Not all Shocks are Shared Equally: Commodity Producers and International Risk Sharing*

Emiliano Luttini
World Bank

Dawit Mekonnen
World Bank

Valerie Mercer-Blackman
World Bank

Bent Sørensen
University of Houston and CEPR

March 2025

Preliminary incomplete draft

Abstract

Using world-commodity prices as an instrument, we propose a novel method for decomposing channels of international risk sharing for commodity-exporting countries. We identify the commodity "sector" as the projection of GDP growth on commodity price growth and the non-commodity "sector" as its orthogonal complement. We find that commodity price risk is shared significantly more than other risk. Shocks to GDP are smoothed via counter-cyclical international factor income and, especially, pro-cyclical savings; in particular, government savings. Risk sharing from government savings is stronger at shorter than at longer time horizons.

Keywords*: risk sharing, consumption, commodity exporters* .
JEL codes: F02, F21, F36, Q02

*Emiliano Luttini, eluttini@worldbank.org; Dawit Mekonnen, dmekonnen@worldbank.org; Valerie Mercer-Blackman, vmercerblackman@worldbank.org; Bent Sørensen, bsorense@Central.UH.EDU. The views expressed in this paper are those of the authors and do not necessarily represent those of the World Bank, its Executive Board, or its management. We thank Ayhan Kose for comments and participants at the Prospects Group Analytical Brown Bag Meeting. All errors are our own.

1 Introduction

Countries with exports dominated by commodities are subject to high risk because shocks to prices of commodities (such as oil and metals) lead to large and persistent output fluctuations. Consequently, commodity-price risk may result in substantial welfare losses. In principle, commodity exporters can hedge against risk by trading ownership rights of their commodities and invest the proceeds in a diversified international portfolio (by trading equity, foreign direct investment (FDI), risky lending, etc.). This "channel of risk sharing" is typically highlighted in stylized perfect-market models, but seems less important in practice. Countries can self-insure via pro-cyclical savings, although this channel of risk sharing is less ideal as savings may run out following a large negative shock, particularly if the shock is persistent.[1]

We estimate channels of risk sharing for commodity-exporting countries following the methodology of Asdrubali, Sorensen and Yosha (1996) (ASY), who estimated these channels based on a covariance decomposition of GDP shocks. Intuitively, a positive shock to the GDP of a country has to either show up in consumption or be "absorbed" (or "smoothed") by "channels of risk sharing," e.g., outgoing international factor income, or an increase in saving. The channels of risk sharing are estimated using panel regressions with time-fixed effects that capture the aggregate risk that cannot be shared away; the amount of risk not shared is measured as the coefficient in a fixed-effect regression of consumption on GDP. The covariance decomposition of ASY is informative, whether GDP shocks are exogenous to the terms in the decomposition or not, but the extent of smoothing may differ for purely exogenous shocks.

We assume that world commodity prices are exogenous to the GDP of individual countries, and we make a methodological innovation and construct an IV-decomposition of the channels of risk sharing. Using a Bartik-style shift-share setup, we decompose the GDP of a country into the projection on the instrument and the projection on the orthogonal space. We interpret the projection components as sectors of the economy, which we label the commodity sector and the non-commodity sector, and estimate channels of risk sharing for each sector. The overall ASY-style channels of risk sharing are weighted averages of our "sectoral" measures of risk sharing, and we refer to our approach as an IV-decomposition of channels of risk sharing.

To our knowledge, this is the first paper to estimate sectoral channels of risk sharing

[1] Implicit in this discussion is that the amount of unshared risk is measured as the correlation of consumption growth with GDP growth after controlling for aggregate effects. This convention has been common since first suggested by (Cochrane, 1991; Mace, 1991), using individual-level data, and Obstfeld (1993), using country-level data.

for commodity-exporting (or other) countries. Related literarute includes, for example, Arroyo-Marioli and Vegh (2023) who illustrate the challenges for government spending in commodity-exporting countries. They show that the degree of fiscal procyclicality is twice as high for commodity exporters than in non-commodity exporters (although they show this pattern has become less pronounced the last 15 years). Early estimates of the degree of international risk sharing consistently found that it is low relative to theoretical predictions, even for highly financially integrated economies (Lewis (1996); Obstfeld (1993)). This holds even more true for emerging markets, in part because these countries have low holdings of international financial assets (Kose, Prasad and Terrones (2009)).

Estimating channels of risk sharing was first suggested by ASY for U.S. states and applied to countries by Sørensen and Yosha (1998). The ASY regressions have a simple intuitive interpretation in terms of diversification of ownership and savings, although the findings are not matched to any specific structural model. Hoffmann et al. (2019) construct a computational quantitative model where income smoothing and risk sharing are functions of cross-ownership of firms and of international banking integration. Simulating the model, they find that it explains well the channels of risk sharing in the European Union. In a theoretical contribution, Maggiori (2017) shows that optimal risk sharing between financially advanced countries, such as the United States, and developing countries can be asymmetric, with the more developed countries absorbing a greater share of global shocks in downturns.

Our work is purely empirical, and we adjust the ASY-type regressions to measure differences in country-level consumption (growth) from the consumption of the world (including developed countries), rather than the more typical specification that measures deviation from the group average—often implicitly, using time fixed effects. This has the interpretation of measuring the deviation from sharing risk with the world's countries, rather than measuring risk sharing between the commodity exporters themselves. Because commodity exporters typically suffer from correlated shocks, benefits from in-group risk sharing are minor and therefore of less interest. We measure deviations from risk sharing with the world also for our sectoral decompositions.

Likely, assets such a ore- or oil-deposits are easier to monitor across borders than, say, small service-oriented firms and it is therefore likely that the commodity-dependent sector will be able to obtain more risk sharing via ownership diversification. Heathcote and Perri (2004) model risk sharing as a function of higher endogenous global financial integration. Risk sharing via sovereign savings may also be higher for commodity-price shocks than for other shocks due to explicit government policies intended to smooth

the large shocks associated with commodities—possibly via dedicated sovereign wealth funds.

We find that commodity exporters share risk significantly more than non-commodity exporters. Having established that commodity exporters share risk differently, we focus our analysis on energy and metals exporting countries, which face significantly more medium-term volatility than agricultural commodity exporters (and commodity importers). By estimating channels of risk sharing at different horizons, we find that most risk sharing in resource rich countries takes place through pro-cyclical savings, especially at shorter time-frequencies, while international factor income plays a smaller but still important role.

Splitting GDP by sector via projections, we identify substantial risk sharing of shocks to the commodity sector, with less than a third of commodity price-driven GDP shocks reflected in consumption at a 5-year frequency. In contrast, two-thirds of non-commodity-price driven shocks are reflected in consumption at the 5-year frequency. These sectoral differences in risk sharing are driven by both international factor income flows and savings, especially government savings. In terms of uses of savings, the commodity sector smooths resource-price shocks significantly via pro-cyclical domestic investment.

The rest of the paper is organized as follows. Section 2 derives the channels of risk sharing by sectors, using instrumental variables. Section 3 describes the data used in the analysis. Section 4 reports our results, and Section 5 and 6 discuss extensions and conclude.

2 IV-Decomposition of Channels of Risk Sharing

The ASY decomposition starts from the following national accounts-based identity[2]:

$$\Delta \log_{GDP} = (\Delta \log_{GDP} - \Delta \log_{GNI}) + (\Delta \log_{GNI} - \Delta \log_{NNDI}) + (\Delta \log_{NNDI} - \Delta \log_{CONS}) + (\Delta \log_{CONS}) .$$

ASY show that the (cross-sectional) variance of GDP-growth can be decomposed into the sum of the covariances of GDP growth with the terms in parenthesis in the above equation. Therefore, a low correlation of consumption growth with GDP growth relative to the variance of GDP growth—usually interpreted as risk sharing—must have been absorbed into the other terms. These correlations can be interpreted as channels of risk sharing;

[2] GDP is Gross Domestic Product; GNI is Gross National Income, $NNDI$ is Net National Disposable Income and $CONS$ is consumption

see ASY for details.

Now consider decomposition using an instrument Z, with the ASY decomposition being the special case of Z being an identity matrix. (In our case, Z is the weighted price growth of commodities). Let P_Z be the projection matrix $Z(Z'Z)^{-1}Z'$ and the "residual maker" $M_Z = (I - P_Z)$. The projection matrix and the residual maker are orthogonal if $M_Z P_Z = 0$ and sum to the identity matrix if $M_Z P_Z = I$.

Consider the national account identity in a cross section of countries in year t. where we suppress the t index for now and shorten notation to $Y = \Delta \log \text{GDP}$. Multiplying each side of the identity with $P_Z Y - \mu_t$ where μ_t is $\Sigma_i P_Z Y_i$), where the i subscript indicates the countries in our sample, yields

$$Y'(P_Z Y - \mu_t) =$$

$$(Y - \Delta \log \text{GNI})'(P_Z Y - \mu_t) + (\Delta \log \text{GNI} - \Delta \log \text{NNDI})(P_Z Y - \mu_t)$$

$$+(\Delta \log \text{NNDI} - \Delta \log \text{CONS})(P_Z Y - \mu_t) + (\Delta \log \text{CONS})(P_Z Y - \mu_t) \, .$$

Observe that $Y'(P_Z Y - \mu_t) = (P_Z Y - \mu_t)'(P_Z Y - \mu_t)$ because $Y = P_Z Y + M_Z Y$ and $(P_Z Y - \mu_t)'\mu_t = 0$. Taking expectations, we have

$$Var(P_Z \Delta \log \text{GDP}) = Covar(P_Z \Delta \log \text{GDP}, \Delta \log \text{GDP} - \Delta \log \text{GNI})$$

$$+Covar(P_Z \Delta \log \text{GDP}, \Delta \log \text{GNI} - \Delta \log \text{NNDI}) + Covar(P_Z \Delta \log \text{GDP}, \Delta \log \text{NNDI} - \Delta \log \text{CONS})$$

$$+Covar(P_Z \Delta \log \text{GDP}, \Delta \log \text{CONS}) \, .$$

Dividing over by the left-hand side and noticing that the covariances divided by the variance are IV-coefficients we get

$$1 = \gamma^F + \gamma^T + \gamma^S + \gamma^U \tag{1}$$

where, for example, γ^U is $\frac{Covar(P_Z \Delta \log \text{GDP}, \Delta \log \text{CONS}))}{Var(P_Z \Delta \log \text{GDP})}$. The superscripts F denotes the factor income coefficient, T the net transfer coefficient, S the savings coefficient, and U the coefficient that gauges the fraction of shocks left unsmoothed.

This co-variance decomposition provides IV-coefficients for a cross-sectional regression of consumption growth on GDP growth predicted by the instrument. Similarly for the other three terms. ASY show that the coefficients from a panel-data regression with fixed effects is a weighted average of the cross-sectional coefficients year-by-year and these are the coefficients that we present. Overall, we have shown that an IV-covariance decomposition of the part of GDP growth predicted by the instrument results in 4 IV-coefficients

that sum to one.

The standard interpretation of IV regressions is one where the independent variable is a linear function of the exogenous instrument plus some noise which is endogenous to the dependent variable. In our setting, we interpret those IV regressions in the vein of Imbens and Angrist (1994) as capturing heterogeneous impacts. In a (commodity exporting) country, we assume the economy consists of two sectors: i) a commodity-dependent "sector," broadly interpreted to include the commodity-producing sector, including parts of other industries that provide inputs to the commodity-producing sector (for example the oil and metal refining sector). It could also include parts of the public sector that are impacted by commodity prices through value chain links but distinct from the other sector in the short term; and ii) the part of the economy that is not dependent on commodities.[3] Ishimaru (2024) maps out how the difference between IV and OLS is caused by either endogeneity or re-weighting of the observations. Our IV-implementation puts higher weight on shocks caused by commodity price shocks, and our interpretation is that it thereby helps separating the "sector" affected by those shocks from the part of the economy that is unaffected. That is, $Y^{com} = P_Z \Delta \log_{GDP}$ is interpreted as the growth of the commodity-dependent part of GDP, and $Y^{ncom} = M_Z \Delta \log_{GDP}$ is interpreted as the growth of the non-commodity-dependent part of GDP.

