The ECB-Global Model for spillover analysis

European Central Bank

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Outline

Background and motivations

International models developed at the ECB and used for forecasting and policy analysis:

- The New-Area Wide Model (NAWM)
- The Euro Area and Global Economy (EAGLE),
- *Link* – 7: New MCM + MUSEL
- NiGEM

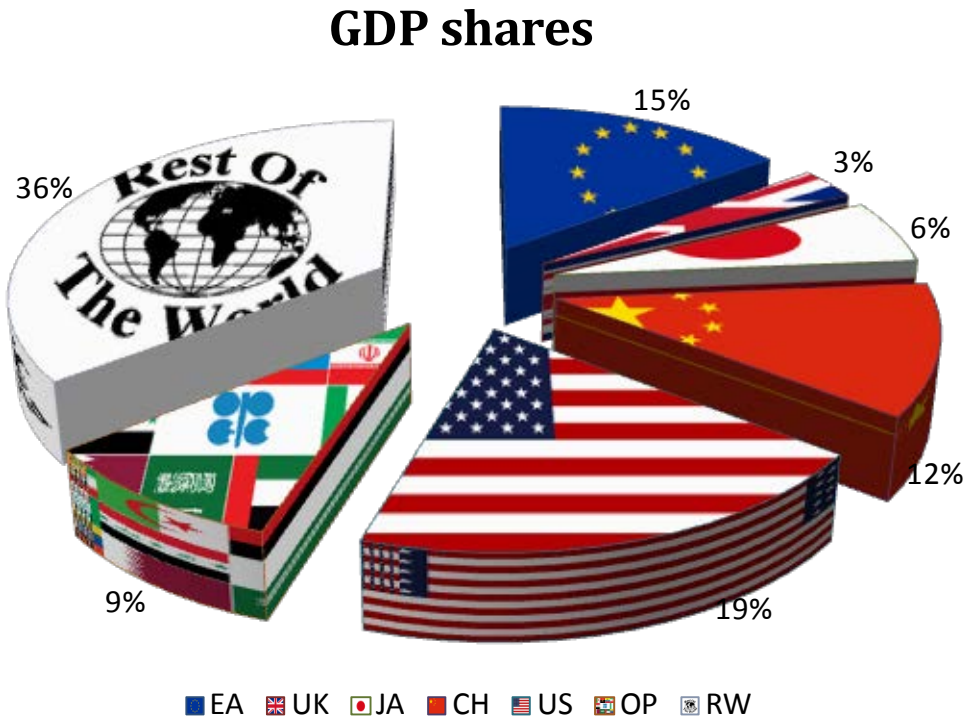
ECB-Global tries to enrich the current toolkit of available models by:

- Having a focus on *global spillovers*
- Trying to incorporate both real and *financial linkages*
- Expanding country coverage and therefore potential policy applications

A first glance at ECB-Global

- A semi-structural general equilibrium model *vs* fully microfunded DSGE models
- Calibrated parameters (Systematic IRFs exploration)
- A rational expectations model
- Shocks propagate via real channels: *trade* and *oil* and via *financial channels*

Comprises 7 Country Blocks/Regions:



Source: IMF - World Economic Outlook

Why is ECB-Global useful

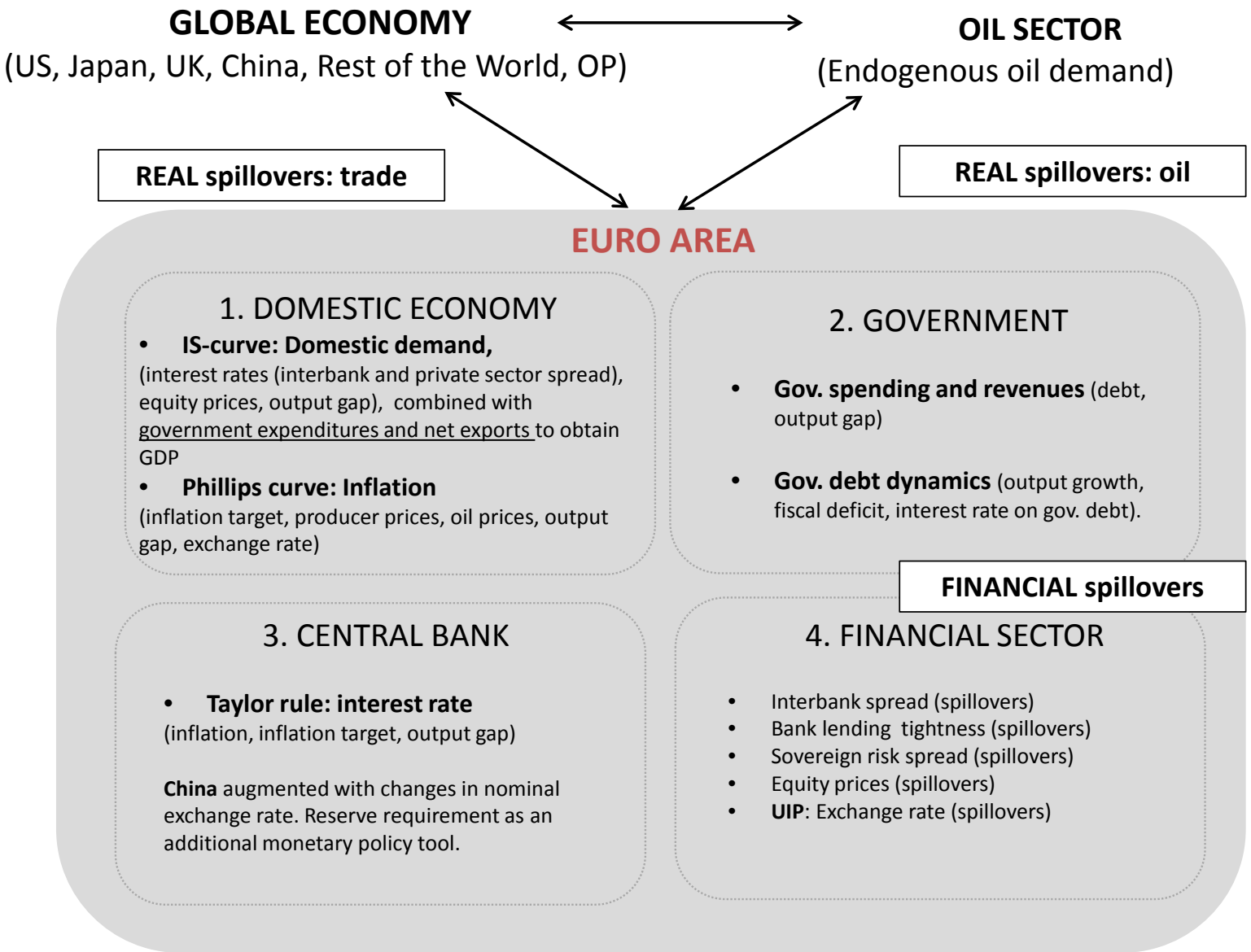
General advantages of using ECB-Global:

