact of price volatility.

(1996) argue that the negative effect of instability on growth is highly conditional to the quality of national institutions. This heterogeneity in the results suggests that some economies benefit from a lower exposure and/or a better capacity to handle these shocks (resilience) than others and highlights the relevance of testing if the marginal impact of commodity price instability on macroeconomic results depends on observable characteristics of economies.

To sum up, this study aims at filling the gap of the existing literature by focusing on the effect of commodity price volatility on tax revenues, breaking up import and exports prices, looking at disaggregated tax revenues, and allowing heterogeneous marginal impacts of commodity price instability.

3. Methodology and Empirical Framework

Our analysis stretches over the period 1980-2008 and covers 80 developing countries (see Annex 3 for the list of countries and annex 4 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 one 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. Share of commodities in developing countries' trade

		Mean	Min	Max	Mean 1980	Mean 1992	Mean 2008
Commodity 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%
Commodity 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%

Source : WITS (COMTRADE) and authors' calculations.

To assess the impact of commodity price instability on tax revenues we rely on commodity price indices rather than on a term of trade measure for two main reasons. First, Bidarkota and Crucini (2000) established that commodity prices are much more volatile than the terms of trade so using terms of trade indices leads to an underestimation of the price volatility faced by countries. Second, it is hard to correctly proxy the extent of fluctuations in the prices of exported and imported commodities with an index like the terms of trade which contains various non-commodity price components (Kose and Riezman, 2010).

Following Deaton and Miller (1996) and Dehn (2000), we thus 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 and export 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 $w_{i,c}$ being for exports instead of imports. Forty-one commodities are distinguished, listed in Annex 5) and their international prices are drawn from IMF data. 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%

Source : WITS (COMTRADE) and authors' calculations.

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.

The volatility of commodity prices is assessed through the standard deviation, which is the most common indicator of variability (Mendoza, 1997, for terms of trade volatility or Aghion et al., 2009, for exchange rate volatility, Raddatz, 2007, Bahattacharyya and Williamson, 2009 among others) [10]. We therefore measure commodity price volatility as the standard deviation of the first-difference of the deflated country-specific price indices. Volatility is thus measured for each year based on the twelve monthly price indices.

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

$$T_{i,t} = \alpha + \beta_1 \log(\sigma^M_{i,t}) + \beta_2 \log(\sigma^X_{i,t}) + \beta_3 \log(I^M_{i,t}) + \beta_4 \log(I^X_{i,t}) + X'_{i,t}\,\beta_3 + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

[10] Bleaney and Greenaway (2001) and Dehn (2000) use uncertainty measures drawn from GARCH models, while Blattman et al. (2007) rely on a Hodrick Prescott filter. Their volatility measure is nevertheless highly correlated (0.86) with the standard deviation measure.

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). μ_i represents the country fixed effect whereas λ_t is the time fixed effect. $\sigma_{i,t}^{M}$ and $\sigma_{i,t}^{X}$ represent the commodity price volatility for imports and exports, respectively, whereas $I_{i,t}^{M}$ and $I_{i,t}^{X}$ are the commodity price indices. 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; Brun et al., 2007; Keen and Lockwood, 2010; Ehrhart, 2011), we include the following variables as control. 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 both 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) and the urbanization rate that should be positively related to tax revenue collection. The degree of openness, measured as the sum of imports and exports as share of GDP, should also be positively associated with tax revenue given that, in developing countries, a large part of the taxes are collected at the borders. All these variables are from the World Development Indicator (WDI) database. Lastly, the volatility of the real exchange rate is included as control variable. It is measured, like the commodity price volatility, as the standard deviation over one year of the twelve monthly real exchange rates. Real exchange rates are computed using nominal exchange rates of each currency toward the US dollar weighted by the ratio of the consumer price index in the US over the consumer price index in the domestic economy. These data are extracted from the International Finance Statistics (IFS) from the IMF.

