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GLOBAL EXCHANGE RATE CONFIGURATIONS

DO OIL SHOCKS MATTER?

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In 2012 all ECB publications feature a motif taken from the €50 banknote.

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Abstract

Do oil shocks matter for exchange rates? This paper addresses this question based on data on real and nominal exchange rates as well as an exchange market pressure index for 44 advanced and emerging countries. We identify three structural shocks (oil supply, global demand, and oil specific demand) which raise the real oil price and analyse their effect on individual exchange rates. Contrary to the predictions of the theoretical literature, we find no evidence that exchange rates of oil exporters systematically appreciate against those of oil importers after shocks raising the real oil price. However, oil exporters experience significant appreciation pressures following an oil demand shock, which they tend to counter by accumulating foreign exchange reserves. Results for general commodity exporters are similar, showing minor differences compared with oil exporters.

Keywords: Oil, structural VAR, exchange rate, exchange market pressure, global imbalances

JEL: F31, Q43.

Non-Technical Summary

The objective of this paper is to find out whether oil shocks matter for exchange rates. Naturally, we are particularly interested whether oil shocks are a factor in exchange rate configurations in countries heavily dependent on oil. Furthermore, we want to understand how these shocks may be absorbed by the accumulation of foreign exchange reserves reflecting policy interventions aimed at limiting exchange rate fluctuations. Since elevated oil prices contributed to the concentration of large external surpluses and deficits in a number of countries, the answer to these questions is highly relevant for the debate on the adjustment of global imbalances.

Theoretically, positive oil price shocks should lead to a real appreciation (depreciation) of the exchange rates of oil exporting (importing) economies although in practice there may be a number of potential second-round effects and offsetting factors that attenuate the link between oil price shocks and the exchange rate. Existing general equilibrium models emphasise the fact that shocks raising the (real) oil price represent a positive (negative) terms of trade and income shock for net oil producing (consuming) countries. To ensure the external sustainability of oil importing countries, the real exchange rate of the latter needs to depreciate in order to improve the non-oil trade balance. As regards foreign exchange reserves, one would expect a trade-off between nominal exchange rate adjustments and changes in reserves following an oil price shock: the smaller the degree of flexibility of the exchange rate, the larger the burden of adjustment falling on foreign exchange reserves.

Being among the first to address this topic empirically, we use data from 44 countries, 12 advanced and 32 emerging economies, spanning a period of 25 years from 1986 to 2011. The sample includes 14 oil exporting countries, out of which 6 have an oil trade balance to GDP ratio larger than 10%.

As put forth by several authors, the impact of oil price shocks crucially depends on the source of oil price fluctuations. In a first stage of our econometric analysis we therefore follow Kilian (2009) and identify three structural oil price shocks - driven by either oil supply, global demand, or oil specific demand - in a structural VAR using two different identification schemes (sign restrictions and Cholesky decomposition). In a second stage we analyse the effect of these shocks on real and nominal exchange rates, inflation, reserves, an exchange market pressure index, and stock prices in a panel regression. In particular, by interacting the shocks with a measure of the oil trade balance as percentage of GDP we can observe whether and how the impact of each shock is different for oil exporters and oil importers. Replacing the oil trade balance by an estimated commodity trade balance and repeating the analysis we can then see whether the obtained results for oil exporters hold true for commodity exporters in general, considering the increased comovement of oil and commodity prices over the past ten years. We apply various robustness checks by introducing time dummies and control for both currency crises and exchange rate regime by employing appropriate self-constructed country and time specific variables.

Our empirical analysis suggests that contrary to the predictions of the theoretical literature, exchange rates of oil exporters do not systematically appreciate more than those of oil importers following oil price shocks.

However, significant appreciation pressures arise in oil exporting countries, especially in response to oil specific demand shocks. Instead of an exchange rate reaction we find evidence for an increased accumulation of foreign exchange reserve with which these appreciation pressures are countered. Furthermore, our findings indicate that the capital losses of oil exporters may be potentially explained by rising domestic asset prices vis-à-vis oil importers, but not by exchange rate movements. Results for general commodity exporters are similar although a few noteworthy differences with strict oil exporters can be detected.

1 Introduction

The objective of this paper is to answer two important questions regarding the constellation of global exchange rates. First, we want to know whether oil shocks (demand and supply) are a factor in global exchange rate configurations, in particular for countries which are heavily dependent on oil, as exporters or importers. Indeed, as suggested by several authors such as Kilian (2009), the impact of oil price shocks greatly depends on the source of oil price fluctuations. Second, we would like to understand how these shocks may be absorbed by the accumulation of foreign exchange reserves and under different exchange rate regimes. While there is a rather large literature on the co-movement of oil (or commodity) prices and exchange rates, so far the empirical investigation has not studied the possibility that the link between these two variables may be driven by shocks of different nature (say, demand and supply) and may be neutralised or modified by the accumulation of foreign assets reflecting policy interventions aimed at limiting exchange rate fluctuations. The answer to these two related questions is particularly relevant for the debate on the adjustment of global imbalances, since elevated oil prices contributed to the concentration of large external surpluses and deficits in a small number of countries. To the extent that exchange rates react to oil price shocks, in particular in oil exporting countries, the adjustment may take place through the traditional trade channel and, potentially, through valuation effects depending on the currency composition of net foreign assets. Insofar as the accumulation of foreign exchange reserves in oil exporting economies alleviates exchange rate adjustment pressures, the trade channel remains muted. Valuation effects may play a role only through changes in asset prices, thereby delaying or hampering the necessary adjustment in the external imbalances.

The greater volatility of oil and commodity prices in the recent years revived the interest of economists on the impact of commodity and oil price shocks on the global economy. A number of papers investigated the macroeconomic effects of oil shocks on major industrialised economies such as the United States (e.g. Hamilton, 2008; Kilian, 2009; Lippi and Nobili, 2009), the euro area (Peersman and van Robays, 2009) and several other developed economies (Baumeister et al., 2010; Peersman and van Robays, 2011). Other studies focused on the impact of oil shocks on the external accounts of oil exporters and major oil importers (Kilian et al., 2009) or the current account of the United States (e.g. Barnett and Straub, 2008). The main novelty of this recent strand of literature is the recognition that changes in the oil price may be driven by different oil-market specific demand or supply shocks or by global economic developments and may therefore have different implications for domestic and global macroeconomic variables (Kilian, 2009; Bodenstein and Guerrieri 2011). Indeed, differently from previous episodes, the sustained increase in oil prices since 1999 was mainly driven by global aggregate demand and, in particular, by buoyant demand stemming from emerging markets, defying the predictions of standard macroeconomic models that treated the rise in oil prices as an exogenous shock (Hamilton, 2008; Kilian, 2009). This recent body of literature has not yet been extended to the investigation of the impact of different oil price shocks on one of the crucial macroeconomic variables in open economy models: the real exchange rate. In this paper, we largely follow Kilian (2009) by applying a two-stage approach: we first identify global demand, oil demand and supply shocks in a VAR model using sign restrictions and the Cholesky approach. We then analyse their impact on nominal and real exchange rates (as well as other key macroeconomic variables). Moreover, unlike several previous papers, we use a large database comprising 44 advanced and emerging countries, over a sample period spanning between 1986 and 2011.

Overall, the main result of our exercise is that there is no evidence of a systematic relative appreciation of oil exporters vs oil importers following oil shocks as would be predicted by theoretical considerations. One key reason for this result is that authorities in oil exporters are active in countering appreciation pressures by accumulating forex reserves, a fact for which we present ample empirical evidence. We also find that appreciation pressures and reserves accumulation are visible only for oil demand shocks, but not for oil supply shocks, a fact that needs to be better incorporated in future modelling efforts. The effect of oil shocks on stock returns is mixed. Stock markets of oil exporters outperform those of oil importers significantly only in response to oil specific demand shocks but tend to fare worse following an oil supply shocks. By contrast, stock prices rise in oil exporters more than in oil importers after oil demand shocks. Extensive robustness checks involving controls for currency crises, differing exchange rate regimes, and structural breaks tend overall to confirm the main findings.

Additionally, we show that the above mentioned key results apply to "commodity currencies" in general as replacing the oil trade balance by an estimated overall commodity trade balance leads to similar results qualitatively.

The paper is organised as follows. Section 2 discusses the nexus between the oil price and exchange rates. Section 3 describes the data. Section 4 presents the empirical approach and Section 5 the results. Section 6 concludes.