- allows to identify shocks easily
- allows to disentangle transmission of shocks

Competitive advantages against similar models at the ECB:

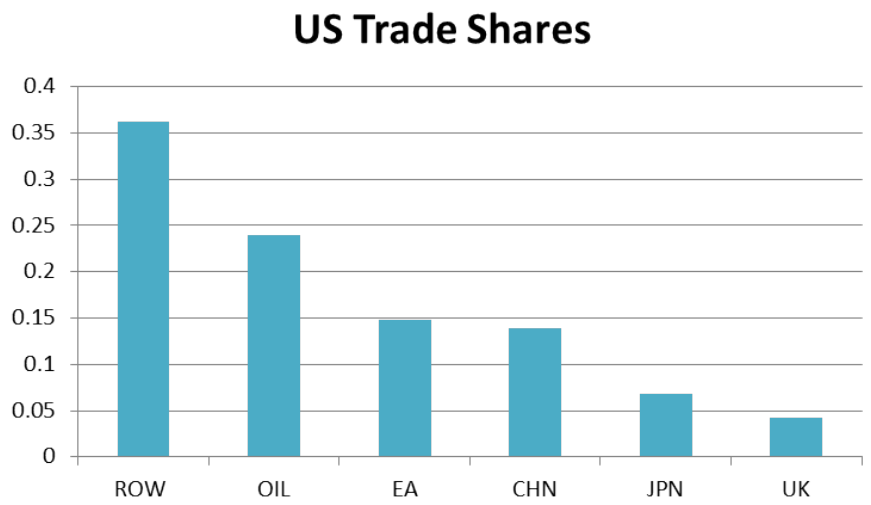
- flexibility and increased possible policy applications:
  - the semi-structural nature makes it easy to add new features in line with empirical findings
  - new countries/regions can be introduced with few technical difficulties (process optimized through Macro-processor)
- it is possible to study shocks in the *oil* sector
- it has a large set of country/regional blocks:
  - differentiated by GDP, trade and financial shares
  - differentiated through country specific equations (e.g. China)

A Graphical Overview of ECB-Global



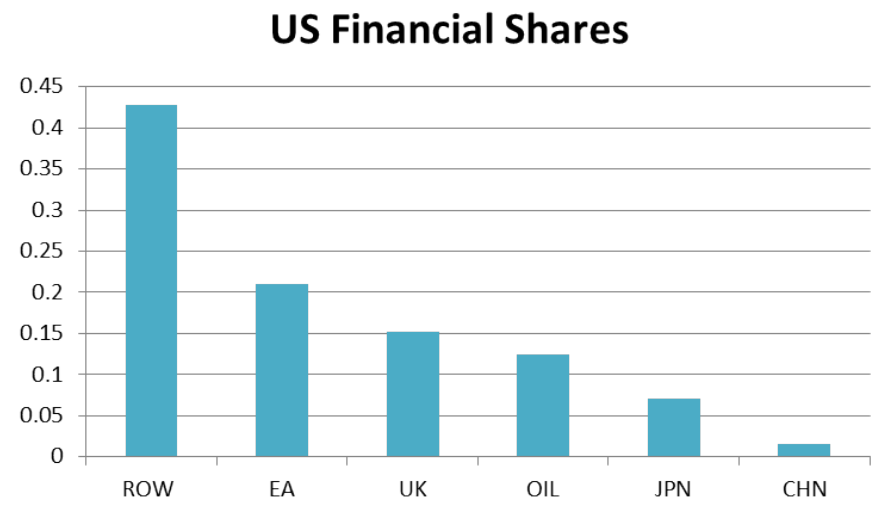
Propagation channels of global spillovers

Trade and oil Channels:
are real channels, spillovers work via import and exports and changes in the demand in the real exchange rate and in oil prices.



IMF dots 1999-2013

Propagation channels of global spillovers



IMF CPIS, assets, 1999-2013

Financial Channel:

- Interbank spreads
- Bank lending conditions
- Sovereign risk
- Equity prices
- UIP

Spillovers are endogenous: a change in financial variables in country i affects all other triggering effects that feed back to the country hit by the shock.

Calibration procedure

In order to calibrate ECB-Global we followed a two-step approach:

1. Step One:
   - set steady-state values based on historical averages
   - Set some coefficients according to country-specific characteristics (financial weights/bilateral imp. and exp. share of intermediate inputs)
   - Set initial structural values for parameters based on literature
2. Step Two:
   - Look at IRFs to make adjustments to parameters
   - Compare ECB-Global's IRFs to other models (SW, CEE, GPM, NAWM)
   - In this step we make use of Systemic IRFs exploration of parameters

Systematic Parameter Exploration

Allows us to dig deeper in the model, identify important issues, solve technical problems, get a better understanding of the model:

- Enables calibration and fine tuning of the model
- Identifies parameters values that change dynamics of the model (sensitivity analysis)
- Rules out non solvable regions

The procedure has been automatized (e.g. define parameter and range and dynare loops over all countries and variables)

- $\rightarrow$ revision/improvement of some equations

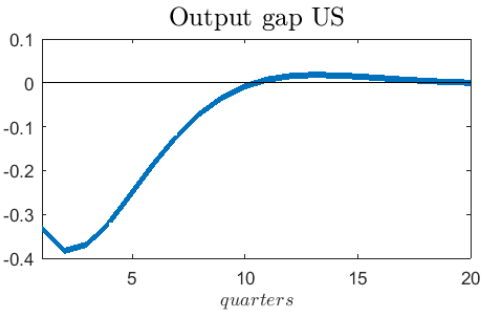
US monetary policy normalization

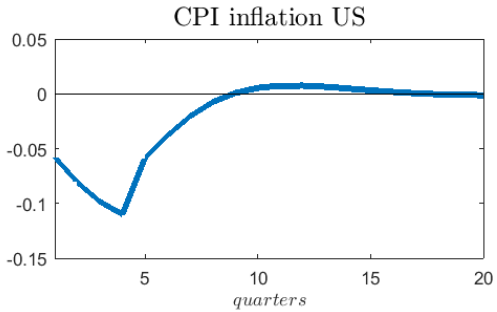
What are the global spillovers if the rise in US interest rates is

