Commodity Price Shocks, Growth and Structural Transformation in Low-Income Countries

Thomas McGregor *

Oxford Centre for the Analysis of Resource Rich Economies (OxCarre)
St Hugh's College, University of Oxford
Department of Economics, University of Oxford

Abstract

The end of the 'commodity super-cycle' has resulted in a baptism of fire for many nascent commodity exporting developing economies. This paper uses a panel-VAR approach to estimate both the dynamic and structural macroeconomic response of resource-rich, low-income countries to global commodity price shocks. I use a Block recursive ordering, as well as a simple Choleski decomposition, to identify structural commodity price shocks for a set of developing countries. The Block recursive identification strategy assumes only that global macroeconomic conditions do not respond to individual low-income country conditions contemporaneously. The results suggest that a one standard deviation increase in commodity prices (around 19% on average) raises per capita income levels, government spending and investment in developing countries by 0.03%-0.05%. Commodity price shocks also result in significant transformation of these economies, with the share of value-added in manufacturing contracting by 0.25 percentage points; although within this, the share of value-added in agricultural manufactures, for example, expands by around 1.5 percentage points. Whilst these effects may appear small, they represent the effect of exogenous commodity price shocks that are not due to changes in aggregate demand or global financial conditions. Taken together, these results present a more nuanced picture of the 'resource curse' in poor countries. Whilst per capital income levels are positively affected by resource booms, the potential for de-industrialisation, particularly in export oriented manufacturing sectors, does exist. The channel through which this link operates appears to be the real exchange rate, with resource booms leading to appreciation pressures. To illustrate these results, I simulate the impact of the recent oil price collapse on the Nigerian economy.

JEL codes: O11, O13, L16, Q02, C01, C33
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*Correspondence: Department of Economics, Manor Road Building, Oxford OX1 3UQ, UK; Email: thomas.mcgregor@economics.ox.ac.uk

1 Introduction

The recent collapse of world commodity prices has lead to many market commentators calling this the end of the 'commodity super-cycle'. With a slowing Chinese economy, the start of a FED 'lift-off' and continued exploration into new technologies such as fracking, the unyielding downward pressure on commodities has taken many commodity exporters by surprise. This is particularly true for countries who are new to the commodity exporting game. Over the past decade or two, a number of sub-Saharan countries had seemingly struck lucky with the discovery of potentially vast hydrocarbon reserves. The question of how resource booms and busts affect growth and structural transformation is particularly pertinent for these nascent commodity exporting low-income countries.

There is a large literature that explores the impact of natural resource wealth on development and economic growth[1]. Most of the empirical evidence in support of a 'natural resource curse' is based on cross country regressions. Original work by Sachs & Warner (1995, 1999) found a negative relationship between resource wealth and long-run economic growth, whilst more recent work Mehlum et al. (2006) finds that this is particularly the case in countries with poor institutions. Given the long time periods used, these findings can be thought of as the long-run relationship between resource booms and economic growth.

One challenge facing this literature is that whilst a negative correlation between natural resource dependence and economic growth is evident at the cross-country level, this tells us nothing about causation. Natural resources may harm the economy through other variables such as lower non-resource exports and FDI, less openness to foreign trade, weaker institutions and governance, and lower levels of school enrolment, educational attainment and public spending. However, as highlighted by Van der Ploeg (2011) controlling for many of these variables still confirms that resource rich economies experience slower growth.

Another challenge is the endogeneity of potential measures of resource wealth. The standard approach in the cross-country literature on the resource curse is to use resource dependence (the share of resources in GNP) as the independent variable. However, this proxy for resource wealth is likely to be endogenous for two reasons. First, by construction, dividing by GDP means that higher GDP will correlate with lower resources as a share of GDP thus setting up a negative correlation. Second, this scaling exercise implies that reserves as a share of GDP is no longer independent of the economic policies and institutions that drive both economic growth and the scale of resource production. Brunnschweiler & Bulte (2008), for example, find that when instrumenting for resource dependence, its negative effect on growth disappears whereas subsoil resource wealth (abundance) positively affects growth. However, Van der Ploeg & Poelhekke (2010) show that even this measure of resource abundance may be endogenous as it is calculated as the present value of natural resource rents. They use the more exogenous measure of economically recoverable reserves instead and find no evidence for either a curse or a blessing

[1] See Van der Ploeg (2011) for a survey of the literature

unless one allows for an indirect effect via volatility.

There have also been a number of attempts to explore the short-run effects of resource shocks on economic output. Raddatz (2007) uses a panel vector auto-regression (panel-VAR) approach to study the impact of different external shocks, including commodity price shocks, on output volatility in low-income countries. They find that commodity prices significantly raise income in the short run, but that external shocks in general can only explain a small fraction of the output variance of a typical low-income country. Deaton & Miller (1995) also use a VAR model to show a positive effect of commodity prices on income levels in Africa. In a slightly different approach, Collier & Goderis (2012) use a panel error correction model (ECM) to study both the short-run and and the long-run effects of international commodity prices on output per capita. They find that commodity booms have unconditional positive short-term effects on output, but in countries with poor governance these booms have adverse long-term effects which dominate the short-run gains.

This paper uses a panel-VAR approach to estimate the dynamic macroeconomic response of resource-rich, low-income countries to fluctuations in commodity prices; specifically minerals and hydrocarbons. It then investigates the impact of these commodity price shocks on the economic structure of the extracting economies. I find evidence of a contraction of domestic tradable sectors, potentially caused by a loss of international competitiveness. The results suggest that a one standard deviation increase in commodity prices (around 19% on average) raises per capita income levels in low-income countries by 0.04%, government spending by 0.05% and investment by 0.03%. Commodity price shocks also result in significant transformation of low-income economies, with the share of value-added in manufacturing contracting by 0.25 percentage points (pp), whilst transport and other non-tradeable service sectors expand by around 0.15 pp and 0.31 pp receptively. Further investigation suggests that the contraction of the manufacturing sector is not evenly spread across all sub-sectors; the share of value-added in agricultural manufactures for example expands by around 1.5 pp. Whilst these effects may appear small, they represent the effect of exogenous commodity price shocks that are not due to changes in aggregate demand or global financial conditions.

The focus on resource-rich, low-income countries is motivated on two fronts. The first, is that recent discoveries of potentially vast hydrocarbon reserves in sub-Saharan Africa[2], makes the question of how commodity shocks affect growth and structural transformation in these countries highly pertinent. Second, low-income countries are often thought of as being highly susceptible to external shocks, particularly commodity price movements. Work by Collier & Gunning (1999), Dehn (2000) and Collier & Dehn (2001) have documented an important effect

[2]According to estimates by Wood Mackenzie, recoverable natural gas reserves in Mozambique are 85 Tcf and 18 Tcf in Tanzania, with another 100 tcf yet to be found; In Uganda, Tullow Oil estimate that recoverable oil reserves are 1.1 bb, with some 1.4 bb potentially yet to be found; In Madagascar, Madagascar Oil estimate recoverable oil reserves to be 1.7 bb, with a further 10.8 bb of oil and 167 Tcf of gas in undiscovered reserves according to an assessment by USGS; Ghana discovered 4 bb of oil in it's Jubilee field in 2007 and production is currently being scaled up; Kenya has also recently discovered potential oil and gas reserves.

of commodity price shocks on growth in developing countries; although, these shocks can only explain a small fraction of the output variance of a typical low-income country. Understanding both the dynamic and structural impact these shocks have on low-income countries is vital.

The use of a VAR framework allows a certain degree of simultaneity and endogeneity between the variables in the system, something which will be important given the interdependence between global economic conditions, commodity prices and low-income country growth. I focus on global commodity price shocks, rather than resource discoveries, as these are likely to be more exogenous with with respect to small developing economies. I impose two sets of restriction on the system in order to identify the structural element of commodity price shocks for each developing country in my dataset. The first is a simple Choleski decomposition which requires a strict causal ordering of the variables in the VAR. The second is a Block recursive identification structure. My approach here is to split the VAR into a global block and a national block. In doing so, the only restrictions I place on the system are that global macroeconomic conditions do not respond to individual low-income country economic conditions contemporaneously.

The paper adds to the existing literature in two ways. First by extending the search for an exogenous measure of resource abundance. Following the approach of Van der Ploeg & Poelhekke (2010), I construct an estimate of economically recoverable hydrocarbon and mineral reserves in 1985 at the mine level before aggregating this up to the country level. It is argued that this measure of resource abundance is wholly exogenous with respect to the future economic performance of low-income countries.

The second contribution of the paper is to shed light on the link between resource wealth and de-industrialisation, in resource-rich, low-income countries. In an important contribution to the early literature, Corden & Neary (1982) formalised the de-industrialisation process that may result from resource booms. They distinguish between two channels, the 'resource movement' effect, which describes the process by which labour may be pulled out of the traditional manufacturing sector following a boom, and the 'spending effect', which describes the increase in demand for non-tradables following a boom. Using a seemingly unrelated panel regression framework and data from the UN on sectoral value added, employment and gross fixed capital formation, I investigate the link between resource shocks and the structural composition output in developing economies. The results suggest that resource booms lead to an increase in the share of value-added in non-tradable goods and service sectors, such as transport, finance and real estate, whilst the manufacturing sectors decline. This link appears to operate through the real exchange rate, with resource shocks leading to appreciations which in turn cause a restructuring of the domestic economy.

The remainder of the paper is structured as follows. Section 2 presents the empirical methodology and the two step estimation procedure. Section 3 describes the construction of the 1985 reserve-weighted commodity price index used to identify exogenous commodity price shocks for each country. Section 4 describes the data. Sections 5 and 6 present the estimation results.

Section 7 explores the Dutch disease mechanism. Section 8 uses these results to simulate the effect of recent oil price collapse on the Nigerian economy, and section 9 concludes.

2 Empirical Methodology

The main challenge in estimating the dynamic response of low-income, resource-rich economies to commodity price shocks is in identifying movements in commodity prices that are truly exogenous to economic conditions in these counties. Movements in global commodity prices will reflect both demand and supply shocks. Work by Hamilton (2003) and Kilian (2008) find that much of the increase in crude oil prices since the 70s, and particularity since 2002, has been due to increases in aggregate demand for all industrial commodities, rather than exogenous supply shocks. The problem is that movements in global aggregate demand, as well as international credit market conditions, are likely to simultaneously affect the economic conditions of low-income countries as well global commodity prices. In order to identify exogenous supply driven commodity price movements, I use a VAR model which orthogonalises the commodity price shocks against global aggregate demand and financial conditions.

The empirical approach consists of two steps. The first step is to estimate the panel-VAR, given our interest in studying a group of countries. The VAR model should, in theory, isolate only supply driven changes in commodity prices (or demand driven price changes that don't immediately affect low-income economies) and therefore be exogenous from the perspective of low-income, resource-rich economies. The second step is then to take these shocks and regress them on the various sectoral components of value added and operating surplus in these countries. The aim is to study both the aggregate macroeconomic response to commodity price shocks, as well as possible structural transformation processes that might take place as a result.

Clearly, the choice to focus on resource-rich, low-income countries is an important one. As discussed, it is motivated on two fronts: (i) recent discoveries of potentially vast hydrocarbon reserves in parts of the developing world, particularly sub-Saharan Africa, and (ii) low-income countries are often thought of as being highly susceptible to external shocks, particularly commodity price movements. Understanding both the dynamic and structural impact these shocks have on low-income countries is vital. However, by restricting the sample to low-income countries raises issues around selection bias. Namely, by focusing on poor countries today the empirical results may be biased towards finding a negative relationship between commodity price shocks and economic growth. For this reason, rather than using current income classifications, I select the sample of low-income countries using per capita GNI data from the World Bank in 1970.

Step 1: Structural Panel VAR

The first step involves estimating a structural vector auto-regression (VAR) model on a panel dataset of macroeconomic variables of resource rich developing economies[3]. Using a VAR ap-

[3] I am grateful to Inessa Love and Lea Ziccino for the use of their panel VAR programme in Stata. See Love & Zicchino (2006)

proach allows all of the variables in the system to be endogenous. This is important, given the simultaneity in global economic conditions, commodity prices and poor countries' economic conditions. Applying it to panel data allows for unobserved heterogeneity.