Given the persistence of tax revenues and to ensure the robustness of our results, we rely on two alternative estimators. First, we use a panel fixed effect estimator that allows for serial correlation in the errors. Second, we include the lagged dependent variable and rely on an estimator suited for

dynamic panels. In this case, the OLS estimator becomes inconsistent because the lagged level of tax revenue is correlated with the error term due to the presence of country fixed effects (Nickell, 1981). One way to handle this issue 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 price volatility on tax revenues

The results of our baseline equation are presented in Table 3. The first four columns present the results for the total government revenue, excluding foreign aid, whereas in the three subsequent columns (5 to 7), the dependent variables are the revenue from the three different categories of taxes, namely income taxes, domestic indirect taxes and taxes on international trade. Results concerning total government revenue are presented with the OLS-fixed-effect estimator corrected for autocorrelation (FE-AR) (columns 1-2) and with the GMM-system estimator (columns 3-4). We use successively disaggregated price indexes (exports and imports prices separately, columns 1 and 3) and an aggregated commodity price index (columns 2 and 4)

Table 3. Impact of commodity price volatility on tax revenues

VARIABLES	FE-AR Tax Revenue (%GDP)	FE-AR Tax Revenue (%GDP)	Sys-GMM Tax Revenue (%GDP)	Sys-GMM Tax Revenue (%GDP)	Sys-GMM International Trade Tax Revenue (%GDP)	Sys-GMM Consumption Tax Revenue (%GDP)	Sys-GMM Income Tax Revenue (%GDP)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Commodity export price volatility	-8.210**	-6.969*	-4.615	-6.887			-6.778**
	(4.062)	(3.926)	(6.779)	(6.781)			(2.632)
Commodity import price volatility	-11.72*	-13.73**	-18.83**	-13.84*	-9.538**	7.686	
	(6.825)	(6.534)	(9.154)	(7.270)	(4.382)	(5.978)	
Commodity import price index	0.932		6.872**		1.794*	0.255	
	(2.018)		(3.100)		(0.957)	(1.242)	
Commodity export price index	3.492***		2.940				1.530*
	(1.329)		(1.992)				(0.786)
Commodity export and import price index		3.833**		6.024**			
		(1.616)		(2.697)			
Lagged dependent variable			0.688***	0.696***	0.886***	0.864***	0.707***
			(0.0794)	(0.0792)	(0.0378)	(0.0459)	(0.0631)
Real exchange rate volatility (log)	-1.497	-1.430	-3.096	-3.355	0.250	-3.292**	-0.197
	(1.636)	(1.635)	(3.271)	(3.347)	(0.816)	(1.632)	(1.113)
Openness	0.0248***	0.0248***	0.00527	0.00644	-0.00464	0.0137	-0.0138**
	(0.00735)	(0.00735)	(0.0161)	(0.0160)	(0.00563)	(0.00863)	(0.00619)
Agriculture (%GDP)	-0.0634**	-0.0650**	-0.166**	-0.151**	-0.0547*	-0.0145	-0.0276
	(0.0263)	(0.0263)	(0.0680)	(0.0645)	(0.0320)	(0.0245)	(0.0251)
Urbanisation rate	-0.0442	-0.0385	0.0636*	0.0621*	0.0120	0.0240*	-0.0152
	(0.0858)	(0.0859)	(0.0362)	(0.0351)	(0.0149)	(0.0133)	(0.0140)
GDP	1.806	1.806	-2.258	-2.066	-1.054	-0.777	0.353
	(1.154)	(1.156)	(1.607)	(1.557)	(0.758)	(0.559)	(0.626)
Observations	1,534	1,534	1,566	1,566	1,445	1,454	1,339
AR(1) test (p-val.)			0.000	0.000	0.001	0.000	0.000
AR(2) test (p-val.)			0.116	0.126	0.331	0.277	0.934
Hansen Test (p-val.)			0.556	0.510	0.376	0.208	0.594
Number of instruments			48	47	54	46	46
Number of countries	80	80	80	80	80	80	80

Note: Robust standard errors in brackets. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Constant, country and time fixed effects included but not reported. The price indices and volatility, the urbanisation rate and the agricultural value-added are treated as exogenous whereas real exchange rate volatility and the lagged dependent variable are considered as predetermined and the level of GDP and openness as endogenous. Instruments are collapsed. The number of lags used to instrument variables varies from one dependent variable to another. In columns 3, 4 and 7, predetermined variables are instrumented with their 1st to 4th-order lagged values and endogenous variables with their 2nd-order lagged values. In columns 5 and 6, predetermined variables instrumented with their 1st to 4th-order lagged values and endogeneous variables with their 2nd to 6th in column 5 and 2nd to 3rd-order in column 6.