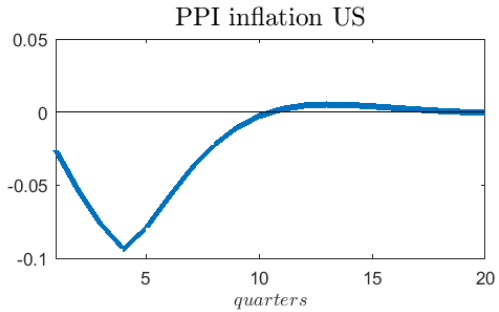
- *due to an unexpected deviation from the FED's reaction function*, modelled as a contractionary monetary policy shock

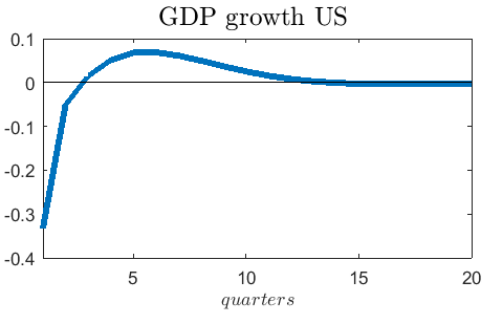
Note answer would be different if the rise in US interest rates is modelled as a demand shock *due to positive news about the strength of the recovery*