γ^U is thus interpreted as the un-smoothed share of the GDP shocks caused by fluctuations in commodity prices. γ^F equals 1 minus the regression of GNI growth on the part of GDP growth caused by commodity price shocks. If the latter regression coefficient is smaller than unity, this means that net international factor income flows correlate negatively with commodity price shocks, possibly due to commodities being (wholly or partially) owned by multinational extraction firms which receive increased dividends after positive shocks. Thus, our interpretation of γ^F is the amount of commodity-induced aggregate risk smoothed via counter-cyclical factor income flows. Or more precisely, factor income flows that are counter-cyclical to commodity price fluctuations. γ^T shows how commodity price-driven shocks affect (incoming) international transfers (in the opposite direction of the price change). γ^S can be interpreted as the increase in the share of savings due to commodity price-driven growth. Or, with a bit more interpretation, the share of commodity-driven output growth saved. The γ IV-coefficients have the same interpretation as the coefficients of the ASY decomposition of GDP shocks into fraction smoothed (plus fraction not-smoothed), except that the γ coefficients zoom in on the part of GDP

[3]Under the assumption that the factors of production of the commodity and non-commodity sectors (labor and capital) are not easily interchangeable as in van der Ploeg (2019) , the spillover will be limited over the short term.

that is caused by commodity price fluctuations.

By the exact same logic, we can repeat the derivation using $M_Z \Delta \log \text{GDP}$ and obtain coefficients, although it is important to keep in mind that for this sector, the coefficients measure average risk sharing but not necessarily how much of an exogenous shock is shared. We have

$$1 = \kappa^F + \kappa^T + \kappa^S + \kappa^U \tag{2}$$

where, e.g., κ^U is $\frac{Covar(M_Z \Delta \log \text{GDP}, \Delta \log \text{CONS}))}{Var(M_Z \Delta \log \text{GDP})}$, which is exactly the coefficient in a cross-sectional regression of consumption growth on the non-commodity-dependent part of GDP.

In ASY-type non-instrumented regressions, the amount unsmoothed, is

$$\frac{Covar(Y, \Delta \log \text{CONS})}{Var(Y)} = \frac{Covar(\text{Y}^{\text{com}} + \text{Y}^{\text{ncom}}, \Delta \log \text{CONS})}{Var(Y)} = \gamma_u \frac{Var(\text{Y}^{\text{com}})}{Var(Y)} + \kappa_u \frac{Var(\text{Y}^{\text{ncom}})}{Var(Y)};$$

that is, a weighted average of the sector-specific coefficients because $Var(\text{Y}^{\text{com}})+\text{Var}(\text{Y}^{\text{ncom}}) = \text{Var(Y)}$ by orthogonality.

If both parts of GDP are exogenous to the right-hand side of the decomposition, and risk is smoothed in the same fashion, then γ and κ coefficients will be similar. The γ-coefficients can be interpreted as the fractions shared of risk emanating from exogenous commodity-price shocks, while the κ-coefficients do not necessarily reflect only exogenous shocks. In general, the difference in the coefficients could be interpreted as "endogeneity bias," but there is only potential "bias" if one wants to interpret the κ-coefficients as responses to exogenous shocks from $M_Z \log \text{GDP}$. We think a broader interpretation is valid; namely, that the differences in the coefficients reflect different economic features of relevance for risk sharing of the commodity- and non-commodity sectors. These sectoral difference in the estimated risk sharing coefficients may partly reflect that $M_Z \log \text{GDP}$ is not exogenous; but without a second instrument, we cannot empirically quantify the importance of any potential "endogeneity bias" (that is, bias if the coefficients are interpreted as reaction to exogenous shocks).

A Stylized Framework. Assume that GDP growth, deflated by consumer prices, of a country is

$$Y = \text{Y}^{\text{com}} + \text{Y}^{\text{ncom}}, \tag{3}$$

where Y^{com} is a commodity-producing sector and Y^{ncom} is a non-commodity-producing sector. The proceeds from GDP growth of each sector are allocated to residents, foreign stock holders, and to the government. The foreign share in sector $j \epsilon [ncom, com]$ is f^j. In return for selling the shares f^j to foreigners, the country receives a share of world produc-

tion (which we omit here as it is captured by the aggregate component in our regressions). The private sector saves a share s_{pr}^{j} of GDP from sector j, where the shares differ by sector as s^{j} captures, among other things, different corporate and financial structures of the sectors, which affect the savings rates. The government sector saves a share s_{g}^{j} of GDP from sector j, where differences in savings rates across countries could reflect, for example, explicit rules governing a sovereign wealth funds intended to smooth fluctuations in commodity prices.

If Y^{com} and Y^{ncom} are orthogonal and Y^{com} is proportional to growth in international commodity prices, the instrumented regression will "pick out" Y^{com} in line with our interpretation. If, say, Y^{ncom} is endogenous to changes in government and private spending caused by shocks to Y^{com}, this endogenous change will also be captured by the instrument, as mentioned earlier. Moreover, other aspects of the difference in the structure of the non-commodity sector and commodity sectors may also be reflected in Y^{com}; however, our estimates will still be informative about whether the risk sharing structure of the economy differs across sectors. In general, the interpretation of the results is far from fool-proof, but it is nonetheless consistent with the notion that commodity producers react differently to commodity price shocks versus other shocks to GDP. [4]

Foreign factor income paid is denoted $\lambda^{c} Y^{com} + \lambda^{n} Y^{ncom}$. Attributing or projecting this onto Y^{com} via an IV-regression of net factor income returns λ^{c}. This heuristic assumption through a logarithmic approximation essentially ignores foreign factor income receipts, but these will ideally be absorbed in the aggregate controls. A similar logic holds for savings.

3 Data

Data for the study for national accounts, consumer prices, and commodity exports is World Development Indicators (WDI). Data on GDP, GNI, Consumption, International Transfers, Gross Savings, Gross Capital Formation, and consumption is taken from the UN National Accounts statistics and WDI. Savings data are from the United Nations National Accounts Statistics, *Main Aggregates and Detailed Tables*, including data for the general government sector. Private savings is the difference between Gross Savings and Government Gross Savings. Table A.6 summarizes the data sources.

Commodity price data are obtained from the World Bank Commodities (Pinksheet)

[4] The distinct difference between the challenges and responses of the tradable commodity sectors and non-commodity sectors, leading to the 'Dutch Disease' has an extensive literature notably detailed in Corden and Neary (1982) and Arezki and van der Ploeg (2018).

database, which cover more than 70 commodity prices and indexes. Energy commodities in the Pinksheet database include crude oil, natural gas, and coal. Metal prices include several base metals, iron ore, and precious metals. Export data are obtained from the World Bank's World Integrated Trade Solutions (WITS) database.

Our sample covers 110 countries for the period 1995 to 2019, although the majority of our regressions focuses on 28 energy and metal exporting countries. We follow the World Bank definition, namely: an economy is defined as a commodity exporter when, on average in 2017-19, either (i) total commodities exports accounted for 30 percent or more of total exports; or (ii) exports of any single commodity accounted for 20 percent or more of total exports. Table A.7 lists the country sample and classification of countries as energy-, metal- or agricultural exporters.

A look at the data shows why commodity exporting countries are impacted by commodity price shocks. The volatility of GDP growth is about twice as high for commodity exporters than for non-commodity exporters (panel (a) of Figure 1). Among commodity exporters, the volatility of GDP is much higher for energy exporters and, to some extent metal exporters, than for agricultural exporters (panel (b) of Figure 1). The high GDP volatility mirrors the high volatility in the growth of the value of commodity exports (panel (c) of Figure 1). The displayed statistics suggest that the ability to smooth income and consumption is particularly important for commodity-exporting countries.

As shown in panel (d) of Figure 1, for commodity exporters on average private savings (as a share of GDP) are slightly lower and government savings slightly higher than for other countries. Government saving as a share of GDP is significantly higher for energy exporters than for other groups of countries.

Net factor income (NFI) outflows are over 2 percent of GDP on average and somewhat larger in commodity-exporting countries than in non-commodity exporting countries. Changes in NFI to GDP across time between commodity exporters and non-commodity exporters are mostly asynchronous. Transfers (net international grants and remittances) do not vary much in size between commodity exporters and non-exporters. However, net transfer income is significantly higher for energy and metal exporters than for agricultural exporters. Table 1 provides descriptive statistics of the selected variables in per-capita terms used in the empirical estimation.

The commodity price data from the Pinksheet database are used to construct the instrumental variable as follows. Let Δp_{it}^{real} be the weighted average of real price changes for the basket of commodity exports of country i, where the weights are determined by

the nominal shares of each commodity in GDP:

$$\Delta_h p_{it}^{real} = \sum_{g \in Commodity} \frac{P_{gt-h}^{USD} X_{git-h}}{GDP_{it-h}^{USD}} \Delta_h \log \frac{P_{gt}^{USD}}{CPI_{it}^{US}}, \tag{4}$$

where P_{gt}^{USD} represents the price of commodity g in U.S. dollars at time t, and X_{git-h} is the export volume of commodity g in country i at time $t-h$. The numerator, export revenue from commodity g of country i, divided by GDP_{git-h}, the value added of sector g in U.S. dollars. This first term represents a country-specific weight for each commodity price. CPI_t^{US} is the U.S. consumer price index at time t. This measure captures the real changes in commodity price of country i.

4 Results

4.1 The extent of risk sharing in commodity exporting countries

We begin our analysis by quantifying the different degree of risk sharing between commodity and non-commodity exporting countries. Across commodity exporters, we differentiate between three distinct groups, energy, metal, and agriculture exporters and we measure the extent of risk sharing at different frequencies, using the following regression model:

$$\begin{aligned} \Delta_h \log \text{CONS}_{it} - \Delta_h \log \text{CONS}_t^W = \beta_{0,h} + \beta_{u,h} \left(\Delta_h \log \text{GDP}_{it} - \Delta_h \log \text{GDP}_t^W \right) \\ + \sum_{x \in \text{Commodity}} \beta_{u,h}^x \left(\Delta_h \log \text{GDP}_{it} - \Delta_h \log \text{GDP}_t^W \right) \times I_i^x + u_{it,h}, \end{aligned} \tag{5}$$

where $Commodity$ is a the set of commodity exporting categories (energy; metal; agriculture), I_i^x is an indicator function taking value of 1 for countries belonging to the commodity exporting category x, and 0 otherwise. The h-difference operator, Δ_h, is defined as $\Delta_h \log \text{CONS}_{it} = \log \text{CONS}_{it} - \log \text{CONS}_{it-h}$ with $h \in \{1; \ldots; 5\}$; $\Delta_h c_t^W$ and $\Delta_h gdp_t^W$ are cross sectional average of log-differenced consumption and Gross Domestic Product per capita.[5] The coefficient $\beta_{u,h}$ is interpreted as the average deviation from full consumption risk sharing and $1 - \beta_{u,h}$ is the average amount of risk sharing. If the shocks to GDP are fully

[5] Our approach yields similar results to those in which risk sharing is measured using the following time fixed-effects specification: $\Delta_h \log \text{CONS}_{it} = \beta_{0,h} + \beta_{u,h} \Delta_h \log \text{GDP}_{it} + \beta_{u,h}^{commodity} \Delta_h \log \text{GDP}_{it} \times I_i^{commodity} + \mu_{t,h} + u_{it,h}$. The advantage of our approach is that we can zoom in on commodity-exporting countries to analyze the same aggregate shocks while disregarding other country groups.

passed on to consumption, the estimate $\beta_{u,h} = 1$; while complete absorption of shocks–full risk sharing–implies the estimate $\beta_{u,h} = 0$. The coefficient $\beta^x_{u,h}$ thus measures the degree of risk sharing achieved by commodity exporting countries of type x.