Given that I am interested in estimating the dynamic macroeconomic response of natural resource shocks, the key challenge is in identifying exogenous structural shock series for each country. I do this in two ways. The first involves using a recursive causal ordering on the system, or a Choleski decomposition. Whilst this is a powerful method for identifying structural shocks in VAR models, it does come at the cost of imposing some prohibitively restrictive assumptions on the dynamics of the system. The second method uses a set of 'block recursive' type restrictions in which global macroeconomic variables are treated as a separate and independent block to the national variables, such as GDP, investment and government spending. This approach imposes much fewer restrictions on the system and is, for that reason, theoretically more appealing a priori.

I begin by describing the problem of identification of shocks in the panel VAR model. Consider, the following first order structural VAR (SVAR) model:

$$Bx_{i,t} = \Gamma_0 + \Gamma_1 x_{i,t-1} + \epsilon_{i,t} \tag{1}$$

where $x_{i,t} = [GDPH, LIBOR, CPIND, G, I, INFL, RGDPPC]'_{i,t}$ is a vector of endogenous variables for country i at time t. The variables included in the vector are: log deviation of real GDP of high income countries ($GDPH$), real US Libor rate ($LIBOR$), log deviation of a GDP weighted commodity price index ($CPIND$) which will be discussed in more detail below, log deviation of real government expenditure (G), log deviation of real fixed capital formation, (or investment) (I)[4], inflation as measures by the GDP deflator index ($INFL$), and the log deviation of real GDP per capita ($RGDPPC$) for each low income country i. The log deviation specification for most of the variables is required in order for to ensure that all variables in $x_{i,t}$ are stationary.

An identification problem arises when attempting to estimate equation 1. What is actually estimated when taking the model to the data is the following reduced form VAR (RVAR):

$$x_{i,t} = A_0 + A_1 x_{i,t-1} + e_{i,t} \tag{2}$$

where $A_0 = B^{-1}\Gamma_0$, $A_1 = B^{-1}\Gamma_1$, $e_{i,t} = B^{-1}\epsilon_{i,t}$, $E(ee') = \Omega = B^{-1}\Phi B^{-1\prime}$, and $E(\epsilon\epsilon')\Phi = B\Omega B$. The immediate challenge in estimating equation 2 using panel data is that we are required to impose the restriction that the structure of the VAR, in particular the dynamics of the system, represented by the A matrices, are common across countries. This is a standard assumption in this literature (see (Broda, 2001, 2004); Ahmed (2003); Uribe & Yue (2006)) because, given the length of the time series dimension of the data (around 29 years), it would not be possible to

[4] G is General government final consumption expenditure (current US\$); I is Gross fixed capital formation (constant 2005 US\$). Both are taken from the World Bank's World Development Indicators.

estimate country-specific dynamics given the number of variables in the system and number of lags. The implication is that the coefficient estimates in the A_0 and A_1 matrices are the same for each country. Since this assumption is likely not to hold in practice, I include country fixed effects f_i. The estimation equation becomes:

$$x_{i,t} = A_0 + A_1 x_{i,t-1} + f_i + e_{i,t} \tag{3}$$

Since the fixed effects are correlated with the regressors due to lags of the dependent variables, the standard fixed effects estimator will be biased. I therefore use forward mean-differencing, also referred to as the 'Helmert procedure' (see Arellano & Bover (1995)). This procedure removes only the forward mean, i.e. the mean of all the future observations available for each firm-year. This transformation preserves the orthogonality between transformed variables and lagged regressors, so the lagged regressors can be used as instruments and estimate the coefficients by system GMM.

Whilst the OLS estimates of the RVAR are consistent, it is not possible to recover the coefficients of the SVAR, which is the object of interest. The RVAR forces the contemporaneous structural shocks of each variables in $x_{i,t}$ into the errors $e_{i,t}$ which consists of some combination of the true structural shocks related to each variable $\epsilon_{i,t}$. To isolate the structural shocks to any one of the variables in the system it is necessary to decompose the residuals in such a way that they become orthogonal.

Choleski

The first approach used, is a simple recursive causal ordering, or a Choleski decomposition, of the B^{-1} matrix, which allows for the identification of the structural shocks $\epsilon_{i,t}$ in the panel-VAR. Identification via a recursive causal ordering implies that the $B{-}1$ matrix linking the structural shocks and the reduced form errors is lower triangular.

$$\begin{bmatrix} e_{GDPHi,t} \\ e_{LIBORi,t} \\ e_{CPINDi,t} \\ e_{Gi,t} \\ e_{Ii,t} \\ e_{INFLi,t} \\ e_{RGDPPCi,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & 1 \end{bmatrix} \times \begin{bmatrix} \epsilon_{GDPHi,t} \\ \epsilon_{LIBORi,t} \\ \epsilon_{CPINDi,t} \\ \epsilon_{Gi,t} \\ \epsilon_{Ii,t} \\ \epsilon_{INFLi,t} \\ \epsilon_{RGDPPCi,t} \end{bmatrix} \tag{4}$$

where ϵ_{xt} is vector of the structural shocks of interest from equation 1, b_{ij} are the parameters of interest from B^{-1} matrix in the structural panel-VAR model, and e_{xt} are the reduced form errors from estimating the panel-VAR in equation 2. In using this approach, the ordering of the variables in $x_{i,t}$ becomes important. The identifying assumption used in this case is that each variable in $x_{i,t}$ affects the variables that appear below it contemporaneously, as well as with a lag, but only affects the variables above it with a lag. More specifically, it assumes that the contemporaneous causal order runs from the GDP of high income countries, to the US Libor rate, to commodity price index for each country. The most endogenous variable is real per capita GDP in each country which is affected by all of the variables appearing before it in the VAR. This includes government spending and aggregate investment. This causal ordering means, for example, that the residual from the first equation of the RVAR, e_{GDPHt}, contains only the orthogonalised shock of high income country GDP, ϵ_{GDPHt}.

The ordering of the commodity price index ($CPIND$) after the global economic indicators ($GDPH$ and $LIBOR$) means that commodity prices are assumed to only affect rich country GDP and the US Libor rate with a lag. Given, that this assumption is unlikely to hold in practice I explore an alternative identification strategy in the following section.

Placing $CPIND$ before individual countries' economic indicators (G, I, $INFL$ and $RGDPPC$) means that commodity prices are not affected by the present economic performance of the low-income country (government spending, investment and GPD). This is the small country assumption. I appeal to two arguments in support of this assumption. First, none of the countries included in our sample are large enough exporters of any individual commodity to have an affect on global prices[5]. And second, the construction of the commodity price index $CPIND$ is such that any risk of contemporaneous correlation between it and national economic conditions is minimized. One concern is that current per capita GDP of the low income country may be affected directly by the level of exports (and commodity exports in particular). If commodity exports are used in the denominator of the weighted price index, as is often the case in studies of natural resource shocks, this would likely violate the contemporaneous homogeneity assumption from $RGDPPC$ to the commodity $CPIND$. The approach taken here is to use historical commodity deposits rather than current commodity exports to weight each price index. The construction of the commodity price index is discussed in detail in section 3.

Block Recursiveness

The second approach involves splitting the VAR into two blocks and applying the recursivenss assumption to the blocks, rather than the specific variables. This is known in the literature as 'Block recursivenss'. The partitioning of the model here is done along the national-international line. That is, in the first block I place the three international, or global, macroeconomic variables, whilst national variables, such as GDP, investment and government spending, enter in the second block.

Identification via block recursiveness implies that the B^{-1} matrix is no longer lower triangular. Instead the zero restrictions are located in the upper right corner as follows:

[5]The list of the 28 countries included in the panel is discussed in the data section and I believe that this assumption is likely to hold in our sample. No countries have been removed.

$$
\begin{bmatrix} e_{GDPHi,t} \\ e_{LIBORi,t} \\ e_{CPINDi,t} \\ e_{Gi,t} \\ e_{Ii,t} \\ e_{INFLi,t} \\ e_{RGDPPCi,t} \end{bmatrix} = \begin{bmatrix} 1 & b_{12} & b_{13} & 0 & 0 & 0 & 0 \\ b_{21} & 1 & b_{23} & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & b_{45} & b_{46} & b_{47} \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & b_{56} & b_{47} \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & b_{67} \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & 1 \end{bmatrix} \times \begin{bmatrix} \epsilon_{GDPHi,t} \\ \epsilon_{LIBORi,t} \\ \epsilon_{CPINDi,t} \\ \epsilon_{Gi,t} \\ \epsilon_{Ii,t} \\ \epsilon_{INFLi,t} \\ \epsilon_{RGDPPCi,t} \end{bmatrix} \tag{5}
$$

where, as before, ϵ_{xt} is the structural shocks of interest from equation 1, b_{ij} are the parameters of interest from B^{-1} matrix in the structural panel-VAR model, and e_{xt} are the reduced form errors from estimating the panel-VAR in equation 2. The identifying assumptions made here are less strict than those in the Choleski decomposition case in two ways. First, all of the national level variables are assumed to depend on each other contemporaneously. That is, I make no prior assumptions about which national level variables are pre-determined with respect to each other. And second, I allow the global variables, rich country GDP, the US libor rate and the commodity price indices, to be contemporaneously inter-dependent with each other. The twelve zeros restrictions in the top right corner of the B matrix are the sole restrictions placed on the system, namely that the three global level variables do not respond to the national level macroeconomic conditions contemporaneously. I justify the first eight restrictions ($b_{14} : b_{17} = 0$ and $b_{24} : b_{27} = 0$) using the small country assumption, i.e. each individual country in our sample is not big enough to influence either global demand or global financial conditions. Given that I restrict the sample to low income countries, these restrictions seem plausible. The final four restrictions ($b_{34} : b_{37} = 0$) are that the commodity price indices for each country in our sample does not react to national level economic conditions (specifically, national level GDP, investment, inflation and government spending). The same problems arise as in the Choleski identification strategy.

It is worth noting that while the Choleski decomposition produces a unique solution for the B^{-1} matrix, the Block recursive identification strategy does not. There are potentially an infinite number of rotations of the B matrix that would satisfy the zero restrictions placed on the block recursive model. I use a numeric solver to find a solution that produces sensible IRFs for the effect of global demand and financial conditions on both real per capita GDP and the commodity price index.

Finally, the model in equation 3 is estimated using a single lag. This is done for ease of interpretation of the results, however, higher order lag structures, up to four lags, are also estimated as are a number of lag-order selection statistics for the model. I find that one lag is a reasonable choice for this model.

Step 2: Seemingly Unrelated Panel Fixed Effects Regressions

Having identified the structural commodity price shocks in the panel-VAR, the second step involves taking the orthogonalised commodity price error ($\epsilon_{CPINDi,t}$) and regressing these on the share of value-added in different sectors of the domestic economy. The aim is to investigate the impact of commodity price shocks on the sectoral performance of low-income, resource-rich economies. The hypothesis is that, if a Dutch disease mechanism is at work, in which resource booms lead to a loss of international competitiveness, then these shocks, as proxied by shocks to the country specific commodity price index, should have a differential impact on the share of value-added in sectors that are more or less *exportable*. This follows from work by Rajan & Subramanian (2011) who find that aid inflows adversely affect manufacturing sectors that are more exportable and that this works through an appreciation of the real exchange rate.

I use a seemingly unrelated regression equations (SURE) framework which assumes that the error terms are correlated across equations. This is important as the residuals from the sectoral regressions are unlikely to be independent.

$$\begin{aligned} y_{i,j,t} = & \alpha + f_i + \eta_t + \beta_1 GDPH_t + \beta_2 LIBOR_t + \beta_3 G_{i,t} + \beta_4 I_{i,t} \\ & + \beta_5 K_{i,j,t} + \beta_6 L_{i,j,t} + \beta_7 y_{i,j}^{ini} + + \beta_8 CSHOCK_t + \epsilon_{i,t} \end{aligned} \tag{6}$$

where $GDPH$, $LIBOR$, G and I are defined as before, $y_{i,j,t}$ is the share of real value-added in sector j of country i at time t in total real value-added, $K_{i,j,t}$ is the log of real gross fixed capital formation in sector j of country i at time t, $L_{i,j,t}$ is the number of employees in that sector, $y_{i,j}^{ini}$ is the initial share of real value-added, f_i are country fixed effects, η_t are year fixed effects, and $CSHOCK_{i,t}$ is the orthogonalised error ($\epsilon_{CPIND,t}$) from the panel-VAR model for country i at time t, scaled by the standard deviation of the shocks. Here, the structural error can be thought of directly as the exogenous component of commodity price shocks. The dependent variable $y_{i,j,t}$ is the share of real value-added in sector j of country i at time t in total real value-added. The sign and size of the coefficient β_8 for each sector will highlight the existence or otherwise of potential de-industrialisation effects from positive commodity price shocks.