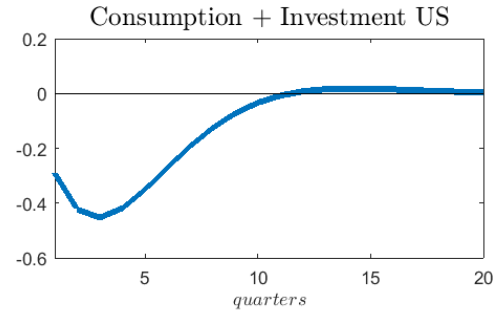
US responses to monetary policy shocks

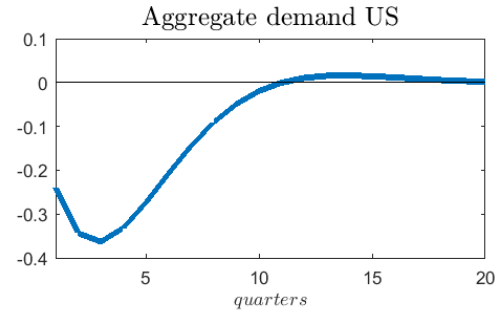


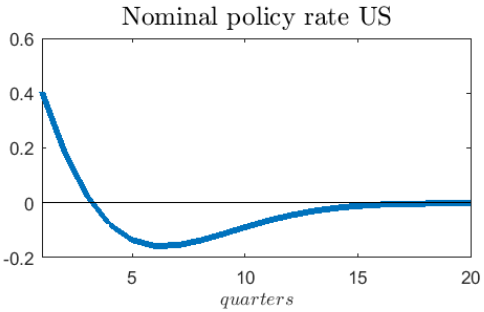


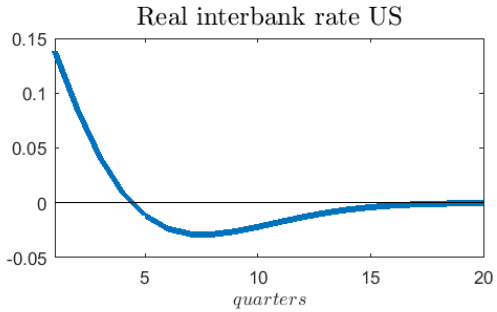


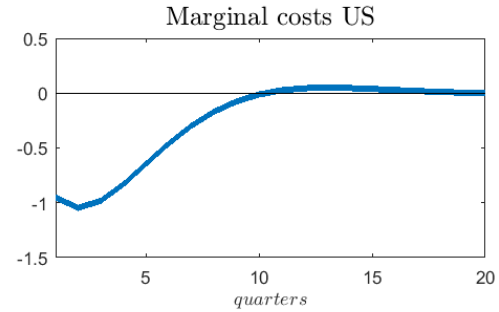




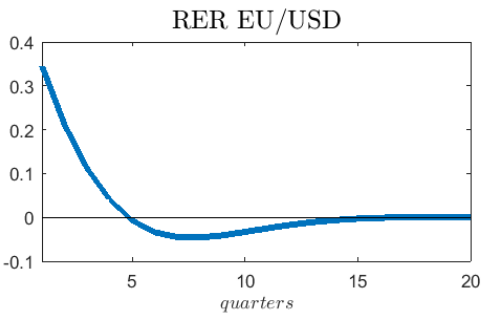


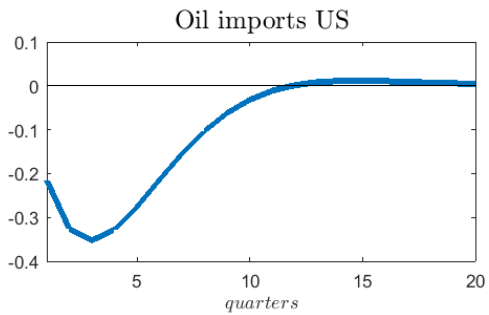


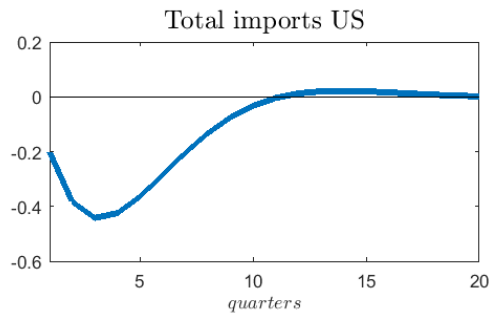


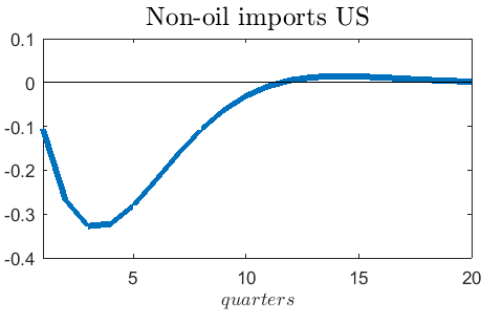


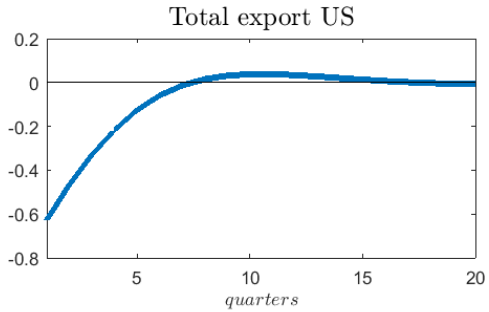
US responses to monetary policy shocks

