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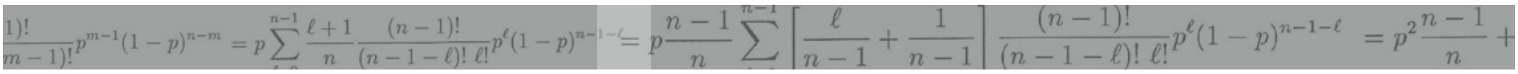
MACROECONOMIC IMPLICATIONS OF OIL-PRICE SHOCKS TO EMERGING ECONOMIES: A MARKOV REGIME-SWITCHING APPROACH

Sophio Togonidze
Evžen Kočenda

IES Working Paper 21/2022



Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Bibliographic information:
Togonidze, S., Kočenda E. (2022): "Macroeconomic Implications of Oil-Price Shocks to Emerging Economies: A Markov Regime-Switching Approach" IES Working Papers 21/2022. IES FSV. Charles University.

Macroeconomic Implications of Oil-Price Shocks to Emerging Economies: A Markov Regime-Switching Approach

Sophio Togonidze[a]
Evžen Kočenda[b]

[a]Institute of Economic Studies, Charles University, Prague, Czech Republic.
Email: 31739570@fsv.cuni.cz.
[b]Institute of Economic Studies, Charles University, Prague, Czech Republic.
Institute of Information Theory and Automation of the CAS, Prague;
CESifo Munich; IOS Regensburg.
Email: evzen.kocenda@fsv.cuni.cz.

September 2022

Abstract:

We investigate an impact of oil-price shocks on GDP and exchange rate dynamics in resource-heterogeneous economies. We employ a Markov regime-switching version of a vector autoregressive (VAR) model to allow for regime shifts, non-linear effects and timevarying parameters of the VAR process. Empirically we use quarterly data series in oil exporting, metal-exporting, and less-resource-intensive economies. On average, real GDP in oil-exporting economies exhibits substantial contraction, while for metal exporters there is a significant real GDP expansion suggesting an offsetting effect of metal exports on oil imports. We find that currency appreciation state is more persistent in oil- and metal exporting economies while less-resource-intensive economies remain longer in a currency depreciation state. Further evidence suggests existence of the counteracting forces such as foreign exchange interventions by authorities in oil-exporting economies. It also emerges that currency appreciation in oil-exporting economies is driven largely by economic performance rather than oil price movement.

JEL: F44, E37, C11, E32, C22, C58, F31, Q43
Keywords: Emerging economies, Oil shocks, GDP, Markov regime-switching, Exchange rate, Oil exporters, Metal exporters

Acknowledgements: We are grateful for useful comments we received from Milan Fičura, Roman Horváth, Milan Ščasný, Jiří Witzany, and presentation participants. This research has been supported by the Czech Science Foundation within the EXPRO Program "Frontiers in Energy Efficiency Economics and Modelling - FE3M": [Grant Number 19-26812X]. The usual disclaimer applies.

1. Introduction

Oil-price movements are in the focus of scholars and policy makers because of the disruptive nature of oil-price shocks on the macroeconomy (Lv et al., 2018; Rasasi, 2017; Habib et al., 2016; Pershin et al., 2016). Most of the existing empirical studies has put emphasis on the relationship between oil prices and key macroeconomic indicators (Kilian, 2009; Nasir et al., 2018; Brahmasrene et al., 2014; Yoshino and Taghizadeh-Hesary, 2014), but a convergence of arguments about the impact and significance of oil-price shocks is yet to be achieved. Moreover, although there is a vast literature on the impacts of oil-price shocks, such research is mostly inclined towards advanced economies, leaving emerging and developing economies inadequately covered. This gap calls for attention because emerging and developing economies are quite vulnerable to potential adverse effects from oil-price shocks due to their varying resource endowments, often small economic size, heterogeneous trade composition, and limited export diversification compared to advanced economies (Kilian and Zhou, 2020; Holm-Hadulla and Hubrich, 2017; Aastveit et al., 2015; Behmiri and Manso, 2013; Turhan et al., 2013). Finally, the extant literature also leans towards assuming a simple linear link between oil-price shocks and macroeconomic responses. In our analysis we contribute to the literature by providing a detailed assessment of the impact of oil-price shocks on GDP and exchange rate dynamics in resource-heterogeneous economies, allowing for changes in regimes to account for non-linear effects. To the best of our knowledge, a similar analysis on a sample of emerging economies has not been performed yet.

This gap motivates our study with an aim to contribute to the literature in two ways. First, our study employs a Markov regime-switching (MRS) model because of its advantage over other methods in capturing the likelihood of jumps in different equilibria that characterize the dynamics of economic development (Hardy, 2001). Throughout the analysis, the heterogeneity of emerging economies in trade flows is maintained when investigating the impact of oil-price shocks on GDP and exchange rate. Second, to the best of our knowledge, there has been no other comparative study on emerging and developing economies that has distinctively shown how reactions of macroeconomic variables substantially alter (switch) in the event of an oil-price shock in countries that are oil exporters, metal exporters, or are less-resource-intensive.

In our analysis we employ a vector autoregression (VAR) model that is among the most exploited economic models in analyzing the disruptive nature of oil demand and supply shocks to global economic activity and the impact of oil-price shocks to macroeconomic fundamentals (Burbidge and Harrison, 1984; Jiménez-Rodríguez* and Sánchez, 2005; Baumeister and Hamilton, 2019). Another area that has been attracting interest in existing studies is the causality relationship between oil prices and exchange rate especially in the recent studies by Habib et al. (2016), Kumar (2019), and Baumeister and Hamilton (2019).

Unlike other studies, including the ones highlighted above, our study deviates from the assumption of a linear relationship between oil-price shocks and macro-economic fundamentals. This assumption has been commonly made, including in VAR models, raising concerns about unobservable mechanisms that can only be estimated as Markov chain processes. For that, we employ a Markov regime-switching VAR approach in our empirical analysis. In addition to using a method that can capture the likelihood of jumps in different equilibria, our study takes into account the heterogeneity of emerging economies in their resource endowment across regions.

Our results indicate the existence of a non-linear relationship between oil-price shocks and exchange rates or GDP. We have established that an oil-price shock results in two highly persistent (economic) states in all types of economies classified by their resource intensity. Specifically, we find that the export composition of a country (oil-exporting, metal-exporting, or less-resource-intensive) impacts the size of switching coefficients and volatility in both states. We find that a state of real GDP contraction prolongs more than an expansionary state. A clear impact of oil-price shock is observed where expansionary state dies out in one period in metal exporting and less- resource-intensive economies. Currency appreciation is more persistent than depreciation in oil-exporting and metal exporting economies while less-resource-intensive economies last long in a currency depreciation state.