2 Oil price and exchange rates: theoretical considerations

Starting from De Gregorio and Wolf (1994) a number of empirical studies showed that the currency of commodity (and oil) exporters tend to co-move with commodity (and oil) prices. Coudert et al. (2011) review this growing body of empirical literature, concluding that the long-run elasticity between commodity prices and the real effective exchange rate of commodity exporters is around 0.5, whereas a similar elasticity between the real effective exchange rate of oil exporters and oil prices is somewhat lower, at around 0.3. It is important however to qualify these conclusions in two ways. First, the relationship between commodity or oil prices and the exchange rate is not present in all countries. For instance, Cashin et al. (2004) find that only in one third of commodity exporting economies it is possible to identify such a relationship. Similarly, Habib and Kalamova (2007), when investigating the exchange rate of three major oil exporters (Norway, Saudi Arabia and Russia), find a robust relationship with oil prices only for Russia. Second, the majority of the studies find that commodity prices are weakly exogenous with respect to the exchange rate, which is consistent with the fact that commodities are priced in competitive world markets.[1]

From a theoretical point of view an oil price shock may be transmitted to the exchange rate through different channels: the terms of trade, wealth effects and the associated trade balance and portfolio reallocation.

First, the impact of oil price shocks to exchange rates is mainly transmitted by changes in the terms of trade. This channel of transmission is not only functioning in oil exporting economies where movements in oil prices, by definition, dominate the terms of trade, but also in major industrialised economies (Backus and Crucini, 2000). According to simple two-country small open economy static models, like in Cashin et al. (2004) or Chen and Rogoff (2003), the price of the traded goods is fixed on international markets, determining domestic wages for both the traded and non-traded good sectors, assuming internal labour mobility across the two sectors. A positive terms of trade shock drives up the price of the non-traded good in the domestic economy and the real exchange rate, which is defined as the relative price of a basket of traded and non-traded goods between the domestic and the foreign economy. The mechanism is similar to the Balassa-Samuelson effect, working through relative productivity differentials between the traded and non-traded good sectors. As noted by Tokarick (2008), an income effect is absent in these models, but is generally expected to reinforce the initial impact, as long as the non-traded good is a "normal" good whose demand increases with income. This "spending effect" can lead to further appreciations of the real exchange rate and Dutch Disease phenomena, where the non-oil export competing sector in the domestic economy is squeezed out by the oil sector and the non-tradeables sector (Corden and Neary, 1982).

Another important channel of transmission of (positive) oil price shocks to exchange rates is through "wealth effects" and the way this is spent or reinvested by the oil exporting countries. Rasmussen and Roitman (2011) show that not controlling for global economic activity the effect of an oil price shock to the real exchange rate can in principle go both ways due to gain sharing. Krugman (1983) and Golub (1983) develop three-country models (two oil-importing countries and one oil exporter) where a rise in oil prices is associated with wealth transfers from oil importers to the oil exporting economy, leading to current account imbalances and portfolio reallocation.

[1] As noted by Chen, Rogoff and Rossi (2010), "commodity prices are a unique exchange rate fundamantal for these (commodity exporting) countries because the causality is clear" and even if one finds that the exchange rate Granger-causes fundamentals, this "could simply be the result of endogenous responses or reverse causality", if the exchange rate is determined as the present value of futere fundamentals as in Engel and West (2005).

The relative dependence on oil imports for oil importers and the import patterns of oil exporters will determine the global current account configuration, whereas oil exporters portfolio preferences will determine capital flows. Eventually, the exchange rate adjusts to clear the trade balance and asset markets.[2]

More recently, Bodenstein et al. (2011) revisited the same issue in the context of a two-country fully fledged DSGE model, where the two countries have different oil endowments, different propensity to consume oil and where international asset markets are not complete. Following an oil shock that modifies the oil balance, the real exchange rate moves to ensure an offsetting adjustment in the *non-oil* trade balance in order to stabilise net foreign assets. Therefore, for an oil importing (exporting) country, the real exchange rate depreciates (appreciates) following a positive shock to the oil price. International financial integration and complete asset markets provide insurance to the shock, allow to smooth the necessary adjustments in the trade balance and are associated with smaller real exchange rate adjustments compared to the case of financial autarky.

In the context of greater financial integration, valuation effects become more important for the sustainability of net foreign assets (Gourinchas and Rey 2007 and Ghironi et al. 2007). In particular, large and persistent exchange rate shocks are not uncommon and may lead to a significant redistribution of wealth across countries, depending on their net foreign currency position (Lane and Shambaugh 2010a). While there is not necessarily a positive correlation between the oil trade balance and the net foreign currency position across countries, following sizable and persistent increases in oil prices major oil exporters usually accumulate foreign assets denominated in foreign currency and tend to shift towards a "long" foreign currency position.[3] In this case, an exchange rate appreciation of oil exporters' currencies vis-a-vis oil importers may act as an automatic oil price shock absorber for net foreign assets, generating a transfer of wealth from oil exporting economies towards those oil importing economies that are also long in foreign currency.[4] Oil importers that are instead short in foreign currency, usually emerging markets experiencing protracted current account deficits

[2] For instance, according to these models, the depreciation of the US dollar during the oil price boom of 2002-2008 could be explained by the greater dependence of the United States on oil imports, the smaller and declining share of US industrial exports to oil producing countries and a diversification of portfolio assets of oil exporters out of the US dollar.

[3] Indeed, based on the recent estimates of the currency composition of foreign assets and liabilities by Lane and Shambaugh (2010b), the major oil exporters in our sample had a long net foreign currency position in 2004, ranging from around 100% of GDP in Norway, to 50% in Venezuela and more than 30% in Algeria and Russia. The only exception was Nigeria which had a small negative short foreing currency position equivalent to 2% of GDP. There are no data for the international investment position of Saudi Arabia, but it is reasonable to assume that this country has also a substantial long foreign currency position.

[4] In our sample, there is a large number of net oil importers that are long in foreign currency, including developed economies such as the United States, Australia, Sweden and Switzerland and Japan, the majority of the other Asian economies, commodity exporters such as Chile and South Africa and emerging markets such as the Czech Republic and Israel.

financed through debt and international borrowing, shall instead experience an additional loss of external wealth through the exchange rate valuation channel.

Overall, all these models converge towards an univocal stylised fact: positive oil price shocks should lead to a real appreciation (depreciation) of the exchange rates of oil exporting (importing) economies, even though for oil importing economies the impact on the effective exchange rate may differ due to compensatory effects through trade and asset channels vis-a-vis other main trading partners. In practice, there are a number of potential second-round effects and offsetting factors that may dampen the impact of oil price shocks on exchange rates. For example, if the oil price shock stems from a negative oil supply shock, it may impact on the global macroeconomic outlook as well as on global financial market conditions (including risk aversion), which may have further repercussions on exchange rates (e.g. safe-haven effects). If the oil price shock stems from a global aggregate demand shock, the response of the non-oil trade balance of oil importing economies may differ according to their relative competitiveness in international markets. The non-oil trade balance could possibly be improving (e.g. China) or worsening (e.g. US), thereby requiring different exchange rate adjustments over the long-run. Furthermore, oil price shocks that are associated with exchange rate and asset price changes produce valuation effects and automatic transfers of wealth across countries, which may lessen or aggravate the necessary adjustment in the non-oil trade balance, depending on the net foreign currency position and the geographical composition of foreign assets in each country. Finally, international risk sharing and accumulation or reduction in foreign exchange reserves may provide a strong cushion to exchange rate adjustments between oil importers and oil exporters. Focusing on Latin America, Aizenman et al. (2011) find strong evidence for the attenuating role of the level and growth rate of international reserves on the real exchange rate in response to a shock in the commodity terms of trade. Following an oil-price shock, one would expect a trade-off between nominal exchange rate adjustments and changes in reserves: the smaller the degree of flexibility of the exchange rate, the larger the burden of adjustment falling on foreign exchange reserves.

3 Data

Our dataset spans 44 countries, 12 advanced and 32 emerging economies, on a sample period of quarterly data from 1986:1 to 2011:1. A key variable for our analysis is the oil trade balance as a share of GDP (see *Figure 1*). Based on this variable, the sample includes 14 oil exporting countries, out of which 6 have an oil trade balance to GDP ratio larger than 10%. Furthermore, we distinguish countries according to whether they are generally considered commodity-dependent and thus potential candidates for having "commodity currencies", i.e. a real exchange rate driven by real commodity prices. Since the price of oil has become increasingly correlated with that of other commodities over the past decade (see *Figure 2*), the possibility arises that currencies of commodity exporters have been similarly affected by oil shocks as currencies of oil exporters, at least over the second half of our time sample.[5] Dividing the country sample according to oil trade balance alone would therefore be insufficient to analyse the heterogeneous response of exchange rates across countries. Within the non-oil exporting group of countries the response of exchange rates of commodity-dependent countries would theoretically counteract the response of non-commodity currencies, such that the coefficient of a simple oil trade balance dummy variable would remain inconclusive with regard to the different exchange rate dynamics following an oil shock.