We find that non-commodity exporting countries are unable to obtain much risk sharing. We estimate Equation 5 and present the results in Table 2. Beginning with how non-commodity exporting countries absorb shocks to year-over-year GDP growth, we observe a fairly low degree of risk sharing: about 30 percent (1 minus 0.7 in column 1, or 0.3 of risk shared compared to the full risk-sharing benchmark of 1). This disparity worsens at lower frequencies, with the proportion of consumption risk smoothed over time declining to 0.2 when considering five-year differences. These findings align with a well-established literature estimating significant departure from the predictions of models posing complete asset markets.

Energy and metal commodity-exporting countries exhibit higher and statistically significant levels of risk sharing compared to other countries. Columns 2 through 4 in Table 2 illustrate the differential levels of risk sharing across energy, metal, and agricultural exporters relative to non-commodity exporters. Energy and metal exporters absorb year-over-year GDP shocks more effectively, by 37 percent more and by 33 percent more than non-commodity exporters, respectively. In other words, more than two-thirds of the GDP shocks in energy exporters are absorbed. Although these differences diminish at lower frequencies, they remain significant even at the five-year frequency, with about 40 percent of GDP shocks smoothed in energy and metal exporters compared to only 20 percent in non-commodity exporters. The data do not reject the hypothesis that energy and metal exporters achieve similar degrees of risk sharing across shocks of different frequencies.

In contrast, agricultural commodity exporting countries do not exhibit statistically significant differences in risk sharing relative to non-commodity exporters (Column 4 in Table 2) . This is consistent with the related literature which treats the economic challenges of energy and metal exporters (such as the resource curse) as fundamentally different from the challenges of other economies, including agricultural exporters (see, for example Venables (2016) and Arezki and van der Ploeg (2018)).[6] Our results show that risk-sharing behavior is also different for resource-rich countries compared to other exporters.

Two key questions arise. First, given the distinctive role of these commodity sectors in these economies, how important is risk sharing within this sector compared to the other

[6]This is likely related to the different behavior of these commodity types. Agricultural prices tend to adjust much faster within a year given the greater possibility of substitution across production of crops and consumption of agricultural goods; whereas the investment-to-production time horizon of ore and fossil fuel extraction are subject to a time-to-build technology.

sectors? Second, what are the channels through which commodity-exporting countries achieve higher levels of risk sharing? We explore these questions in the following sections, limiting the remaining analysis to energy and metal commodity-exporting countries.[7]

4.2 The relevance of commodity prices for output: the commodity sector and non-commodity sector

We now turn to constructing an instrument using the commodity price shock defined in equation 4. Commodity price movements are relevant for GDP shocks, since they influence output mainly by increasing the value of CPI-deflated GDP and secondary by stimulating production in economic activities tied to the commodity sector. Global commodity prices are expected to be exogenous to the commodity exporter's GDP, as individual economies are unlikely to dictate global prices.[8] A common global component of output might affect global prices, but not a country's relative stance as our regressions consider changes to output and consumption relative to world output growth and consumption growth. Moreover, commodity prices affect consumption in commodity-exporting countries only through their impact on GDP. That is, for a commodity-exporting country, movements in global commodity prices will affect the GDP of a country that relies on that commodity for its export earnings and related domestic activities, but once the effect of global prices on GDP is controlled for, it does not have another direct pathway to influence consumption. Thus, the instrument satisfies the excludability condition of instrumental variable estimation and its relatedness to the endogenous variable.

Whether our instrument satisfies the relevance criteria for an instrumental variable estimation can be seen from the results of a least squares projection of $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ onto Δp_{it}^{real}. In addition, the fitted values from this projection allow us to identify all the movements in activity caused by changes in the value of the bundle of commodities exported by country i. We interpret this as the commodity-producing sector. The residual component captures the activity originating in the non-commodity sector, that is, the projection onto the orthogonal complement of the commodity-producing sector. This decomposition allows us to identify the components of Equation 3.

Define the $N', T\times 2$ data matrix Z^h such that the row corresponding to country i at time t is $[1, \Delta_h p_{it}^{real}]$ for frequency h. Define P_Z^h as the projection matrix on to the space spanned

[7] Henceforth, the term 'commodity exporters' refers to energy and metals exporters.

[8] A possible exception in the case of oil is Saudi Arabia which tends to have the largest spare capacity and substantial influence on OPEC policies. Even in this case, its influence tends to be short-lived over the medium-term. Moreover, excluding Saudi Arabia from the estimation did not materially change the results.

by Z^h. Then $\mathrm{Y}^{\mathrm{com}h}$ and $\mathrm{Y}^{\mathrm{ncom}\mathrm{h}}$ are the growth rates at frequency h of the commodity and non-commodity sectors defined as:

$$\mathrm{Y}^{\mathrm{com}h}_{it} = P^h_Z \, \Delta_h \left(gdp_{it} - gdp^{world}_t \right),$$
$$\mathrm{Y}^{\mathrm{ncom}\mathrm{h}}_{\mathrm{it}} = (I - P^h_Z) \, \Delta_h \left(gdp_{it} - gdp^{world}_t \right),$$

where the projections can be found using least squares regressions.

Table 3 shows that commodity price shocks are economically and statistically significant for the growth of cross-sectionally demeaned GDP across all horizons considered. Equipped with the commodity and non-commodity sector components of GDP, we proceed to gauge the extent of risk sharing from the $\mathrm{Y}^{\mathrm{com}}{}_{\mathrm{it}}$ and $\mathrm{Y}^{\mathrm{ncom}}{}_{\mathrm{it}}$ sectors and their channels.

4.3 Risk sharing in commodity-exporting countries: a tale of two sectors

Estimates of risk sharing are provided for both the commodity and non-commodity sectors. To achieve this, we compute the coefficients γ^U and κ^U, as defined in Equations 1 and 2, keeping in mind that the first one allows us to interpret it as the extent of risk sharing out of an exogenous shock while the second one lacks an instrument, so that the results may not correspond to the impact of exogenous productivity shocks in the sector. For reference, in addition to these coefficients, we also report aggregate risk-sharing estimates in Table 4.

Energy and metal commodity-exporting countries demonstrate exceptional effectiveness in hedging GDP fluctuations driven by commodity prices. Column 1 in table 4 presents aggregate results, consistent with earlier findings: risk sharing is high, with approximately 61 percent of output fluctuations smoothed. Specifically, risk sharing of shocks triggered by commodity price fluctuations is remarkably high, smoothing about 90 percent of shocks—approaching the complete asset market benchmark. This is a remarkable result given the typically low risk-sharing values reported in the literature. The non-commodity sector has a much lower degree of risk sharing than the commodity sector, but about 10 percent higher than the aggregate, showing the influence of the commodity sector in improving the overall risk sharing outcome.

Over time, the high degree of risk sharing in the commodity sector wears out, yet it remains significantly higher than in the non-commodity sector. When we consider the de-

gree of risk sharing of more persistent shocks, for instance, over a 5-year horizon, we find a lower degree of risk sharing across sectors. However, risk sharing in the commodity sector is 36 percentage points higher than in the non-commodity sector. The higher degree of risk sharing at the longer (medium-term) frequency reflects a key finding, as oil and metal price shocks are typically persistent. We posit that commodity-exporting economies engage in different behaviors to avoid the substantial welfare losses they would experience if they failed to hedge against the persistent changes in commodity prices.

4.3.1 Channels of risk sharing in the commodity and non-commodity sectors

In practice, risk sharing can be achieved through the proceeds of a diversified international portfolio (the mechanism highlighted in stylized perfect-market models); international transfers including remittances; or self-insure via procyclical savings. The coefficients γ^F (κ^F), γ^T (κ^T), and γ^S (κ^S) as defined in Equation 1 (2) estimate the importance of each of these mechanisms in the commodity (non-commodity) sector. Table 5 presents estimates of the channels of risk sharing in each sector.

Our results show that the proceeds of a diversified international portfolio contribute to smoothing approximately 8 percent of output shocks in the commodity sector. However, international income from capital ownership does not significantly smooth output fluctuations in the non-commodity sector. One possible explanation for these results is the stabilizing role of multinational corporations in the commodity sector, which often hold significant shares in the mining operations within these countries. These corporations may mitigate the effects of commodity price fluctuations through pro-cyclical movements in net factor income. For instance, during periods of high commodity prices, international corporations may remit dividends abroad, while during downturns, they retain earnings [9].

This pattern reflects the comparative ease of monitoring profits in the commodity sector, where performance is closely tied to observable commodity price movements, as opposed to non-commodity sectors where profitability depends more on corporate governance where production costs are more tied to the price. This difference could lead to an endogenous lower participation of international investors in the non-commodity sector. Notably, this source of risk sharing in the commodity sector remains stable over time, achieving similar levels of smoothing for both annual and five-year differences.

[9] In many countries, national resource companies also play an important role in production and benefit from the resource revenue through joint ventures, or by sending dividends to its owner: the state. To the extent that these proceeds are invested abroad, for example, through investments of sovereign wealth funds, such international capital movements could also contribute to changes in net factor income.

The results also show that procyclical savings largely account for the superior risk sharing observed in the commodity sector compared to the non-commodity sector. Starting with the capacity to smooth annual shocks to GDP growth, savings consistently explain the majority of risk sharing across sectors. However, this effect is particularly pronounced in the commodity sector, where savings smooth approximately 91 percent of output fluctuations, compared to 45 percent in the non-commodity sector. A possible explanation for the significant role of savings in smoothing commodity price fluctuations, which we provide evidence for in the next section, is the role of governments. Two key factors contribute to this. First, if taxes on the commodity sector are proportional to revenues, they can act as an automatic stabilizer for the economy, increasing revenues during periods of high commodity prices and decreasing them during downturns. However, this stabilizing effect can be dampened if government spending is highly procyclical. Second, stabilizing mechanisms such as sovereign wealth funds can also mitigate the procyclical nature of government spending; these funds require governments to accumulate assets in response to high commodity prices, ensuring that financial buffers are built during boom periods. This can help prevent excessive spending during good times and preserves the capacity to weather economic downturns.

As time passes, savings continue to smooth some of the consumption, as observed in the five-year differences in table 5. The longer frequencies filter out short-term shocks, but for longer-lasting shocks and less certainty over the value of commodity prices, savings may become depleted. In other words, the elasticity of consumption to output growth increases over time. It is also possible that consumption reacts slowly due to some forms of habit formation or credit constraints.[10] The outcome is in stark contrast with the stable smoothing from net factor income, highlighting the importance of these economies taking advantage of increasing global financial integration to deal with more persistent output fluctuations. Regarding net international transfers, we find that they play a limited role for the commodity sector as far as risk sharing is concerned.