Although the real exchange rate appreciates in oil-exporting economies due to a positive shock to the oil prices, the level of statistical significance is notably not as high as in other economies. This hints there could be counteracting forces such as foreign exchange interventions by authorities in oil-exporting economies. In fact, it emerges that currency appreciation is driven largely by economic performance rather than oil price movement in oil-exporting economies. On average, real GDP in oil-exporting economies is established to have a huge contraction implying that currency adversely impacts oil exports before authorities intervene to counter the appreciation pressure in the foreign exchange market. Moreover, in theory, oil-price shock is a supply-side shock expected to cause real GDP contraction in oil-importing economies due to the rise in production cost. However, real GDP does not contract in both states of oil-importing economies. Surprisingly, in less-resource-intensive economies, the impact is both statistically and economically insignificant. In metal exporting economies, there is a significant real GDP expansion; a phenomenon that can be interpreted as an offsetting effect of metal exports on oil imports.

The remainder of this study is organized as follows. In the next section we summarize the existing literature relevant to the issues under research. In Section three we present the methodology, while Section four describes the data and shows some preliminary analysis. Results and discussion are provided in Section five, and last section briefly concludes.

2. Theoretical consideration and literature review

Oil-price shocks can be transmitted to oil-importing and oil-exporting economies through the wealth effect (Cashin et al., 2004; Chen and Rogoff, 2003) and the terms-of-trade channel (Backus and Crucini, 2000). The trade balance in oil-importing economies deteriorate while the domestic currency depreciates in the case of a rise in oil prices (Fratzscher et al., 2014). The opposite is experienced by oil exporters, whose currency appreciates, and the Dutch Disease phenomena may arise and the prices of non-tradable goods rise following a positive terms-of-trade shock (Habib et al., 2016). This is demonstrated empirically by Backus and Crucini (2000).

The theoretical framework of the wealth effect channel as developed by Golub (1983) has been applied empirically in different studies. Such studies include Kilian (2009), Bodenstein et al. (2011), and Habib et al. (2016), where the reported findings underscore the relevance of distinguishing economies by their trade flows when analyzing external shocks. A wealth transfer from oil importers to exporters takes place if oil prices go up. Consequently, through current account imbalances and portfolio reallocation, a real exchange appreciation is experienced in oil-exporting economies and a depreciation in oil-importing economies.

In addition to the trade and wealth effect channel, the empirical literature analyzing the impact of oil shocks has evolved in terms of focus and econometric methodology. For instance, some studies have focused on the impact of oil prices on exchange rates (Brahmasrene et al., 2014), stock market returns (Kumar, 2019; Gay Jr et al., 2008), and inflation and GDP among other macroeconomic indicators (Nasir et al., 2018; Yoshino and Taghizadeh-Hesary, 2014). Demand and supply-side factors have also been analyzed where different methodologies are employed. These include a VAR analysis (Jiménez-Rodríguez* and Sánchez, 2005; Aastveit et al., 2015), Markov chain switching (Basher et al., 2016), Granger causality (Cunado and De Gracia, 2005), and panel data analysis (Behmiri and Manso, 2013; Turhan et al., 2013).

For both oil-importing and -exporting economies, oil-price shocks through exchange rate movements affect domestic economic indicators such as GDP, inflation, investment, and interest rates. Due to the complexity of oil-price shocks and exchange rates, different methodologies are applied in the analysis. One thread including Rasasi (2017), Habib et al. (2016), and Pershin et al. (2016) employs linear models, while another thread including Hamilton (2003), Basher et al. (2016), Coudert and Mignon (2016), and Xiao et al. (2018) employs nonlinear models. Although these studies have researched well the linearity and nonlinearity of the relationship between oil-price shocks and exchange rate movement, they ignore the likelihood of oil-price shocks varying throughout the time period.

Due to the likelihood of oil-price shocks varying over time, Markov regime-switching modelling (henceforth MRS) has become popular among economists. Using a Markov regime-switching quantile regression model, Youssef and Mokni (2020) establishes that currency markets respond differently to oil-price shocks among countries and oil-price regimes and that high volatility regimes are associated with stronger responses. Roubaud and Arouri (2018) uses a MRS-VAR model and demonstrates a non-linear relationship between exchange rates, stock markets, and oil prices.

Unlike other studies that assume linearity, our study deviates from the assumption of a linear relationship between oil-price shocks and macroeconomic fundamentals. The assumption of linearity has been commonly made, including in VAR models, thus raising concerns over unobservable mechanisms that can only be estimated as Markov chain processes. In addition to using a Markov regime-switching model that can capture the likelihood of jumps in different equilibria, our study takes into account the heterogeneity of emerging economies in their resource endowment across regions.

3. Methodology

Our main objective is to analyze the dynamic effect of oil-price shocks on two principal macroeconomic indicators: real GDP and real exchange rates. Empirical studies have commonly been imposing a ceteris paribus assumption when analyzing the response of macroeconomic variables to oil-price movements. Taking this approach ends up being not well defined because demand and supply oil shocks have different short-run and long-run dynamics and oil-price shocks can impact an economy indirectly though the domestic price levels of industrial commodities (Yoshino and Taghizadeh-Hesary, 2014; Kilian, 2009). There could also be a bi-directional causality between oil prices and exchange rates (Lv et al., 2018). For such reasons, the use of VAR in the identification of oil-price shocks and the explanation of dynamic responses of macroeconomic variables to oil shocks is important.

3.1. Vector autoregression

Generalization of a basic VAR model of order p can be considered a Markov regime-switching vector autoregressions when the model is subject to regime shifts and the parameters of the VAR process (in this case ϑ) are time-varying. However, the process might be time-invariant. This is conditional on a regime variable S_t that is unobservable and which indicates the prevailing regime at time t.