3 Weighted Price Index

The construction of the export weighted commodity price index ($CPIND$) deserves further explanation. The aim is to construct a country specific commodity price index which measures the exposure of each low income country to movements in various global commodity prices, but which doesn't violate the contemporaneous exogeneity assumption between the commodity price index and income levels ($b_{34} : b_{b3} = 0$).

I construct an annual commodity price index ($PIND_{c,t}$) using UNCTAD commodity data for nine minerals[6] and EIA data for oil and gas prices, were 2010 = 100. Changes in commodity

[6]These are: gold, silver, tungsten, iron, copper, lead, nickel, tin and zinc

prices may affect low income commodity exporters differently depending on the importance of these commodities in the economy. The problem with simply weighting the commodity price index by the share of that commodity in exports or GDP, is that this scaling exercise implies that this variable is no longer independent of economic policies and institutions and so potentially endogenous to domestic economic conditions. Instead, I construct a weight for each commodity and country which is equal to the value of commodity reserves as a proportion of GDP in 1985. The key is that this *1985 reserve-GDP weight* is independent of economic policy and institutions from 1985 onwards and is thus exogenous to local economic conditions. This weight is held constant over time and constructed as follows:

$$w_{c,i}^{1985} = \frac{p_c^{1985} r_{c,i}^{1985}}{Y_i^{1985}} \tag{7}$$

where p_c^{1985} is the price of commodity c in 1985, $r_{c,i}^{1985}$ is the volume of reserves of commodity c in country i in 1985, and Y_i^{1985} is nominal GDP in country i in 1985. One problem with using 1985 reserve directly, is that the discovery of subterranean natural resources is likely to be endogenous to local economic and political conditions. New discoveries post-1985 are more likely to occur in countries that have favourable economic conditions. The risk is that, by ignoring these newly discovered reserves, we risk over-estimating the impact of commodity price shocks, which are weighted by reserves, on growth.

To deal with this, I construct an estimate of commodity reserves in each country in 1985 by summing up the annual production over the period and adding this to the 2013 estimate of sub-soil commodity reserves from the IntierrarRMG database. The definition of $r_{c,i}^{1985}$ is therefore given by:

$$r_{c,i}^{1985} = r_{c,i}^{2013} + \sum_{t=1985}^{2013} y_{c,i}^{t} \tag{8}$$

where $r_{c,i}^{2013}$ is the volume of reserves of commodity c in country i in 2013, and $y_{c,i}^{t}$ is the production of commodity c in country i at time t. I then apply these weights to the annual price index $pind_{c,t}$ for each commodity (c) in each year (t). This forms the *1985 reserve-GDP weighted commodity price index* for each commodity produced in each country, which is summed over all commodities to produce a reserve-GDP country commodity price index ($CPIND_{i,t}$) as follows:

$$CPIND_{i,t} = \sum_{c=1}^{c=13} w_{c,i}^{1985} pind_{c,t} \tag{9}$$

This allows the effect of commodity prices shocks to be larger for countries in which commodities represent a larger share of GDP, as measure by the size of their commodity reserves in 1985.

4 Data

Sources

The analysis in this paper makes use of data from a number of different sources: United Nations (UN) Statistics, United Nations Industrial Development Organisation's (UNIDO) INDSTAT2 database, UN Conference on Trade and Development (UNCTAD), International Monetary Fund (IMF) World Economic Outlook (WEO), IMF International Financial Statistics (IFS), World Bank (WB) World Development Indicators (WDI), The Penn World Tables 6.2 (PWT), The Natural Resource Governance Institute, US Energy Information Agency (EIA) and Intierrar-RMG.

I categorise a country as being resource-rich based on the IMF's definition. According to the IMF, a country is defined as resource-rich if it has either natural resource revenue or exports at least 20 percent of total fiscal revenue or total exports, on average, over the period 2006 to 2010[7]. There are 51 countries classified as resource rich. In addition, I add 12 countries who have recently discovered substantial natural resource reserves but where production may not yet have begun[8]. I also include 9 countries where, according to the Natural Resources Governance Institute, minerals hold great potential for future fiscal revenue[9]. This gives a total of 72 resource-rich countries.

I classify countries as low-income using data on real GNI per capita using the World Bank Atlas method. These are countries whose real GNI per capita in 1970 was below the equivalent of 1,045 USD in the 2015 fiscal year. Of the 72 resource-rich countries, 46 are classified as low-income according to this definition.

Data on the sectoral breakdown of value added, employment and gross fixed capital formation comes from the United Nations (UN) database on National Accounts Estimates of Main Aggregates and UNIDO. The National Accounts data records the value added by industry according to International Standard Industrial Classification of All Economic Activities (ISIC), revision 4, 1-digit codes. The data is only available for the main groups and some categories are grouped together. The data covers 7 sectors[10] in 211 countries from 1970 to 2012. UNIDO provides a disaggregation of value-a added, employment and gross fixed capital formation by sub-sector within manufacturing. I use the INDSTAT2 database. This data covers 24 sectors in 166 countries from 1962 to 2013, although coverage by sub-sector is patchy.

[7]Gabon and Equatorial Guinea are included because of CEMAC monetary union membership; while Liberia, Niger, Cote d 'Ivoire and Uzbekistan are included in spite of incomplete data availability

[8]These are: Sierra Leone, Afghanistan, Madagascar, Mozambique, CAR, Uganda, Tanzania, Togo, Kyrgyz Republic, Sao Tome and Principe, Ghana and Guatemala

[9]These are: Cambodia, Colombia, Egypt, India, Myanmar, Morocco, Philippines, South Sudan and Zimbabwe

[10]The sectors are: Agriculture, hunting, forestry, fishing (ISIC A-B); Mining, Manufacturing, Utilities (ISIC C-E); Manufacturing (ISIC D); Construction (ISIC F); Wholesale, retail trade, restaurants and hotels (ISIC G-H); Transport, storage and communication (ISIC I); Other Activities (ISIC J-P).

Rich country GDP, which covers advanced economies[11] only, as well as data on the US Libor rate and the US deflator, comes from the IMF's WEO database from 1980 to 2013. Data on the real exchange rate, inflation, population, T-bill rate, real per capita GDP in PPP terms for each low income country also comes from the WEO, also from 1980 to 2013.

Purchasing power parity (PPP) conversion factors and nominal exchange rates for the calculation of the real exchange rate and over valuation measure come from the Penn World Tables version 6.2.

Annual production of natural gas and oil comes from the US Energy Information Administration (EIA) and covers 208 countries from 1980 to 2013. The EIA also provides a time series of gas prices from 1922, and crude oil prices from 1986.

Data on individual mineral production and reserves comes from the IntierraRMG database on mining intelligence. The Database includes annual production, at the mine level, from 1984 to 2013 as well as reserve data at the mine level for 2013. This data is aggregated up to the national level, and reserves in 1985 are calculated by adding the cumulative annual production to the reserves remaining in the ground in 2013, as discussed in above. The RMG database also includes data on major mineral prices, but only from 1992 onwards. Instead I use commodity price data from UNCTAD from 1960 - 2013[12]. The minerals for which I have production, reserves and prices for are: gold, silver, platinum, palladium, aluminium, iron, copper, lead, nickel, tin, zinc, diamonds and tungsten[13].

Summary Statistics

Of the original available sample of 46 low-income, resource-rich countries, 16 are dropped from the analysis due to insufficient data. Table 1 shows the list of 30 countries used in the paper for which there is sufficient coverage of all relevant variables from the various data sources. Given the original available sample of 46 low-income, resource-rich countries, this means that 16 countries are dropped from the analysis due to insufficient data. Of the 30 countries, half are in Sub-Saharan Africa, 8 are in Latin America or the Caribbean, 4 are in North Africa or the Middle East and 3 are in Asia (East or South). The majority, 12, are LMICs today (according to their per capital GNI in 2013), with 8 UMICs and 2 HICs. 8 of the countries remain LICs today.

The table also summarizes the main variables used in the analysis for each country (first panel) and across income groups (second panel). These are growth in: the reserve-GDP weighted

[11] Composed of 35 countries: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, San Marino, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China, United Kingdom, and United States.

[12] Price data for Palladium and platinum are not available from UNCTAD so I use data from the RMG database instead

[13] The diamond price is calculated by dividing production quantity by production value - thus specific to each country

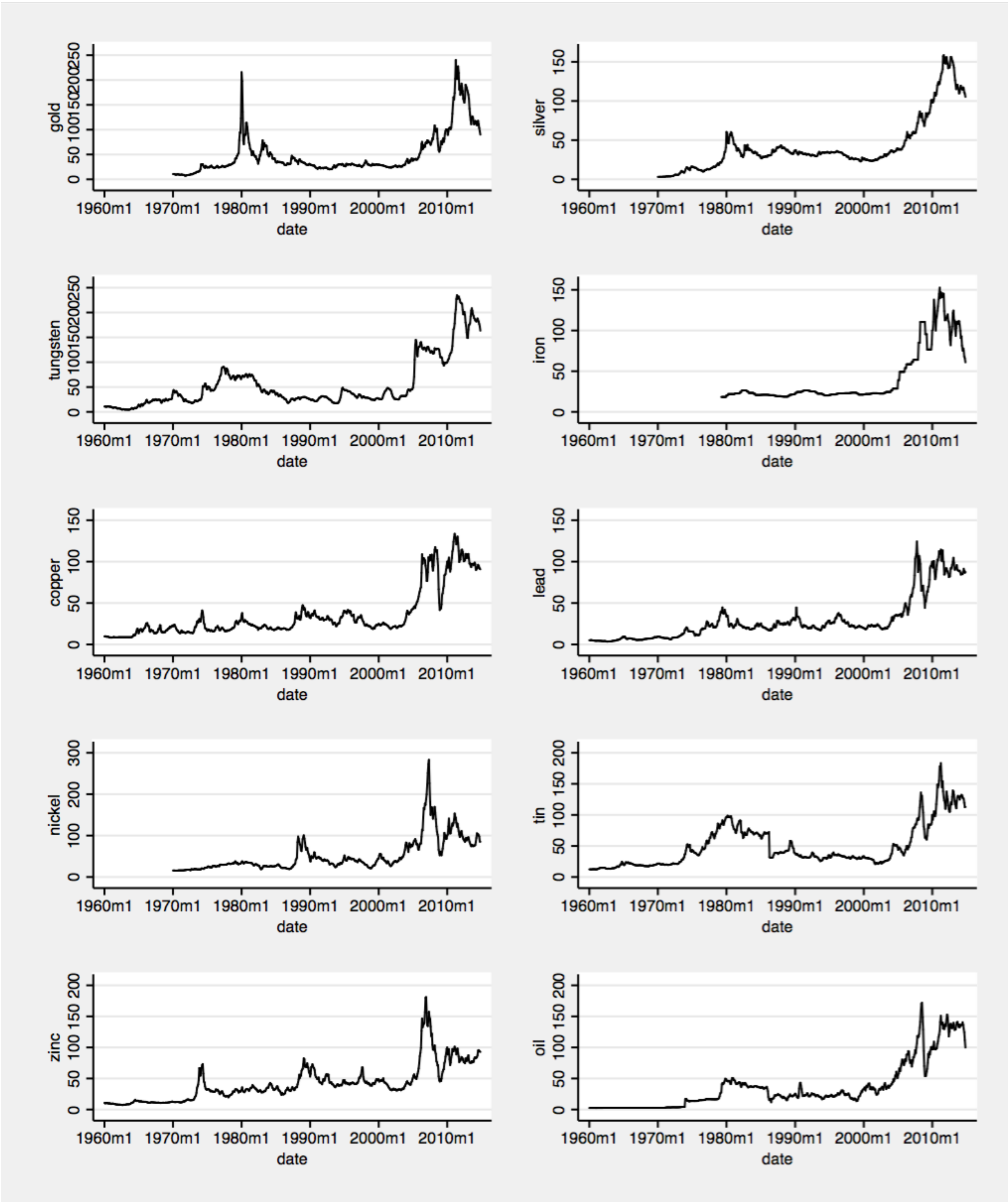
commodity price index, real government expenditure, real fixed capital formation, inflation (as measured by the GDP deflator), and real per capita GDP.