Results for the total government revenue show that tax revenues in developing countries are hurt by the volatility of commodity prices (once controlled for the positive effect of price levels). This result is new –since it has not been tested before- and broadens the set of negative effects of volatility identified in developing countries. Both import and export price volatility have this negative effect, but it seems smaller and less robust as far as export prices are concerned (non-significant with GMM-system estimator, see columns 3 and 4). The latter result may be explained by some heterogeneity between oil exporters and others, an assumption that we will test in Table 4. Given the potential colinearity between export and import commodity prices, the pair of commodity price indices is replaced by a single commodity price index, which is the sum of the two indices, in columns 2 and 4. Results are unchanged to this modification. The negative effect of import commodity price volatility on tax revenues is quite substantial. A one standard deviation increase of the price volatility leads to a decrease of 0.38 GDP percentage points of tax revenues. For the mean level of tax revenues in our sample, it represents a decrease of 2% in tax revenues.

The effect of commodity price volatility might be different on the different components of tax revenues. Commodity imports being mainly taxed through the tariffs and VAT, the volatility of their prices could affect these two categories of tax revenues. For exports, the effect of the price volatility could solely be on income tax revenue through which the exporting sector is mainly taxed. In columns 5 to 7, we assess the impact of commodity price volatility on the revenue from the different categories of taxes. We find that the volatility of imported commodity prices negatively affects trade tax revenues but not revenues from domestic consumption taxes. The volatility of export prices reduces income tax revenues. These results are consistent with the mechanisms presented in section 2 and show that VAT revenues are less vulnerable to external shocks than other taxes.

The control variables included in the model exhibit the expected sign. The lagged dependent variables, openness and the urbanization rate are significantly positively associated with tax revenues. The value added in the agriculture sector is inducing decreased consumption taxes being collected. The

remaining control variables are non-significant. AR(1), AR(2) and Hansen tests confirm the adequacy and the validity of our estimations when we use the GMM-System estimator.

4.2. Conditional effects: on what does the commodity price volatility effect depend?

We might expect that the magnitude of the negative impact of commodity price volatility depends on several aspects. For exports, given the strong heterogeneity between countries in the share of commodities in their exports, the negative impact of commodity price volatility on tax revenue might depend on the extent of the exposure to the price risk i.e. the share of commodities in their total export value[11]. Regarding imports, the relationship between commodity price volatility and tax revenues can depend on both the ease of tax evasion and the extent of use of temporary tax exemptions by the governments.

First, we can test the conditional effects on the side of exports by adding an interactive variable between the price volatility of exported commodities and the average share of commodities in total export value over the sample period in our baseline equation. The results are presented in Table 4. In columns 1 and 2, we find a negative effect of the price volatility of exported commodities on tax revenues but the coefficient on the interactive variable is positive. This indicates that the negative impact of volatility decreases as the share of commodities in total exports increases. The negative effect of commodity price volatility on tax revenues turns null when the share of commodities in total exports is equal or larger than 79%. In our sample, the mean value of the share of commodities in exports being 42.5 %, the commodity price volatility negatively affects tax revenues for most of the countries in our sample.

This counter-intuitive result of a lower negative impact on revenues the larger the share of commodities in total exports may be due, as explained above, to the use of margin taxation in oil exporting countries. Indeed, most of the countries with the largest share of commodities in their

[11] For imports, the share of commodities in total imports being less dispersed than the share in exports, there are few reasons to suspect the presence of heterogeneity in the relationship.

exports are the major oil exporting countries which rely on the margin taxation of their oil sector that, by definition, increases the collection of tax revenues if the international price is volatile.

Table 4. Impact of commodity price volatility according to the share of commodities in exports