Consider a $p-th$ order autoregression for a $K-dimensional$ time series vector $Y_t = (Y_{lt}, ..., Y_{Kt}), t = 1, ..., T$

$$Y_t = \upsilon + \vartheta_1 Y_{t-1} + ... + \vartheta_p Y_{t-p} + \epsilon_t \tag{1}$$

where $\epsilon \sim IID(0, \sigma)$ and $Y_0, ..., Y_{1-P}$ are fixed. While denoting a KxK lag polynomial as $A(L) = I_K - A_1 L - .. - A_p L^p$, we assume that there are no roots inside the unit circle $|A(z)| \neq 0 \; for \; |z| \leq 1$, so that $Y_{t-j} = L^j Y_t$ where L is a lag operator. By changing this assumption to a normal distribution of the error term, $\epsilon \sim NID(0, \sigma)$, Equation 1 turns to an intercept form of a stable Gaussian VAR(P) model.

3.1.1. Markov regime-switching VAR

A stable VAR model with time-invariant parameters which consist of time series that are subject to regime shifts can be considered a general MS-VAR (Krolzig, 1997). That is, the data generating process of the observable time series depend on an unobservable regime variable with a probability of being in a given state.

Let M denote the number of feasible regimes. A Markov regime-switching model assumes that a discrete Markov stochastic process in a discrete time governs the unobservable process of regime $s_t \in \{1, .., M\}$. The conditional probability density function

$$p(y_t|Y_{t-1}, s_t) = \begin{cases} f(y_t|Y_{t-1},\vartheta_1) \ if \ s_t = 1 \\ \\ f(y_t|Y_{t-1},\vartheta_M) \ if \ s_t = M \end{cases} \tag{2}$$

where ϑ are VAR parameters, $m = 1, .., M$ are regimes and Y_{t-1} are observations $\{y_{t-j}\}_{j=1}^{\infty}$.

A VAR process of order p generate a time series process y_t for a given regime s_t such that

$$E(y_t|Y_{t-1}, s_t) = \upsilon(s_t) + \Sigma_{j=1}^{p} A_j s_t y_{t-j} + u_t \tag{3}$$

with an innovation process ϵ_t that is white noise and a variance-covariance matrix $\sigma(s_t)$. The innovation process is assumed to be Gaussian $[\epsilon \sim NID(0, \sigma(s_t)]$.

In MS-VAR models, a discrete-state homogeneous Markov chain is assumed to generate the regime s_t [1]

$$Pr(s_t|\{s_{t-j}\}_{j=1}^{\infty}, \{y_{t-j}\}_{j=1}^{\infty}) = Pr(s_t|s_{t-1}; \theta) \tag{4}$$

where θ is the vector of parameters of the regime generating process

At this point, it is worth noting that reparametrizing Equation 1 as the mean adjusted VAR model gives an immediate one-time jump in the process if there is a regime change. In this case, a model that has a regime-dependent intercept term $\upsilon(St)$ may be used.

$$Y_t = \upsilon(s_t) + \vartheta_1(s_t)Y_{t-1} + ... + \vartheta_p(s_t)Y_{t-p} + z_t \tag{5}$$

---

[1] $p(.)$ is a probability function while $Pr(.)$ is a discrete probability measure.

3.1.2. *Regime shift function*

To demonstrate parameter shifts clearly, a single equation with ”dummy” indicators is formulated

$$I(s_t = m) = \begin{cases} 1 & if \quad s_t{=}m \\ 0 & otherwise \end{cases} \tag{6}$$

where $m = 1, .., M$. Information for the realized Markov chain can be summarized in a vector ξ that represents the unobserved state of the system

$$\xi_t = \begin{bmatrix} I(s_t = 1) \\ \vdots \\ I(s_t = M) \end{bmatrix} \tag{7}$$

ξ has particular properties because it consists binary variables

$$E[\xi_t] = \begin{bmatrix} Pr(s_t = 1) \\ \vdots \\ Pr(s_t = M) \end{bmatrix} = \begin{bmatrix} Pr(\xi_t = \lambda_1) \\ \vdots \\ Pr(\xi_t = \lambda_M) \end{bmatrix} \tag{8}$$

where λ_M is the m-th column of the identity matrix.

3.1.3. *Hidden Markov*

Observational Equation 5 does not complete the description of the data-generating process. Therefore, formulation of a model for the parameter generating process is paramount (Krolzig, 1997). Postulating a generating process for the states s_t should be done under the assumption that parameters are dependent on stochastic and unobservable regimes.

In a MS-VAR model, the state process is a Markov chain with a finite number of states $s_t = 1, ..., M$, transition probabilities P_{ij} and a transition matrix P. These probabilities can further be expressed in a matrix NxN with the j probability of occurrence after regime i:

$$P = \begin{bmatrix} p_{11} & \dots & p_{1N} \\ | & \dots & | \\ p_{N1} & \dots & p_{NN} \end{bmatrix} \tag{9}$$

By making an assumption similar to Ehrmann et al. (2003) that a first-order Markov chain generates regime s_t , and that the state in t depends on state in $t - 1$ only. Then, transfer probabilities between states are computed as:

$$Pr(\xi_{t+1}|\xi_t, \xi_{t-1}, ...; y_t, y_{t-1}, ...) = Pr(\xi_{t+1}|\xi_t) \tag{10}$$

Precisely put, the present state ξ_t includes all relevant information about the future of the Markovian process.

3.2. Estimation

The exchange rate is central to conventional economic literature as it can on one hand impact trade and GDP while on the other can act as a shock absorber. Through the trade channel, oil-price shocks permeate the real economy thus impacting GDP. Exports fall if movement in oil prices causes an appreciation of the domestic currency. Existing literature is, however, not conclusive on the type and causal relationship between oil price and exchange rate fluctuations and the degree to which resource intensity can impact the transmission of oil-price shocks to the real economy.

When determining a model that fits our analysis, we have considered empirical evidence on the relationship between oil prices and exchange rate. For instance, Lv et al. (2018) reports a non-linear relationship between oil prices and exchange rate. This justifies the use of a Markov regime-switching approach to analyse unobservable dynamics in the relationship between real exchange rate, real GDP, and oil prices in economies with different resource intensities.

First, in the baseline results, linearity is assumed where only oil prices and lagged values of the dependent variables are included as regressors. The two estimations are expressed as follows:

$$\Delta RER_{i,t} = \beta + \beta_1 \Delta OP_t + \beta_2 \Delta RER_{i,t-1} + \epsilon_t^{RER} \tag{11}$$

$$\Delta y_{i,t} = \delta + \delta_1 \Delta OP_t + \delta_2 \Delta y_{i,t-1} + \epsilon_t^{y} \tag{12}$$

where i denotes each country in the panel, t is the time subscript, ΔRER is the difference of log real exchange rate and Δy is the difference of log real GDP. ϵ^{RER} and ϵ^{y} denote the error terms.