The first point to note is that the majority of countries in our sample are no longer low-income countries. That is to say, many of the resource-rich countries who were poor in 1970 have in fact managed to foster sufficient economic growth to move themselves out of low-income country status. Clearly, the countries who have grown faster over the period are now richer, as is reflected in the average growth rates by income group. However, those countries that have remained poor have not only grown at a slower pace over the period, but this growth has been much more volatile than any other group. Second, the countries that have remained poor have also experienced the largest declines in government expenditure on average. Those that have managed to achieve middle income country status have seen government expenditure fall by far less over the period. Only the high income country group have had positive growth in government expenditure. Finally, it would appear that the low growth rates observed in low-income countries does not appear to have been due to low levels of investment. Investment, as measured by the growth in real fixed capital formation, has actually been relatively high in the low-income country group at around 7.2% per annum on average. However, this investment has been extremely volatile over the period.

The monthly evolution of commodity prices over the period 1960-2013 for the nine mineral commodities, plus oil[14], used in this paper are given in figure 1. The first thing to note is the significant amount of volatility in each of the series over the time period. Second, there appear to be three periods in which the commodity price series' display common shocks. These are around 1980, 1990 and 2008, all of which correspond to major global economic crises. It is important that, when using commodity prices as a proxy for commodity shocks, these potentially demand driven movements in commodity prices are dealt with appropriately.

[14] I do not have monthly prices for natural gas, only annual prices

Figure 1: Commodity Prices - 1970-2013



Notes: Monthly commodity price index calculated using commodity price data from UNCTAD for the following commodities: gold, silver, tungsten, copper, lead, iron, nickel, tin, zinc and oil. Monthly price index for gas not available.

Table 1: Sample of countries included in the PVAR with summary statistics

Country	Region	2013 income group	no. of obs	year		Mean real GDP per capita growth		Mean price index growth		Mean real gov expenditure growth		Mean real investment growth		Mean inflation	
			count	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Indonesia	East Asia & Pacific	Low income	28	1986	2013	0.0363	0.0408	0.0532	0.1281	-0.0359	0.3323	0.0609	0.1131	12.252	13.138
Philippines	East Asia & Pacific	Lower middle income	28	1986	2013	0.0198	0.0228	0.0532	0.1281	0.0251	0.1137	0.0508	0.0808	6.937	4.461
Bolivia	Latin America & Caribbean	Lower middle income	27	1986	2012	0.0150	0.0190	0.0612	0.1277	-0.0576	0.3167	0.0569	0.1213	17.209	42.845
Chile	Latin America & Caribbean	High income	28	1986	2013	0.0392	0.0261	0.0532	0.1282	0.0096	0.0972	0.0836	0.1018	9.484	7.602
Colombia	Latin America & Caribbean	Upper middle income	13	2001	2013	0.0272	0.0171	0.0450	0.3498	0.0500	0.1061	0.0954	0.0517	5.352	1.772
Ecuador	Latin America & Caribbean	Upper middle income	28	1986	2013	0.0120	0.0260	0.0482	0.2625	0.0296	0.0872	0.0380	0.0923	3.274	10.231
Guatemala	Latin America & Caribbean	Lower middle income	28	1986	2013	0.0112	0.0125	0.0532	0.1282	-0.0189	0.2012	0.0426	0.0894	10.362	10.530
Mexico	Latin America & Caribbean	Upper middle income	28	1986	2013	0.0089	0.0313	0.0532	0.1282	-0.1055	0.2825	0.0331	0.0964	23.189	32.909
Peru	Latin America & Caribbean	Upper middle income	28	1986	2013	0.0205	0.0571	0.0532	0.1282	-0.4046	1.0169	0.0889	0.1728	356.014	N/A
Trinidad And Tob	Latin America & Caribbean	High income	18	1991	2008	0.0461	0.0395	0.0823	0.2167	0.0164	0.1044	0.0658	0.2783	7.069	7.187
Algeria	Middle East & North Africa	Upper middle income	24	1986	2009	0.0039	0.0287	0.0464	0.1168	-0.0894	0.2343	0.0224	0.0863	13.938	13.622
Egypt	Middle East & North Africa	Lower middle income	28	1986	2013	0.0240	0.0162	0.0533	0.1278	-0.0407	0.1228	0.0165	0.1023	10.713	6.218
Iran	Middle East & North Africa	Upper middle income	19	1986	2007	0.0143	0.0574	0.0672	0.2680	-0.1578	0.2035	0.0324	0.1122	20.460	7.972
Morocco	Middle East & North Africa	Lower middle income	27	1986	2012	0.0229	0.0446	0.0615	0.1225	0.0501	0.0604	0.0475	0.0529	3.245	3.207
India	South Asia	Low income	28	1986	2013	0.0445	0.0229	0.0530	0.1288	0.0052	0.0951	0.0775	0.0620	7.255	2.551
Botswana	Sub-Saharan Africa	Upper middle income	27	1986	2012	0.0365	0.0438	0.0615	0.1228	-0.0022	0.1373	0.0804	0.0889	9.600	5.410
Cameroon	Sub-Saharan Africa	Lower middle income	27	1986	2012	-0.0113	0.0404	0.0503	0.2671	0.0266	0.2268	0.0149	0.1326	3.200	4.414
Cote d'Ivoire	Sub-Saharan Africa	Lower middle income	20	1986	2005	-0.0126	0.0285	0.0169	0.1006	-0.0205	0.2693	-0.0134	0.1350	4.133	10.631
DRC	Sub-Saharan Africa	Low income	16	1994	2009	-0.0173	0.0457	0.0622	0.1227	-1.0894	1.9730	0.0349	0.1332	N/A	N/A
Gabon	Sub-Saharan Africa	Upper middle income	22	1986	2007	-0.0085	0.0626	0.0441	0.2626	-0.0238	0.2650	-0.0101	0.2785	5.275	14.703
Liberia	Sub-Saharan Africa	Low income	12	2001	2012	0.0419	0.1625	0.1310	0.2458	0.0840	0.3851	0.0242	0.5389	8.059	8.334
Madagascar	Sub-Saharan Africa	Low income	24	1986	2009	-0.0068	0.0473	0.0456	0.3724	-0.0820	0.3009	0.0699	0.2231	14.788	9.989
Mali	Sub-Saharan Africa	Low income	27	1986	2012	0.0180	0.0354	0.0615	0.1225	0.0390	0.3016	0.0775	0.2574	4.031	7.180
Mauritania	Sub-Saharan Africa	Lower middle income	14	1999	2012	0.0185	0.0468	0.1240	0.1065	0.0060	0.1216	0.1570	0.3270	6.594	8.181
Mozambique	Sub-Saharan Africa	Low income	27	1986	2012	0.0389	0.0415	0.0021	0.2726	-0.1751	0.4650	0.0868	0.1492	28.382	36.820
Nigeria	Sub-Saharan Africa	Lower middle income	8	2006	2013	0.0340	0.0136	0.0834	0.2463	0.0618	0.2372	0.1299	0.2554	19.638	34.567
Rep Congo	Sub-Saharan Africa	Lower middle income	26	1986	2011	-0.0037	0.0385	0.0519	0.2724	0.0025	0.2874	0.0188	0.2397	6.719	17.836
Sierra Leone	Sub-Saharan Africa	Low income	24	1986	2011	0.0014	0.0729	0.0766	0.1791	-0.2193	0.3818	0.1388	0.9614	40.431	42.339
Sudan	Sub-Saharan Africa	Lower middle income	23	1986	2008	0.0282	0.0397	0.0439	0.1202	-0.2592	0.5184	0.0925	0.1499	43.342	43.071
Zambia	Sub-Saharan Africa	Lower middle income	28	1986	2013	0.0049	0.0381	0.0533	0.1278	-0.2425	0.4403	0.1027	0.1716	42.095	42.328
Total			705	1986	2013	0.0166	0.0465	0.0551	0.1869	-0.0839	0.4738	0.0585	0.2421	71.795	N/A

2013 Income group	Number of countries	no. of obs	year		Mean real GDP per capita growth		Mean price index growth		Mean real gov expenditure growth		Mean real investment growth		Mean inflation	
		count	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
LIC	8	22	1990	2011	0.0127	0.0675	0.0632	0.2192	-0.2405	0.6346	0.0720	0.3772	19.1382	N/A
LMIC	12	24	1988	2012	0.0165	0.0303	0.0580	0.1523	-0.0356	0.2388	0.0611	0.1452	13.8351	17.4270
UMIC	8	24	1988	2011	0.0143	0.0405	0.0524	0.2049	-0.0880	0.2916	0.0476	0.1224	N/A	N/A
HIC	2	23	1989	2011	0.0427	0.0328	0.0678	0.1725	0.0130	0.1008	0.0747	0.1901	8.2767	7.3943

* investment is given by fixed capital formation

5 Panel-VAR Estimation Results

This section presents the results from estimating the panel-VAR model in equation 3. The model is estimated using all available data for the 30 low-income, resource-rich countries in our dataset, covering the period 1985-2013. The average number of years for for which data exists for each country is 24, giving 704 observations in total. Of these, some observations (and their lags) are used as instruments in the GMM estimation and so the sample size is reduced slightly to 643.

The following two figures present the IRFs for various shocks identified using the Choleski and Block rescursiveness strategies. Only selected IRFs are presented here and confidence intervals are left our for ease of viewing. Note however, that all of these IRFs are statistically significant at the 5% level or better[15] As most of the variables in the model are in log differences, the IRFs show the log deviations of each variable. The IRFs are scaled by the standard deviation of the shocks, and so they represent responses of variables to shocks of the order of magnitude often seen in practice. Each panel plots the dynamic response of one variable to a one standard deviation shock to another.

Choleski

Figure 2 presents the orthogonalised and cumulative impulse response functions (IRFs) from the applying the Choleski decomposition. Panel (a) shows the own IRF for the country specific reserve-GDP weighted commodity price index ($CPIND$), that is, the dynamic response of the index to a single period one-standard shock to itself. We see that the bulk of the effect of shocks on the price of commodities produced by low-income, resource rich, countries tend to last no more than about one year on average.

Panels (b) and (c) show the dynamic response of the commodity price index ($CPIND$) to a one standard deviation impulse to advanced economy real GDP ($GDPH$) and the US Libor rate ($LIBOR$) respectively. These two panels correspond to the dynamic response of commodity prices to shocks in aggregate global demand and global financial conditions. As expected, a one standard deviation increase in global aggregate demand (or around 5.4%), leads to an immediate and statistically significant increase of the average commodity price index for low-income countries of just under 30%; a one standard deviation shocks to the 3-month US Libor rate (or an increase of around 2.6 percentage points), which proxies for the actual cost of borrowing for LICs, leads to an immediate fall in commodity prices by around 1.2%. This is likely due to the fact that in normal times, the US Libor rate will move with the Federal Funds rate. Any positive shock to this rate will result in lower demand holding supply constant, and so lower commodity prices. The dynamic response of commodity prices to global demand shocks lasts

[15] The full set of IRFs are presented in the appendix along with 95% confidence bands which are generated by Monte Carlo simulation with 100 simulations. The process involves randomly generate a draw of coefficients of A_0 and A_1 from equation 2 using the estimated coefficients and their variancecovariance matrix and re-calculate the impulse-responses. This process is repeated 100 times and the 5th and 95th percentiles of the distribution of coefficients are used to generate the confidence interval for the IRFs. I re-estimate the model with 1,000 and 10,000 simulations and the confidence intervals remain largely unchanged.

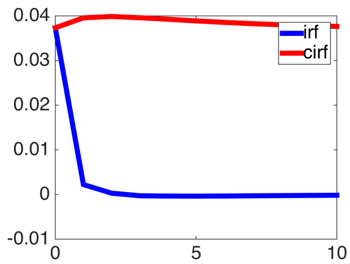
for around 3 years.

Panel (d) shows the response of real per capita GDP ($RGDPPC$) to a shock in the commodity price index ($CPIND$). A one standard deviation increase in the commodity price index (just over 19% on average) results in an increase in real per capita GDP in the following period of just under 0.002%. Income growth remains above its baseline level for around 3 years following a commodity price shock, before returning to their pre-shock level. This is a particularly small effect.

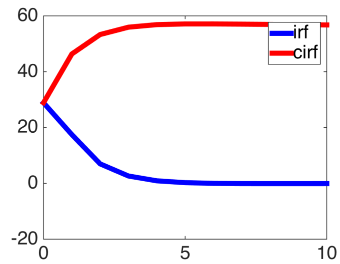
The remaining panels, (e) through (g), show the response of government spending (G) and fixed investment (I) to the same commodity price shock. We see that the same positive commodity price shocks result in higher government expenditure and aggregate investment, and lower inflation. From panel (d) we see that a one standard deviation increase in $CPIND$ results in a statistically significant increase in real government expenditure (G) of 0.015% in the following period. Government expenditure remains above its baseline level for at least 4 years following a commodity price shock. Finally, from panel (e) we see that the same commodity price shock results in an increase in real capital formation (I) of around 0.006%. Investment then returns quickly to its baseline level in year 2, but remains volatile as a result for at least four years.