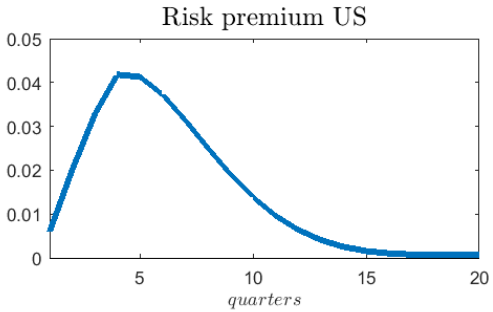


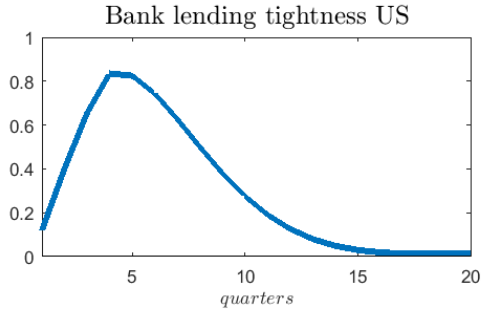


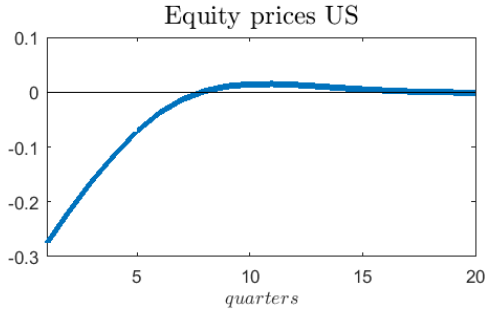


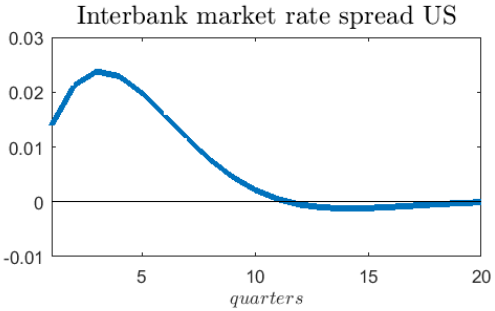






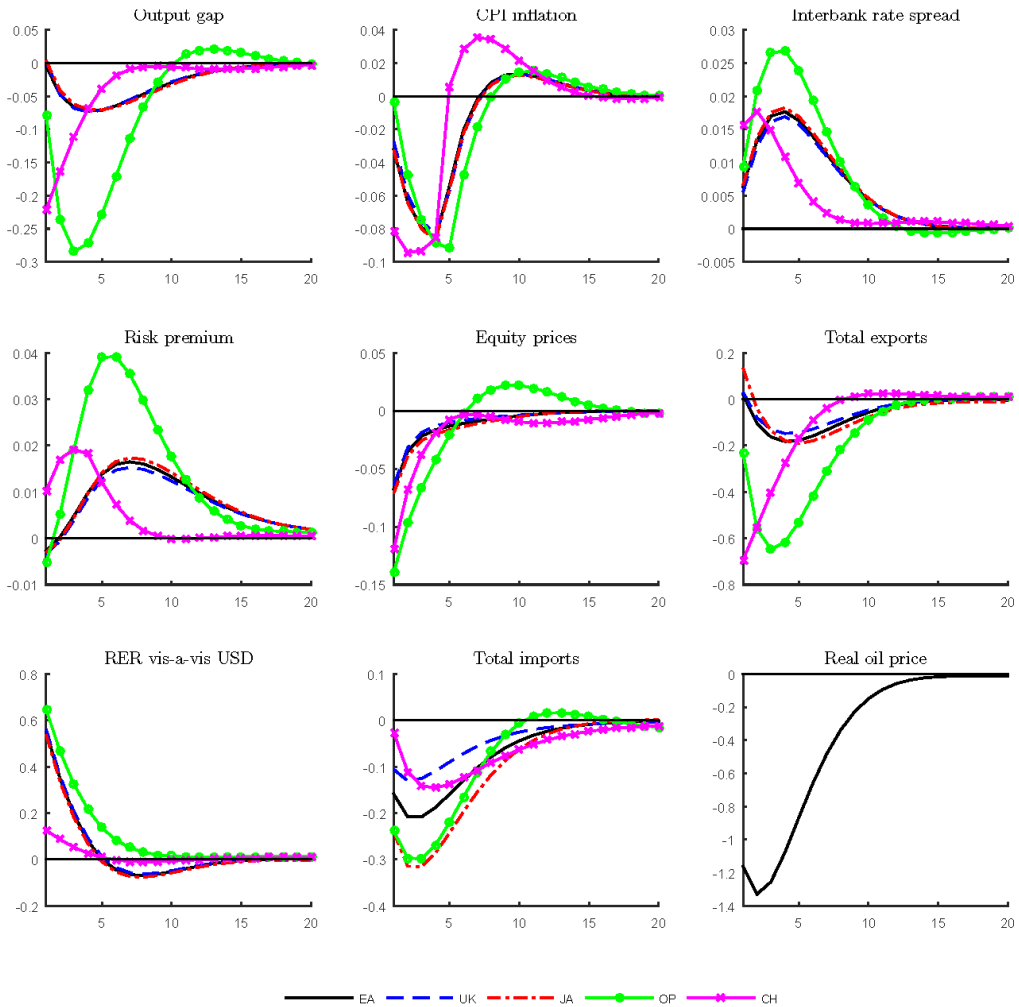






Spillovers of US monetary policy shocks

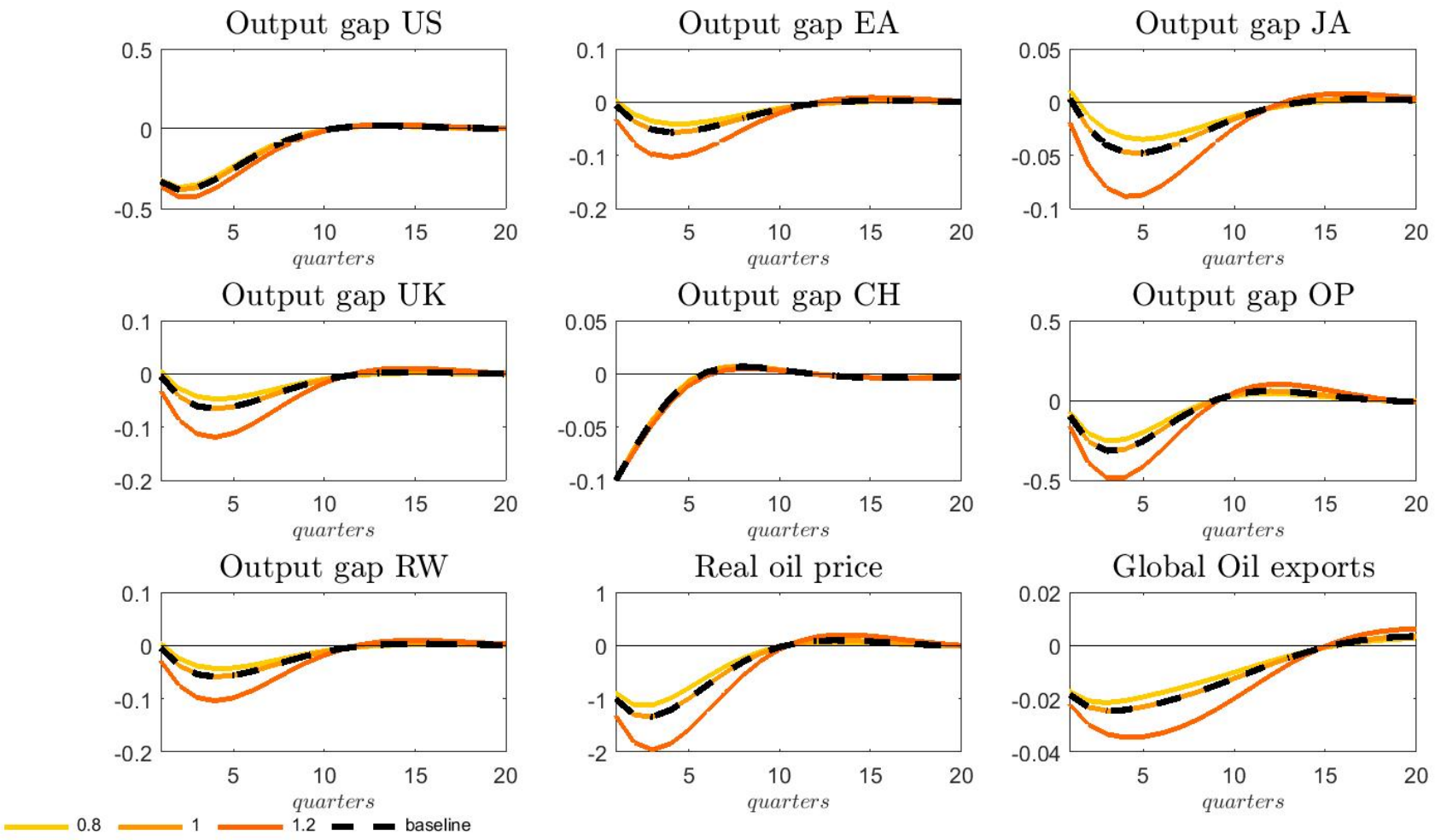
Figure 2
US MONETARY POLICY SHOCK: IMPULSE RESPONSES OF FOREIGN VARIABLES



Note: All variables are expressed as percentage change from steady state. Interest rates are in basis points while inflation is expressed in percentage points.