4.3.2 Sources and uses of savings

We decompose savings into its sources and uses following Kalemli-Ozcan, Luttini and Sørensen (2014). From the 'use of funds' perspective, savings can be allocated either to investments in domestic real assets (INV_{it}); or accumulation of net foreign assets through the current account (CA_{it}). The contribution of savings to risk sharing can be decomposed into the sum of coefficients $\beta_{ca,h}$ and $\beta_{inv,h}$, where each coefficient results from the

[10] At a deeper level, credit constraints (particularly in the public sector) could reflect institutional fiscal constraints such as the lack of a functioning medium-term expenditure framework.

following regressions, respectively:

$$\Delta_h \frac{CA_{it}}{C_{it}} - \Delta_h \frac{CA_t}{C_t}^W = \beta_{0,h} + \beta_{ca,h}\Delta_h \mathrm{Y}^{\mathrm{com}h}_{it} + u_{it,h}$$
$$\Delta_h \frac{INV_{it}}{C_{it}} - \Delta_h \frac{INV_t}{C_t}^W = \beta_{0,h} + \beta_{inv,h}\Delta_h \mathrm{Y}^{\mathrm{com}h}_{it} + u_{it,h}$$

The coefficients $\beta_{ca,h}$ and $\beta_{inv,h}$ are interpreted as the percentage of consumption smoothing of GDP risk correlated with commodity price shocks ($\mathrm{Y}^{\mathrm{com}h}_{it}$) obtained by purchasing and selling foreign assets; and through domestic investment, respectively. This is compared against the global average W.

Similarly, from a 'sources' perspective, savings is the sum of government and private savings, which allows us to quantify the contribution of each of these sources of funds to achieve risk sharing. In this case, we can decompose the previous equation to consider the commodity sector as follows:

$$\Delta_h \frac{S^j_{it}}{C_{it}} - \Delta_h \frac{S^j_t}{C_t}^W = \beta_{0,h} + \beta_{s^j,h}\Delta_h \mathrm{Y}^{\mathrm{com}h}_{it} + u_{it,h}$$

where $j \in \{\text{Private}; \text{Government}\}$. The share of savings from each source is then regressed on sectoral output growth over h periods, in this case $\Delta_h \mathrm{Y}^{\mathrm{com}h}_{it}$. The coefficients $\beta^{\text{Private}}_{s,h}$ and $\beta^{\text{Government}}_{s,h}$ are interpreted as the percentage of consumption-smoothing of GDP risk correlated with commodity price shocks obtained through private sector savings and through government savings, respectively.

Table 6 shows the relative importance of risk sharing after decomposing savings into its sources and uses. The results in panel a of the table show that government savings are the main source of risk sharing, accounting for most (78 percentage points) of the 91 percent of the consumption smoothing from savings in the commodity-dependent sector. This is an important result, because it means that the government is doing most of the consumption smoothing via procyclical savings, even though government savings comprise only 25 percent of total savings on average in commodity-exporting countries (figure 1.d). The effects of government savings are particularly large over a 1-year horizon, but the coefficients decline by about half over the 5-year horizon. This is consistent with the earlier interpretation that fiscal constraints may begin to kick in earlier for the public sector. In contrast, private savings provide a low but stable role for risk sharing.

From the uses of saving perspective, procyclical current accounts play a large role

in risk sharing. However, the effect declines over time, with the coefficient on the current account declining from 0.79 in a 1-year horizon to 0.45 in a 5-year horizon for the commodity-dependent sector.[11] The use of commodity sector savings for domestic investment plays a small but important role in risk sharing, with its coefficients increasing with the length of period from 0.12 in a 1-year horizon to 0.18 in a 5-year horizon (Table 6, panel b).

The risk sharing components are all larger for the commodity-producing sector, but the large procyclical effect of the current account stands out, with a coefficient that is 7 times larger than that found for domestic investment. This is particularly high for energy exporters, which may find it easy, for example, to invest windfall energy revenues abroad. At the same time, the steep decline of the coefficient at the 5-year horizon may reflect the difficulty for energy extraction firms to gauge the persistence of shocks. In contrast, the risk sharing role of domestic investment increases with the horizon, possibly due to greater control by governments in the rate of disbursement of domestic projects. At the 5-year frequency, the current account impact is only twice as large as the risk-sharing achieved through savings used for domestic investment.

For the non-commodity producing sector, the role of the current account balance is smaller, commensurate with the smaller role of savings in risk sharing in this sector; while the smoothing role of domestic investment is similar to that of the commodity sector. For this sector the effect of domestic investment on risk sharing is roughly maintained over the 5-year interval as well, as time-to-build will be determined by the economy's structure.

4.4 Robustness

The results above have been checked against a battery of robustness tests, and we find that they hold up well. We discuss four main ones.

First, our main equation estimates the risk-sharing coefficient by looking at how much consumption of country i is smoothed relative to a benchmark consumption yardstick, when its output is subject to commodity price shocks relative to a benchmark international average. Our yardstick is world output and world GDP. We also ran the estimations using a time fixed effect estimator, which essentially measures how the group of countries smooth risk over a time-bound average. Two other benchmarks were used. The first was against a group of advanced economies, hypothesizing that these countries are more integrated financially and would offer opportunities for commodity exporters to buy and

[11] In practice, the use of savings can be made by any institution or individual in the country, but the risk sharing effects will vary by sector.

sell assets. We also used as benchmark the group of non-commodity exporters, hypothesizing that commodity exporters would face risks orthogonal to this group of countries. The results in all cases are very similar to what was obtained above.

Second, we also considered an unbalanced number of observations across horizons regressions. As we moved back in time, data for some countries is not available so the loss of observations is inevitable. Again, the results did not qualitatively change.

Third, our benchmark world output, consumption, and other aggregates were constructed by defining world GDP growth as the cross-country average growth rate. In other words, we are giving the same weight to each country in this aggregate. But some may argue that larger countries could have a larger "pull" effect, so we also tried averaging weighted by GDP. Either way, the results hold even when we consider the growth rate of world GDP, or equal weights per country.

Finally, our results remain virtually unchanged when we normalize the country-specific commodity price instrument using the country's commodity exports rather than its GDP as in equation 4. Appendix tables A.6-A.9 report the results with this alternative instrument, defined as follows:

$$\Delta_h p_{it}^{real,robustness} = \sum_{g \in Commodity} \frac{P_{gt-h}^{USD} X_{git-h}}{\sum_{g \in Commodity} P_{gt-h}^{USD} X_{git-h}} \Delta_h \log \frac{P_{gt}^{USD}}{CPI_{it}^{US}}.$$

5 Discussion

The above results show that government savings are the most important channel used to smooth consumption, particularly against commodity price fluctuations. This effect is particularly large over a 1- to 2-year horizon, and the smoothing of consumption from commodity price fluctuations persists over the 5-year horizon. Moreover, if the state is the main shareholder in oil production, it means that government savings invested and maintained abroad provide an additional risk-sharing mechanism for the country to smooth consumption over a longer horizon.

One successful policy instrument used by many governments in commodity-exporting countries is the accumulation of assets via sovereign wealth funds (SWFs). SWFs allow countries to smooth consumption through contributions and withdrawals from the fund across time (a savings mechanism). To the extent that those assets under management are invested in equity that yields a return, such changes will also be reflected in net factor income from abroad in the following periods.

SWF assets under management in commodity-exporting countries grew significantly

more than for non-commodity exporters (Figure A.1). By 2021, commodity exporters were almost twice as likely to have a sovereign wealth fund than non-commodity exporters, particularly energy exporters (Figure A.1). For commodity exporters, about half of government savings were invested in the SWF during the 2000-2022 period, and many of those investments then make their way back to the local economy through stakes in equity or portfolio assets in the domestic economy[12]. This is consistent with the policy advice that resource-rich developing countries, in particular, should invest more windfall profits from exports into the domestic economy and less in foreign assets van der Ploeg and Venables (2011). Future research will investigate more closely the role of SWFs to enhance savings, but also the success of the instrument in achieving financial diversification in commodity exporting countries and its role in risk sharing.

6 Conclusions

In this paper, we show that energy and metals commodity-exporting countries achieve a higher degree of risk sharing than agricultural and non-commodity exporting countries. Risk sharing is mainly achieved via procyclical savings, although international factor income flows play a small but significant role.

Commodities are priced globally, and fluctuation in commodity prices significantly impact the GDP volatility of commodity exporters. We measure the extent of risk sharing as (one minus) the correlation of consumption with GDP, but under the assumption that world commodity prices are exogenous. We also estimate how much of the exogenous commodity-related risk is shared internationally. We propose a novel decomposition of GDP into the share of GDP driven by commodity prices and the orthogonal component. We then estimate risk sharing obtained for each of these components, showing significantly higher risk sharing for commodity-induced shocks.

We find that the main channels of risk-sharing for the commodity-dependent sector of GDP are factor income flows and savings, with counter-cyclical government savings playing the largest role. Although the effect of government savings wanes over time, net factor income, in contrast, contributes between 6 and 8 percent to consumption smoothing from commodity price volatility throughout the 5-year horizon. This suggests that procyclical repatriation of dividends abroad by companies in the commodity-producing

[12] In the 2000-22 period, the correlation coefficient between sovereign wealth funds and portfolio equity assets is 0.58 for commodity-exporting countries compared to 0.15 for non-commodity exporters, which is consistent with the hypothesis that the mechanism through which commodity exporters have accumulated equity assets abroad and improved risk sharing outcomes has been SWFs. No such relationship exists for non-commodity exporters.

sector contribute to risk sharing.

Our results highlight the importance of risk sharing for commodity exporters and, given the lack of greater capital market integration, which could allow the diversification of resource ownership, the important role of government savings. Preliminary work also indicates that sovereign wealth funds managed by governments play an important role in this process.

References

Arezki, Rabah, Raouf Boucekkine Jeffrey A. Frankel, and Rick van der Ploeg. 2018. *Rethinking the Macroeconomics of Resource-Rich Countries.* Center for Economic Policy Research.

Arroyo-Marioli, Francisco, and Carlos A. Vegh. 2023. "Fiscal Procyclicality in Commodity Exporting Countries: How Much Does it Pour and Why?" National Bureau of Economic Research, Inc NBER Working Papers 31431.

Asdrubali, P., B. E. Sorensen, and O. Yosha. 1996. "Channels of Interstate Risk Sharing: United States 1963-1990." *The Quarterly Journal of Economics*, 111(4): 1081–1110. Number: 4.

Cochrane, John H. 1991. "A Simple Test of Consumption Insurance." *Journal of Political Economy*, 99 (5): 957–76.

Corden, W. Max, and J. Peter Neary. 1982. "Booming Sector and De-Industrialisation in a Small Open Economy." *The Economic Journal*, 92(368): 825–48.

Heathcote, Jonathan, and Fabrizio Perri. 2004. "Financial globalization and real regionalization." *Journal of Economic Theory*, 119(1): 207–243.

Hoffmann, Mathias, Egor Maslov, Bent Sorensen, and Iryna Stewen. 2019. "Channels of Risk Sharing in the Eurozone: What Can Banking and Capital Market Union Achieve?" *IMF Economic Review*, 67(3): 443–495.

Imbens, Guido W, and Joshua D Angrist. 1994. "Identification and Estimation of Local Average Treatment Effects." *Econometrica*, 62(2): 467–475.

Ishimaru, Shoya. 2024. "Empirical Decomposition of the IV-OLS Gap with Heterogeneous and Nonlinear Effects." *The Review of Economics and Statistics*, 106(2): 505–520.

Kalemli-Ozcan, Sebnem, Emiliano Luttini, and Bent E. Sørensen. 2014. "Debt Crises and Risk-Sharing: The Role of Markets versus Sovereigns." *The Scandinavian Journal of Economics*, 116(1): 253–276.