For this purpose, we calculate a time-varying estimate of the degree to which countries are overall commodity exporters or importers (*estimated* commodity trade balance). In the absence of direct observations on commodity exports and imports, we compute a proxy measure based on the recursively calculated correlation between changes in a country's nominal net trade balance and the growth rate of an overall commodity price index. As an overall commodity price index we use the IMF's Commodity Price Index, based on both fuel and non-fuel price indices, which we back-casted for the pre-1992 time period using the appropriate weights. The robustness of this criterion was checked against a commodity currency criterion suggested by Cashin et al. (2004), who identify commodity-dependent countries according to their share of non-fuel primary products in total export earnings, yielding similar results. The dependent variables used in the empirical analysis include the real effective exchange rate (REER), the bilateral nominal exchange rate with the U.S. Dollar (henceforth USD), the consumer price index (CPI), stock market returns (constructed using the respective major local stock market index), and foreign exchange reserves. All exchange rates are denoted such that an increase implies appreciation (i.e. reference currency / national currency). The oil price is the U.S. CPI-deflated Brent (in US$ per barrel). A notable feature of the sample is that oil production and oil trade surpluses are concentrated in a handful of countries, with a large number of importers (including most advanced countries). To identify structural shocks in the oil market, we use oil production from the International Energy Agency and the Global Real Economic Activity Index in industrial commodity markets proposed by Kilian (2009), as a proxy of the global business cycle. This index is based on dry cargo single voyage ocean freight rates to capture global demand pressures and is expressed in monthly percentage deviations from the trend. An overview of the dataset and its sources can be found in *Table 1.*

In addition, three variables have been constructed to control for currency crises and exchange market pressure and to distinguish between exchange rate regimes.

Currency Crisis Dummy. In the empirical analysis, we use quarterly country and time-specific currency crisis dummy variables to control for large up- and down-

[5] Tang and Xiong (2010) attribute this trend to an *"increasing presence of commodity index investors"* and detect *"evidence suggesting that before early 2000s, commodities markets were partially segmented from outside financial markets and from each other"* (p. 15).

swings of exchange rates that could potentially confound the effect of the shocks. Following Milesi-Ferretti and Razin (2000), we construct the dummy variable such that it takes value 1 if the year-over-year depreciation in the quarterly bilateral nominal exchange rate is greater or equal than 25% and twice as much as the preceding year's year-over-year depreciation. In addition, this depreciation itself has to have been less than 40% to rule out the detection of several currency crises during prolonged episodes of hyper-inflation. The robustness of this criterion is controlled against three alternative criteria and a qualitative check with the currency crises identified by Laeven and Valencia (2006).[6]

Exchange Market Pressure. We also compute a monthly Exchange Market Pressure (EMP) index to control for the impact of oil shocks in countries that limit exchange rate fluctuations - in particular a number of oil exporting economies - by increasing (or decreasing) foreign exchange reserves. Among the several definitions of the EMP that are in the literature, we eventually opted for a specification along the lines of Cardarelli, Elekdag, and Kose (CEK) (2010), which in turn draws upon the seminal paper of Eichengreen, Rose, and Wyplosz (ERW) (1996):

$$EMP_{i,t} = \frac{1}{\sigma_{E_{i,t}}} E_{i,t} + \frac{1}{\sigma_{R_{i,t}}} R_{i,t} \tag{1}$$

where

$$E_{i,t} = \triangle\% e_{i,t} = \frac{e_{i,t} - e_{i,t-1}}{e_{i,t-1}} \tag{2}$$

$$R_{i,t} = Res_{i,t} - Res_{i,t-1} \tag{3}$$

and

e	=	Nominal bilateral exchange rate (Reference Currency / National Currency)
Res	=	Foreign exchange reserves
σ	=	Standard deviation of E (resp. R), measured over the preceding 8 quarters. Country and region specific (see footnote).

The index is based on a weighted average of two components: (i) the quarter-over-quarter change in the nominal bilateral exchange rate towards a reference currency and (ii) the change in foreign exchange reserves. By construction, an increase in the EMP index hence indicates appreciation pressure. For bilateral rates, the reference currency is determined following the de facto currency regime classification of Reinhart and Rogoff (2002), resulting in 30 countries benchmarked against the USD and the remaining 14 countries against the DEM/EUR (see *Table 3*). In line with ERW (1996), we use gross foreign reserves instead of net foreign assets of monetary authorities, since the latter series presents a number of jumps and structural breaks that

[6] For a comprehensive assessment of different criterions including the CRISIS2 criterion by Milesi-Ferretti and Razin (2000) that we used, see Burkart and Coudert (2002).

are difficult to interpret. In general, the correlation between gross and net foreign assets of the monetary authorities is high and this choice does not substantially alter the index. This is particularly the case for the monetary authorities of oil exporting economies that tend to have limited or no foreign liabilities at all. More importantly, we augment foreign exchange reserves with sovereign wealth funds (SWF) data when available, as in the case of Norway and Russia.[7] Notably, we exclude interest rates from the EMP index due to the absence of a market-determined interest rate in several of our countries. The lack of sufficient volatility in the (available) policy interest rates prevents the construction of a consistent weighting rule for this variable. Indeed, one of the main technical challenges in the construction of EMP indices is the weighting scheme of the separate components. The weighting scheme is designed to equalize the volatility such that one avoids excessive influence of one variable over the other in the index; this is done by scaling each component by the inverse of its standard deviation. A number of countries pegging their currencies may display an extremely low volatility in exchange rates. In such a situation, any small change in the exchange rate would result in a very large movement in the EMP. To overcome this problem, similarly to CEK (2010), we assign 23 countries to 3 regional groups for which we use average "regional" standard deviations instead of country-specific ones:

Africa: Saudi Arabia, Egypt, Algeria, Morocco, Nigeria, Tunisia

Central and South America: Argentina, Brazil, Chile, Mexico, Peru, Venezuela

Asia: Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Singapore, Thailand, Taiwan[8]

Peg and Floating Currencies. In the paper, we distinguish between fixed and floating currencies according to a de facto measure of currency flexibility. A certain currency i is de facto pegged to the US dollar (or the DEM/EUR) at time t. Similar to Levy-Yeyati and Sturzenegger (2005) and Habib and Stracca (2011), we start from a de facto measure of exchange rate flexibility vis-à-vis the USD (or DEM/EUR) defined as

$$FLEX_{it} = \frac{1}{12}\sum_{j=1}^{12} Abs(\Delta e'_{i,t-j}) \tag{4}$$

where $\Delta e'_{i,t}$ is the bilateral appreciation vis-a-vis the USD (or DEM/EUR). This cumulative absolute depreciation or appreciation in the previous year should give an idea of the degree to which a given currency is floating against the USD (or

[7] Saudi-Arabia does not have a separate SWF as its foreign assets are entirely administrated by the Saudi-Arabian Monetary Authority (SAMA) and listed in its balance sheet. Relevant sovereign wealth funds with a SWF assets to reserve ratio larger than 1 for which we lack time series data are Singapore and Australia at 3 and 1.06 respectively (Chhaochharia and Laeven 2008, p.36).

[8] Note that China is not included in the regional average due to the pecularity of its exchange rate regime. However, China's exchange rate change is scaled by the regional average of the Asia region to attain a more balanced weighting scheme.

DEM/EUR).[9] Based on the $FLEX_{it}$ variable, obtained from monthly series, we then construct a quarterly time-varying dummy variable PEG_{it} for the panel analysis which takes value 1 if $FLEX_{it} < 1\%$ in all the three months of the relevant quarter. The threshold value of 1% is chosen based on the statistical distribution of the $FLEX$ variable across time and countries, but we have experimented with other values with similar results.

4 The econometric approach

We largely follow Kilian (2009) and Kilian et al. (2009) by following a two-stage approach where we first identify oil supply and demand shocks using a sign restrictions identification scheme and alternatively a recursive identification, and then condition exchange rates and other macro variables in each individual country to the shocks estimated in the first stage, in a panel setting.

4.1 The identification of global oil shocks

The starting point of the analysis is a VAR model specified as

$$A_0 y_t = A(L) y_{t-1} + u_t \tag{5}$$

where y includes (i) the growth rate of oil production, (ii) a detrended measure of global economic activity, as described in the data section, and (iii) the real oil price in dollars, deflated using the US CPI. We estimate the model on monthly data from 1986:1 to 2011:7. The lag length is chosen according to the Akaike information criterion, which points to only 3 monthly lags (much shorter than 24 as in Kilian et al. 2009). The identification scheme is based on sign restrictions and follows Kilian (2009):

	Oil supply	*Aggregate demand*	*Oil-specific demand*
Oil production	-	+	+
Global activity	-	+	- (including zero)
Real oil price	+	+	+

As suggested by Fry and Pagan (2011), we identify a single identification scheme satisfying the sign restrictions and are therefore able to recover series of structural oil demand and supply shocks satisfying the restrictions.