US monetary policy shock

Different degrees of financial integration



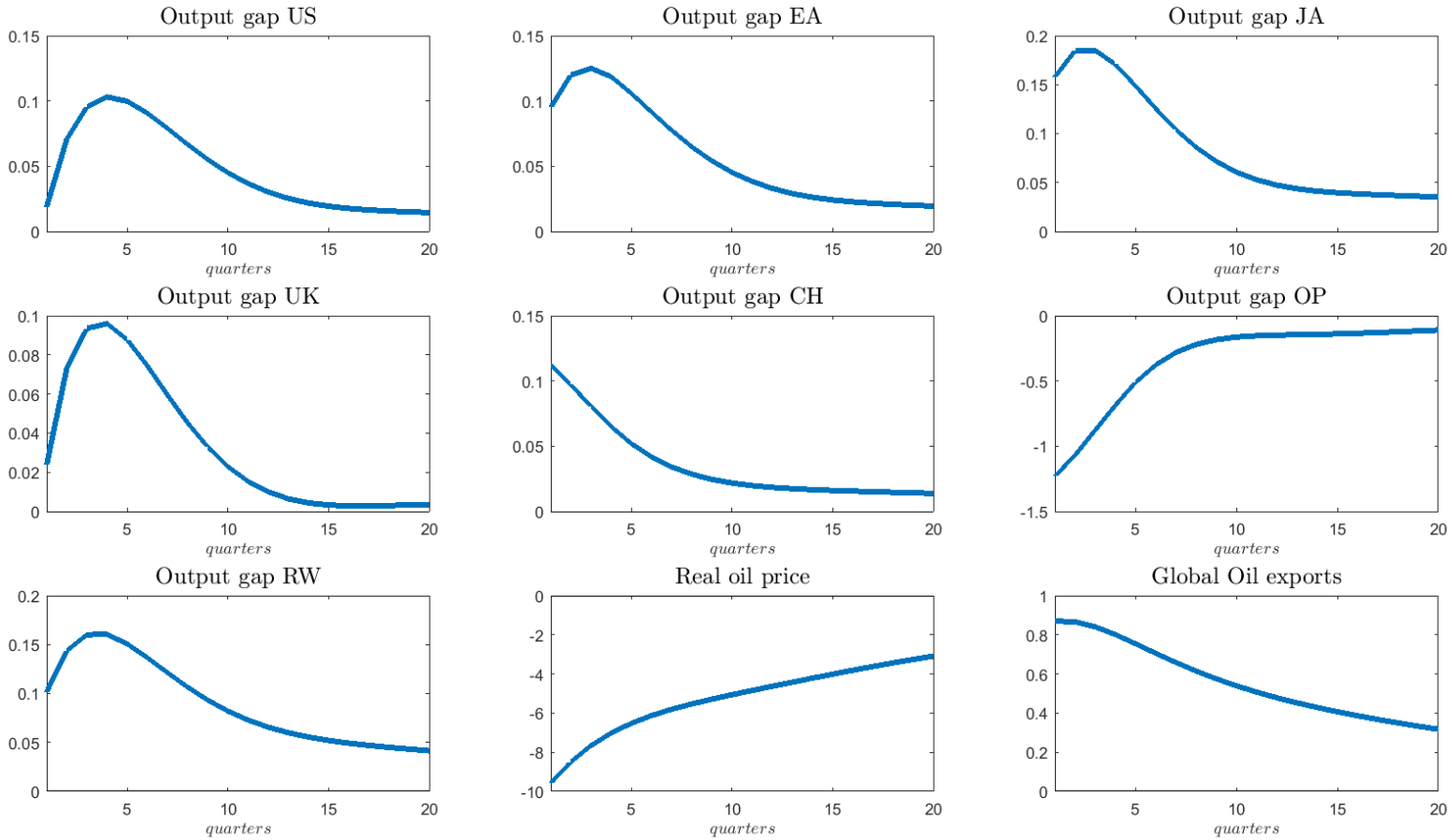
The effect of an oil price decline

We simulate a 10 percent decline in crude-oil prices.

Oil market is modeled similarly to Blagrave et al. (2013), Medina and Soto (2005)

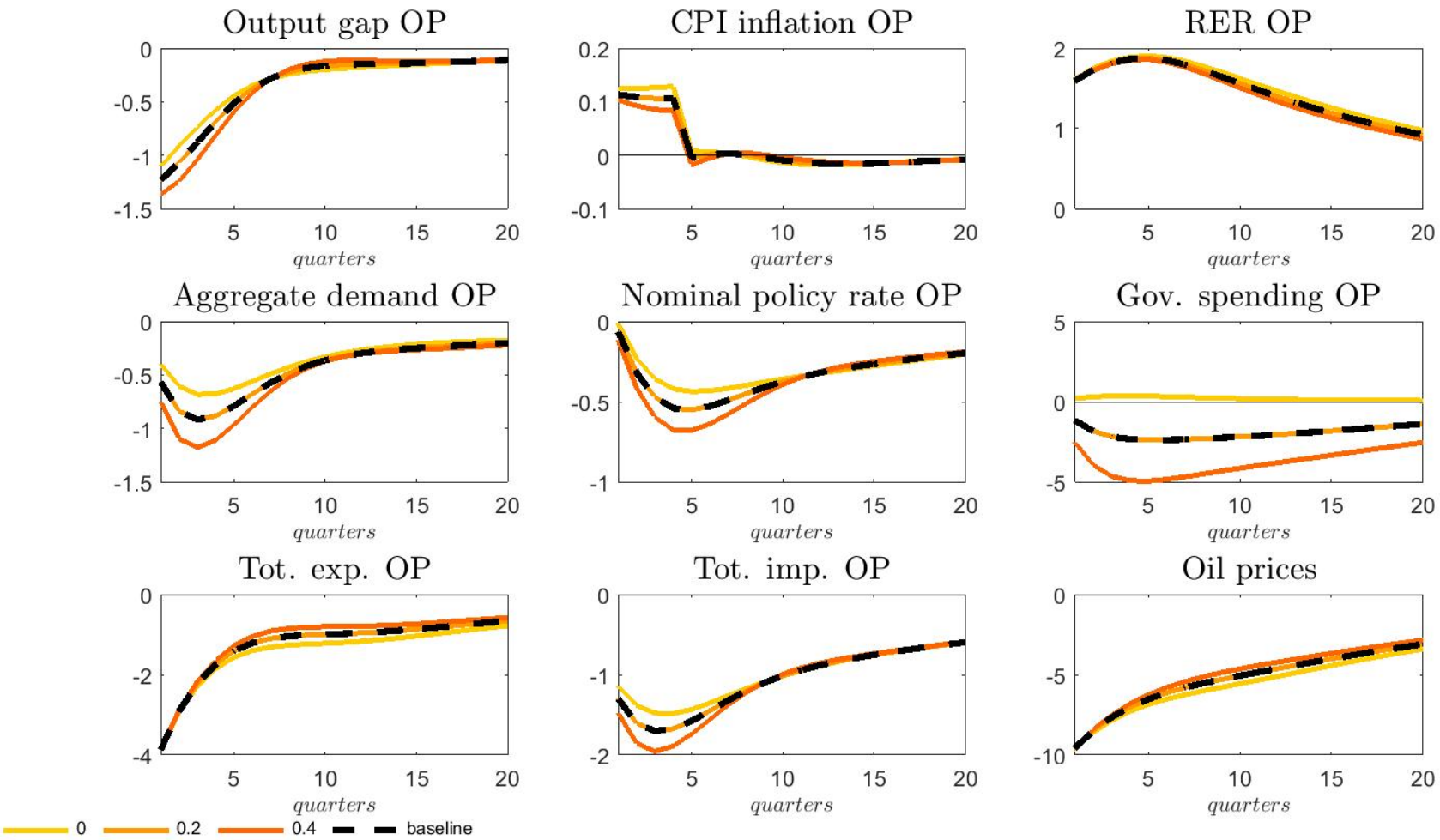
- Oil demand depends on global production
- Oil price depends on oil demand and an exogenous oil supply shock
- Fiscal policy and domestic conditions in oil exporting countries depend on oil revenues

Effect of a 10 percent decline in oil prices



Effect on oil exporters

Different response of government expenditure to oil revenues in oil producing countries