	FE-AR	Sys-GMM	FE-AR	Sys-GMM
VARIABLES	Tax Revenue (%GDP)	Tax Revenue (%GDP)	Tax Revenue (%GDP)	Tax Revenue (%GDP)
	(1)	(2)	(3)	(4)
Commodity export price volatility	-21.89***	-23.89**	-12.33***	-12.45*
	(7.289)	(11.30)	(4.641)	(7.305)
Com. export price volatility x Share of commodities in exports	0.277**	0.343*		
	(0.123)	(0.197)		
Com. export price volatility x Oil exporting country			11.44*	19.21*
			(6.253)	(10.38)
Commodity import price volatility	-10.47	-14.84*	-11.48*	-15.77*
	(6.836)	(9.020)	(6.820)	(8.608)
Commodity import price index	1.299	6.205**	1.085	6.198**
	(2.022)	(2.915)	(2.018)	(2.875)
Commodity export price index	3.414**	3.001	3.494***	2.998
	(1.328)	(2.036)	(1.328)	(2.078)
Lagged dependent variable		0.690***		0.694***
		(0.0831)		(0.0842)
Real exchange rate volatility (log)	-1.322	-2.883	-1.503	-2.907
	(1.635)	(3.312)	(1.634)	(3.375)
Openness	0.0252***	0.00733	0.0254***	0.00648
	(0.00734)	(0.0188)	(0.00735)	(0.0175)
Agriculture (%GDP)	-0.0637**	-0.134**	-0.0625**	-0.139**
	(0.0263)	(0.0616)	(0.0263)	(0.0631)
Urbanisation rate	-0.0514	0.0571*	-0.0552	0.0568
	(0.0861)	(0.0346)	(0.0862)	(0.0348)
GDP (log)	2.108*	-1.796	1.888	-1.965
	(1.162)	(1.520)	(1.155)	(1.641)
Observations	1,534	1,541	1,534	1,541
AR(1) test (p-val.)		0.000		0.000
AR(2) test (p-val.)		0.195		0.204
Hansen test (p-val.)		0.400		0.409
Nb of instruments		50		50
Nb of countries	80	80	80	80

Note: Robust standard errors in brackets. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Constant, time and country fixed effects included but not reported. The price indices and volatility, the urbanization rate and the agricultural value-added are treated as exogenous whereas real exchange rate volatility and the lagged dependent variable are considered as predetermined and the level of GDP and openness as endogenous. Instruments are collapsed. Predetermined variables are instrumented with their 1st to 4th-order lagged values and endogenous variables with their 2nd-order lagged values.

We thus test whether there is some heterogeneity between major oil exporting countries and other economies in the relationship between price volatility and tax revenues by interacting the variable commodity price volatility with a dummy variable "major oil exporter". The variable oil exporter takes the value 1 for the 25 countries in our sample that export a substantial level of oil (exports of oil represent at least 20% of their commodity exports).

The results are displayed in columns 3 and 4 of Table 4. The coefficient of the interactive variable being significantly positive, it suggests a positive effect of commodity price volatility specific to oil exporters, which offsets the average negative effect. The effect for oil exporters is the sum of the coefficient on the « average effect » and the coefficient on « oil exporter ». This sum is close to zero and according to the Wald test, is not significantly different from zero (respectively Wald test p-value equal to 0.875 in columns 3 and to 0.463 in column 4). In other words, the commodity export price volatility impact is indeed negative for non-oil exporters, and null for oil exporters.

Regarding the effect of import commodity price volatility on tax revenues, it may vary according to both the ease of tax evasion and the use of temporary tax exemptions.

First, peaks in commodity prices increase the incentives for importers to avoid taxation in order to decrease the net cost of their imports. Tariff evasion is particularly eased when the dispersion of tariffs is large since it often takes place through misclassification of imports from higher-taxed categories to lower-taxed ones (Fisman and Wei, 2004). We thus hypothesize that the negative impact of the price volatility of imported commodities on tax revenues should be magnified when the tariff dispersion is large. We test this hypothesis by adding an interactive variable between imported commodity price volatility and the dispersion of tariffs in our baseline equation. Tariff dispersion for each country is measured by the standard deviation of tariffs which is drawn from the UNCTAD TRAINS database. For the developing countries in our sample, data are generally not available before 1997 and tariffs indicators are not reported for every year so we use the mean value for each country of its tariff dispersion over the period 1997-2002, which is about in the middle of our time period.

Results are presented in Table 5. In both columns 1 and 2, with our two estimators, we find that the magnitude of the negative impact of import price volatility on tax revenues depends indeed on the tax structure, i.e. is greater in countries where tariffs dispersion is higher. Given that tariffs dispersion is always strictly positive, the marginal impact of commodity import price volatility is strictly negative for all countries.