Kose, M. Ayhan, Eswar S. Prasad, and Marco E. Terrones. 2009. "Does financial globalization promote risk sharing?" *Journal of Development Economics*, 89(2): 258–270. Number: 2.

Lewis, Karen K. 1996. "What Can Explain the Apparent Lack of International Consumption Risk Sharing?" *Journal of Political Economy*, 104(2): 267–297.

Mace, Barbara. 1991. "Full Insurance in the Presence of Aggregate Uncertainty." *Journal of Political Economy*, 99 (5): 928–56.

Maggiori, Matteo. 2017. "Financial Intermediation, International Risk Sharing, and Reserve Currencies." *American Economic Review*, 107(10): 3038–71.

Obstfeld, Maurice. 1993. "Are Industrial-Country Consumption Risks Globally Diversified?" National Bureau of Economic Research, Inc NBER Working Papers 4308.

Sørensen, Bent E., and Oved Yosha. 1998. "International risk sharing and European monetary unification." *Journal of International Economics*, 45(2): 211–238. Number: 2.

van der Ploeg, Frederick. 2019. "Macro policy responses to natural resource windfalls and the crash in commodity prices." *Journal of International Money and Finance*, 96: 263–282.

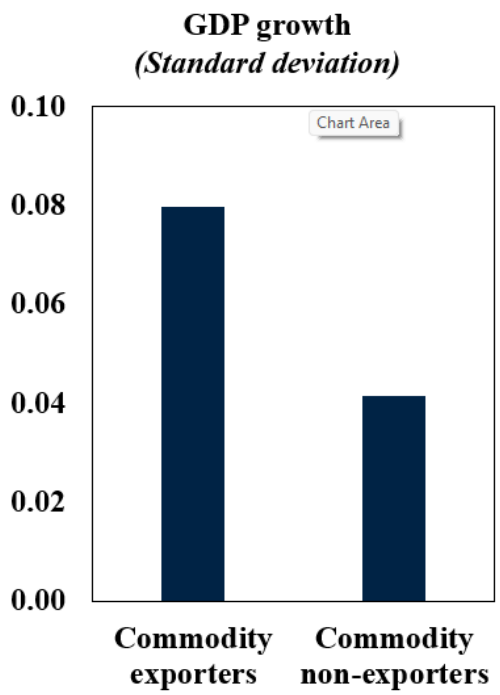
van der Ploeg, Frederick, and Anthony J. Venables. 2011. "Harnessing Windfall Revenues: Optimal Policies for Resource-Rich Developing Economies." *The Economic Journal*, 121(551): 1–30.

Venables, Anthony J. 2016. "Using Natural Resources for Development: Why Has It Proven So Difficult?" *Journal of Economic Perspectives*, 30(1): 161–84.

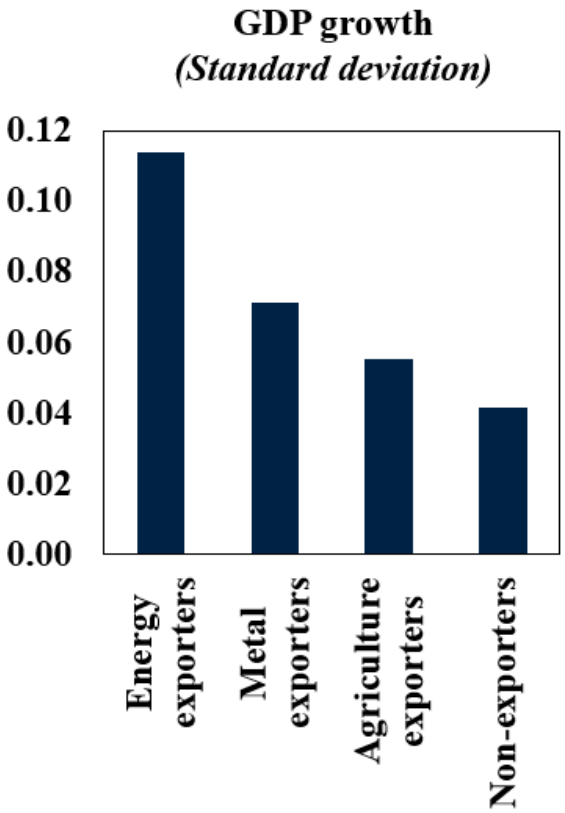
Figures

Figure 1: Savings and volatility of GDP and export growth

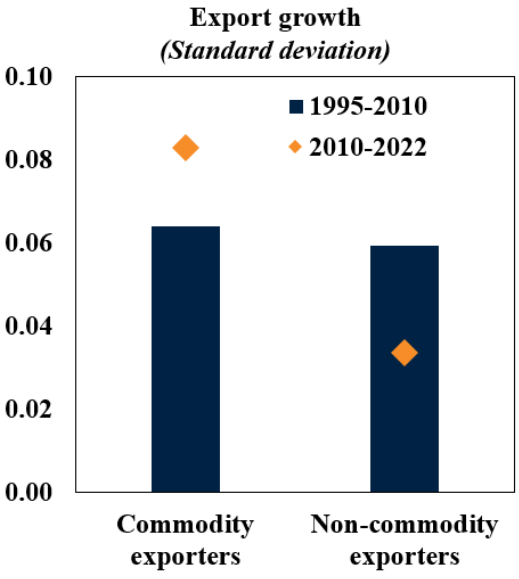
(a) Volatility of GDP growth



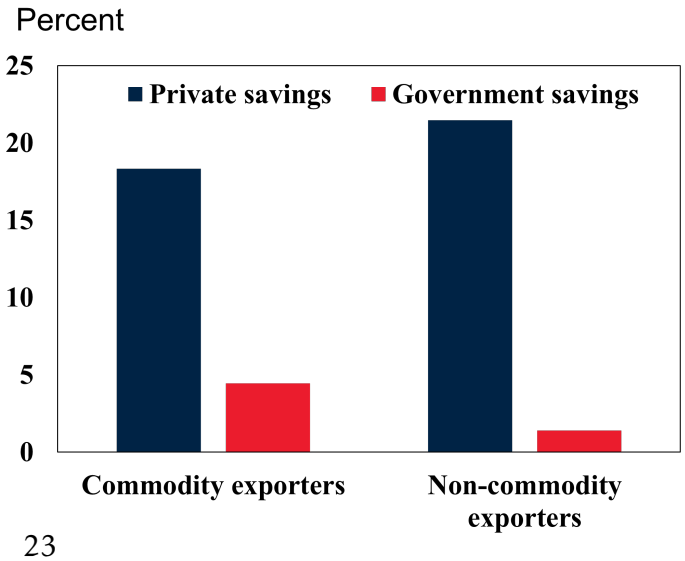
(b) Volatility of GDP growth by type of commodity exports



(c) Volatility of export growth



(d) Private and Government savings as a share of GDP



Tables

Table 1: Descriptive summary of variables by commodity exporting status

	Non exporters	Agriculture exporters	Metal exporters	Energy exporters
Δ log real consumption per capita (Δ lnconsreal)	0.027	0.022	0.031	0.029
	(0.045)	(0.057)	(0.066)	(0.067)
Δ log real GDP per capita (Δ lngdpreal)	0.028	0.024	0.032	0.034
	(0.050)	(0.055)	(0.065)	(0.102)
Δ log real net factor income per capita (dcap)	0.000	0.000	0.001	0.000
	(0.012)	(0.013)	(0.018)	(0.014)
Δ log real transfers per capita (dtransf)	-0.000	-0.001	-0.001	0.001
	(0.010)	(0.012)	(0.014)	(0.012)
Δ log real savings per capita (dsavi)	0.001	0.003	0.001	0.001
	(0.028)	(0.030)	(0.052)	(0.079)

Average values reported. Standard deviations in parentheses.

Δ lnconsreal =Δ log [(conslcu/cpi)/pop], where conslcu is consumption in local currency units, cpi is consumer price index, and pop is population. Δ lngdpreal=Δ log [(GDP/cpi)/pop]; dcap = dlngdpreal - dlngnireal, where dlngnireal= Δ log [(GNI/cpi)/pop]; dtrans = dlngnireal - dlngndireal, where

dlngndireal = Δ log [(GNDI/cpi)/pop and GNDI is gross national disposable income; and

dsavi = dlngndireal - dlnconsreal.

Table 2: Unshared consumption risk in commodity and non-commodity exporting countries: OLS estimates

Consumption risk	Non-commodity exporters	Difference to non-commodity exporters		
		Energy	Metal	Agriculture
$\Delta\left(gdp_{it} - gdp_t^{world}\right)$	0.705***	-0.370***	-0.303***	0.111
	(0.0363)	(0.0625)	(0.0876)	(0.0716)
$\Delta_2\left(gdp_{it} - gdp_t^{world}\right)$	0.755***	-0.337***	-0.323***	0.0508
	(0.0247)	(0.0483)	(0.0822)	(0.0446)
$\Delta_3\left(gdp_{it} - gdp_t^{world}\right)$	0.778***	-0.263***	-0.338***	0.0423
	(0.0202)	(0.0481)	(0.0720)	(0.0366)
$\Delta_4\left(gdp_{it} - gdp_t^{world}\right)$	0.794***	-0.230***	-0.319***	0.0490
	(0.0181)	(0.0442)	(0.0681)	(0.0303)
$\Delta_5\left(gdp_{it} - gdp_t^{world}\right)$	0.804***	-0.218***	-0.265***	0.0360
	(0.0165)	(0.0403)	(0.0639)	(0.0272)
Observations	1887			

The first column reports the proportion of consumption risk unshared, for non-commodity exporters, defined as the $\beta_{u,h}$ calculated from the regression model $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) + \beta_{u,h}^{commodity}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_i^{commodity} + u_{it,h}$ with $h \in \{1;\ldots;5\}$, the second column reports the difference between commodity and non-commodity exporters, the $beta_{u,h}^{commodity}$ coefficient. Δ_h is defined as $\Delta_h x_t = x_t - x_{t-h}$ c_{it} (gdp_{it}) is log of aggregate consumption (GDP) in country i in year t. $\Delta_h c_t^W$ $(\Delta_h gpd_t^W)$ is the cross-sectional average of consumption (GDP) growth of all the countries in the sample, $I_i^{commodity}$ is an indicator function that takes the value of one for commodity-exporting countries.

Columns three and four report differential coefficient for energy and metal, and agriculture commodity exporters separately $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) + \beta_{u,h}^{nrg-metal}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_c^{nrg-metal} + \beta_{u,h}^{aggriculture}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_c^{aggriculture} + u_{it,h}$, $I_i^{nrg-metal}$ and $I_i^{agriculture}$ are indicator functions that take the value of one for energy and metal exporting and agriculture exporting countries, respectively.