Figure 2: Panel VAR IRFs - Choleski

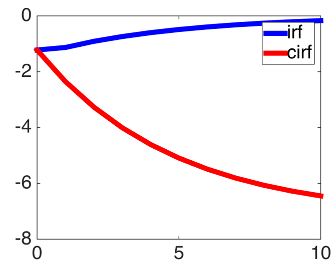
(a) imp: cpind - resp: cpind



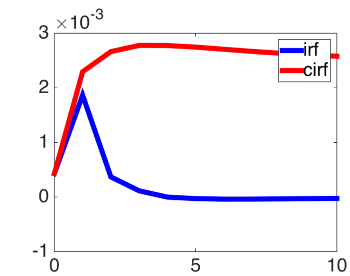
(b) imp: gdph - resp: cpind



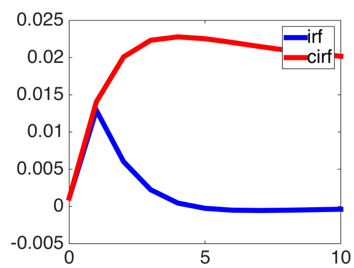
(c) imp: libor - resp: cpind



(d) imp: cpind - resp: rgdppc



(e) imp: cpind - resp: g



(f) imp: cpind - resp: i

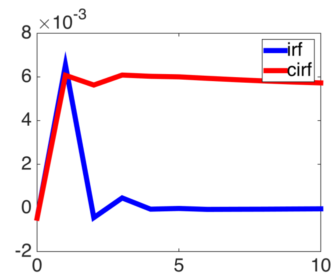
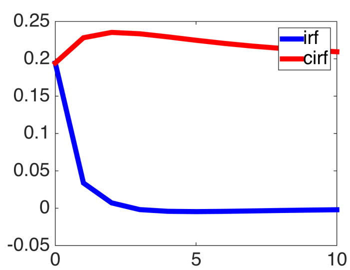
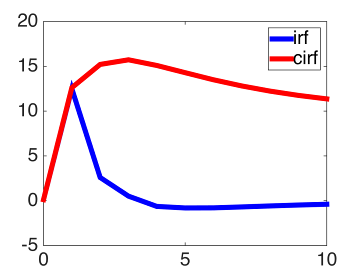


Figure 3: Panel VAR IRFs - Block Recursiveness

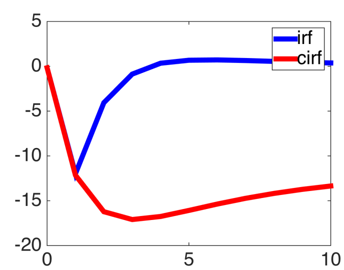
(a) imp: cpind - resp: cpind



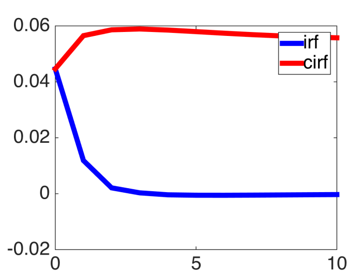
(b) imp: gdph - resp: cpind



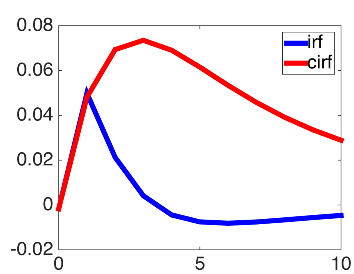
(c) imp: libor - resp: cpind



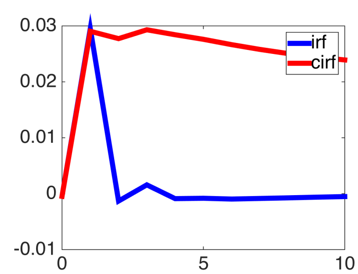
(d) imp: cpind - resp: rgdppc



(e) imp: cpind - resp: g



(f) imp: cpind - resp: i



Block Recursiveness

Figure 3 presents the same IRFs as above, but now using the block recursiveness restriction rather than Choleski to retrieve the structural shocks to the panel-VAR system. The results suggest that the Choleski and the Block recursive identification strategies largely agree on the direction, and in some cases the magnitude, of the response key variables to various shocks. However, the Block recursive strategy yields larger responses of GDP, government spending and investment to commodity price shocks. Given the more plausible restrictions placed on the B^{-1} matrix under Block recursiveness, the difference in the IRFs is evidence that the simple recursive ordering approach vastly underestimates the impact of commodity price movements on macroeconomic conditions in resource rich, low-income countries.

Panel (a) shows the own IRF for the commodity price index ($CPIND$). Using a block recursive identification strategy leaves the size of the average structural commodity price shock for low income, resource rich economies, unchanged. Again, the bulk of the effect of the shock is eliminated after 3 years.

The dynamic response of commodity prices to shocks in aggregate global demand and global financial conditions however, are altered slightly under the Block recursive identification strategy. From panels (b) and (c) we see that shocks to aggregate global demand and tighter financial conditions still move the commodity price index for low-income countries in the expected directions, but the magnitudes over the 2-3 years move in different directions. A positive shock to global aggregate demand ($GDPH$) of one standard deviation, or 5.4%, leads to a 12.5% increase in in the commodity price index ($CPIND$) in the following period, less than half the size of the impact under Choleski, whilst a one standard deviation shock in the 3-month US Libor rate ($LIBOR$), around 2.6 percentage points, leads to an immediate fall in commodity prices by around 12%, a substantially larger response than under Choleski. The duration of the impact of these shocks on commodity prices are also much more short lived.

Despite the similar magnitude and profile of the structural commodity price shocks, the Block recursive identification yields a much larger and persistent IRF for the impact of a commodity price shocks on low income country real per capita GDP. Panel (d) of figure 3 shows that a one standard deviation increase in the commodity price index (an increase of around 19% on average) leads to an immediate increase in per capita GDP of around 0.04%. This is substantially larger than the 0.002% estimated from the Choleski identification. The positive effect on income levels is eliminated after 2 years.

Panels, (e) through (g) of figure 3, show the response of government spending (G) and fixed investment (I) to the same commodity price shock under Block recursiveness. The direction of the IRFs are all in agreement with the results from the Choleski identification strategy, however the magnitudes of the responses are all substantially larger. From panel (d) we see that a one standard deviation increase in $CPIND$ results in a statistically significant increase in real government expenditure (G) of 0.05% in the following period. From panel (e) we see that the same commodity price shock results in an increase in real capital formation (I) of around 0.03%. Investment then returns quickly to its baseline level in year 2, but remains volatile as a result for at least four years.

Extensions

One concern may be the inclusion of OPEC members in the analysis[16], who are likely to set their oil production levels strategically in response to the oil price. I therefore re-estimate the IRFs without OPEC members. The results are presented in figures 4 and 5 in the appendix. The results change somewhat depending on the identification strategy and specific IRF, but broadly speaking the IRFs are in terms of direction and magnitude with the full sample IRFs presented here.

I also explore the link between countries' exposure to commodity price shocks and the magnitude of the dynamic responses of macroeconomic variables to these shocks. We may expect the size of the response to depend on the importance of these exports to each economy. Countries with larger resource exports should have a larger IRFs. I investigate this by splitting the sample of countries into three groups: (i) those with no natural resource exports in 2013, (ii) those with moderate levels of resource exports (between zero and $US 10 million in 2013), (iii) and those with great high levels of resource exports, (above $US 10 million). Specifically, I compare the magnitude of the response of real per capita GDP levels to shocks in the commodity price index between these three groups. The results, reported in figures 6 and 7 in the appendix, appear to support this. This is particularly visible in the Block recursive IRFs presented in figure 7 where the size of the immediate response of real GDP per capita to a one standard deviation commodity price shock increases from -0.13% for group (a) to 0.02% for group (b) to 0.07% for group (c).

6 Sectoral Regression Results

This section investigates the impact that resource booms have on the sectoral structure of resource rich, low income economies. The aim here is to test the hypothesis that resource booms lead to a surge in demand for non-tradables and so a re-allocation of economic activity away from more exportable sectors. Whether this is due to a simple sending effect or a combination of this and a real exchange rate effect will be investigated further in the following section.

I present the results from estimating the SURE fixed effects model in equation 6. The Block recursive orthogonalised structural shocks[17] for the commodity price index ($\epsilon_{CPINDi,t}$) from the panel-VAR model in the previous section are included as a regressor in the model with up to

[16]The OPEC memebrs included in the dataset are: Algeria, Ecuador, Gabon, Indonesia, Iran, Nigeria and Saudi Arabia, although Gabon, Ecuador and Indonesia all suspended the membership at some point over the period from 1985 to 2013.

[17]The results from estimating these regressions using the structural shocks from the Choleski decomposition are presented in the Annex. The results largely agree, albeit with smaller coefficient estimates

three lags. The dependent variable ($y_{i,t,j}$) is the share of real-value added in sector j of country i at time t in total real value added. The commodity shock variable is scaled by its standard deviation, and so the coefficient estimates show the effect of an *exogenous commodity price shock* equivalent to one standard deviation, or a 19% increase.

Table 1 below presents the results from estimating the model using data on real value-added from the UN National Accounts Estimates of Main Aggregates Database. Sectoral gross capital formation ($K_{i,t}$) and employment ($L_{i,t}$) are omitted from the regression due to lack of data. This data breaks total value-added into seven sectoral categories which correspond roughly to the ISIC 1-digit codes. Columns 1 to 7 in present the results of the model for each sector. The sectors are:

1. Agriculture, hunting, forestry, fishing (ISIC A-B) (*agric*)
2. Mining, Utilities (ISIC C-E) (*min*)
3. Manufacturing (ISIC D) ($manuf$)
4. Construction (ISIC F) (*constr*)
5. Wholesale, retail trade, restaurants and hotels (ISIC G-H) (*whole*)
6. Transport, storage and communication (ISIC I) (*trans*)
7. Other Activities (ISIC J-P) (*other*)

The first point to note is the slight reduction in sample size, compared to the panel-VAR, for the various regressions at the 1-digit sectoral level. This is due to missing data on value added at the sectoral level for some countries included in the analysis. The estimates for real value-added cover 30 countries with around 16 years of data for each, giving 570 observations in total.

Positive commodity price movements are associated with contractions in the share of value added in the manufacturing sector, expansions in the transport and other[18] sectors, but no effect on agriculture as a whole. A one standard deviation, or 19%, exogenous increase in the country specific commodity price index results in an immediate reduction in the manufacturing sector of around 0.25 percentage points (pp). The share of value-added in the transport sector increases by 0.12 pp immediately, and a 0.15 pp after two to three years, whilst the share of value-added in the other sectors, which consists of a number of non-tradable goods and services, increases by 0.31 pp after one year. These results lend some support to previous empirical findings of a de-industrialisation process following positive resource shocks.

Table 2 below investigates further this decline in the manufacturing sector. It presents the results from estimating the model with the dependent variable now the share of real value-added

[18]The other category includes: Financial intermediation (ISIC J); Real estate, renting and business activities (ISIC K); Public administration and defence (ISIC L); compulsory social security (ISIC M); Education (ISIC N); Health and social work (ISIC O); Other community, social and personal service activities (ISIC P); and, Private households with employed persons (ISIC Q)

in total value added in each of the twenty-four 2-digit ISIC sectors that make up manufacturing. The data comes from UNDIO. Sectoral gross capital formation ($K_{i,t}$) and employment ($L_{o.t}$) are included, along with the initial share of value-added for each sector at the beginning of the sample period (1984) to control for convergence. Given the large number of missing values for each sector, I aggregate the twenty-four ISIC 2-digit sectors into eight groups as follows:

1. Food and beverages; Tobacco products (*food*)
2. Leather, leather products and footwear; Textiles; Wearing apparel (*textiles*)
3. Printing and publishing; Paper and paper products; Wood products (*printing*)
4. Chemicals and chemical products; Coke, refined petroleum products, nuclear products; Medical, precision and optical instruments; Rubber and plastics products; Non-metallic mineral products (*chemical*)
5. Basic metals; Fabricated metal products (*metal*)
6. Electrical machinery and apparatus; Machinery and equipment; Office, accounting and computing machinery; Radio, television and communication equipment (*electric*)
7. Motor vehicles, trailers, semi-trailers; Other transport equipment (*transport*)
8. Furniture; manufacturing; Recycling (*other*)

Once again, the sample size for these regressions are substantially reduced. The data covers 14 countries[19] with around 12 years each, giving 164 observations. Nevertheless, the results begin to reveal a picture of structural transformation within manufacturing. The industrial sectors which can be thought of as being particularly outward facing (that is, particularly exportable) appear to suffer the most from positive commodity price shocks, whilst those that are typically less exportable benefit (these include: transport, chemical and paper & wood manufacturing).