Second, to account for potential non-linear relationships between oil prices and the dependent variables, MS-VAR model is estimated with the real exchange rate and real GDP. That is, Eq. 5 is expressed as follows for the two variables of interest:

$$\Delta RER_t = \upsilon(s_t) + \vartheta_1(s_t)\Delta RER_{t-1} + \vartheta_2(s_t)\Delta X_t + \gamma_t \tag{13}$$

where X is a vector of control variables oil price and real GDP.

$$\Delta y_t = \upsilon(s_t) + \vartheta_1(s_t)\Delta y_{t-1} + \vartheta_2(s_t)\Delta X_t + \eta_t \tag{14}$$

where X is a vector of control variables oil price and real exchange rate.

The impulse responses are regime-dependent. As Koop et al. (1996) notes, impulse response functions depend on the phase and time during which the economy experienced the shocks.

4. Data and preliminary analysis

We use panel data with quarterly frequency from 2000:Q1 to 2019:Q4 for emerging economies classified by their resource capacities and divided by world regions (East Asia and the Pacific, Europe and Central Asia, and Latin America and the Caribbean; see list in Table A1). A country is classified as an oil exporter if the net of oil imports minus oil exports is negative, a metal exporter if the net of metal imports minus metal exports is negative, and less-resource-intensive if the net of oil imports minus oil exports is positive and the net of metal imports minus metal exports is positive.

Real GDP, nominal exchange rates, and consumer price indices are obtained from the International Monetary Statistics of the IMF. Nominal exchange rates per U.S. dollar are converted to the real exchange rate using the consumer price indices (CPI) of the U.S. and the respective countries listed in Table A1. Thus, the real exchange rate is defined as a number of units of domestic currency per one U.S. dollar. As is standard in the literature, crude oil prices are proxied by the West Texas Intermediate (WTI) and are obtained from the Fred database of the St. Louis branch of the Fed.

To ensure that the results are not spurious, stationary variables are used in the estimations. However, differencing data for stationarity is not a critical requirement if the data is cointegrated (Sims et al., 1990; Toda and Yamamoto, 1995).We evaluated cointegration tests in compliance with Kao (1999) and Pedroni (1999).Cointegration results are reported in Table A2. A summary of unit root tests for the choice variables is shown in Table 1.

Table 1: Unit root tests

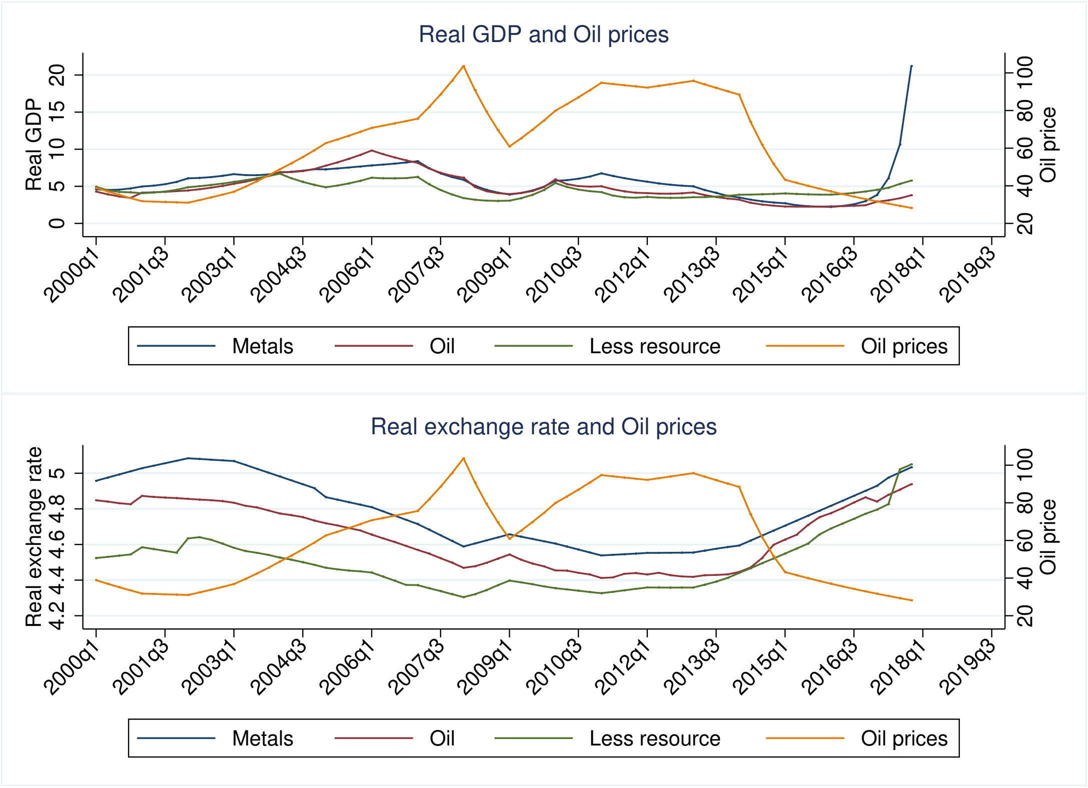
Variable	Test	t-calculated	t-critical			Decision
			1%	5%	10%	
Real GDP	ADF	-0.64	-2.58	-1.95	-1.62	Do not reject
	KPSS	0.77	0.22	0.15	0.12	Reject
Real exchange rate	ADF	-0.81	-2.58	-1.95	-1.62	Do not reject
	KPSS	0.14	0.22	0.15	0.12	Reject at 10%
Oil price	ADF	-0.72	-2.58	-1.95	-1.62	Do not reject H_0
	KPSS	0.39	0.22	0.15	0.12	Reject

ADF denotes Augmented Dickey-Fuller (with no drift and trend) and KPSS denotes Kwiatkowski-Phillips-Schmidt-Shin. ADF H_0 : *Data series contain unit root.KPSS* H_0 : *Data series has no unit root.Note* : *Reject* H_0 *if t−calculated* $>$ $t - critical$.