Moreover, similar to Kilian et al. (2009) and Kilian (2009), we identify oil supply shocks, aggregate demand shocks and oil demand shocks using a recursive (Cholesky) identification scheme where oil production is the most exogenous variable in the ordering and the real oil price the most endogenous.

[9] In this respect, we believe that a de facto measure is more reliable than a de iure one, as many emerging countries have "fear of floating".

Figure 3 reports the impulse responses to the three structural shocks identified respectively using the recursive scheme (thin black lines) and the sign restrictions scheme (thick green lines). Note that the shocks are all normalised so that they lead to a rise of the real oil price by 10% on impact. While the responses are qualitatively similar, they are sometimes quantitatively different. Moreover, one notable difference is the response of global activity to the oil demand shock, which is initially zero (by assumption) and then *positive* under the recursive scheme, while it is significantly negative under the sign restrictions approach. Nevertheless, the estimated structural shocks under the two identification schemes are highly pairwise correlated.

Let us denote $\widehat{\varepsilon} = [\widehat{\varepsilon}^{oils}, \widehat{\varepsilon}^{globdem}, \widehat{\varepsilon}^{oild}]$ the vector of oil supply shocks, aggregate global demand shocks and oil demand shocks identified under the sign restrictions (or the Cholesky recursive) scheme. We convert the monthly series of shocks into a quarterly frequency by averaging them. Note that by doing so the structural shocks are not necessarily orthogonal any more, nor serially uncorrelated, due to temporal aggregation. The effect of the temporal aggregation is however quite small, so we can consider the $\widehat{\varepsilon}$ vector as composed by structural shocks for all practical purposes.[10]

4.2 The second stage analysis

In the second stage, we estimate a fixed effects pooled panel model,

$$x_{it} = k_i + \lambda_t + \beta(L)x_{i,t-1} + \gamma(L)y_{it} + \delta(L)\widehat{\varepsilon}_t * y_{it} + \zeta D_{it}^{crisis} + v_{it} \tag{6}$$

where x_{it} is a variable of interest in country i, λ_t is a time dummy, y_{it} is a structural characteristic of the country, namely (i) the lagged (in order to avoid simultaneity) country's oil trade balance and estimated commodity trade balance[11] and (ii) conditional on the oil trade balance, a dummy variable measuring whether the country has mainly a floating or a pegging regime; D_t^{crisis} is a dummy variable indicating a currency crisis or a structural break in the exchange rate parity, to correct for infrequent structural shifts that could distort the estimates (see Section 3 for more details). Note that this specification is based on the assumption that global shocks (oil demand, oil supply and global demand) are exogenous for each country and, as in Kilian (2009), there is no correction for the generated regressors bias. We repeat the same analysis for the vector of shocks identified with the recursive scheme.

As a preliminary step, we do not distinguish between the different sources of shocks and we use oil price shocks computed by taking the residuals from an autoregressive

[10] In theory we do not need to estimate shocks at a monthly frequency and then convert them, in particular when using sign restrictions. However, the recursive identification scheme is much more credible at a monthly frequency and we also prefer to run the sign restrictions on monthly data to ensure full comparability with the recursive identification.

[11] The oil trade balance is interpolated (cubic spline) from annual data and therefore enters with four lags. The estimated commodity trade balance is obtained from quarterly data and enters with one lag.

model of the real oil price, whose lag length is chosen according to the Schwarz information criterion. Subsequently, we consider three structural shocks (oil demand, oil supply, general demand) which we identify either using sign restrictions or the Cholesky approach.

The coefficients of the $\gamma(L)$ polynomial measure the effects for a country with an average oil trade balance or a floating regime, while the coefficients in $\delta(L)$ for the interaction term measure the marginal impact of (i) an oil trade balance larger than the average and (ii) the additional effect of being a country with a pegging exchange rate regime. An advantage of the panel approach is the possibility to include a time dummy which corrects for all common factors (including e.g. factors that are specific to the dollar exchange rate as the oil price is denominated in USD). This allows the interaction term to be interpreted as a 'diff in diff' estimate, where the effect of a "treatment" (the oil trade balance, the exchange rate regime) is evaluated both against a control group and over time.

In order to summarise the effect for various lags in the $\gamma(L)$ and $\delta(L)$ polynomials and for ease of illustration in the tables, we consider moving averages of the shocks up to 4 quarters and collapse $\gamma(L)$ and $\delta(L)$ to individual coefficients γ and δ.[12] The results are not very sensitive to the choice of the order of the moving average for values between 1 and 4.

We consider six variables in the x vector: the log change (appreciation) in the real effective exchange rate, the log change (appreciation) in the bilateral exchange rate vs. the US dollar, the growth rate in foreign exchange reserves, the standardized exchange market pressure measure (EMP) index, the inflation rate (based on the CPI) and quarterly nominal stock returns. In particular, the inclusion of the EMP index is motivated by the need to have a measure of the impact of the shocks on the foreign exchange market that is not sensitive to the prevailing exchange rate regime with the respective reference currency as this is difficult to measure and changing over time. The inclusion of the inflation rate allows us to understand how the behaviour of the real exchange rate can be decomposed into movements of the nominal exchange rate and in the inflation rate, although (due to data limitations) this decomposition is possible only in a very approximate way, due to a lack of harmonised data on the nominal effective exchange rates.

5 Results of the second stage analysis

5.1 Baseline results

We are interested in whether the response of oil exporting economies to oil price shocks is different from that of oil importers, taking into account shifts in the oil

[12] For example, the effect of the oil supply shocks is computed as $\frac{\gamma}{p+1}\sum_{g=0}^{p}\varepsilon_{t-g}^{oils}$.

trade balance and exchange rate regimes in 44 countries.

Table 4 reports our baseline results for surprise changes in oil prices, irrespective of the underlying structural shock. The main focus of our analysis is in the interaction term between the oil price shock and the oil trade balance, which gauges the different response of the dependent variable to oil price shocks for a net oil exporter compared with the average.

Notably, positive oil price surprises lead to a statistically significant increase in the EMP index in countries with a better oil trade balance.[13] This appreciation pressure, however, manifests itself mainly through an increase in forex reserves (positive and strongly significant) and less so in a bilateral appreciation vis-a-vis the dollar (weakly significant) or in a real effective appreciation (insignificant). One could expect that the rise in forex reserves should be stronger in pegging countries, but we do not find this to be the case as the interaction dummy with the pegging regime turns out insignificant, and is hence excluded in the rest of the analysis. Equity returns are higher in net oil exporters, probably reflecting the windfall gains for local oil producers. Finally, note that our currency crisis dummy is strongly significant and negative for all forex-related variables. In terms of economic significance, a higher oil trade balance to GDP by one per cent implies a 1.6% extra rise in forex reserves after an oil price shock raising the real oil price by 10%, and an extra 1.3% rise in the stock market.

In *Table 5*, we substitute the (estimated) overall commodity trade balance for the oil trade balance in order to control whether oil price shocks, potentially associated with broader commodity price cycles, may lead to a systematic response of commodity currencies. The main result is the same as in Table 4; the oil shock leads to appreciation pressure in commodity exporters which is countered by the accumulation of forex reserves. Note that the much larger magnitude of the coefficients compared with Table 4 reflects the fact that the oil trade balance and the estimated overall commodity balance have a different scale.

In order to find out which particular structural shock lies beneath the relationship between positive oil price surprises and rising exchange market pressure, as well as better stock market performance in oil exporting economies, we impose sign restrictions to identify three different structural shocks. *Table 6* unequivocally shows that the aforementioned result is mainly driven by the *oil demand shock* which creates significant appreciation pressure that manifests itself in an increase in the real exchange rate and foreign reserves. The size of the coefficients is similar to the baseline analysis in Table 4: after an oil demand shock raising the real oil price by 10%, forex reserves go up by about 1% more for any additional 1% of GDP for the oil trade balance, and the stock market goes up also by about 1%; the real effective exchange rate goes up by about 0.3%. The coefficients for global demand shocks are entirely insignificant and even slightly negative for the oil supply shock although the latter observation

[13] Note that the EMP index is standardized in the regression such that its value gives its difference from the (zero) mean in terms of standard deviations.

vanishes after 1999 (see Table 8). There are at least two possible explanations for the different impact of shocks. First, oil supply shocks are most likely too small and not material for the adjustment of external imbalances in oil producers and consumers. Indeed, Kilian (2009) shows that aggregate demand shocks and oil market–specific demand shocks explain the bulk of the variation in the oil price. Second, global demand shocks are by definition symmetric shocks, hitting both producers and consumers at the same time and in the same direction. Oil demand shocks, by contrast, represent a "diversion" of demand from other goods to oil, and hence a net change in favour of oil producers and away from oil consumers.[14] *Table 6a* reports results when the structural shocks are identified using the Cholesky decomposition, which leads to very similar conclusions, although the coefficients are somewhat smaller in magnitude.