Following a one standard deviation, or 19%, exogenous increase in the commodity price index for each country, the share of real value-added in the transport manufacturing sector (that is, the production of motor vehicles and transport equipment) declines by 0.7 percentage points (pp) immediately, and by a further 0.35-0.45 pp after 2 to 3 years. The chemical sectors (that is, the production of chemicals, medical instruments, rubbers and other non-metallic products) also decline dramatically, with their share of real-value added falling by 1.25 pp, albeit after three years. The printing sectors (which includes printing and publishing, paper and wood products) is also negatively affected. In contrast, the production of agricultural products, which we might expect to be substantially less tradable, is positively affected by resource booms. The share of value-added increases by over 1.5 pp immediately, following a one standard deviation increase in the country specific commodity price index, and remains larger for up to 3 years following the shock.

Taken together, these results present evidence of a 'de-industrialisation' effect of resource booms in low-income countries. The sectors that appear to benefit most from commodity

[19] These countries are: Bolivia, Cameroon, Chile, Ecuador, Egypt, India, Indonesia, Iran, Madagascar, Mexico, Morocco, Peru, Philippines, Trinidad and Tobago

Table 1: SUREG FE Regression - Sectoral Real Value Added Share - All Sectors

VARIABLES	(1) rva_shareagric	(2) rva_shareconstr	(3) rva_sharemanuf	(4) rva_sharemin	(5) rva_sharetrans	(6) rva_sharewhole	(7) rva_shareother
reah	4.354***	-2.252***	2.214***	-5.018***	0.759**	1.165*	1.658*
	(5.281)	(-8.487)	(3.190)	(-2.645)	(2.187)	(1.950)	(1.806)
rUSlib	0.271**	0.0128	0.0324	0.122	-0.303***	-0.0105	0.173
	(2.367)	(0.277)	(0.388)	(0.556)	(-5.878)	(-0.117)	(1.313)
ln_govexp	-0.864***	-0.208***	-0.168	0.432	0.234***	-0.0620	0.298
	(-5.385)	(-3.261)	(-1.434)	(1.404)	(3.240)	(-0.492)	(1.607)
ln_inv	-1.225***	1.689***	-0.432*	1.561**	-0.408***	-0.186	-0.759**
	(-3.760)	(13.09)	(-1.817)	(2.503)	(-2.792)	(-0.728)	(-2.019)
infl_defl	-0.000117	-0.000146	0.000222	-0.000417	-0.000125	0.000174	0.000560
	(-0.325)	(-1.019)	(0.844)	(-0.604)	(-0.772)	(0.614)	(1.346)
sresid3	0.0351	0.0338	-0.248**	-0.106	0.119*	0.0722	0.148
	(0.260)	(0.632)	(-2.518)	(-0.408)	(1.960)	(0.682)	(0.946)
L.sresid3	-0.120	0.0420	-0.102	-0.369	0.160***	0.117	0.316**
	(-0.916)	(0.806)	(-1.060)	(-1.463)	(2.701)	(1.131)	(2.081)
L2.sresid3	0.0414	-0.0291	-0.0881	-0.514**	0.145**	0.113	0.314**
	(0.323)	(-0.572)	(-0.942)	(-2.094)	(2.512)	(1.126)	(2.120)
L3.sresid3	-0.0158	0.0464	0.0493	-0.440*	0.0352	0.0862	0.183
	(-0.120)	(0.891)	(0.515)	(-1.750)	(0.598)	(0.837)	(1.209)
inirva_shareagric	1.046***						
	(37.45)						
inirva_shareconstr		-0.226***					
		(-7.516)					
inirva_sharemanuf			0.223***				
			(7.383)				
inirva_sharemin				1.026***			
				(21.13)			
inirva_sharetrans					0.840***		
					(40.44)		
inirva_sharewhole						0.296***	
						(6.821)	
inirva_shareother							0.596***
							(12.23)
Observations	577	577	577	577	577	577	577
R-squared	0.979	0.895	0.947	0.956	0.946	0.875	0.930
Labour and Capiital Controls	NO	NO	NO	NO	NO	NO	NO

z-statistics in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

sresid3; Country and year fixed effects included; Low-income, resource rich countries

Table 2: SUREG FE Regression - Sectoral Real Value Added Share - Manufactures

VARIABLES	(1) rva_share_food	(2) rva_share_textiles	(3) rva_share_printing	(4) rva_share_chemical	(5) rva_share_transport	(6) rva_share_other
reah	-13.44***	1.691	0.121	-4.294	-7.193***	-0.641
	(-3.063)	(1.110)	(0.0668)	(-1.039)	(-4.575)	(-1.216)
rUSlib	1.873***	0.988***	0.139	-2.554***	-0.161	0.0812
	(2.975)	(3.478)	(0.498)	(-3.156)	(-0.509)	(0.675)
ln_govexp	2.277***	0.434	0.0353	0.271	-2.497***	0.119
	(3.251)	(1.300)	(0.117)	(0.293)	(-6.931)	(0.967)
ln_inv	-2.286	-2.042***	-1.444**	-1.475	5.309***	0.161
	(-1.506)	(-2.756)	(-2.142)	(-0.720)	(6.649)	(0.562)
infl_defl	-0.00160**	-0.000158	-0.000322	-0.00125	0.00126***	-0.000140
	(-2.403)	(-0.488)	(-1.099)	(-1.397)	(3.679)	(-1.140)
inirva_share_food	1.751***					
	(7.113)					
sresid3	1.645***	-0.140	-0.0559	-0.0289	-0.643**	0.162*
	(3.065)	(-0.541)	(-0.239)	(-0.0411)	(-2.347)	(1.654)
L.sresid3	0.520	0.509**	-0.402*	-0.635	-0.307	0.0684
	(1.006)	(2.010)	(-1.778)	(-0.936)	(-1.171)	(0.732)
L2.sresid3	1.149**	-0.0870	-0.181	-0.136	-0.412	0.138
	(2.174)	(-0.341)	(-0.780)	(-0.194)	(-1.521)	(1.438)
L3.sresid3	1.053*	-0.173	-0.216	-1.326*	0.155	0.0268
	(1.931)	(-0.655)	(-0.907)	(-1.849)	(0.561)	(0.270)
inirva_share_textiles		0.538***				
		(6.078)				
inirva_share_printing			1.075***			
			(3.866)			
inirva_share_chemical				0.624***		
				(8.222)		
inirva_share_transport					0.0222	
					(0.0606)	
inirva_share_other						-0.568**
						(-2.469)
Observations	166	166	166	166	166	166
R-squared	0.922	0.956	0.916	0.852	0.952	0.818
Labour and Capiital Controls	YES	YES	YES	YES	YES	YES

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
sresid3; Country and year fixed effects included; Low-income, resource rich countries; metal and electric manufacturing sectors omitted

booms are transportation, finance, real estate and public administration. This may be due to the complementaries that exist between these sectors and the natural resource sectors in low-income countries. The manufacturing sector as a whole, which is typically thought of as a tradable sector suffers. This may be due to a combination of the 'resource movement' and 'spending effect' channels, in which the tradable nature of manufacturing output leaves the sector susceptible to de-industrialisation pressures following a resource boom. However, disaggregating the value-added of the manufacturing sector into is various components reveals an interesting story. Agricultural products, which we may think of as being less tradable, are positively affected by resource booms whilst the more export oriented manufacturing sectors struggle. I explore one of the channels through which this de-industrialisation effect may operate in the following section; namely, the Dutch disease.

Extensions

As with the IRFs in the previous section, I repeat the above regressions for the non-OPEC sub sample. The results are presented in tables 5 and 6 of the Appendix. Removing the OPEC members from the sample increases the magnitude of point estimate of the effect of commodity price shocks on the share of value added in manufacturing from -0.25 pp to -0.44 pp, in transport from 0.12 pp to 0.22 pp and in other sectors from 0.32 pp to 0.5 pp after a year. Looking within the manufacturing sector, removing the OPEC members results in many of the point estimates becoming insignificant, particularly the effect on value added in food manufactures. It is worth noting however, that the sample size is reduced to 123 observations in these regressions.

Unfortunately, it is not possible to run these regressions by exposure sub-sample as in the panel-VAR and IRF section because the sample sizes become too small.

7 The Dutch Disease Mechanism

So far the results have shown that whilst resource booms are associated with higher levels of income, government spending and investment over the short-run, they also lead to significant re-allocation of economic activity away from tradable sectors. This section explores the possibility of a Dutch disease mechanism at work, in which the real exchange rate appreciates following resource booms thus leading to de-industrialisation. A formal exposition of this link was first presented by Corden & Neary (1982) who argue that resource booms lead to (a) increasing domestic income levels and so an expansion in the demand for non-tradable goods and services, that is a *spending channel*, and (b) a movement of resources, particularly labour, out of the tradable or exportable sector and into the nontradable sector, that is a *resource movement channel*. Both of these channels would lead to an appreciation of the real exchange rate as the price of non-tradables increases relative to tradables to clear the domestic market. This mechanism is more commonly known as the Dutch Disease. The evidence presented in the previous section raises an important question: does the re-structuring of the domestic economy following resource booms operate through a real exchange rate appreciation channel? This section shows that this does appear to be the case. I find evidence of a positive link between exogenous resource shocks and appreciations of the real exchange rate in my sample of resource-rich, low-income countries.

Before presenting the results, I discuss the construction of the measure of real exchange rate appreciation used. The key challenge here is coming up with a way to measure whether the real exchange rare us under or over-valued, and by how much. One problem with using a simple measure of the real exchange rate itself is that as countries develop their real exchange rate is likely to appreciate naturally due to the Balassa-Samuelson effect[20]. I therefore use a measure of real exchange rate 'over-valuation'. Following Rodrik (2008) the measure of over-valuation is based on the departure from long-run purchasing power parity (PPP). It is based on three steps. First, I use data on nominal exchange rates (E) and purchasing power parity conversion factors (PPP) from the Penn World Tables (PWT) version 6.2 to calculate the real exchange rate (e) as follows:

$$\ln e_{i,t} = \ln \left(\frac{E_{i,t}}{PPP_{i,t}} \right) \tag{10}$$

where $e_{i,t}$ is the real exchange rate in country i at time t. Next, I account for the Balassa-Samuelson effect by regressing e on per capita GDP ($rgdppc$) as follows:

$$\ln e_{i,t} = \beta_0 + \beta_1 \ln rgdppc_{i,t} + f_t + \epsilon_{i,t} \tag{11}$$

where f_t are year fixed effects. This regression is run on all 178 countries in the PWT dataset, over the period 1970-2013 for which data exists. The results are shown in column (1) of table 3 below. The estimate of β_1 is -0.12, suggesting a reasonably strong Balassa-Samuelson effect: when incomes rise by 10%, the real exchange rate falls by around 1.2%. Finally, I calculate the index of over-valuation ($overval$) by taking the difference between the real exchange rate and the fitted value from (10) as follows:

$$\ln overval_{i,t} = \ln \bar{e}_{i,t} - \ln e_{i,t} \tag{12}$$

The index of over-valuation is comparable across countries and over time, and controls for the natural relationship between income and the real exchange rate via the Balassa-Samuelson effect.

Finally, in order to asses the link between resource shocks and the real exchange rate, I regress the change in the measure of real exchange rate over-valuation for each country on the exogenous, country specific, commodity shock series shock over the same period ($shock_{i,t}$). The regression equation is as follows:

$$\Delta \ln overval_{i,t} = \alpha + \sum_{j=0}^{3} \beta_j shock_{i,t-j} + \gamma \ln va_{i,t} + f_i + \epsilon_{i,t} \tag{13}$$

where f_i are country fixed effects, va_i is the average real value-added for each country, included to control for the size of the economy, and j indexes the number of lags of the shock

[20] The Balasssa-Smuelson effect is the observation that richer countries have systematically consumer prices and so more appreciated real exchange rates

variable. I estimate equation 13 for the restricted sample of resource-rich, low-income countries. A positive β_j coefficient would mean that positive resource shocks are associated with upward movements in the *overval* measure, and so an overvalued real exchange rate. The results are presented in columns (2)-(4) of table 3.