The variables selected for this study have been commonly used in other earlier empirical studies. These studies are more inclined to VAR models when analyzing the demand-side and supply-side effects of oil-price movements on advanced and developing economies (Kilian, 2009; Holm-Hadulla and Hubrich, 2017; Kilian and Zhou, 2020). Others have analyzed the impact of oil-price shocks on the exchange rate and inflation (Turhan et al., 2013) or the impact of oil-price shocks on real GDP and other macro variables (Behmiri and Manso, 2013; Cunado and De Gracia, 2005). Moreover, previous studies have also focused on the analysis of the impact of oil-price shocks on unemployment (Davis and Haltiwanger, 2001), the impact of oil-price shocks on oil-exporting and -importing economies (Youssef and Mokni, 2020; Roubaud and Arouri, 2018), and the reverse impact of oil-price shocks on the exchange rate markets (Hamilton, 2003).

In Figure 1, we show the plots of real GDP growth, the real exchange rate, and oil prices to illustrate the time series properties and data generating process. There exists a high level of co-movement in GDP in metal-exporting, oil-exporting, and less-resource-intensive economies. Also, it is observed in Figure 1 that real exchange movement varies across the export profiles, but a relative co-movement is noted when the plots are done on different scales. Metal-exporting economies show large currency depreciation, while less-resource-intensive economies keep (surprisingly) a relatively stronger exchange rate against the dollar. From the plots, there is no trend observed to support a linear structure in the data generating process. However, a degree of synchronization is displayed but the cause of this synchronization is unobservable. The property motivates and justifies use of the Markov regime-switching approach in our analysis.

Figure 1: Dynamics of real GDP, real exchange rate and oil prices



Note: Real GDP, oil prices, and real exchange rate is plotted for metal exporters, oil exporters and less-resource-intensive economies.

A summary statistics of the variables used are shown in Table 2. Metal exporters exhibit the highest GDP compared to the mean of the full sample, as well as means of the oil exporters, and less-resource-intensive economies. Similarly, metal exporters experience the highest GDP volatility. Higher volatility is also seen in oil prices (in levels) compared to other variables.

5. Results

5.1. Economic and Financial impact of the oil-price shocks

In this sub-section, we provide results of the impact of oil prices on the main macroeconomic indicators real GDP growth and the real exchange rate. Baseline results come from specifications 11 and 12 that are estimated with GDP and the real exchange rate as dependent variables and oil price as an independent variable. A one-period lag of the dependent variables is also included, and regime switching is restricted.

Table 2: Summary statistics

Panel a: Full sample

	mean	sd	min	max	N
Real GDP	4.95	4.08	0.07	113.65	2058.00
RER	0.00	0.03	-0.07	0.08	1888.00
Oil prices	62.84	24.10	28.23	103.67	2058.00

Panel b: Metal exporters

	mean	sd	min	max	N
Real GDP	5.65	5.77	0.20	113.65	588.00
RER	0.00	0.03	-0.05	0.07	579.00
Oil prices	63.99	23.97	28.23	103.67	588.00

Panel c: Oil exporters

	mean	sd	min	max	N
Real GDP	4.91	4.23	0.07	34.50	568.00
RER	0.00	0.03	-0.07	0.08	489.00
Oil prices	62.24	24.07	28.23	103.67	568.00

Panel d: Less-resource-intensive

	mean	sd	min	max	N
Real GDP	4.51	2.12	0.24	14.07	902.00
RER	0.00	0.02	-0.05	0.07	820.00
Oil prices	62.46	24.20	28.23	103.67	902.00

Note: Real GDP and RER denotes the log of real GDP and real exchange rate.

Baseline results are reported in Table 3. The results are in accordance with our expectations that the oil price has a negative and significant effect on GDP. An increase in oil price channels into inflation, hence low real GDP. Moreover, when production costs rise due to high oil prices, they negatively impact GDP. For the full sample and each export category, the lags of dependent variables have positive and significant coefficients ranging from 0.89 for less-resource-intensive economies to 0.98 for oil exporters. Oil prices have a negative and significant effect on GDP even in oil-exporting economies. This is because an increase in oil prices causes an appreciation in the domestic currency leading to a fall in oil exports, and the net effect results in a fall in the real GDP (Baumeister and Hamilton, 2019; Holm-Hadulla and Hubrich, 2017).

As pointed out earlier, the exchange rate is defined in domestic currency units per U.S. dollar. Therefore, a positive coefficient means that the domestic currency has depreciated against the U.S. dollar. Since the oil price is determined in U.S. dollars, an increase in the oil price causes metal exporters and less-resource-intensive economies to ”chase” the U.S.

dollar, hence domestic currency depreciates. This is confirmed by real exchange rate depreciation for metal exporters (0.042) and less-resource-intensive economies (0.043) although the relatively small coefficients suggest there could be exchange rate volatility smoothing in the foreign exchange market by authorities in non-oil-exporting economies. Our results contradict Basher et al. (2016) who report no evidence in oil supply shock impacting exchange rate in oil-importing economies. In theory, an increase in oil prices should raise foreign reserves for oil exporters, thus causing an appreciation of the domestic currency. However, the results do not support a positive oil price shock causing the expected exchange rate appreciation in oil-exporting economies. This is not surprising and we interpret this finding in a similar way as Habib et al. (2016) that the tendency of oil producers to peg their exchange rate or accumulate foreign exchange reserves counters the appreciations pressure stemming from positive oil price shock. This means that there could exist foreign exchange interventions by authorities in oil-exporting economies. [2]

Table 3: Baseline regression for real GDP and real exchange rate

	Full sample		Metal exporters		Oil exporters		Less-resource-intensive	
	Real GDP	RER	Real GDP	RER	Real GDP	RER	Real GDP	RER
Oil prices	-0.055**	0.034***	-0.107**	0.042***	-0.029**	0.017	-0.052***	0.043***
	(-2.37)	(5.25)	(-2.06)	(2.83)	(-2.51)	(1.29)	(-4.06)	(4.72)
L.Real GDP	0.919***		0.909***		0.986***		0.952***	
	(7.82)		(5.70)		(193.22)		(69.26)	
L.RER		0.903***		0.914***		0.908***		0.890***
		(73.99)		(37.33)		(39.50)		(57.16)
Observations	2028	1860	579	570	560	482	889	808

Note: L.Y is the lag of log real GDP, *L.RER* is lagged value of log RER. t-statistics are reported in parenthesis. *,**,*** represents significance at 10, 5, and 1 percent respectively.

5.2. *Non-linear effect of oil-price shocks*

Our next objective is to investigate the nonlinear relationship between oil price and our main macroeconomic indicators (real GDP and real exchange rate). This is achieved by estimating a Markov regime-switching model described in Equations 13 and 14.