It is interesting to analyse the implications of our results for the debate on the adjustment of global imbalances, relating them to those of a previous study by Kilian et al. (2009). These authors show that following an oil specific demand shock: (i) the overall trade balance and the current account of oil exporters (major oil importers) improves (deteriorates) even though the non-oil trade balance deteriorates and (ii) oil exporters experience persistent and significant capital losses. Together with these results our findings indicate that for oil exporters: (a) the exchange rate does not play a role in the adjustment of the non-oil trade balance; (b) foreign exchange reserves, in particular, absorb the oil specific demand shock, and (c) the capital losses of oil exporters may be potentially explained by rising domestic asset prices vis-à-vis oil importers, but not by exchange rate movements.[15]

Replacing oil trade balance with estimated commodity trade balance in the regression we find a number of interesting results in *Tables 7 and 7a*. Apart from oil specific demand shocks, also global aggregate demand shocks seem to matter for commodity currencies, in particular when shocks are identified using the Cholesky identification scheme. This suggests that the world business cycle may lead to a diversion of demand and an asymmetric macroeconomic impact for *all-commodities* exporters as a group, but not specifically for *oil* exporters. This is an interesting result that needs to be corroborated by further research.

Another noteworthy result of Table 7 and 7a is that stock markets in commodity exporting economies outperform those of commodity importing ones significantly after an oil demand shock but do not appear to be affected in response to one of the other shocks. Considering that fuel and non-fuel commodity returns have become highly correlated just recently and the presumed fading influence of oil supply and global

[14] This is also confirmed by the higher equity returns when interacted with the oil trade balance.

[15] It is important to remember that the foreigners' participation in the domestic stock market represents a foreign *liability* for domestic residents. Assuming a balanced or negative net foreign equity position, the out-performance of the domestic stock market relative to the rest of the world generates a *negative* valuation effect, i.e. a capital loss, for the international investment position of the domestic economy.

demand shocks on the real price of oil, this outcome does not come as a surprise. Generally, results are similar irrespective of using the sign restrictions or the Cholesky identification scheme.

5.2 Robustness across time

How stable are our results over time? There is little doubt that the oil market has changed substantially in the past three decades and new key players, such as China, have emerged. Changes in oil efficiency over time (Bodenstein and Guerrieri 2011) are also an important consideration. Finally, there has been much debate over recent years on the increasingly erratic behaviour of commodity prices, in particular after the early 2000s, and on the so-called financialization of commodities. It is therefore interesting to see whether and how our results are robust to possible structural breaks.

In *Table 8*, therefore, we include an additional interaction term which multiplies the interaction variable between the oil shocks and the lagged oil trade balance by a dummy variable identifying a particular period. The estimated equation is

$$x_{it} = k_i + \lambda_t + \beta x_{i,t-1} + \delta \overline{\overline{\varepsilon}}_t * OTB_{i,t-4} + \eta \overline{\overline{\varepsilon}}_t * OTB_{i,t-4} * T_t + \zeta D_{it}^{crisis} + v_{it} \quad (7)$$

where $\overline{\overline{\varepsilon}}_t$ is a moving average of the original structural shocks (as discussed before), OTB is the trade oil balance, T_t is a dummy variable identifying a particular period. The coefficient η indicates whether the interaction term $\overline{\overline{\varepsilon}}_t * TOB_{it}$ has a different effect on x_{it}, compared with the average over the whole period, during the sub-period identified by the T dummy. We consider four possible candidate structural breaks: (i) 1999:1 (the trough of the oil price cycle and the date of the introduction of the euro), (ii) 2002:1 (the start of the large rise in oil prices and of their erratic behaviour),[16] (iii) 2007:3 (the start of the global financial crisis)and (iv) 2008:3 (the peak of the crisis).

Notably, the counter-intuitive decrease of the real exchange rate following an oil supply shock (as detected in Table 6) disappears over the second half of the sample since the coefficient turns out significantly positive for the post-1999 and the post-2002 period. As can be seen in the table, almost all other coefficients associated with interaction terms are insignificant, indicating that our results are remarkably robust over time. Similar robust results (not shown for reasons of space) are obtained when using the estimated commodity trade balance instead of the oil trade balance.

6 Conclusions

In this paper, we have focused on the link between global oil shocks and exchange rates. The question we have addressed is whether oil shocks affect global exchange

[16] Kilian (2009) argues that while oil-specific demand was the key driver behind the surge of the real oil price in 1999/2000, the subsequent rise starting in 2002 can almost exlusively be attributed to demand pressures arising from real economic activity.

rate configurations. Existing general equilibrium models emphasise the fact that shocks raising the (real) oil price represent a positive (negative) terms of trade and income shock for net oil producing (consuming) countries. To ensure the external sustainability of oil importing countries, the real exchange rate of the latter needs to depreciate in order to foster the creation of a more positive non-oil trade balance. Is this mechanism visible in the data?

Following Kilian (2009) and Kilian et al. (2009) we have identified global oil shocks in a VAR approach, where structural shocks are identified recursively and using sign restrictions. In a second stage, we have looked at the effect of these shocks on exchange rates, the accumulation of forex reserves, and an index of exchange market pressure which combines information from both indicators. Our main finding is that there is no evidence that the currencies of oil exporting countries systematically appreciate after oil shocks. In part, this is determined by the fact that oil exporters (not only those having a mainly fixed exchange rate regime) actively counter appreciation pressures by accumulating forex reserves. That is, in a nutshell, the main message of our paper.

A main implication of our findings is that, as a result of this widespread policy, oil shocks are not an important factor in global exchange rate configurations after all, a stylised fact which could be taken into account in future modelling efforts of the global oil market. Moreover, we detect significant appreciation pressures (however countered by the accumulation of forex reserves) in oil exporting economies after oil demand shocks while no such differential pressure is detected for oil supply and global demand shocks.

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Appendix

Table 1. Description of Variables and Sources

Variable	Description	Source	Freq.
Macroeconomic Core Variables			
CPI	Consumer Price Index	IMF IFS, Global Insight, and ECB Area-wide Model (AWM)	Q
Interest Rate	Money Market Rate (IMF IFS line 60b) if available. The Central Bank monetary policy rate was used for 10 countries: Cyprus, Egypt, Algeria, Nigeria, Chile, Peru, Venezuela, India, China, Hungary For Hong Kong the 1-month interbank rate was used.	IMF IFS, Haver, Thomson Reuters, and ECB AWM	Q
Global Economic Activity	The Global Real Economic Activity Index in industrial commodity markets as proposed by Kilian (2009) is constructed using dry cargo single voyage ocean freight rates with data provided by Drewry Shipping Consultants Ltd. The index is based on US CPI deflated and linearly detrended (HP 1600) growth rates which are expressed in monthly percent deviations from the trend.	Kilian (2009)	M
Nominal GDP, Exports, Imports	in USD bn	IMF WEO and Global Insight	A
Oil & Commodities			
Oil Price	US$ per Barrell Brent (U.S. CPI Deflated)	International Energy Agency (IEA)	M
Oil Supply	Total World Supply (in thousands Barrell / day)	IEA	M
Oil trade balance	in USD bn	IMF WEO and Global Insight	A
Commodity Price	IMF PINDU Industrial Materials Price Index	IMF Primary Commodity Prices	M
Financial Data			
Stock Price	Local major indices (backcasted where applicable)	Thomson Reuters and Global Financial Data	Q
Monetary Indicators			
Foreign Exchange Reserves	in USD bn. Reserves of Saudi-Arabia in 2005M1 and Cyprus 2008M1 were smoothed due to a structural break (owing to accounting reasons in Saudi-Arabia and the adoption of the Euro in Cyprus)	IMF IFS and Global Insight	M
Monetary Base	in USD bn	IMF IFS and Global Insight	M
Sovereign Wealth Fund Assets	For Norway and Russia (in USD bn)	National Authority	M
Exchange Rates			
REER	Real Effective Exchange Rate (denoted such that an increase implies appreciation)	IMF IFS and Global Insight	Q
NEER	Nominal Effective Exchange Rate (denoted such that an increase implies appreciation)	IMF IFS and Global Insight	Q
USD	Bilateral nominal exchange rate of national currency with USD (quarterly average of daily data for VAR), end of period for monthly data for EMP). Unit: US$ per National Currency	IMF IFS and Global Insight	M / Q
EUR	Bilateral nominal exchange rate of national currency with the Euro (quarterly average of daily data for VAR), end of period for monthly data for EMP), Unit: € per National Currency	IMF IFS and Global Insight	M / Q
Currency Regime Classification	Dummy variable (1=Peg, 0=Float), Criterion: Peg, if average absolute change in the monthly bilateral nominal exchange rate was less than 1% over past 12 months (decision rule based on Levy-Yeyati and Sturzenegger (2005))	Own calculations	Q
Currency crisis	Dummy variable (1=crisis, 0=no crisis), Identification according to the CRISIS2 criterion suggested by Milesi-Ferretti and Razin (2000): D=1 if E(t) > 25%, E(t) > 2*E(t-1), and E(t-1) < 40%, D = 0 otherwise. E is the YoY percentage change in the bilateral nominal exchange rate, based on quarterly data.	Own calculations	Q
Exchange Market Pressure Index	*see explanations in Data Section*	Own calculations	M