Table 5. Impact of commodity import price volatility according to the dispersion of tariffs

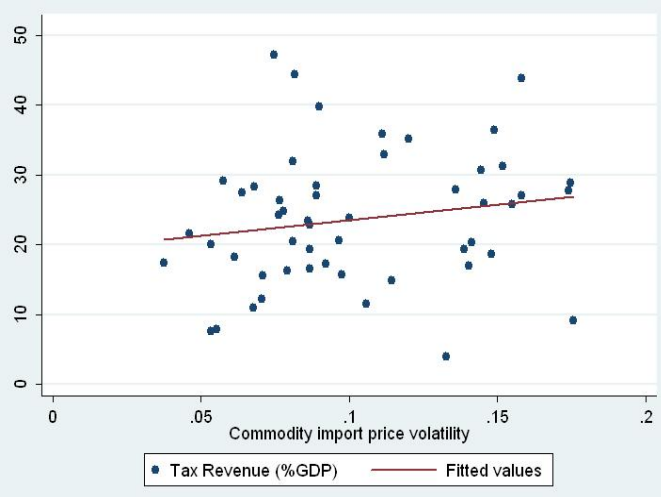
	FE-AR	Sys-GMM
VARIABLES	Tax Revenue (%GDP)	Tax Revenue (%GDP)
	(1)	(2)
Commodity export price volatility	-7.560*	-5.772
	(4.224)	(8.032)
Commodity import price volatility	-6.096	-8.872
	(7.922)	(9.925)
Commodity import price volatility x dispersion of tariffs	-0.640*	-0.695**
	(0.357)	(0.275)
Commodity import price index	0.257	5.098*
	(2.053)	(2.971)
Commodity export price index	3.469**	3.215
	(1.354)	(2.277)
Lagged dependent variable		0.711***
		(0.0843)
Real exchange rate volatility (log)	-1.206	-2.423
	(1.662)	(3.328)
Openness	0.0212***	-0.000124
	(0.00761)	(0.0189)
Agriculture (%GDP)	-0.0644**	-0.154**
	(0.0270)	(0.0706)
Urbanisation rate	-0.0277	0.0703
	(0.0886)	(0.0450)
GDP	1.689	-2.497
	(1.169)	(1.875)
Observations	1,487	1,492
AR(1) test (p-val.)		0.000
AR(2) test (p-val.)		0.113
Hansen test (p-val.)		0.292
Nb of instruments		50
Nb of countries	76	76

Note: Robust standard errors in brackets. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Constant, time and country fixed effects included but not reported. The price indices and volatility, the urbanization rate and the agricultural value-added are treated as exogenous whereas real exchange rate volatility and the lagged dependent variable are considered as predetermined and the level of GDP and openness as endogenous. Instruments are collapsed. Predetermined variables are instrumented with their 1st to 4th-order lagged values and endogenous variables with their 2nd-order lagged values.

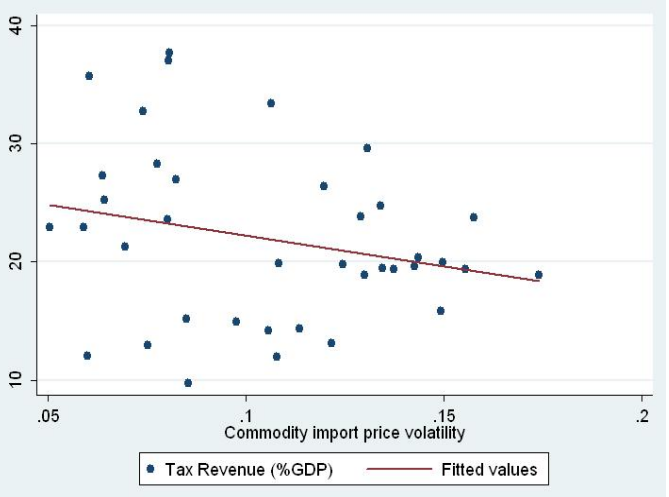
Second, to analyze whether the negative relationship between commodity import price volatility and tax revenue is depending on the extent of use by governments of tax exemptions in times of high international prices, we unfortunately cannot implement the same kind of direct test due to lack of data over a long period on the use of tax exemptions. However, in a survey on the country responses to the 2008 food price surge, FAO (2009) provide the list of countries that implemented either exemptions of tax and tariffs or reductions in the tax rates (see annex 2). Considering only the year 2008, we thus present in Figure 1 two scatterplots of the relation between the import commodity price volatility and the tax revenue mobilization. The scatterplot on the left presents the relationship for the countries that did not use any tax exemption in 2008 whereas the one on the right is for those countries that implemented temporary tax exemptions. The comparison between these two plots indicates that the negative relationship between commodity price volatility and tax revenue seems to especially hold for countries that used tax exemptions.[12]

Figure 1. Relation between volatility of imported commodity prices in 2008

Non-Use of VAT or tariff reduction cuts



Use of VAT or tariff reduction



Source: author's calculations.