There are two states in which macroeconomic indicators respond to oil-price shocks. Both states emerge as a result of the Markov regime-switching model and can be used to illustrate the state of economy. State one is characterized by a positive coefficient associated

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[2] In a different context, importance of an exchange rate channel with respect to energy commodities is documented by Aliyev and Kocenda (2022) who show that the effect of ECB monetary policy on commodity prices transmits through the exchange rate channel, which impacts European market demand.

with a macroeconomic variable. In the case of real GDP, a positive coefficient is simply linked to expansion state. However, due to the exchange rate definition, a positive coefficient corresponds to a state of domestic currency depreciation. State two is defined in a similar but opposite manner: a negative coefficient of the real GDP is interpreted as output contraction and a negative coefficient of the exchange rate indicates a state of domestic currency appreciation.

The results shown in Table 4 establish the existence of two states in all the resource categories as indicated by statistically significant switching coefficient sigma. Further, autocorrelations are missing as a Durbin-Watson statistics ranges within the normal range of 0 – 4; metal exporters exhibit a close to no-autocorrelation results. In economic theory, oil-price shock is a supply-side shock to metal exporters and less- resource-intensive economies (Kilian, 2009; Basher et al., 2016). Therefore, a contraction of real GDP is expected due to the rise in production costs. However, real GDP does not contract in both states. The impact in less-resource-intensive economies is both statistically and economically insignificant while the significant effect in state two in metal exporting economies can be interpreted as an offsetting effect of metal exports with respect to oil imports. State one, as shown in Table 4, supports the boom effect of oil-price shock on the real GDP in oil-exporting economies.

On average, a shock to oil prices causes a significant contraction in real GDP in state one followed by an expansion in state two. In both states, the movement in real GDP is highest in oil-exporting economies. A likely explanation for the huge real GDP contraction (of 14.3%) in oil-exporting economies is that a rise in oil prices lowers the oil demand, thus adversely impacting output in oil-exporting economies, as also argued by Behmiri and Manso (2013). Second explanation is that a positive shock to oil prices causes real exchange appreciation that adversely impacts exports from the tradable sector in oil-exporting economies. After state one, oil-exporting economies bounce back to a 6.5% expansion.

Next, in Table 5, we show evidence of the impact of the oil-price shock on the real exchange rate. Like real GDP, a significant switching coefficient sigma supports the existence of two states for real exchange rate. The exchange rate is more volatile in metal-exporting and less-resource-intensive economies. Intuitively, the difference in volatility and magnitude of switching coefficients is pinned to the contribution of natural resources to macroe-

Table 4: Markov regime-switching results: Impact of oil prices on real GDP

	Oil exporters	Metal exporters	Less-resource-intensive
State1			
Oil price	0.006***	0.000	0.000
	(-3.38)	(-0.85)	(-0.28)
Real exchange rate	-0.219	-0.209	0.172
	(-1.47)	(-1.60)	(-0.6)
L.Real GDP	-1.004***	-0.526***	-0.148*
	(-2.93)	(-10.74)	(-1.69)
Constant	-0.143***	-0.007***	-0.022***
	(-12.87)	(-3.29)	(-7.23)
State2			
Oil price	0.001	0.002**	0.000
	(-0.93)	(-2.05)	(-0.4)
Real exchange rate	0.006	0.067	-0.395
	(-0.1)	(-0.4)	(-1.59)
L.Real GDP	-0.085***	-1.073***	-0.252***
	(-2.68)	(-17.29)	(-3.00)
Constant	0.065***	0.058***	0.046***
	(-18.02)	(-21.93)	(-14.95)
Log(sigma)	-3.645***	-4.423***	-4.125***
	(-43.13)	(-45.81)	(-43.39)
Durbin-Watson stat	0.823	2.155	1.803
Akaike info criterion	-3.225	-5.151	-4.024
Schwarz criterion	-2.833	-4.76	-3.632
Hannan-Quinn criter.	-3.069	-4.996	-3.869

Note: t statistics in parentheses where $*p < 10, **p < 0.05, ***p < 0.01$.
L.Real GDP is lag Real GDP

conomic fundamentals. Durbin-Watson test results further indicate that there are no serious concerns of serial correlation.

Consistent with prior expectations and the theory, following a positive shock to oil prices the real exchange rate appreciates in oil-exporting economies. The finding is consistent with the real exchange rate appreciation caused by positive shock to oil prices reported earlier by Kumar (2019) , Roubaud and Arouri (2018) and Turhan et al. (2013). Notably, the level of statistical significance in appreciation caused by oil price movement, as shown in Table 5, is not large compared to other resource-classified economies, hinting that there could be counteracting forces such as the behavior of monetary authorities. That is, the accumulation of foreign reserves by central banks in oil-exporting economies can be taken as attempts to counter the pressure of real exchange appreciation (argument related to Habib et al. (2016)). It is also evident that currency appreciation in oil-exporting economies is largely driven by economic performance rather than a rise in oil prices.

Table 5: Markov regime-switching results: Impact of oil prices on real exchange rate

	Oil exporters	Metal exporters	Less-resource-intensive
State1			
Oil price	-0.148*	-0.003***	-0.002***
	(-1.78)	(-8.82)	(-11.33)
Real GDP	-0.169***	0.007	-0.038
	(-3.38)	(-0.21)	(-1.48)
L.Real exchange rate	-0.009	0.195	0.136*
	(-0.12)	(-1.61)	(-1.95)
Constant	-0.031***	-0.014***	-0.012***
	(-6.37)	(-5.85)	(-10.59)
State2			
Oil price	-0.002	-0.001***	0.000
	(-0.44)	(-4.39)	(-1.45)
Real GDP	0.462***	0.01	0.024**
	(-4.19)	(-0.78)	(-2.07)
L.Real exchange rate	0.649***	0.764***	0.895***
	(-3.22)	(-17.09)	(-19.79)
Constant	0.132***	0.003***	0.001
	(-5.8)	(-3.33)	(-1.6)
Log(sigma)	-3.355***	-5.374***	-5.752***
	(-36.72)	(-60.99)	(-65.59)
Durbin-Watson stat	1.958	2.023	2.127
Akaike info criterion	-3.247	-16.491	-16.748
Schwarz criterion	-2.856	-16.1	-16.357
Hannan-Quinn criter.	-3.092	-16.336	-16.593

Note: t statistics in parentheses where $*p < 10, **p < 0.05, ***p < 0.01$.
L.Real exchange rate is lag Real exchange rate

The results, as indicated by the switching coefficients sigma, fail to establish the causal effect of real exchange rate depreciation in non-oil-exporting economies. The real exchange rate appreciates in oil-importing economies (metal exporters and less-resource-intensive), following a positive oil-price shock, Such dynamics implies an improvement in the non-oil trade balance that offsets a deterioration of the oil component in the trade balance. Further, a large average real exchange rate depreciation (of 13.2%) in oil-exporting economies in state two supports our inference that there could be counteracting forces, i.e. behavior of monetary authorities.