Table 3: Exploring the Real Exchange Rate Channel

	(1)	(2)	(3)	(4)
VARIABLES	ln_rer	Dln_overval	Dln_overval	Dln_overval
ln_rvatotal		0.00237	0.00168	0.0482
		(0.648)	(0.450)	(1.615)
sresid3		0.0132*	0.0123*	0.0101
		(1.958)	(1.812)	(1.401)
L.sresid3		0.0118*	0.0111*	0.00657
		(1.790)	(1.655)	(0.879)
L2.sresid3		0.0104	0.00902	0.00323
		(1.568)	(1.344)	(0.425)
L3.sresid3		0.0183**	0.0173**	0.0143*
		(2.491)	(2.331)	(1.824)
ln_rgdppc	-0.119***			
	(-31.82)			
ka_open			0.0216	0.0322
			(1.079)	(0.944)
Constant	1.450***	-0.0738	-0.0650	-1.334*
	(48.24)	(-0.838)	(-0.731)	(-1.653)
Observations	6,369	536	519	519
R-squared	0.191	0.030	0.030	0.050
Year FE	YES	NO	NO	NO
Country FE	NO	NO	NO	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Column (2), which omits country and year fixed effects, suggests a strong statistically significant positive link between resource shocks and rate of change of real exchange rate over valuation. A one standard deviation shock to a country's commodity price index results in the real exchange rate appreciating by 1.3% immediately, rising to 1.8% after 3 years.

One concern might be that this result is being driven purely by the large developing economies int he sample who have relatively open capital accounts, thus allowing the nominal exchange rate to move relatively freely. Column (3) adds the Chinn-Ito index of capital account openness[21] as a control (see Chinn & Ito (2006)). The coefficient on the index is not statistically different from zero whilst the effect of the commodity shock on the real exchange rate falls slightly to 1.1% immediately, rising to 1.7% after 3 years. Column (4) adds country fixed effects to the model. The immediate effect of the commodity shock disappears but the effect after 3 years remains significant, although at a slightly lower level of significance, and slightly larger in size at 1.4%.

[21] The Chinn-Ito index is a de jure measure of financial openness, going from 0 to 1, produced by Menzie Chinn at the University of Wisconsin and Hiro Ito at Portland State University.

Extensions

Once again, I repeat the above with OPEC members removed from the sample as well as exploring the possibility of the magnitude of this Dutch disease channel varying depending on the exposure of countries' to commodity markets. Colum (4) of table **??** shows that removing the OPEC members from the sample increases the point estimate of the commodity shock on the change in the real exchange slightly and bring the impact to within one year rather than three. Table 8 shows the estimation of equation 13 for each of the three exposure subsamples; those with (i) zero resource production in 2013, (ii) between zero and $US 10 million, and (iii) over $US 10 million. The effects of commodity price index shocks on movements in the real exchange rate disappear for the first two sub-samples (those with zero or low levels of exposure), whilst countries with high levels of resource production in 2013 experience large real exchange rate overvaluations than the average of the whole sample. The point estimate increases from 1.4% to 12.5% and move from occurring after one year to occurring immediately.

8 Counterfactual Exercise - Nigeria and the Oil Collapse

This paper has argued that exogenous commodity price movements can be used as a proxy for resource shocks in resource rich, low income countries. Over the short run, booms tend to lead to modest increases in income levels, government expenditure and fixed capital investment in these countries. However, they also result in significant short run structural transformation away from 'exportable' sectors towards more 'non-tradable' activities; perhaps as a result of movements in the real exchange rate that undermine competitiveness.

But how large are these effects in practice. To put these results into context, this section analyses the recent oil price collapse at the beginning of 2015. I focus specifically on Nigeria as a major oil exporter in my sample, and construct the implied change in the country specific price index after the shock. The key simplifying assumption I make is that the full oil price movement is treated as a structural oil price shock, and so not due to movements in global demand or financial conditions, I calculate the cumulative effect on growth, government spending and investment as a result of the shock, as well as the degree of structural transformation and loss of competitiveness.

The first step is to identify how the recent oil price collapse compares to the normal variation in the data? In the six months between 2014q3 and 2015q1, the global Brent Crude Price fell from 100.4 USD per barrel to 51.7 USD per barrel, equivalent to a 48.5% collapse. This price movement is more than twice as large as the typical variation of the average price index for the resource rich, low-income countries in the sample, which is around 19%. How important is this for Nigeria? Oil reserves make up all of the Nigeria's natural resource reserves and therefore any movement in the oil price is exactly reflected in the movement of its reserve-weighted commodity price index[22].

[22] Nigeria produces a small amount of natural gas but reserves are insignificant compared to oil.

Table 4 below shows the results of simulating a one period collapse in the price of oil of 48.5% for Nigeria. The first three columns show the simulation of the cumulative IRFs in response to such a shock immediately and after 3 years. As a result of the oil price shock, Nigeria suffers a contraction of real per capita GDP of 0.11% in the same period. After 3 years the cumulative effect rises to around 0.15%; government spending and investment shrink by 0.17% and 0.07% respectively. The next three columns show the impact on various sectoral value-added shares. Manufacturing value-added rises by 0.64 percentage points (pp), whilst the share of value-added in transport and manufactured agricultural products, both considered to be relatively less tradable, decline by 0.38 pp and 2.93 pp respectively after 3 years. Finally, the real exchange rate moves to improve competitiveness, depreciating by 3.6% after 3 years.

These impacts may seem small, given then magnitude of the price collapse in question, however, it is worth bearing in mind that these impacts are due solely to an *exogenous movement in the oil price*, that is without any corresponding shifts in global demand or financial conditions. One caveat worth pointing out here is that this type of counterfactual exercise may be subject to the Lucas critique.

Table 4: Impact of the 2014-15 Oil Price Collapse on Nigeria

Year	***G***	***I***	***GDPpc***	***VAman***	***VAtrans***	***VAagric_manuf***	**Δ*overval***
0	-	-	-0.11%	0.64pp	-0.31pp	-3.83pp	-
3	-0.19%	-0.07%	-0.15%	-	-0.38pp	-2.93pp	-3.6%

Notes: Simulated response of Nigerian economy to the 2015 oil price collapse, equivalent to a 48.5% reduction.

9 Conclusion

Over the past decade extractive industries in Africa have emerged as a powerful engine of economic growth, driven in part by surging demand for natural resources in emerging markets. The continent's hydrocarbon and mineral potential has been a powerful magnet for foreign investment with new exploration revealing vast reserves, particularly in sub-Saharan Africa. Recent discoveries of natural gas in Mozambique and Tanzania, and oil in Ghana, Uganda and Madagascar are cases in point. The challenge facing the region now is how to transform these temporary resource windfalls into permanent economic and human development successes.

This paper presents an empirical investigation of the dynamic macroeconomic response of resource-rich, low-income countries to global commodity price fluctuations; specifically minerals and hydrocarbons. I provide new evidence on the relationship between resource booms, economic growth and structural transformation in these economies. The endogeneity problems inherent in the cross-country literature on resource booms make it challenging to identify a causal effect of resource wealth on economic development. This paper improves upon previous estimates by identifying exogenous, supply driven commodity price shocks for resource-rich, low-income economies. It then uses these shocks to investigate the potential Dutch disease effects of resource booms at the sectoral level.

I use a panel vector auto regression (or panel-VAR) approach to identify exogenous shocks to global commodity prices and to estimate the dynamic, short-run, response of these shocks on economic growth, government spending and domestic investment. The potential for short-term Dutch disease effects are investigated using a seemingly unrelated regression equations (SURE) framework. Finally, I present preliminary evidence that the channel through which the link between resource booms and sectoral growth operates is the real exchange rate.

Focusing on resource-rich, low-income economies, the results suggest that positive commodity price shocks raises per capita income levels, investment and government spending in the short to medium term, as well as lowering inflation. These effects, however, are quantitatively small. Resource booms also result in significant re-structuring of the domestic economy. I show that an empirically robust link exists between resource wealth and the relative growth of tradable or exportable industries. The share of value-added in non-tradable goods and services, such as transport, finance and real estate, expands, increases in response to positive resource shocks whilst value-added in manufacturing declines. Disaggregating value-added in the manufacturing sector even further reveals significant Dutch disease effects. Industrial sectors which are typically thought of as more export oriented, such as the production of motor vehicles or petrochemicals, are negatively affected by resource booms, whilst the manufacturing of agricultural products, which can be thought of as being less tradable, benefit. This link appears to operate through the real exchange rate, with resource shocks leading to appreciations which in turn cause a restructuring of the domestic economy.

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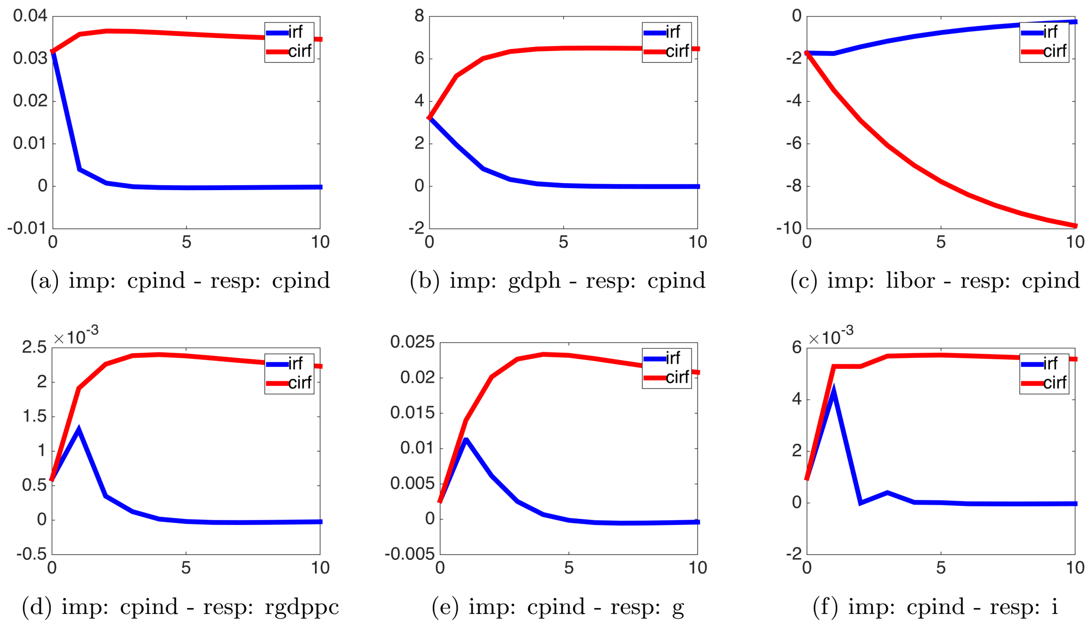
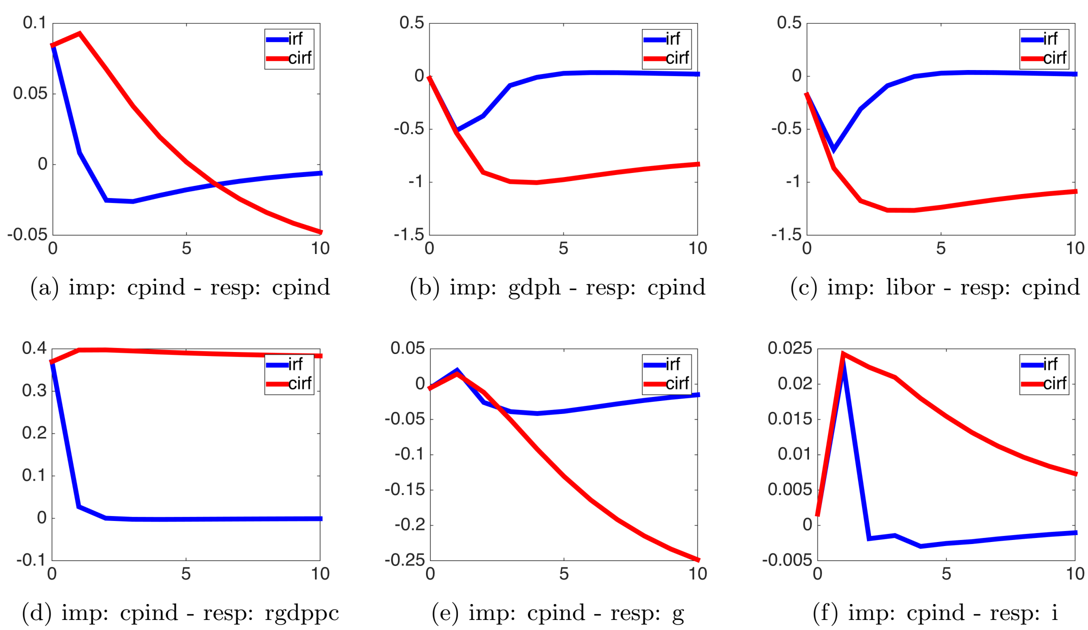
Appendix