Table 2. Average Oil trade balance to GDP (%), 1986-2010

Oil Exporters		Oil Importers			
Saudi Arabia	35.6	Tunisia	-0.1	South Africa	-2.3
Nigeria	35.4	Australia	-0.2	India	-2.3
Algeria	28.0	Peru	-0.6	Chile	-2.5
Venezuela	21.2	China	-1.0	Czech Republic	-2.7
Norway	11.1	Brazil	-1.1	Hong Kong	-2.7
Russia	11.0	United States	-1.1	Turkey	-2.9
Malaysia	3.3	Singapore	-1.1	Hungary	-3.0
Mexico	1.9	Euro area	-1.4	Pakistan	-3.2
Egypt	1.4	Sweden	-1.4	Israel	-3.3
Argentina	1.2	Japan	-1.5	Korea	-3.8
Indonesia	1.1	New Zealand	-1.8	Philippines	-3.8
Canada	0.6	Romania	-2.1	Taiwan	-4.1
Denmark	0.4	Iceland	-2.2	Morocco	-4.6
United Kingdom	0.3	Switzerland	-2.2	Thailand	-5.8
		Poland	-2.3	Cyprus	-6.0

Source: see Table 1.

Table 3. Reference Currency

USD		Euro
Euro area	Venezuela	United States
Japan	Taiwan	United Kingdom
Canada	Hong Kong	Denmark
Australia	India	Norway
New Zealand	Indonesia	Sweden
South Africa	Korea	Switzerland
Israel	Malaysia	Iceland
Saudi Arabia	Pakistan	Turkey
Egypt	Philippines	Cyprus
Nigeria	Singapore	Algeria
Argentina	Thailand	Morocco
Brazil	China	Tunisia
Chile	Russia	Czech Republic
Mexico	Poland*	Hungary
Peru		Poland*

The reference country for the nominal bilateral exchange rate follows Reinhart and Rogoff's (2002) classification of de facto currency regimes. Free floating currencies are benchmarked against the USD except for the USD itself which is benchmarked against the Euro.

* Poland is benchmarked against the Euro from May 1995 on, when Poland shifted its currency regime from a pre announced crawling peg to the USD to a de facto crawling band to the Euro.

Table 4. Panel regression with country fixed effects and time dummies. Oil price surprises from autoregressive model and oil trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
Lag of dependent variable	0.511***	0.243***	0.022	0.164***	0.191***	0.214***
	(0.063)	(0.088)	(0.036)	(0.029)	(0.027)	(0.058)
Oil price shock*Oil TB (t-4)	0.008*	-0.002	0.002	0.016***	0.097**	0.013*
	(0.005)	(0.001)	(0.003)	(0.004)	(0.044)	(0.007)
Oil price shock*Oil TB (t-4)*Peg	-0.007	0.001	-0.003	-0.002	-0.016	-0.007
	(0.005)	(0.002)	(0.003)	(0.004)	(0.043)	(0.008)
Peg	0.014***	-0.018**	0.005**	-0.011*	0.041	-0.033***
	(0.004)	(0.008)	(0.002)	(0.006)	(0.031)	(0.011)
Oil TB (t-4)	0.000	0.000	0.000	0.001	0.013**	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.001)
Currency crisis	-0.025***	0.016	-0.027***	-0.017***	-0.366***	0.001
	(0.006)	(0.010)	(0.004)	(0.006)	(0.058)	(0.007)
Observations	4,101	4,022	4,070	4,024	3,987	3,751
Number of groups	44	44	44	44	44	43
R2 Within	0.377	0.159	0.0734	0.0942	0.196	0.296

Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Oil price shocks are calculated as moving averages between t and t-4 of the residuals of an auto-regressive, AR(3), model of the real oil price. Oil TB indicates the oil trade balance as % of GDP. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 5. Panel regression with country fixed effects and time dummies. Oil price surprises from autoregressive model and estimated commodity trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
Lag of dependent variable	0.440***	0.367**	0.080	0.226***	0.172***	0.122*
	(0.102)	(0.167)	(0.047)	(0.036)	(0.031)	(0.068)
Oil price shock*Est. Comm. TB (t-1)	0.123	0.305	0.085	0.508***	4.392***	0.264
	(0.153)	(0.323)	(0.084)	(0.120)	(1.572)	(0.176)
Est. Comm. TB (t-1)	-0.057**	0.063	-0.017	0.049	0.077	0.020
	(0.021)	(0.043)	(0.016)	(0.044)	(0.389)	(0.045)
Currency crisis	-0.022***	0.008	-0.024***	-0.021***	-0.427***	0.002
	(0.006)	(0.008)	(0.004)	(0.005)	(0.075)	(0.007)
Observations	3,073	3,063	3,073	2,998	2,981	3,002
Number of groups	44	44	44	44	44	43
R2 Within	0.332	0.189	0.113	0.137	0.220	0.326

Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Oil price shocks are calculated as moving averages between t and t-4 of the residuals of an auto-regressive, AR(3), model of the real oil price. Est. Comm. TB indicates an estimated commodity trade balance obtained by recursively computing the correlation between changes in countries' net nominal trade balance in US dollars and the rate of growth of a commodity price index. A higher correlation indicates that countries are more likely to be net exporters of commodities. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 6. Panel regression with country fixed effects and time dummies – Structural shocks identified with the sign restrictions approach and oil trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
Lag of dependent var.	0.507***	0.245***	0.025	0.172***	0.195***	0.220***
	(0.062)	(0.088)	(0.034)	(0.027)	(0.027)	(0.059)
Oil supply shock*Oil TB (t-4)	0.001	-0.001*	-0.002**	0.001	0.016	-0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.012)	(0.001)
Oil demand shock*Oil TB (t-4)	0.002	-0.001	0.003*	0.009**	0.037*	0.009**
	(0.002)	(0.001)	(0.001)	(0.004)	(0.021)	(0.004)
Global demand shock*Oil TB (t-4)	0.000	0.000	-0.001	0.001	0.006	-0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.013)	(0.003)
Oil TB (t-4)	0.000	0.000	0.001*	0.000	0.011**	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.001)
Currency crisis	-0.027***	0.018*	-0.027***	-0.015**	-0.371***	0.005
	(0.006)	(0.010)	(0.004)	(0.006)	(0.058)	(0.007)
Observations	4,183	4,090	4,150	4,101	4,061	3,810
Number of groups	44	44	44	44	44	43
R2 Within	0.369	0.157	0.0752	0.0897	0.192	0.293

Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Structural shocks are calculated as moving averages between t and t-4 of the underlying structural shocks (see section 4.1 of the paper for further details). Oil TB indicates the oil trade balance as % of GDP. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 6a. Panel regression with country fixed effects and time dummies – Structural shocks identified with the Cholesky approach and oil trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
Lag of dependent var.	0.507***	0.245***	0.025	0.172***	0.195***	0.220***
	(0.062)	(0.088)	(0.034)	(0.027)	(0.027)	(0.059)
Oil supply shock*Oil TB (t-4)	-0.001	-0.003	-0.021***	-0.028	-0.057	-0.036*
	(0.010)	(0.007)	(0.007)	(0.023)	(0.119)	(0.018)
Oil demand shock*Oil TB (t-4)	0.001*	-0.001*	-0.001	0.003**	0.019**	0.002*
	(0.001)	(0.000)	(0.001)	(0.001)	(0.009)	(0.001)
Global demand shock*Oil TB (t-4)	0.002	0.000	-0.001	0.007	0.032	0.002
	(0.002)	(0.001)	(0.002)	(0.005)	(0.021)	(0.004)
Oil TB (t-4)	0.000	0.000	0.001*	0.000	0.011**	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.001)
Currency crisis	-0.027***	0.018*	-0.027***	-0.015**	-0.371***	0.005
	(0.006)	(0.010)	(0.004)	(0.006)	(0.058)	(0.007)
Observations	4,183	4,090	4,150	4,101	4,061	3,810
Number of groups	44	44	44	44	44	43
R2 Within	0.369	0.157	0.0752	0.0897	0.192	0.293

Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Structural shocks are calculated as moving averages between t and t-4 of the underlying structural shocks (see section 4.1 of the paper for further details). Oil TB indicates the oil trade balance as % of GDP. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 7. Panel regression with country fixed effects and time dummies – Structural shocks identified with the sign restrictions approach and estimated commodity trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
Lag of dependent var.	0.441***	0.367**	0.079*	0.223***	0.174***	0.121*
	(0.101)	(0.167)	(0.046)	(0.034)	(0.031)	(0.068)
Oil supply shock*Est. Comm. TB (t-1)	0.094	0.131	-0.006	0.103	1.581**	-0.021
	(0.109)	(0.200)	(0.040)	(0.092)	(0.668)	(0.101)
Oil demand shock*Est. Comm. TB (t-1)	-0.170	0.335	0.048	0.286*	1.653	0.579***
	(0.158)	(0.325)	(0.074)	(0.149)	(1.122)	(0.184)
Global demand shock*Est. Comm. TB (t-1)	0.182	-0.348	0.067	0.101	2.179*	-0.276
	(0.126)	(0.342)	(0.061)	(0.120)	(1.218)	(0.173)
Est. Comm. TB (t-1)	-0.056***	0.052	-0.012	0.053	0.109	0.023
	(0.020)	(0.033)	(0.016)	(0.042)	(0.366)	(0.040)
Currency crisis	-0.022***	0.008	-0.025***	-0.022***	-0.433***	0.001
	(0.006)	(0.007)	(0.004)	(0.005)	(0.075)	(0.007)
Observations	3,109	3,097	3,109	3,030	3,013	3,037
Number of groups	44	44	44	44	44	43
R2 Within	0.335	0.192	0.113	0.137	0.220	0.328

Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Structural shocks are calculated as moving averages between t and t-4 of the underlying structural shocks (see section 4.1 of the paper for further details). Est. Comm. TB indicates an estimated commodity trade balance obtained by recursively computing the correlation between changes in countries' net nominal trade balance in US dollars and the rate of growth of a commodity price index. A higher correlation indicates that countries are more likely to be net exporters of commodities. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 7a. Panel regression with country fixed effects and time dummies – Structural shocks identified with the Cholesky approach and estimated commodity trade balance

Dependent variable	(1) Δ USD	(2) Inflation	(3) Δ REER	(4) Δ Res	(5) EMP	(6) Δ Stock P
Lag of dependent var.	0.441***	0.367**	0.079*	0.223***	0.174***	0.121*
	(0.101)	(0.167)	(0.046)	(0.034)	(0.031)	(0.068)
Oil supply shock*Est. Comm. TB (t-1)	1.295	-0.876	-0.170	-0.509	3.413	-2.581**
	(0.982)	(1.283)	(0.349)	(0.895)	(4.704)	(0.966)
Oil demand shock*Est. Comm. TB (t-1)	0.007	0.196	0.002	0.131**	1.293**	0.149*
	(0.078)	(0.211)	(0.034)	(0.064)	(0.630)	(0.088)
Global demand shock*Est. Comm. TB (t-1)	0.292	-0.487	0.148	0.344*	5.257**	-0.273
	(0.194)	(0.490)	(0.117)	(0.204)	(2.262)	(0.278)
Est. Comm. TB (t-1)	-0.056***	0.052	-0.012	0.053	0.109	0.023
	(0.020)	(0.033)	(0.016)	(0.042)	(0.366)	(0.040)
Currency crisis	-0.022***	0.008	-0.025***	-0.022***	-0.433***	0.001
	(0.006)	(0.007)	(0.004)	(0.005)	(0.075)	(0.007)
Observations	3,109	3,097	3,109	3,030	3,013	3,037
Number of groups	44	44	44	44	44	43
R2 Within	0.335	0.192	0.113	0.137	0.220	0.328

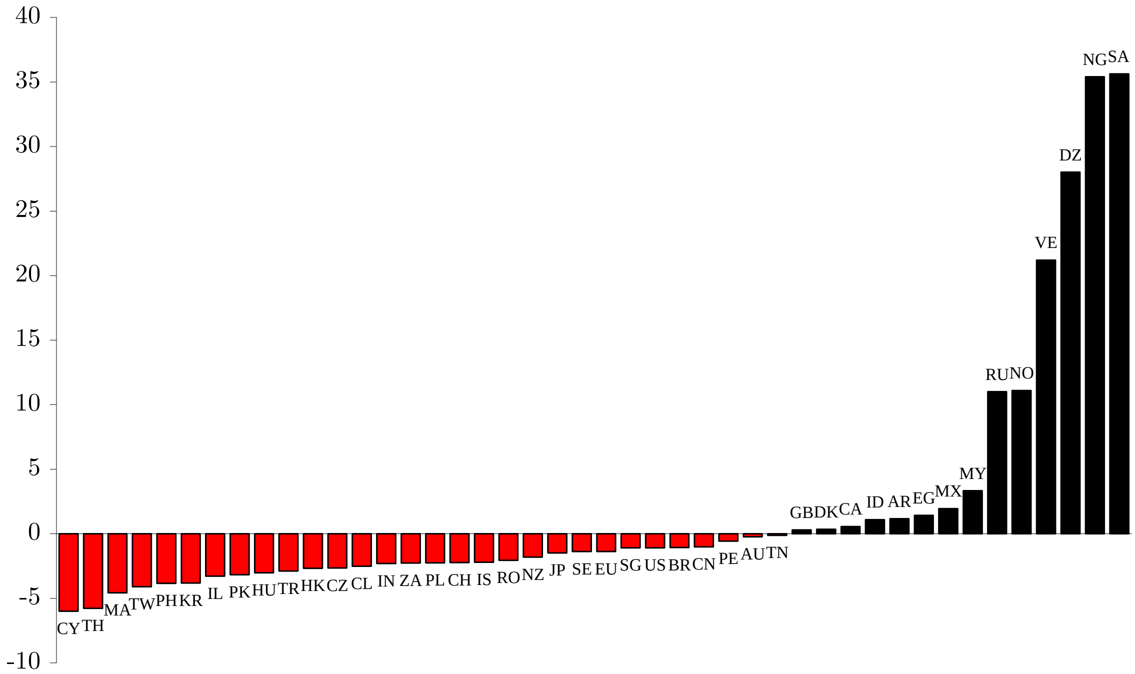
Notes: Pooled OLS with Driscoll-Kraay standard errors, accounting for temporal and cross-sectional dependence (reported in parentheses). ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively. The model includes both time dummies and country fixed effects. Structural shocks are calculated as moving averages between t and t-4 of the underlying structural shocks (see section 4.1 of the paper for further details). Est. Comm. TB indicates an estimated commodity trade balance obtained by recursively computing the correlation between changes in countries' net nominal trade balance in US dollars and the rate of growth of a commodity price index. A higher correlation indicates that countries are more likely to be net exporters of commodities. See Table 1 for a description of the data. Sample period 1986:1 to 2011:1, quarterly data.

Table 8. Robustness to time variation. Model augmented with time step-dummy – Structural shocks identified with the signs restrictions approach and oil trade balance