Finally, we present evidence on the persistence in specific states related to the MS-VAR results presented earlier. Smoothed probabilities are applied at a 95% confidence level. Transition probabilities between states and expected duration are reported in Table 6. Plots of probabilities and the states are plotted in Appendix C. In all the classifications, and for both real GDP and real exchange rate, the economies experience periods of persistence when they remain in a specific state. That is, currency appreciation is experienced in state one and depreciation in state two, while real GDP contracts in state one followed by an expansion in state two. This is evident from the constant terms showing average effects in Tables 4 and 5. Both states exhibit time-limited persistency and the duration for which an economy remains in a given state can be linked to specific resource categories (see Table 6). Oil exporters experience prolonged real GDP contractions (64 periods) and expansions (56 periods), compared to other economies where the duration is much shorter; in case of metal exporters and less-resource-intensive economies expansions dissipate after 1 and 2 periods, respectively. As for the currency states, metal and oil exporters experience twice as long periods of appreciation than depreciation, albeit of different lengths. On the other hand, less-resource-intensive economies experience persistent periods of currency depreciation (15 periods) while the currency appreciation state dies out after one period.

Table 6: Transition probabilities and expected duration

Real GDP					Contraction	Expansion
	p11	p12	p21	p22	DU1	DU2
Oil exporters	0.984	0.016	0.018	0.982	64	56
Metal exporters	0.970	0.030	0.999	0.001	33	1
Less-resource-intensive	0.911	0.089	0.560	0.440	11	1
Real exchange rate					**Appreciation**	**Depreciation**
	p11	p12	p21	p22	DU1	DU2
Oil exporters	0.977	0.023	0.050	0.950	43	20
Metal exporters	0.894	0.106	0.216	0.784	9	4
Less-resource-intensive	0.000	1.000	0.066	0.934	1	15

Note: p denotes transition probabilities and DU is expected duration in each state.

6. Conclusion

We provide a detailed assessment of how dynamically changing oil prices affect GDP and exchange rates in emerging economies with different resources in three geographical regions: Central Asia and Europe, Latin America and the Caribbean, and East Asia and the Pacific. Most of the previous research has concentrated on the effects of oil-price shocks in industrialized economies, particularly oil importers. By examining how oil-price shocks impact GDP and exchange rates in emerging economies and how country-level export heterogeneity may affect the unobserved non-linear linkage between GDP and exchange rates (analyze via a Markov process), we add to the knowledge of the existing literature on these issues.

In all economies classified by the intensity of their use of natural resources, we find that real GDP contracts in state one (output contraction) followed by an expansion in state two (output expansion). On the contrary, currency appreciates in state one but depreciates in state two. The results also indicate that a state of real GDP contraction last longer than an expansionary state. A clear impact of oil-price shock is observed where expansionary state dies out in one period in metal exporting and less-resource-intensive economies. Currency appreciation is more persistent than depreciation in oil-exporting and metal exporting economies while a shock is more persistent in less-resource-intensive economies in a currency depreciation state. Although the real exchange rate appreciates in oil-exporting economies due to a positive shock in oil prices, the level of statistical significance is lower than in other resource-classified economies. This evidence suggests that there could be counteracting forces such as foreign exchange interventions by authorities in oil-exporting economies. In fact, it becomes evident that currency appreciation is driven largely by economic performance rather than oil price movements in oil-exporting economies. On average, real GDP in oil-exporting economies is established to exhibit a huge contraction, implying that currency adversely impacts oil exports before authorities intervene to counter the appreciation pressure in the foreign exchange market. Moreover, in theory, oil-price shock is a supply-side shock expected to cause real GDP contraction in oil-importing economies due to the rise in production cost. However, real GDP does not contract in both states in oil-importing economies. Surprisingly, in less-resource-intensive economies, the impact is both statistically and economically insignificant. In metal exporting economies, there is a significant real GDP expansion; a phenomenon that can be interpreted as an offsetting effect of metal exports on oil imports. The switching coefficients could, however, not establish a causal effect of real exchange rate depreciation in non-oil-exporting economies.

We conclude that when an economy is impacted by an oil-price shock, the output contraction (expansion) and currency appreciation (depreciation) varies in length depending on a country's trade profile. Hence, the extent of natural resources in specific countries contributes in a non-linear fashion to the size and length of how the macroeconomic fundamentals respond to oil-price shocks.

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Appendix

Appendix A. Countries used in the analysis

Table A1: List by region and resource profile

Country name	Region	Resource profile
Thailand	East Asia and Pacific	none
Malaysia	East Asia and Pacific	none
Brunei Darussalam	East Asia and Pacific	oil
Philippines	East Asia and Pacific	none
Mongolia	East Asia and Pacific	minerals
Indonesia	East Asia and Pacific	oil
Turkey	Europe and Central Asia	none
Georgia	Europe and Central Asia	minerals
Kazakhstan	Europe and Central Asia	minerals
Romania	Europe and Central Asia	none
Albania	Europe and Central Asia	minerals
Russian Federation	Europe and Central Asia	oil
Armenia	Europe and Central Asia	minerals
Azerbaijan	Europe and Central Asia	oil
Poland	Europe and Central Asia	none
Ukraine	Europe and Central Asia	none
Hungary	Europe and Central Asia	none
Bosnia and Herzegovina	Europe and Central Asia	none
Bolivia	Latin America and Caribbean	minerals
Brazil	Latin America and Caribbean	minerals
Colombia	Latin America and Caribbean	oil
Chile	Latin America and Caribbean	minerals
Paraguay	Latin America and Caribbean	oil
Costa Rica	Latin America and Caribbean	none
Guatemala	Latin America and Caribbean	none
Ecuador	Latin America and Caribbean	oil
Peru	Latin America and Caribbean	minerals
Mexico	Latin America and Caribbean	oil