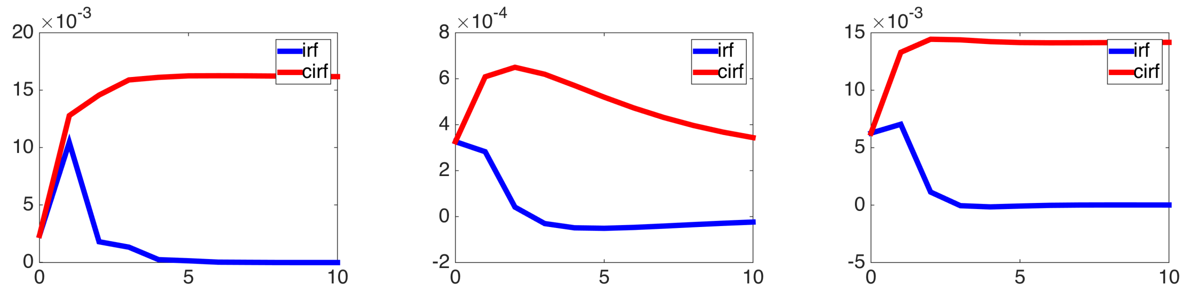
(a) imp: cpind - resp: cpind
(b) imp: gdph - resp: cpind
(c) imp: libor - resp: cpind
(d) imp: cpind - resp: rgdppc
(e) imp: cpind - resp: g
(f) imp: cpind - resp: i

Figure 4: Panel VAR IRFs - Choleski - No OPEC Members



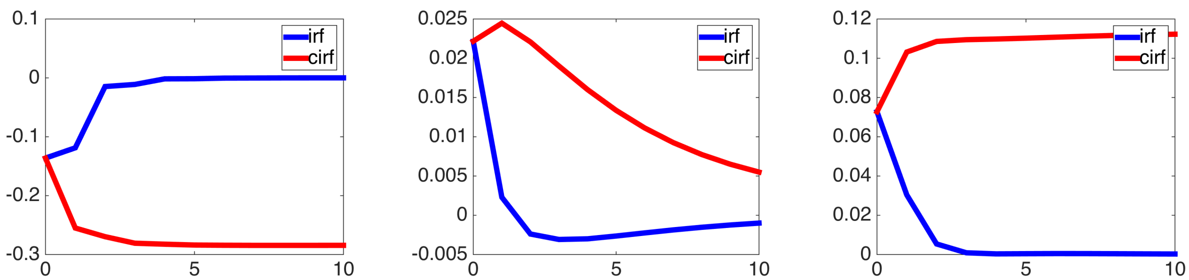
(a) imp: cpind - resp: cpind
(b) imp: gdph - resp: cpind
(c) imp: libor - resp: cpind
(d) imp: cpind - resp: rgdppc
(e) imp: cpind - resp: g
(f) imp: cpind - resp: i

Figure 5: Panel VAR IRFs - Block Recursiveness - No OPEC Members



(a) imp: cpind - resp: rgdppc (b) imp: cpind - resp: rgdppc (c) imp: cpind - resp: rgdppc

Figure 6: Choleski IRFs for $CPIND$ impulse on $RGDPPC$ for different levels of exposure to commodity price shocks. Panel (a) shows countries with zero resource exports in 2013, panel (b) shows countries with low resource exports, and panel (c) shows countries with high resource exports.



(a) imp: cpind - resp: rgdppc (b) imp: cpind - resp: rgdppc (c) imp: cpind - resp: rgdppc

Figure 7: Block recursive IRFs for $CPIND$ impulse on $RGDPPC$ for different levels of exposure to commodity price shocks. Panel (a) shows countries with zero resource exports in 2013, panel (b) shows countries with low resource exports, and panel (c) shows countries with high resource exports.

Table 5: SUREG FE Regression - Sectoral Real Value Added Share - All Sectors - No OPEC Members

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	rva_shareagric	rva_shareconstr	rva_sharemanuf	rva_sharemin	rva_sharetrans	rva_sharewhole	rva_shareother
reah	4.332***	-2.472***	1.005**	-0.502	0.740**	0.425	-1.685***
	(4.600)	(-7.664)	(2.081)	(-0.405)	(1.962)	(0.769)	(-3.047)
rUSlib	0.279*	-0.0590	0.282***	0.416*	-0.452***	-0.185*	-0.211*
	(1.863)	(-1.176)	(2.889)	(1.832)	(-6.780)	(-1.802)	(-1.875)
ln_govexp	-0.962***	-0.252***	-0.245**	0.336	0.259***	-0.0207	0.432***
	(-5.290)	(-3.597)	(-2.164)	(1.231)	(3.344)	(-0.144)	(2.762)
ln_inv	-1.129***	1.715***	-0.141	0.0748	-0.423***	-0.313	-0.0377
	(-3.038)	(11.98)	(-0.609)	(0.134)	(-2.671)	(-1.070)	(-0.118)
infl_defl	-0.000120	-0.000153	0.000173	-0.000329	-0.000148	0.000181	0.000590*
	(-0.307)	(-1.019)	(0.714)	(-0.563)	(-0.890)	(0.590)	(1.761)
sresid3	0.104	0.0252	-0.439***	-0.0947	0.129	0.0619	0.289*
	(0.518)	(0.327)	(-3.524)	(-0.315)	(1.517)	(0.393)	(1.679)
L.sresid3	-0.132	0.0243	-0.286**	-0.361	0.216**	0.113	0.506***
	(-0.665)	(0.319)	(-2.318)	(-1.213)	(2.557)	(0.726)	(2.969)
L2.sresid3	-0.0139	-0.0664	-0.290**	-0.270	0.161*	0.151	0.431**
	(-0.0709)	(-0.880)	(-2.376)	(-0.919)	(1.924)	(0.976)	(2.560)
L3.sresid3	-0.0335	0.0434	-0.0557	-0.315	0.0527	0.0841	0.167
	(-0.174)	(0.584)	(-0.464)	(-1.087)	(0.642)	(0.554)	(1.005)
inirva_shareagric	1.049***						
	(33.60)						
inirva_shareconstr		-0.102***					
		(-5.258)					
inirva_sharemanuf			0.417***				
			(14.22)				
inirva_sharemin				0.480***			
				(13.08)			
inirva_sharetrans					0.837***		
					(39.24)		
inirva_sharewhole						0.734***	
						(6.718)	
inirva_shareother							1.145***
							(11.97)
Observations	476	476	476	476	476	476	476
R-squared	0.979	0.889	0.945	0.953	0.946	0.851	0.948
Labour and Capiital Controls	NO	NO	NO	NO	NO	NO	NO

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
sresid3; Country and year fixed effects included; Low-income, resource rich countries

Table 6: SUREG FE Regression - Sectoral Real Value Added Share - Manufactures - No OPEC Members

VARIABLES	(1) rva_share_food	(2) rva_share_textiles	(3) rva_share_printing	(4) rva_share_chemical	(5) rva_share_transport	(6) rva_share_other
reah	-21.39***	2.596*	1.894	-7.627*	-3.706***	-1.548**
	(-5.430)	(1.865)	(1.090)	(-1.780)	(-2.862)	(-2.256)
rUSlib	-1.081*	1.355***	1.190***	-2.435***	0.193	-0.123
	(-1.884)	(6.716)	(4.484)	(-3.041)	(0.755)	(-0.876)
ln_govexp	1.525	-2.004***	-1.357***	0.240	-1.045**	0.120
	(1.537)	(-4.470)	(-3.042)	(0.175)	(-2.454)	(0.501)
ln_inv	2.023	-0.0852	-0.966	-6.888***	2.497***	0.659*
	(1.270)	(-0.118)	(-1.338)	(-3.034)	(3.511)	(1.687)
infl_defl	-0.000864	0.000845***	0.000266	-0.00196**	0.000727***	-9.15e-05
	(-1.353)	(2.869)	(0.906)	(-2.129)	(2.595)	(-0.588)
inirva_share_food	2.123***					
	(9.769)					
sresid3	0.987	-0.433	-1.085***	0.723	-0.487	0.0648
	(1.416)	(-1.321)	(-3.452)	(0.738)	(-1.587)	(0.383)
L.sresid3	0.0597	0.179	-1.391***	1.583*	-0.242	-0.108
	(0.0885)	(0.562)	(-4.540)	(1.659)	(-0.797)	(-0.654)
L2.sresid3	1.358*	-0.212	-1.658***	-0.225	-0.205	0.0710
	(1.884)	(-0.640)	(-5.071)	(-0.221)	(-0.642)	(0.403)
L3.sresid3	1.454**	-0.581*	-1.007***	-0.151	0.351	-0.0384
	(2.143)	(-1.865)	(-3.300)	(-0.157)	(1.174)	(-0.235)
inirva_share_textiles		0.608***				
		(7.949)				
inirva_share_printing			0.880***			
			(3.366)			
inirva_share_chemical				2.051***		
				(14.42)		
inirva_share_transport					0.587	
					(1.607)	
inirva_share_other						-0.740***
						(-2.709)
Observations	123	123	123	123	123	123
R-squared	0.939	0.975	0.931	0.899	0.972	0.826
Labour and Capiital Controls	YES	YES	YES	YES	YES	YES

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
sresid3; Country and year fixed effects included; Low-income, resource rich countries; metal and electric manufacturing sectors omitted

VARIABLES	(1) ln_rer	(2) Dln_overval	(3) Dln_overval	(4) Dln_overval
ln_rvatotal		0.00182	0.000918	0.0616**
		(0.446)	(0.222)	(2.156)
sresid3		-0.0111	-0.0107	-0.00929
		(-1.569)	(-1.502)	(-1.271)
L.sresid3		0.0130*	0.0122*	0.0126*
		(1.850)	(1.703)	(1.734)
L2.sresid3		-0.00602	-0.00658	-0.00733
		(-0.828)	(-0.892)	(-0.977)
L3.sresid3		-0.00489	-0.00495	-0.00649
		(-0.666)	(-0.668)	(-0.860)
ln_rgdppc	-0.119***			
	(-31.82)			
ka_open			0.0302	0.0410
			(1.370)	(1.076)
Constant	1.450***	-0.0409	-0.0319	-1.689**
	(48.24)	(-0.419)	(-0.325)	(-2.190)
Observations	6,369	440	423	423
R-squared	0.191	0.017	0.020	0.050
Year FE	YES	NO	NO	NO
Country FE	NO	NO	NO	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Exploring the Real Exchange Rate Channel - No OPEC Members

VARIABLES	(1) Dln_overval	(2) Dln_overval	(3) Dln_overval
ln_rvatotal	0.118	0.0304	0.0332
	(1.099)	(1.131)	(0.651)
sresid3	0.0245	-0.00209	0.125*
	(0.952)	(-0.257)	(1.674)
L.sresid3	-0.0253	0.00390	0.0211
	(-0.976)	(0.464)	(0.290)
L2.sresid3	0.00919	-0.00376	0.0734
	(0.323)	(-0.437)	(0.983)
L3.sresid3	0.0182	0.000328	0.0902
	(0.618)	(0.0386)	(1.165)
ka_open	-0.0478	0.0368	0.153**
	(-0.294)	(1.121)	(2.343)
Constant	-2.819	-0.621	-1.019
	(-1.108)	(-1.096)	(-0.743)
Observations	92	232	99
R-squared	0.048	0.041	0.197
Year FE	NO	NO	NO
Country FE	YES	YES	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: *Notes:* Real exchange rate overvaluation regressions for different levels of exposure to commodity price shocks. Column (2) shows countries with zero resource exports in 2013, column (3) shows countries with low resource exports, and column (4) shows countries with high resource exports.