	(1)	(2)	(3)	(4)	(5)	(6)
	Δ USD	Inflation	Δ REER	Δ Res	EMP	Δ Stock P
DUM_t=1 if t > 1998Q4						
Oil supply shock*Oil TB (t-4)*DUM_t	0.000	0.001	0.004**	-0.005	0.023	-0.007*
	(0.002)	(0.001)	(0.002)	(0.005)	(0.020)	(0.004)
Oil demand shock*Oil TB (t-4)*DUM_t	-0.001	0.003	-0.001	0.002	0.051	-0.009
	(0.004)	(0.004)	(0.004)	(0.009)	(0.035)	(0.008)
Global demand shock*Oil TB (t-4)*DUM_t	-0.000	-0.003	0.002	-0.012	-0.001	-0.004
	(0.002)	(0.003)	(0.003)	(0.010)	(0.028)	(0.006)
DUM_t=1 if t > 2001Q4						
Oil supply shock*Oil TB (t-4)*DUM_t	-0.001	0.001	0.004**	-0.004	0.021	-0.003
	(0.002)	(0.001)	(0.002)	(0.004)	(0.023)	(0.003)
Oil demand shock*Oil TB (t-4)*DUM_t	-0.001	0.001	-0.003	-0.004	-0.001	-0.008
	(0.004)	(0.002)	(0.003)	(0.007)	(0.045)	(0.006)
Global demand shock*Oil TB (t-4)*DUM_t	-0.003	-0.003	0.002	-0.009	-0.011	0.005
	(0.003)	(0.002)	(0.003)	(0.009)	(0.031)	(0.007)
DUM_t=1 if t > 2007Q2						
Oil supply shock*Oil TB (t-4)*DUM_t	-0.000	0.002	0.005	-0.007	0.007	0.001
	(0.002)	(0.001)	(0.003)	(0.006)	(0.072)	(0.005)
Oil demand shock*Oil TB (t-4)*DUM_t	-0.002	-0.001	-0.006	-0.003	0.001	-0.011
	(0.004)	(0.002)	(0.005)	(0.008)	(0.074)	(0.007)
Global demand shock*Oil TB (t-4)*DUM_t	-0.001	-0.001	0.000	-0.004	-0.020	0.009**
	(0.002)	(0.001)	(0.003)	(0.006)	(0.047)	(0.005)
DUM_t=1 if t > 2008Q2						
Oil supply shock*Oil TB (t-4)*DUM_t	0.000	0.001	0.004	-0.005	0.000	0.000
	(0.002)	(0.001)	(0.003)	(0.007)	(0.077)	(0.005)
Oil demand shock*Oil TB (t-4)*DUM_t	-0.002	-0.000	-0.005	-0.001	-0.003	-0.011
	(0.004)	(0.001)	(0.005)	(0.008)	(0.102)	(0.008)
Global demand shock*Oil TB (t-4)*DUM_t	-0.001	-0.002	-0.001	-0.006	-0.031	0.003
	(0.003)	(0.001)	(0.005)	(0.005)	(0.071)	(0.004)
memo: whole sample, no time step-dummy						
Oil supply shock*Oil TB (t-4)	0.001	-0.001*	-0.002**	0.001	0.016	-0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.012)	(0.001)
Oil demand shock*Oil TB (t-4)	0.002	-0.001	0.003*	0.009**	0.037*	0.009**
	(0.002)	(0.001)	(0.001)	(0.004)	(0.021)	(0.004)
Global demand shock*Oil TB (t-4)	0.000	0.000	-0.001	0.001	0.006	-0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.013)	(0.003)

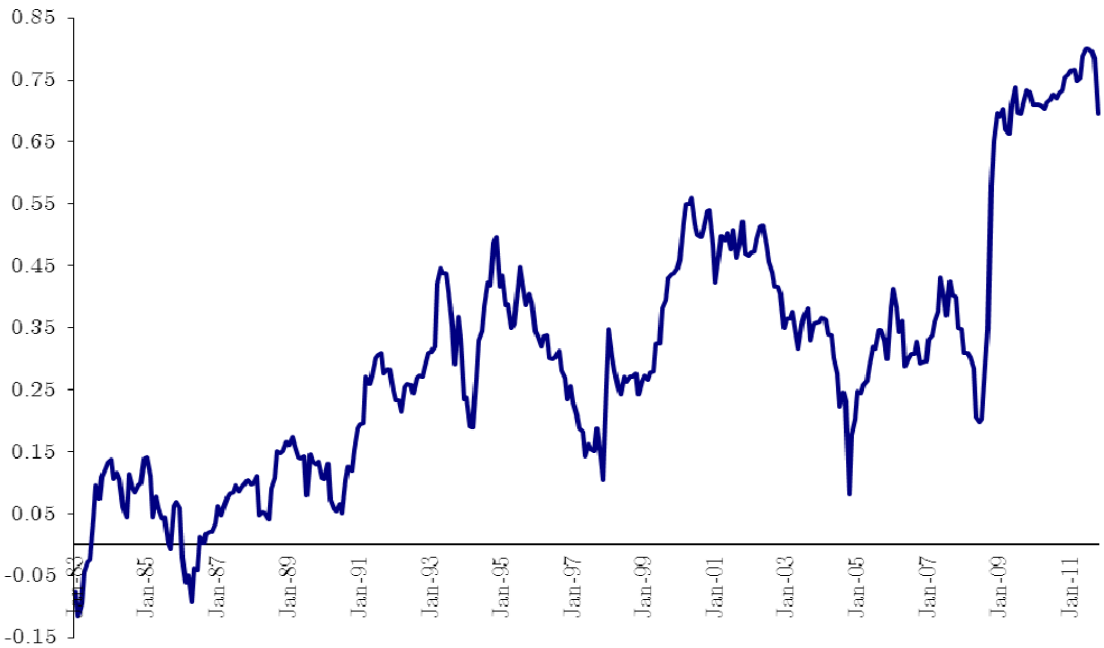
Notes: The model in Table 6 (panel OLS: structural oil shocks identified through sign restrictions and oil trade balance) was re-estimated adding different time step-dummies - separately in each regression - interacted with the oil shocks multiplied by the oil trade balance in order to control for the stability of these coefficients in different sub-samples. For reason of space, the table reports only the coefficients of the relevant interaction terms for each separate regression. ***, **, * indicate statistical significance at the 1, 5, 10 percent level, respectively, and potential instability of the coefficients across the sample period.

Figure 1. Average Oil trade balance to GDP (%) 1986 - 2010



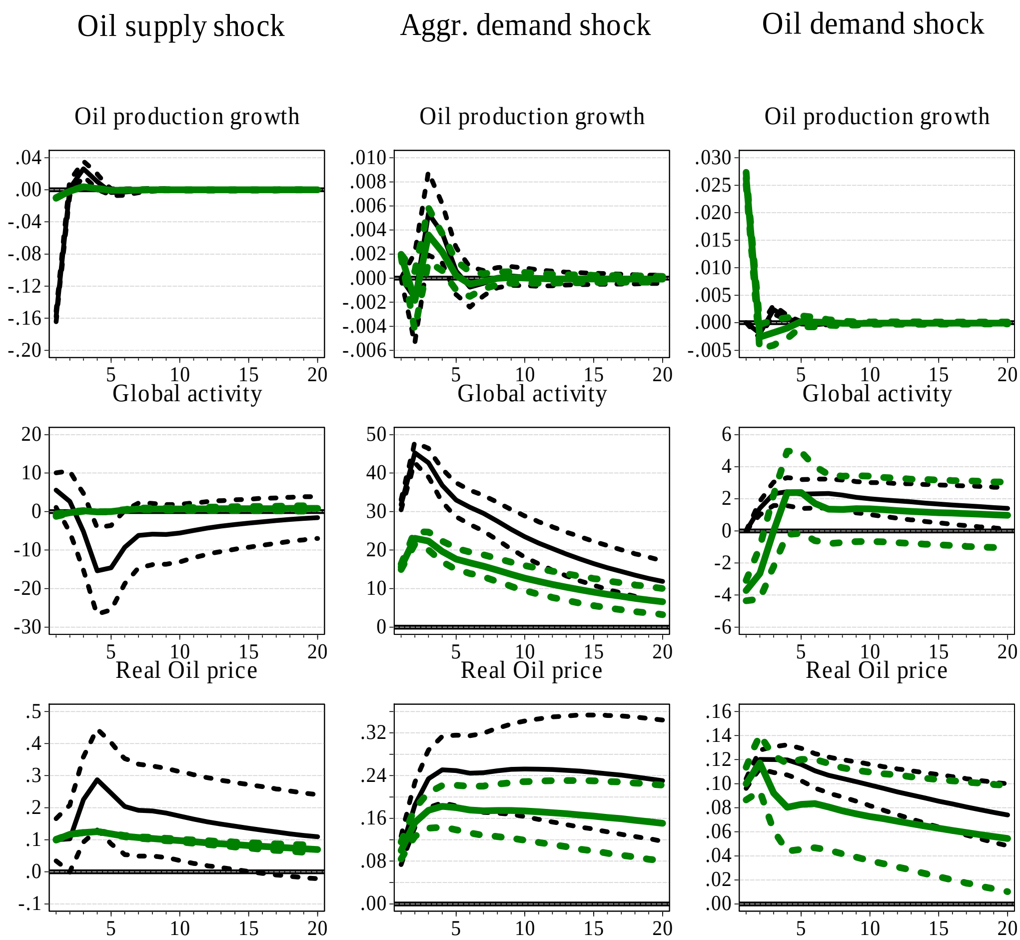
Source: IMF WEO

Figure 2. Correlation between oil prices and non-fuel commodity prices



Source: IMF and authors' calculations.
Note: The correlations are computed using a 3-year moving window on monthly growth rates of the IMF Oil Price Index (POILAPSP) based on an average of U.K. Brent, Dubai, and West Texas Intermediate and the IMF Industrial Materials Price Index (PINDU) based on non-fuel commodities.

Figure 3. Impulse responses from global shocks: comparing sign restrictions and recursive identification



Note: The figure reports impulse responses from structural shocks identified using the sign restrictions approach (thick, green lines) or the Cholesky approach (thin, black lines). The impulse responses are based on a VAR estimated on monthly data from 1986:1 to 2011:6. The three structural shocks are normalised so as to increase the real oil price by 10% on impact.