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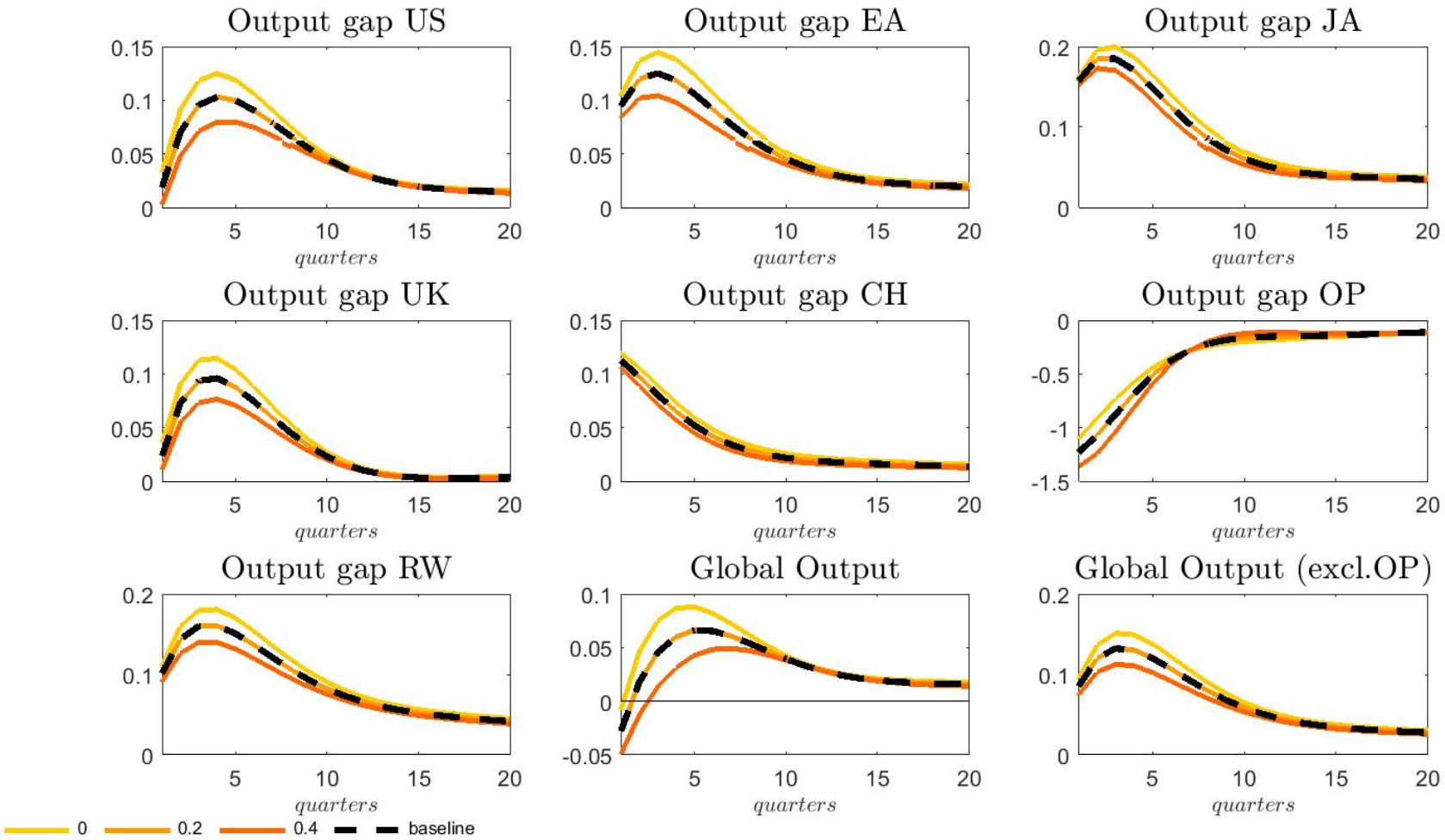
Response of oil importers

Implies different global response



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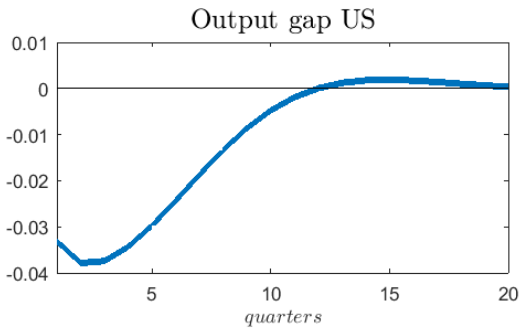
China's slowdown

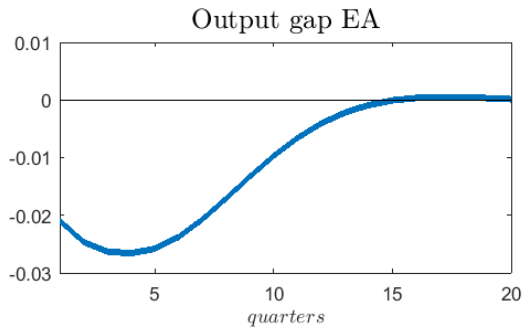
We simulate a slowdown in China, which takes the form of a persistent shock to China's aggregate demand, that decreases output by 1%.

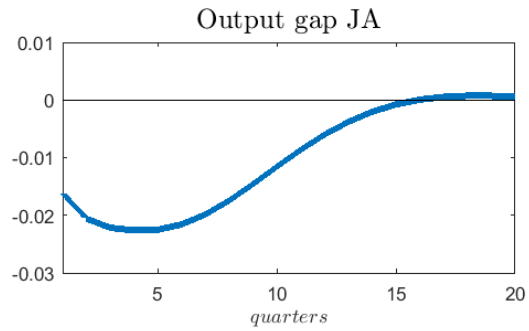
China's modellization mainly differs from the rest of the countries for:

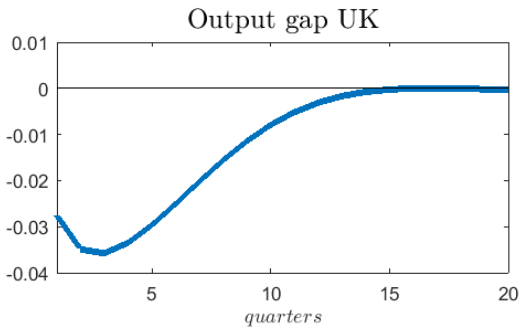
- UIP includes a friction - to allow partial peg of renminbi to the dollar i.e. exchange rate does not fully adjust to changes in interest rate
- Monetary authorities react to changes in the nominal exchange rate (enters in the Taylor Rule)
- Reserve requirement ratio as an additional tool for monetary policy (enters in the aggregate demand)
- Small financial linkages (assumption is that other countries do not hold Chinese debt and equity)

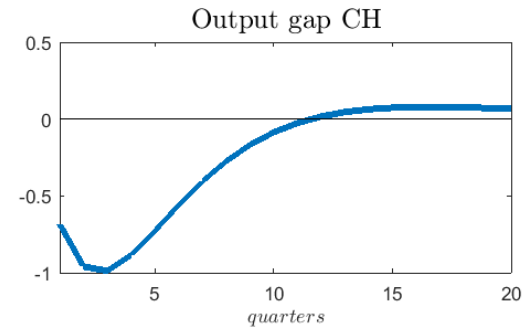
Spillovers from a persistent decrease in Chinese demand