[12] A cross-section multivariate analysis of the effect of commodity price volatility on tax revenues on the two sub-samples confirms the graphical evidence of a negative significant relation for countries that implemented tax exemptions and a non-significant relation for the other countries. The number of observations in each sub-sample being small, this result only constitutes preliminary evidence.

This suggests that countries using tax exemptions are more vulnerable (or less resilient) to commodity price volatility. The use of tax exemptions during instability episodes has not only a direct negative impact on tax revenue, but is also a symptom of vulnerability. Indeed, countries having a strong incidence of poverty and no safety net in place are prompted to implement tax cuts when the price of food or oil is high, which magnify their structural tax revenue vulnerability.

These findings not only confirm the detrimental effect of commodity price volatility on developing countries tax revenue, but above all identify the more vulnerable countries, which are the non-oil exporters with highly dispersed tariffs, highly dependent to trade taxes and using tax exemptions.

5. Conclusion and policy implications

In this paper we estimated, on a sample of 80 developing countries over the period 1980-2008, the impact on tax revenues of commodity price volatility rather than focusing only on price levels. We tested whether this impact is different for exports and imports commodity prices, different according the kind of taxes (income tax, consumption tax and international trade tax) and if its magnitude depends on both the trade and tariff structure of the economies.

We find robust evidence that tax revenues in developing countries are hurt by the volatility of commodity prices (once controlled for the positive effect of price levels). More specifically, the volatility of import prices decreases revenues from international trade taxes while the volatility of export prices reduces proceeds from income taxes. We also show that this negative effect is not homogenous between countries. First, the export price volatility impact is negative for non-oil exporters but null for oil exporters. Second, the magnitude of the negative impact of import price volatility on tax revenues depends on the tariff structure, i.e. is greater in countries where tariff

dispersion is high. Also this negative impact might be related to the use of temporary tax or tariff exemptions.

Our results confirm 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). More interestingly, this paper identifies the most vulnerable countries (non-oil exporters, dependent to trade taxes, with highly dispersed tariffs and using tax exemptions) and thus provides specific policy recommendations to handle this vulnerability. First, the shift from tariffs to consumption taxes could be expected to reduce the vulnerability of tax revenues to commodity price volatility. Second, a reduction of tariffs dispersion is needed to reduce incentives of tax evasion and limit the negative effect of commodity price volatility on tax revenues. 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 building of safety nets is of particular importance to replace non-targeted (thus very costly) tax cuts by interventions targeted on poor. Fourth, integrating commodity price volatility in tax revenue forecast equations would improve their accuracy and the exhaustiveness of the vulnerability diagnosis of commodity-dependent countries.

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7. Annexes

Annex 1: Food Tax decreases (International Monetary Fund, 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
Low er-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. The 80 developing countries in the sample

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

Annex 4. Descriptive Statistics

Variable	Obs.	Mean	Std Dev	Min	Max
Revenue (%GDP)	1566	19.68	8.042	3	54.4
Income Taxes (%GDP)	1339	4.521	2.892	.3	21.3
Consumption Taxes (%GDP)	1454	5.950	3.244	0	21.962
International Trade Taxes (%GDP)	1445	3.710	3.583	0.054	37.1
Commodity import price index (log)	1566	0.559	0.121	0.311	1.159
Commodity export price index (log)	1566	0.543	0.128	0.275	1.162
Commodity price index (log)	1566	0.904	0.149	0.597	1.565
Volatility of commodity import prices (log)	1566	0.028	0.021	0.006	0.174
Volatility of commodity export prices (log)	1566	0.033	0.024	0.006	0.203
Real exchange rate volatility (log)	1566	0.029	0.039	0.0013	0.569
Openness	1566	71.755	38.558	10.831	255.015
GDP (log)	1566	7.663	0.996	5.497	9.964
Urbanization	1566	42.96	20.15	4.48	92.3
Agriculture (%GDP)	1566	22.434	13.99	1.833	68.879
Mean share of commodities in exports	1541	42.506	25.91	2.733	97.401
Oil exporting country	1541	0.313	0.464	0	1
Mean tariff dispersion	1492	13.588	12.483	2.736	74.185

Annex 5. The 41 commodities in the price indices

Agricultural commodities: 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.

Minerals: aluminium, copper, iron ore, lead, nickel, tin, uranium, zinc, gold, silver.

Energetic commodities: coal, gas and oil.

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