The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table 3: First stage estimates—GDP risk correlated with commodity prices

	$\Delta\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_2\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_3\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_4\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_5\left(gdp_{it}-gdp_t^{world}\right)$
Commodity price shock	0.666***	0.646***	0.668***	0.727***	0.867***
	(0.0723)	(0.0727)	(0.102)	(0.116)	(0.139)
Observations	436	436	436	436	436
R-squared	0.3477	0.3012	0.2587	0.2340	0.2361

Estimates for the $\beta_{0h}^{first,stage}$ coefficients from estimating the relationship $\Delta_h\left(gdp_{it}-gdp_t^{world}\right) = \beta_{0h}^{first,stage} + \beta_h^{first,stage}\Delta_h p_{it}^{real,commodity} + \epsilon_{it}$ with $h \in \{1;\ldots;5\}$. The commodity price shock is defined as $\Delta_h p_{it}^{real} = \sum_{g\in Commodity} \frac{P_{gt-h}^{USD} X_{git-h}}{\text{GDP}_{it-h}^{USD}} \Delta_h \log \frac{P_{gt}^{USD}}{CPI_{it}^{US}}$. The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table 4: Overall, commodity, and non-commodity sector unshared consumption risk

	Unshared consumption	Unshared consumption risk by sector	
	risk	Commodity	Non-commodity
$\Delta_1 risk_{it}$	0.390***	0.0362	0.507***
	(0.0630)	(0.0794)	(0.0435)
$\Delta_2 risk_{it}$	0.460***	0.197**	0.513***
	(0.0477)	(0.0856)	(0.0458)
$\Delta_3 risk_{it}$	0.521***	0.249***	0.590***
	(0.0412)	(0.0721)	(0.0514)
$\Delta_4 risk_{it}$	0.559***	0.251***	0.638***
	(0.0369)	(0.0661)	(0.0477)
$\Delta_5 risk_{it}$	0.586***	0.299***	0.661***
	(0.0337)	(0.0693)	(0.0445)
Observations		436	

Each column reports the proportion of consumption risk unshared. The first column report it for the aggregate economy estimated from the panel regression $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h\left(gdp_{it} - gdp_t^{world}\right) + u_{it,h}$ where $h \in \{1;\ldots;5\}$; $\Delta_h c_t^W$ and $\Delta_h gpd_t^W$ are cross sectional average of log differencing Consumption and Gross Domestic Product of all countries included in the sample of Table 2.

The second column reports the proportion of consumption risk unshared from the commodity sector output fluctuations estimated from the panel regression $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h commodity_{it} + u_{it,h}$, where $\Delta_h commodity_t$ is the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real,commodity}$.

The third column reports $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h non-commodity_{it} + u_{it,h}$, where $\Delta_h non-commodity_t$ is the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real,commodity}$.

In all cases, $\beta_{u,h}$ is interpreted as the percentage of consumption risk from the aggregate, commodity and non-commodity sector unsmoothed. The estimation period is 1995-2019. In columns one and three Estimates and (robust) standard errors are calculated trough ordinary-least-squares. In column two estimates and (robust) standard errors are calculated trough two-stage-least squares. Standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table 5: Channels of risk sharing: Overall and by commodity and non-commodity sectors

	Overall risk sharing	Risk sharing by sector	
		Commodity	Non-commdity
Panel a. Net factor income			
$\Delta_1 risk_{it}$	0.0372***	0.0833***	0.0104
	(0.0123)	(0.0238)	(0.0187)
$\Delta_5 risk_{it}$	0.0354***	0.0562***	0.0297***
	(0.00863)	(0.0119)	(0.0110)
Observations		436	
Panel b. International net transfers			
$\Delta_1 risk_{it}$	0.0127	-0.0338**	0.0162
	(0.0163)	(0.0156)	(0.0123)
$\Delta_5 risk_{it}$	0.0245***	0.000687	0.0268***
	(0.00770)	(0.00968)	(0.00928)
Observations		415	
Panel c. Savings			
$\Delta_1 risk_{it}$	0.551***	0.908***	0.447***
	(0.0781)	(0.0772)	(0.0760)
$\Delta_5 risk_{it}$	0.340***	0.631***	0.265***
	(0.0330)	(0.0672)	(0.0448)
Observations		415	

Channels of risk sharing. Each panel reports the slope from the univariate regressions $\Delta_h gdp_{it} - \Delta_h gni_{it} - \left(\Delta_h gdp_t^W - \Delta_h gni_t^W\right) = \beta_{0,h} + \beta_{f,h}\Delta_h risk_{it} + u_{it,h}$ (panel a. Net factor income), $\Delta_h gni_{it} - \Delta_h gndi_{it} - \left(\Delta_h gni_{it}^W - \Delta_h gndi_{it}^W\right) = \beta_{0,h} + \beta_{\tau,h}\Delta_h risk_{it} + u_{it,h}$ (panel b. International net transfers), and $\Delta_h gndi_{it} - \Delta_h c_{it} - \left(\Delta_h gndi_t^W - \Delta_h c_t^W\right) = \beta_{0,h} + \beta_{s,h}\Delta_h risk_{it} + u_{it,h}$ (panel c. Savings), with $h \in \{1;\ldots;5\}$; $\Delta_h c_t^W$, $\Delta_h gpd_t^W$, $\Delta_h gni_t^W$, and $\Delta_h gndi_t^W$ are cross sectional average of log differencing Consumption, Gross Domestic Product, Gross National Income, and Gross National Disposable Income, respectively, of all countries included in the sample of Table 2.

Consumption risk denoted as $\Delta_h risk_{it}$ is defined according to the sector considered. For the aggregate, first column, $\Delta_h risk_{it}$ is $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$; for the commodity sector, second column, it is defined as the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$; for the non-commodity sector, third column, it is defined as the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

The estimated values of $\beta_{f,h}$, $\beta_{\tau,h}$, and $\beta_{s,h}$ are interpreted as the percentage of consumption-smoothing of shocks corresponding to the sector under analysis, obtained through international capital markets, net transfers, and domestic saving, respectively.

The estimation period is 1995-2019. In columns one and three Estimates and (robust) standard errors are calculated trough ordinary-least-squares. In column two estimates and (robust) standard errors are calculated trough two-stage-least squares. Standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table 6: Contribution of sources and uses of savings to risk-sharing across commodity and non-commodity sectors

Consumption risk	Commodity sector		Non-commodity sector		
Panel a. Savings' sources	Private	Government	Private	Government	Obs
$\Delta_1 risk_{it}$	0.1273*	0.7807***	0.1734	0.2736	264
	(0.0695)	(0.1592)	(0.1426)	(0.1965)	
$\Delta_5 risk_{it}$	0.162***	0.469***	0.1058***	0.1592***	248
	(0.0553)	(0.0819)	(0.0387)	(0.0473)	
Panel b. Savings' uses	Current account	Investment	Current account	Investment	Obs
$\Delta_1 risk_{it}$	0.79262***	0.11542**	0.36932***	0.07772	408
	(0.087)	(0.0586)	(0.0941)	(0.0518)	
$\Delta_5 risk_{it}$	0.44622***	0.18482***	0.16152***	0.10352***	400
	(0.074)	(0.0259)	(0.0549)	(0.0355)	

Decomposition of contribution of savings to risk sharing. Panel a. Sources. Each column reports the slope from the univariate regressions $\Delta_h \frac{S^j_{it}}{C_{it}} - \Delta_h \frac{S^j_t}{C_t}^W = \beta_{0,h} + \beta_{s^j,h}\Delta_h Y_{it} + u_{it,h}$, where $j \in \{\text{Private;Government}\}$, $h \in \{1;\ldots;5\}$. Panel b. Uses reports the slope from the univariate regressions $\Delta_h \frac{CA_{it}}{C_{it}} - \Delta_h \frac{CA_t}{C_t}^W = \beta_{0,h} + \beta_{ca,h}\Delta_h risk_{it} + u_{it,h}$ and $\Delta_h \frac{Investment_{it}}{C_{it}} - \Delta_h \frac{Investment_t}{C_t}^W = \beta_{0,h} + \beta_{inv,h}\Delta_h commodity_{it} + u_{it,h}$.

The coefficients $\beta_{s^{\text{Private}},h}$ and $\beta_{s^{\text{Government}},h}$ are interpreted as the percentage of consumption-smoothing of GDP risk correlated with commodity price shocks obtained through government and private saving. The coefficients $\beta_{ca,h}$ and $\beta_{inv,h}$ are interpreted as the percentage of consumption-smoothing of GDP risk correlated with commodity price shocks obtained through purchasing and selling foreign assets and domestic investment, respectively.

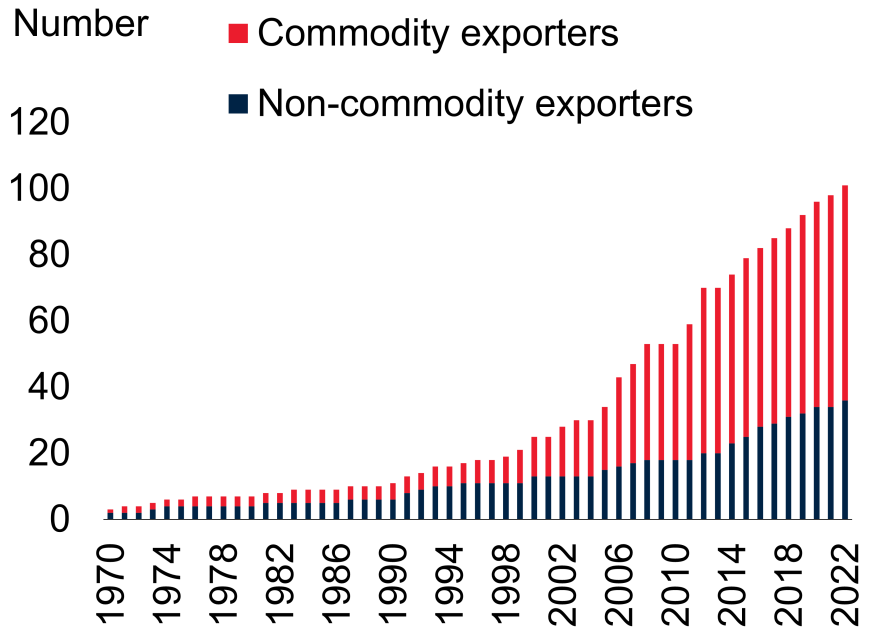
Consumption risk denoted as $\Delta_h risk_{it}$ is defined according to the sector. For the commodity sector, first and second column, it is defined as the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real,commodity}$ where $\Delta_h gpd_t^W$, is the cross sectional average of log differencing Gross Domestic Product, of all countries included in the sample of Table 2. For the non-commodity sector, columns three and four, it is defined as the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

The estimation period is 1995-2019. In column one and two estimates and (robust) standard errors are calculated trough two-stage-least squares. In columns three and four estimates and (robust) standard errors are calculated trough ordinary-least-squares. The coefficients $\beta_{s^j,h}$ were rescaled such that their sum equates the coefficients $\beta_{s,h}$ in Table 5 (the standard deviations were rescaled as well). Standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

A Appendix figures

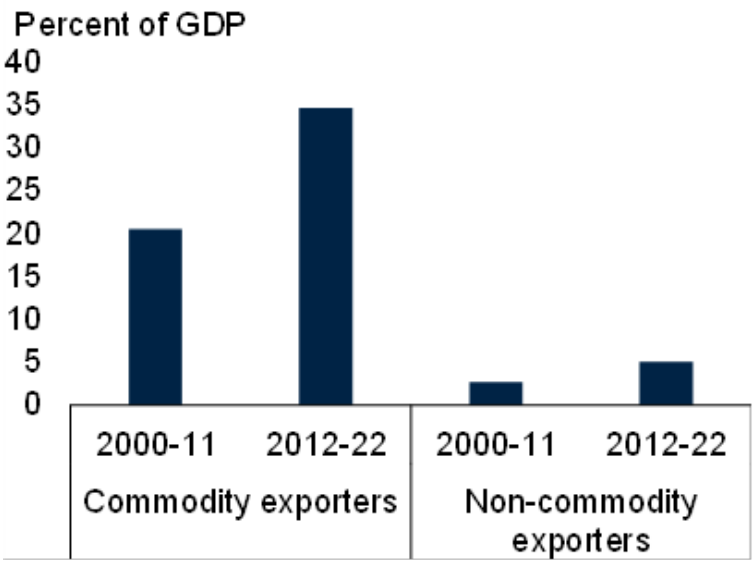
Figure A.1: Sovereign wealth fund (SWF)