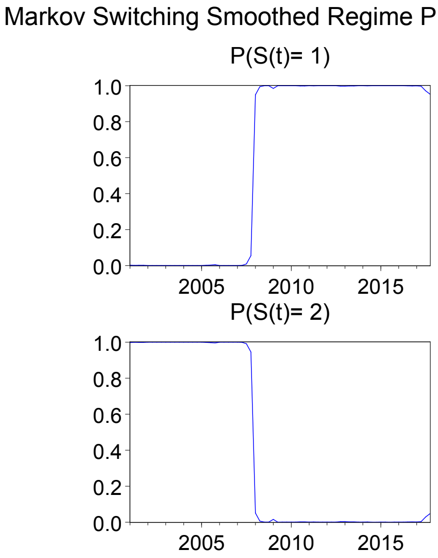
Appendix B. Cointegration results

Table A2: Cointegration results

Kao test for cointegration	Statistic	p-value
Modified Dickey-Fuller t	1.463	0.072
Dickey-Fuller t	1.807	0.035
Augmented Dickey-Fuller t	3.965	0.000
Unadjusted modified Dickey	-9.483	0.000
Unadjusted Dickey-Fuller t	-4.660	0.000
Pedroni test for cointegration	Statistic	p-value
Modified Phillips-Perron t	-1.947	0.026
Phillips-Perron t	-2.825	0.002
Augmented Dickey-Fuller t	-5.964	0.000

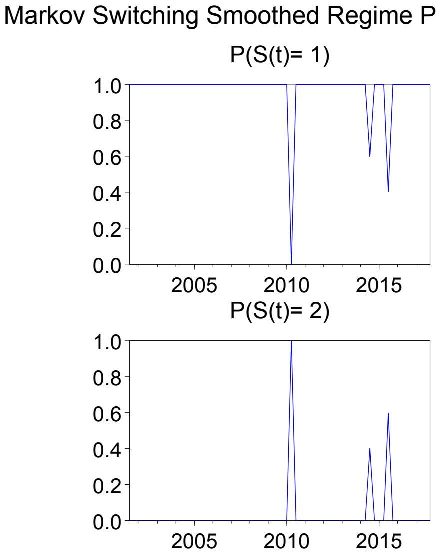
Appendix C. Regimes and smoothed probabilities

Figure A1: Oil exporters: Real GDP



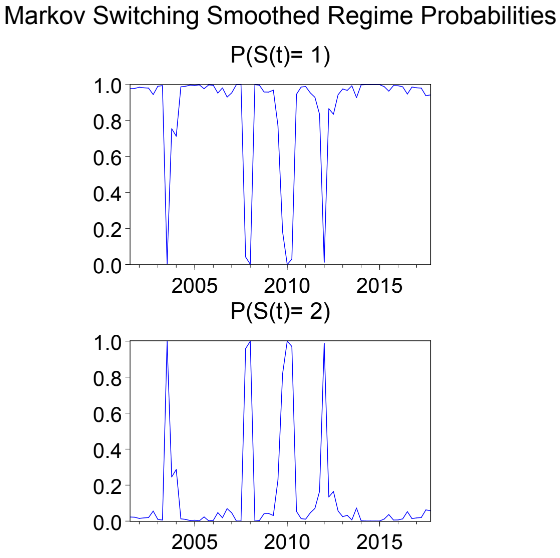
Note: Transition Probabilities across states for the real GDP in oil exporter economies.

Figure A2: Metal exporters: Real GDP



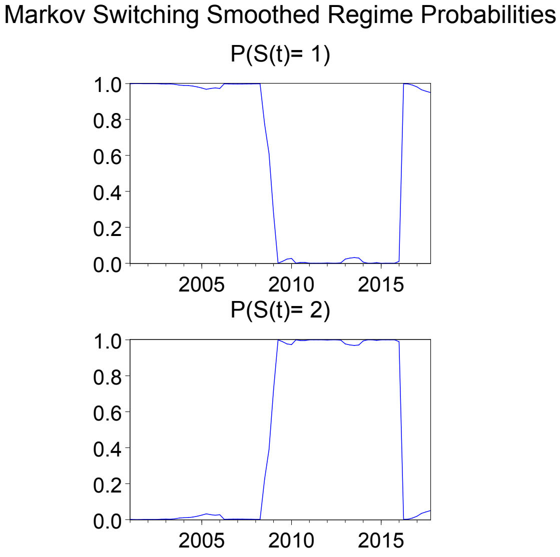
Note: Transition Probabilities across states for the real GDP in metal exporter economies.

Figure A3: Less-resource-intensive: Real GDP



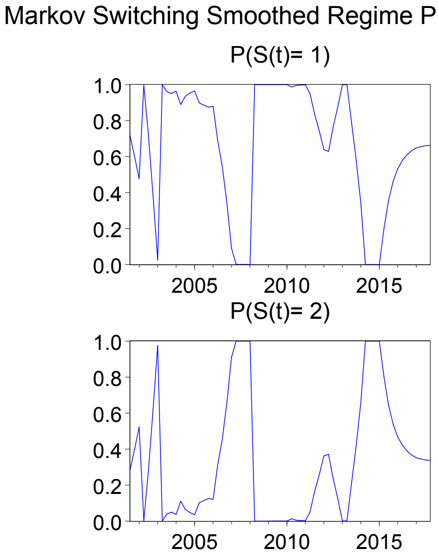
Note: Transition Probabilities across states for the real GDP in less-resource-intensive economies.

Figure A4: Oil exporters: Real exchange rate



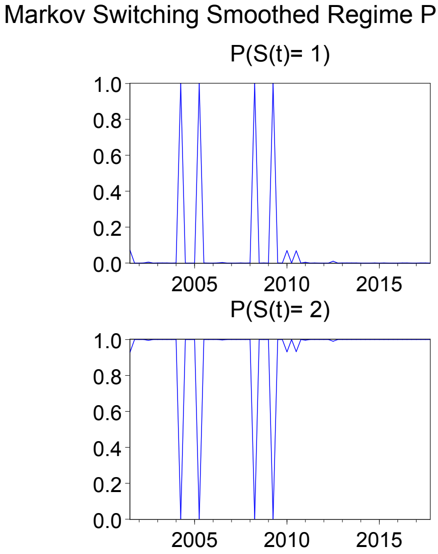
Note: Transition Probabilities across states for the real exchange rate in oil exporter economies.

Figure A5: Metal exporters: Real exchange rate



Note: Transition Probabilities across states for the real exchange rate in metal exporter economies.

Figure A6: Less-resource-intensive: Real exchange rate



Note: Transition Probabilities across states for the real exchange rate in less-resource-intensive economies.

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz