The US dollar exchange rate and the demand for oil

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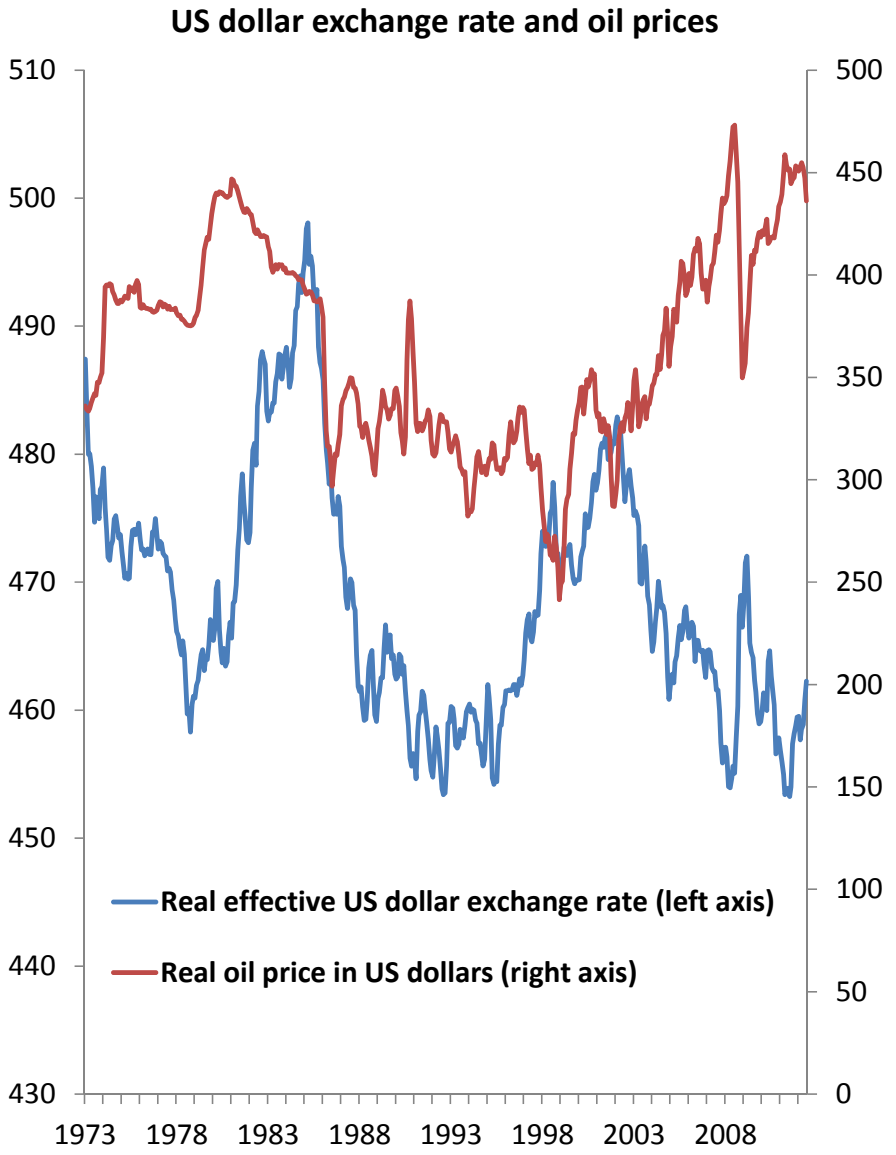
Motivation

- Growing consensus: oil price fluctuations are mainly driven by changes in oil demand in recent times
  - Hamilton (2009): strong income growth primary cause of oil price surge in 2007-08, while subsequent collapse of oil prices result of global downturn
  - SVAR literature: dominant role for shocks at the demand side of the global crude oil market
    - E.g. Peersman (2005), Kilian (2009), Peersman and Van Robays (2009), Lombardi and Van Robays (2011), Kilian and Murphy (2012)

Motivation

- The role of the US dollar exchange rate has been ignored in these studies
  - Global oil prices expressed in US dollar: a shift in dollar exchange rate should affect oil demand in countries that do not use the dollar for local transactions
    - For oil consumption, it is the "local" price that matters (Austvik 1987)
  - If exchange rate matters, changes in US dollar shift global oil demand curve
    - E.g. US dollar depreciation: boosts global oil demand, prices and production
  - Evolution exchange rate, oil production and oil prices over time suggests that this could indeed be the case: oil production and oil prices decline when the US dollar exchange rate appreciates, and vice versa (see figures)

Motivation


US dollar exchange rate and oil prices
510
500
490
480
470
460
450
440
430
500
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300
250
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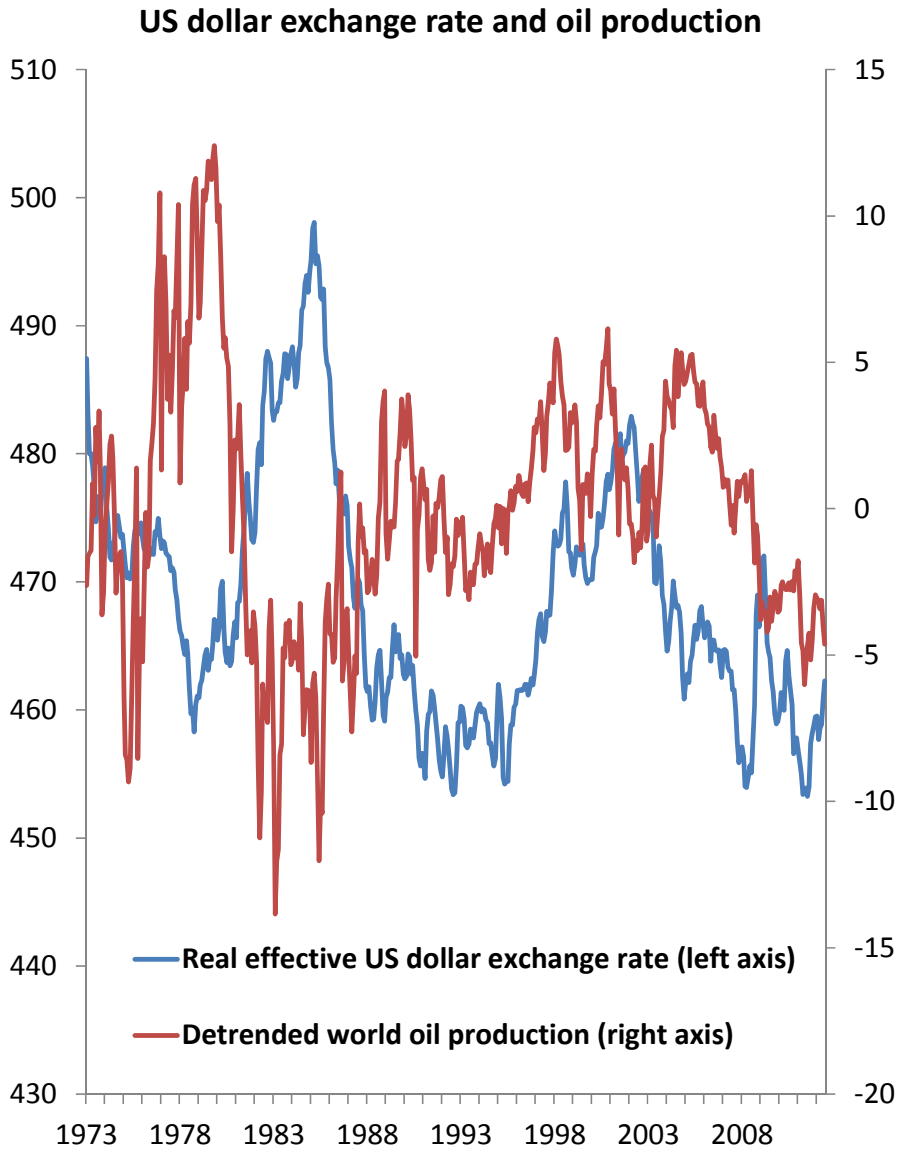
1973
1978
1983
1988
1993
1998
2003
2008
Real effective US dollar exchange rate (left axis)
Real oil price in US dollars (right axis)


US dollar exchange rate and oil production
510
500
490
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-15
-20
1973
1978
1983
1988
1993
1998
2003
2008
Real effective US dollar exchange rate (left axis)
Detrended world oil production (right axis)

Motivation

- Same is true for multi-country (panel) studies that examine determinants of oil demand more directly
  - E.g. Gately and Huntington (2002), Dargay et al. (2007), Narayan and Smith (2007), Dargay and Gately (2010)
  - Focus on estimation of income and oil price elasticity expressed in US dollar: ignoring the exchange rate could bias the results
  - Some studies use local oil prices in the estimations but do not distinguish between changes of global oil price and shifts in US dollar exchange rate
    - E.g. Griffin and Schulman (2005) and Fawcett and Price (2012)

This paper

- Explores the role of US dollar exchange rate for oil demand
  - Panel dataset of 23 OECD and 42 non-OECD countries over 1971-2008 sample period (annual data - oil exporting countries are excluded)
- Using recent advanced in panel data estimation techniques
  - Existing panel studies on oil demand suffer a number of econometric problems
- Are there similar nonlinearities as for price elasticity of oil demand?
  - Decline over time, and increases versus decreases

Benchmark specification

$$\Delta dem_{i,t} = \alpha_i + \tau_i * trend + \lambda_i * dem_{i,t-1} + \gamma_i^l * gdp_{i,t-1} + \beta_i^l * oilp_{t-1} + \theta_i^l * rer_{t-1} + \gamma_i * \Delta gdp_{i,t} + \beta_i * \Delta oilp_t + \theta_i * \Delta rer_t + \varepsilon_{i,t}$$

- dem : total oil demand (consumption) per capita
- gdp : real income per capita
- $oilp$: international real crude oil price in US dollars
- rer : real effective US dollar exchange rate

- Panel error correction model
  - All variables are non-stationary (ADF and PANIC tests)
  - Null hypothesis of no error correction between variables is rejected (GUW test)

Econometric issues

- Panel oil demand estimations typically with standard fixed effects estimator
  - E.g. Gately and Huntington (2002), Griffin and Schulman (2005)
  - FE estimators are biased when there is heterogeneity in slope coefficients
    - Likely the case given differences in economic structures across countries
  - Homogeneity consistently rejected by Hausman and likelihood-ratio tests: also for subsamples of OECD and non-OECD countries
  - We use the Mean Group estimator in the analysis

Econometric issues

- Cross-sectional dependence in error terms is ignored
  - Results are biased when observed explanatory variables are correlated with unobserved common factors (e.g. common global business cycle)
  - CD-test of Pesaran (2004) shows that there is a significant degree of cross-sectional correlation in the error terms for both FE and MG estimators
  - Bai et al. (2009): Include estimated common component of residuals to eliminate cross-sectional dependence in error terms of cointegrating model
- Both econometric issues matter for the (magnitudes) of results
  - Bias in different directions

Empirical results – estimated elasticities

	OECD	Non-OECD	Total
Real income	**0,568***** (0,073)	**0,639***** (0,119)	**0,614***** (0,081)
Oil price	**-0,051***** (0,007)	**-0,026**** (0,012)	**-0,035***** (0,008)
Exchange rate	**-0,204***** (0,040)	**-0,051** (0,068)	**-0,105**** (0,047)
	(median) long-run coefficients		
Real income	**0,674**	**0,885**	**0,775**
Oil price	**-0,150**	**-0,104**	**-0,126**
Exchange rate	**-0,385**	**-0,324**	**-0,325**

Instrumental variables estimations

Real effective US dollar short-run exchange rate elasticity		
OECD	**Non-OECD**	**Total**
-0,819* **	**-0,412** **	**-0,556*** **
(0,151)	(0,180)	(0,130)

Real bilateral US dollar short-run exchange rate elasticity		
OECD	**Non-OECD**	**Total**
-0,513* **	**-0,008**	**-0,238** **
(0,130)	(0,228)	(0,141)

- Some carefulness when interpreting the results
  - Usual problem of finding good instruments (level, first difference FF-rate and lagged exchange rate)
  - Smaller samples for bilateral exchange rate estimations

Average versus global elasticity

- Estimated elasticity is (unweighted) average of individual countries
  - Not very useful for the analysis of global oil market dynamics
  - E.g. Kilian and Murphy (2010) implement estimated price elasticity oil demand as a boundary restriction in a global VAR to identify different types of oil shocks
- Since we are using MG estimator, we can accommodate this by deriving the Weighted Mean Group estimates
  - Shares of individual countries in total oil demand are used as weights
  - Sample represents 59% of non-US global oil demand

Average versus global elasticity

	Unweighted	Weighted
Real income	**0,614***** (0,081)	**0,484***** (0,164)
Oil price	**-0,035***** (0,008)	**-0,045***** (0,015)
Exchange rate	**-0,105**** (0,047)	**-0,168**** (0,067)

- Global exchange rate elasticity: -0,168 * (1-0,27) = -0,133
  - Note: US represents on average 27% of global oil demand

Economic relevance

- A simple back of the envelope calculation
  - (simplified) benchmark oil demand: $\Delta q = -0{,}045\ \Delta p - 0{,}123\ \Delta USD$
  - Kilian and Murphy (2010) oil supply: $\Delta q < 0{,}025\ \Delta p$
  - In the data, the monthly average of $\Delta USD = 1{,}16\%$
  - To clear the market, this implies that:
    - $\Delta q > 0{,}05\%$ (whereas monthly average Δq is 1,08% in the data)
    - $\Delta p > 2{,}04\%$ (monthly average Δp 4,76% in the data)
    - Exchange rate is hence very important contributor to oil price volatility

US dollar exchange rate and nonlinearities

- Hughes et al. (2008), Baumeister and Peersman (2012): price elasticity has declined over time
  - Reason could be structural change in the real economy or the crude oil market
- Same is true for US dollar exchange rate
  - Interaction of the exchange rate with a simple linear trend

	OECD	Non-OECD	Total
Exchange rate	**-0,432***** (0,122)	**-0,268**** (0,134)	**-0,326***** (0,097)
Exchange rate * trend	**0,013**** (0,005)	**0,012** (0,008)	**0,012**** (0,006)

US dollar exchange rate and nonlinearities

- Gately and Huntington (2002): Price elasticity is higher for oil price increases versus decreases

- Same is true for appreciation versus depreciation US dollar exchange rate in OECD countries, but not for non-OECD countries

	OECD	Non-OECD	Total
Exchange rate depreciation	**-0,020** (0,049)	**-0,178*** (0,107)	**-0,122*** (0,072)
Exchange rate appreciation	**-0,410***** (0,094)	**0,110** (0,168)	**-0,074** (0,117)

US dollar exchange rate and nonlinearities

- What happens if we combine both nonlinearities?
  - Note: both nonlinearities could be correlated because US dollar exchange rate experienced persistent depreciation after its peak in 1985
  - Results still hold

	OECD	Non-OECD	Total
Exchange rate * trend	**0,012****	**0,010**	**0,011***
	(0,005)	(0,008)	(0,006)
Exchange rate depreciation	**-0,233****	**-0,352****	**-0,310*****
	(0,110)	(0,176)	(0,120)
Exchange rate appreciation	**-0,606*****	**-0,074**	**-0,262****
	(0,165)	(0,168)	(0,127)

Conclusions

- The US dollar exchange rate is a crucial determinant for oil demand
  - Appreciation of US dollar consistently leads to decline in oil demand
  - The elasticity turns out to be much higher than the price elasticity of oil demand (expressed in US dollar)
  - Economically important to explain fluctuations in the oil market: should be taken into account in the analysis of the global oil market
  - Similar nonlinearities for exchange rate as for oil price elasticity
- Open issue: why is the elasticity much higher than price elasticity?
  - Stronger responsiveness to a less volatile variable (e.g. signal to noise)?
  - Short term responsiveness is constrained, which implies a larger estimated elasticity of smaller shocks (another nonlinearity in oil demand)?