(a) SWF, by commodity exporters



The panel shows the number of countries with SWFs by commodity-exporting groups. In 2022 there were 65 commodity exporters and 36 non-commodity exporters countries with SWF. Source: Global SWF Institute

(b) SWF assets under management, GDP-weighted



B Appendix tables

Table A.1: Unshared consumption risk in commodity and non-commodity exporting countries: OLS estimates

Consumption risk	Non-commodity exporters	Difference to non-commodity exporters	
		Energy and Metal	Agriculture
$\Delta\left(gdp_{it} - gdp_t^{world}\right)$	0.705***	-0.360***	0.111
	(0.0363)	(0.0577)	(0.0715)
$\Delta_2\left(gdp_{it} - gdp_t^{world}\right)$	0.755***	-0.335***	0.0509
	(0.0247)	(0.0448)	(0.0446)
$\Delta_3\left(gdp_{it} - gdp_t^{world}\right)$	0.778***	-0.274***	0.0422
	(0.0202)	(0.0439)	(0.0366)
$\Delta_4\left(gdp_{it} - gdp_t^{world}\right)$	0.794***	-0.243***	0.0489
	(0.0181)	(0.0403)	(0.0303)
$\Delta_5\left(gdp_{it} - gdp_t^{world}\right)$	0.804***	-0.224***	0.0359
	(0.0165)	(0.0370)	(0.0272)
Observations		1887	

The first column reports the proportion of consumption risk unshared, for non-commodity exporters, defined as the $\beta_{u,h}$ calculated from the regression model $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) + \beta_{u,h}^{commodity}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_i^{commodity} + u_{it,h}$ with $h \in \{1;\ldots;5\}$, the second column reports the difference between commodity and non-commodity exporters, the $beta_{u,h}^{commodity}$ coefficient. Δ_h is defined as $\Delta_h x_t = x_t - x_{t-h}$ c_{it} (gdp_{it}) is log of aggregate consumption (GDP) in country i in year t. $\Delta_h c_t^W$ $(\Delta_h gpd_t^W)$ is the cross-sectional average of consumption (GDP) growth of all the countries in the sample, $I_i^{commodity}$ is an indicator function that takes the value of one for commodity-exporting countries.

Columns three and four report differential coefficient for energy and metal, and agriculture commodity exporters separately $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) + \beta_{u,h}^{nrg-metal}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_c^{nrg-metal} + \beta_{u,h}^{aggriculture}\left(\Delta_h gdp_{it} - \Delta_h gdp_t^W\right) \times I_c^{aggriculture} + u_{it,h}$, $I_i^{nrg-metal}$ and $I_i^{agriculture}$ are indicator functions that take the value of one for energy and metal exporting and agriculture exporting countries, respectively.

The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.2: Commodity exporters risk-sharing with the world—IV estimates: alternative construction of output growth

Consumption risk	Unshared consumption	Channels of risk sharing		
	risk	Factor income	Transfers	Savings
$\Delta\left(gdp_{it} - gdp_t^{world}\right)$	0.118*	0.125***	-0.0448***	0.785***
	(0.0694)	(0.0225)	(0.0137)	(0.0696)
$\Delta_2\left(gdp_{it} - gdp_t^{world}\right)$	0.212***	0.121***	-0.0381***	0.688***
	(0.0610)	(0.0167)	(0.0126)	(0.0602)
$\Delta_3\left(gdp_{it} - gdp_t^{world}\right)$	0.354***	0.0953***	-0.0325***	0.571***
	(0.0473)	(0.0137)	(0.0120)	(0.0476)
$\Delta_4\left(gdp_{it} - gdp_t^{world}\right)$	0.433***	0.0739***	-0.0227**	0.502***
	(0.0410)	(0.0122)	(0.0114)	(0.0418)
$\Delta_5\left(gdp_{it} - gdp_t^{world}\right)$	0.500***	0.0604***	-0.0208*	0.439***
	(0.0372)	(0.00996)	(0.0109)	(0.0367)
Observations		436		

Note: $\Delta \log asy_{it} - \Delta \log asy_t = \beta_0 + \beta_1\left(gdp_{it} - gdp_t^{world}\right) + \epsilon_{it}$ $\Delta \log asy_t$ is the cross-sectional average of $\Delta \log asy_{it}$ and gdp_{it}^{world} is the cross-sectional average of $\Delta \log gdp_{it}$, also try with gdp_{it}^{world} from WDI.

The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.3: Unshared consumption risk in commodity and non-commodity exporting countries—OLS estimates: unbalanced observations across horizons

Consumption risk	Non-commodity	Difference to non-commodity exporters			Observations
	exporters	Commodity	Energy and Metal	Agriculture	
$\Delta\left(gdp_{it} - gdp_t^{world}\right)$	0.750***	-0.169**	-0.289***	0.114*	2371
	(0.0369)	(0.0657)	(0.0740)	(0.0594)	
$\Delta_2\left(gdp_{it} - gdp_t^{world}\right)$	0.768***	-0.176***	-0.261***	0.0780**	2269
	(0.0229)	(0.0465)	(0.0543)	(0.0394)	
$\Delta_3\left(gdp_{it} - gdp_t^{world}\right)$	0.784***	-0.165***	-0.243***	0.0602*	2170
	(0.0190)	(0.0394)	(0.0466)	(0.0336)	
$\Delta_4\left(gdp_{it} - gdp_t^{world}\right)$	0.796***	-0.178***	-0.257***	0.0442	2069
	(0.0174)	(0.0346)	(0.0406)	(0.0285)	
$\Delta_5\left(gdp_{it} - gdp_t^{world}\right)$	0.802***	-0.172***	-0.242***	0.0312	1972
	(0.0164)	(0.0311)	(0.0367)	(0.0257)	

Note: The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.4: Channels of risk sharing: Overall and by commodity and non-commodity sectors

	Overall risk sharing	Risk sharing by sector	
		Commodity	Non-commdity
Panel a. Net factor income			
$\Delta risk_{it}$	0.0358***	0.0861***	0.0177
	(0.0137)	(0.0220)	(0.0159)
$\Delta_2 risk_{it}$	0.0409***	0.0952***	0.0199
	(0.0106)	(0.0169)	(0.0126)
$\Delta_3 risk_{it}$	0.0377***	0.0888***	0.0186
	(0.0102)	(0.0157)	(0.0128)
$\Delta_4 risk_{it}$	0.0382***	0.0812***	0.0223*
	(0.00946)	(0.0151)	(0.0115)
$\Delta_5 risk_{it}$	0.0359***	0.0703***	0.0239**
	(0.00877)	(0.0132)	(0.0104)
Panel b. International net transfers			
$\Delta risk_{it}$	-0.00172	-0.0283*	0.00831
	(0.0119)	(0.0147)	(0.0130)
$\Delta_2 risk_{it}$	0.0144	-0.0169	0.0267***
	(0.00930)	(0.0132)	(0.00983)
$\Delta_3 risk_{it}$	0.0210**	-0.0109	0.0331***
	(0.00883)	(0.0134)	(0.00969)
$\Delta_4 risk_{it}$	0.0235***	-0.00126	0.0328***
	(0.00830)	(0.0133)	(0.00992)
$\Delta_5 risk_{it}$	0.0207***	-0.000523	0.0282***
	(0.00767)	(0.0135)	(0.00972)
Panel c. Savings			
$\Delta risk_{it}$	0.617***	0.815***	0.544***
	(0.0504)	(0.0700)	(0.0660)
$\Delta_2 risk_{it}$	0.514***	0.731***	0.429***
	(0.0396)	(0.0630)	(0.0463)
$\Delta_3 risk_{it}$	0.427***	0.643***	0.347***
	(0.0400)	(0.0555)	(0.0447)
$\Delta_4 risk_{it}$	0.379***	0.584***	0.305***
	(0.0363)	(0.0522)	(0.0424)
$\Delta_5 risk_{it}$	0.353***	0.535***	0.291***
	(0.0325)	(0.0489)	(0.0389)
Observations		436	

See Table 5 notes.

Table A.5: Contribution of sources and uses of savings to risk-sharing—IV estimates: GDP risk correlated with commodity prices

Consumption risk	Commodity		Non-commodity		
Panel a. Sources	Private	Government	Private	Government	Obs
$\Delta\left(gdp_{it}-gdp_t^{world}\right)$	0.1701	0.6449	0.1377	0.4063	264
	(0.0822)	(0.1081)	(0.1117)	(0.1004)	
$\Delta_2\left(gdp_{it}-gdp_t^{world}\right)$	0.229	0.502	0.1217	0.3073	259
	(0.0765)	(0.0747)	(0.0937)	(0.0739)	
$\Delta_3\left(gdp_{it}-gdp_t^{world}\right)$	0.2573	0.3857	0.1066	0.2404	254
	(0.0619)	(0.0631)	(0.0793)	(0.0719)	
$\Delta_4\left(gdp_{it}-gdp_t^{world}\right)$	0.2206	0.3634	0.0996	0.2054	251
	(0.0472)	(0.0623)	(0.0549)	(0.0643)	
$\Delta_5\left(gdp_{it}-gdp_t^{world}\right)$	0.1787	0.3563	0.1071	0.1839	248
	(0.0428)	(0.0636)	(0.0463)	(0.0524)	
Panel b. Uses	Current account	Investment	Current account	Investment	Obs
$\Delta\left(gdp_{it}-gdp_t^{world}\right)$	0.737	0.078	0.4472	0.0968	408
	(0.0798)	(0.0468)	(0.084)	(0.0462)	
$\Delta_2\left(gdp_{it}-gdp_t^{world}\right)$	0.6088	0.1222	0.3148	0.1142	406
	(0.0758)	(0.0403)	(0.0787)	(0.0497)	
$\Delta_3\left(gdp_{it}-gdp_t^{world}\right)$	0.4658	0.1772	0.2313	0.1157	404
	(0.0647)	(0.0388)	(0.0789)	(0.0508)	
$\Delta_4\left(gdp_{it}-gdp_t^{world}\right)$	0.3955	0.1885	0.1962	0.1088	402
	(0.0607)	(0.0377)	(0.0694)	(0.0427)	
$\Delta_5\left(gdp_{it}-gdp_t^{world}\right)$	0.3425	0.1925	0.1906	0.1004	400
	(0.0546)	(0.0332)	(0.0505)	(0.0328)	

See Table 6 notes.

Table A.6: Alternative instrument definition: First stage estimates

	$\Delta\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_2\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_3\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_4\left(gdp_{it}-gdp_t^{world}\right)$	$\Delta_5\left(gdp_{it}-gdp_t^{world}\right)$
Commodity price shock	0.144***	0.158***	0.182***	0.200***	0.203***
	(0.0142)	(0.0128)	(0.0156)	(0.0178)	(0.0179)
Observations	436	436	436	436	436
R-squared	0.2644	0.2786	0.2718	0.2703	0.2593

Estimates for the $\beta_{0h}^{first,stage}$ coefficients from estimating the relationship $\Delta_h\left(gdp_{it}-gdp_t^{world}\right) = \beta_{0h}^{first,stage} + \beta_h^{first,stage}\Delta_h p_{it}^{real,commodity} + \epsilon_{it}$ with $h \in \{1;\ldots;5\}$. The commodity price shock is defined as $\Delta_h p_{it}^{real} = \sum_{g\in Commodity} \frac{P_{gt-h}^{USD} X_{git-h}}{\sum_{g\in Commodity} P_{gt-h}^{USD} X_{git-h}} \Delta_h \log \frac{P_{gt}^{USD}}{CPI_{it}^{US}}$. The estimation period is 1995-2019. Robust standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.7: Alternative instrument definition: Overall, commodity, and non-commodity sector unshared consumption risk

	Unshared consumption	Unshared consumption risk by sector	
	risk	Commodity	Non-commodity
$\Delta risk_{it}$	0.343***	0.106	0.429***
	(0.0447)	(0.0689)	(0.0429)
$\Delta_2 risk_{it}$	0.418***	0.177***	0.511***
	(0.0374)	(0.0615)	(0.0361)
$\Delta_3 risk_{it}$	0.502***	0.269***	0.588***
	(0.0390)	(0.0548)	(0.0426)
$\Delta_4 risk_{it}$	0.547***	0.324***	0.630***
	(0.0364)	(0.0512)	(0.0408)
$\Delta_5 risk_{it}$	0.576***	0.374***	0.646***
	(0.0336)	(0.0492)	(0.0387)
Observations		436	

Each column reports the proportion of consumption risk unshared. The first column report it for the aggregate economy estimated from the panel regression $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h\left(gdp_{it} - gdp_t^{world}\right) + u_{it,h}$ where $h \in \{1;\ldots;5\}$; $\Delta_h c_t^W$ and $\Delta_h gpd_t^W$ are cross sectional average of log differencing Consumption and Gross Domestic Product of all countries included in the sample of Table 2.

The second column reports the proportion of consumption risk unshared from the commodity sector output fluctuations estimated from the panel regression $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h commodity_{it} + u_{it,h}$, where $\Delta_h commodity_t$ is the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

The third column reports $\Delta_h c_{it} - \Delta_h c_t^W = \beta_{0,h} + \beta_{u,h}\Delta_h non-commodity_{it} + u_{it,h}$, where $\Delta_h non-commodity_t$ is the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

In all cases, $\beta_{u,h}$ is interpreted as the percentage of consumption risk from the aggregate, commodity and non-commodity sector unsmoothed. The estimation period is 1995-2019. In columns one and three Estimates and (robust) standard errors are calculated trough ordinary-least-squares. In column two estimates and (robust) standard errors are calculated trough two-stage-least squares. Standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.8: Alternative instrument definition: Channels of risk sharing: Overall and by commodity and non-commodity sectors

	Overall risk sharing	Risk sharing by sector	
		Commodity	Non-commdity
Panel a. Net factor income			
$\Delta risk_{it}$	0.0358***	0.0861***	0.0177
	(0.0137)	(0.0220)	(0.0159)
$\Delta_5 risk_{it}$	0.0359***	0.0703***	0.0239**
	(0.00877)	(0.0132)	(0.0104)
Panel b. International net transfers			
$\Delta risk_{it}$	-0.00172	-0.0283*	0.00831
	(0.0119)	(0.0147)	(0.0130)
$\Delta_5 risk_{it}$	0.0207***	-0.000523	0.0282***
	(0.00767)	(0.0135)	(0.00972)
Panel c. Savings			
$\Delta risk_{it}$	0.617***	0.815***	0.544***
	(0.0504)	(0.0700)	(0.0660)
$\Delta_5 risk_{it}$	0.353***	0.535***	0.291***
	(0.0325)	(0.0489)	(0.0389)
Observations		436	

Channels of risk sharing. Each panel reports the slope from the univariate regressions $\Delta_h gdp_{it} - \Delta_h gni_{it} - \left(\Delta_h gdp_t^W - \Delta_h gni_t^W\right) = \beta_{0,h} + \beta_{f,h}\Delta_h risk_{it} + u_{it,h}$ (panel a. Net factor income), $\Delta_h gni_{it} - \Delta_h gndi_{it} - \left(\Delta_h gni_{it}^W - \Delta_h gndi_{it}^W\right) = \beta_{0,h} + \beta_{\tau,h}\Delta_h risk_{it} + u_{it,h}$ (panel b. International net transfers), and $\Delta_h gndi_{it} - \Delta_h c_{it} - \left(\Delta_h gndi_t^W - \Delta_h c_t^W\right) = \beta_{0,h} + \beta_{s,h}\Delta_h risk_{it} + u_{it,h}$ (panel c. Savings), with $h \in \{1;\ldots;5\}$; $\Delta_h c_t^W$, $\Delta_h gpd_t^W$, $\Delta_h gni_t^W$, and $\Delta_h gndi_t^W$ are cross-sectional average of log differencing Consumption, Gross Domestic Product, Gross National Income, and Gross National Disposable Income, respectively, of all countries included in the sample of Table 2.

Consumption risk denoted as $\Delta_h risk_{it}$ is defined according to the sector considered. For the aggregate, first column, $\Delta_h risk_{it}$ is $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$; for the commodity sector, second column, it is defined as the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$; for the non-commodity sector, third column, it is defined as the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

The estimated values of $\beta_{f,h}$, $\beta_{\tau,h}$, and $\beta_{s,h}$ are interpreted as the percentage of consumption-smoothing of shocks corresponding to the sector under analysis, obtained through international capital markets, net transfers, and domestic saving, respectively.

The estimation period is 1995-2019. In columns one and three Estimates and (robust) standard errors are calculated trough ordinary-least-squares. In column two estimates and (robust) standard errors are calculated trough two-stage-least squares. Standard errors are in parenthesis. ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.

Table A.9: Alternative instrument definition: Contribution of sources and uses of savings to risk-sharing across commodity and non-commodity sectors

Consumption risk	Commodity sector		Non-commodity sector		
Panel a. Savings' sources	Private	Government	Private	Government	Obs
$\Delta risk_{it}$	0.1701	0.6449	0.1377	0.4063	264
	(0.0822)	(0.1081)	(0.1117)	(0.1004)	
$\Delta_5 risk_{it}$	0.1787	0.3563	0.1071	0.1839	248
	(0.0428)	(0.0636)	(0.0463)	(0.0524)	
Panel b. Savings' uses	Current account	Investment	Current account	Investment	Obs
$\Delta risk_{it}$	0.737	0.078	0.4472	0.0968	408
	(0.0798)	(0.0468)	(0.084)	(0.0462)	
$\Delta_5 risk_{it}$	0.3425	0.1925	0.1906	0.1004	400
	(0.0546)	(0.0332)	(0.0505)	(0.0328)	

Decomposition of contribution of savings to risk sharing. Panel a. Sources. Each column reports the slope from the univariate regressions $\Delta_h \frac{S^j_{it}}{C_{it}} - \Delta_h \frac{S^j_t}{C_t}^W = \beta_{0,h} + \beta_{s^j,h}\Delta_h Y_{it} + u_{it,h}$, where $j \in \{\text{Private;Government}\}$, $h \in \{1;\ldots;5\}$. Panel b. Uses reports the slope from the univariate regressions $\Delta_h \frac{CA_{it}}{C_{it}} - \Delta_h \frac{CA_t}{C_t}^W = \beta_{0,h} + \beta_{ca,h}\Delta_h risk_{it} + u_{it,h}$ and $\Delta_h \frac{Investment_{it}}{C_{it}} - \Delta_h \frac{Investment_t}{C_t}^W = \beta_{0,h} + \beta_{inv,h}\Delta_h commodity_{it} + u_{it,h}$.

The coefficients $\beta_{s^{\text{Private}},h}$ and $\beta_{s^{\text{Government}},h}$ are interpreted as the percentage of consumption-smoothing of GDP risk correlated with commodity price shocks obtained through government and private saving. The coefficients $\beta_{ca,h}$ and $\beta_{inv,h}$ are interpreted as the percentage of consumption-smoothing of GDP risk correlated with commodity price shocks obtained through purchasing and selling foreign assets and domestic investment, respectively.

Consumption risk denoted as $\Delta_h risk_{it}$ is defined according to the sector. For the commodity sector, first and second column, it is defined as the fitted value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real,commodity}$ where $\Delta_h gpd_t^W$, is the cross sectional average of log differencing Gross Domestic Product, of all countries included in the sample of Table 2. For the non-commodity sector, columns three and four, it is defined as the residual value from projecting $\Delta_h\left(gdp_{it} - gdp_t^{world}\right)$ on $\Delta_h p_{it}^{real}$.

The estimation period is 1995-2019. Incolumns one and two, estimates and (robust) standard errors are calculated using two-stage-least squares. In columns (3) and (4) estimates and (robust) standard errors are calculated using ordinary-least-squares. The coefficients $\beta_{s^j,h}$ were rescaled such that their sum equals the coefficients $\beta_{s,h}$ in Table 5 (the standard deviations were rescaled as well). Standard errors are in parenthesis. ***, **, and * represent significance levels at the 1%, 5%, and 10%, level, respectively.

Table A.10: Variables: description and sources

Variables	Definition	Source
Transfers	The difference between Net Disposable National Income and Gross National Income	WDI (database), authors calculations
Net factor Income	The difference between Gross National Income and GDP	WDI (database), authors calculations
Savings	Gross national savings, the difference between Consumption and Net	WDI (database), authors calculations
Domestic investment	Gross capital formation (public and private)	WDI (database), authors calculations
Government savings	General government tax revenue, non-tax revenue, and short-term grants minus	National account statistics
Private savings	Gross national savings minus government savings	National account statistics

Table A.11: Countries used in the sample

Country groups	Countries in sample
Commodity-exporting countries	Algeria, Angola, Argentina, Armenia,Australia, Azerbaijan, Benin, Brazil, Bolivia, Canada, Chile, Colombia, Costa Rica, Cote d'Ivoire, Ecuador, Ghana, Greenland, Guatemala, Guinea, Honduras, Indonesia, Iran, Islamic Rep., Kazakhstan, Kenya, Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Madagascar, Mauritania, Mongolia, Nicaragua, New Zealand. Norway, Oman, Peru, Paraguay, Rwanda, Russian Federation, Saudi Arabia, Senegal, Sierra Leone, South Africa, Tajikistan, Tanzania, Togo, Turkmenistan, Uganda, United Arab Emirates. Uruguay, Uzbekistan, Zambia.
Commodity-exporters by type	**Energy exporters:** Algeria, Angola, Azerbaijan, Bolivia, Canada, Colombia, Ecuador, Ghana, Indonesia, Iran, Islamic Rep., Kazakhstan, Kuwait, Norway, Oman, Russian Federation, Saudi Arabia, Turkmenistan, United Arab Emirates. **Metal exporters**: Armenia, Australia, Chile, Guinea, Kyrgyz Republic, Mauritania, Mongolia, Peru, Sierra Leone, South Africa, Tajikistan, Zambia. **Agriculture exporters:** Argentina, Benin, Brazil, Costa Rica, Cote d'Ivoire, Guatemala, Honduras, Kenya, Lao PDR, Madagascar, New Zealand, Nicaragua, Paraguay, Rwanda, Senegal, Tajikistan, Tanzania, Togo, Uganda, Uruguay, Uzbekistan.
Non-commodity exporting countries	Albania, Bangladesh, Bosnia and Herzegovina, Bulgaria, Cambodia, China, Dominican Republic, Egypt, Arab Rep., El Salvador, Georgia, Hungary, India, Jordan, Malaysia, Mexico, Moldova, Morocco, Nepal, North Macedonia, Pakistan, Panama, Philippines, Poland, Romania, Serbia, Sri Lanka, Thailand, Tunisia, Türkiye, Viet Nam.Aruba, Austria, Belgium, Croatia, Czechia, Denmark, Finland, France, Germany, Greece, Greenland, Hong Kong SAR, China, Ireland, Israel, Italy, Japan, Korea, Rep., Lithuania, Luxembourg, Macao SAR, China, Netherlands, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.

Note: definitions are taken from the World Bank Global Economic Prospects.