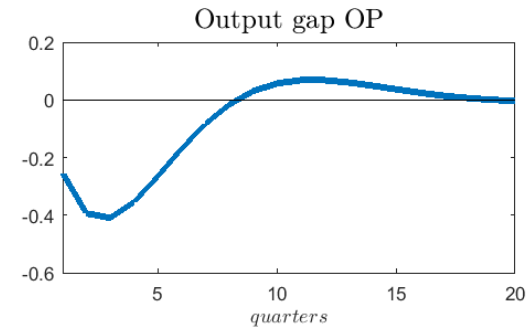


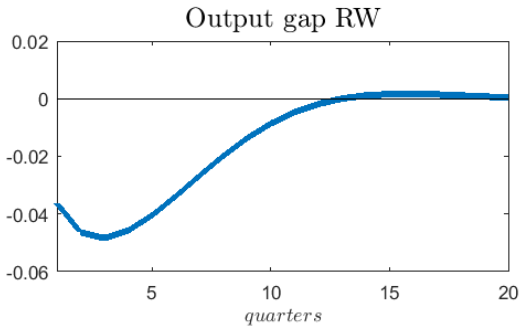


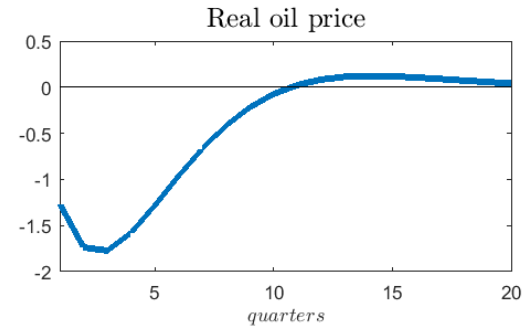


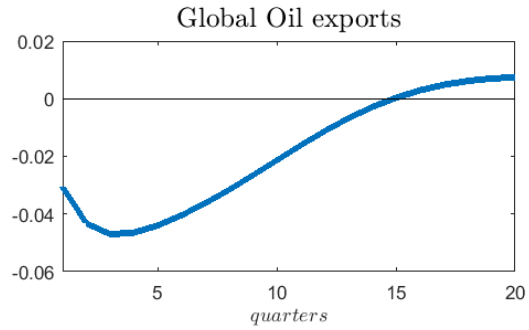












China's slowdown

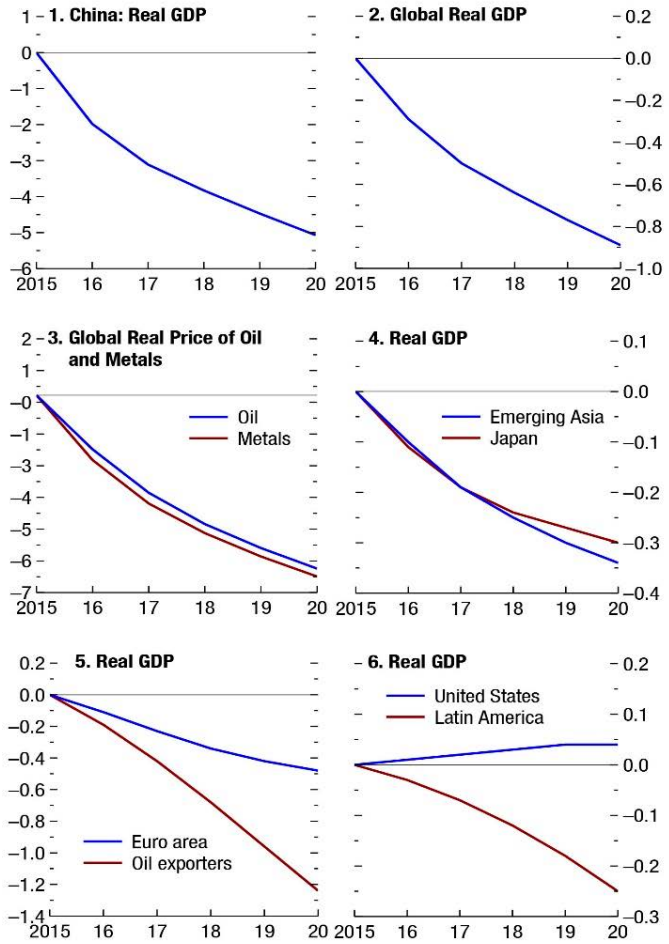
A negative demand shock in China causes a mild fall in Output and Consumption in Europe.

Main spillover channels are:

- Trade Channel
- Oil Price Channel. The fall in oil prices after a negative chinese demand shock strongly mitigates the effects on the other countries
- Financial Spillovers are switched off (we assume that other countries do not hold Chinese debt/equity)

Strong general equilibrium effects are at play which are often disregarded in other types of analysis

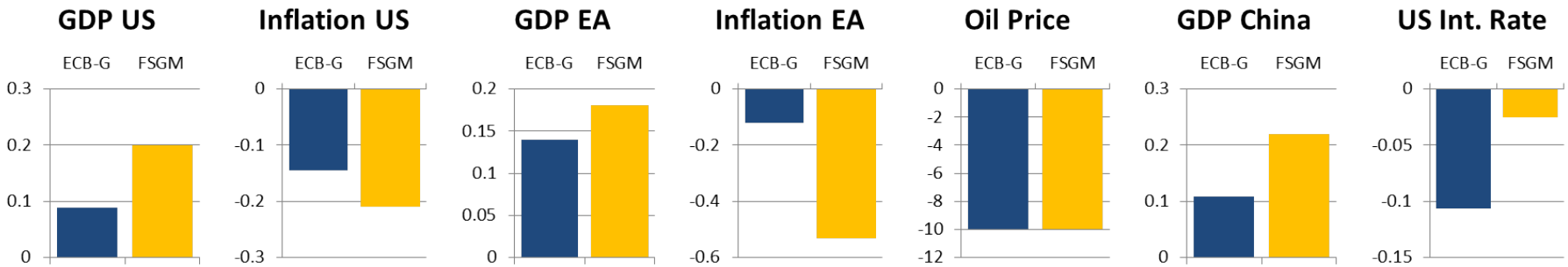
Figure 4.10. China: Slowdown Scenario
(Percent deviation from no-slowdown baseline)



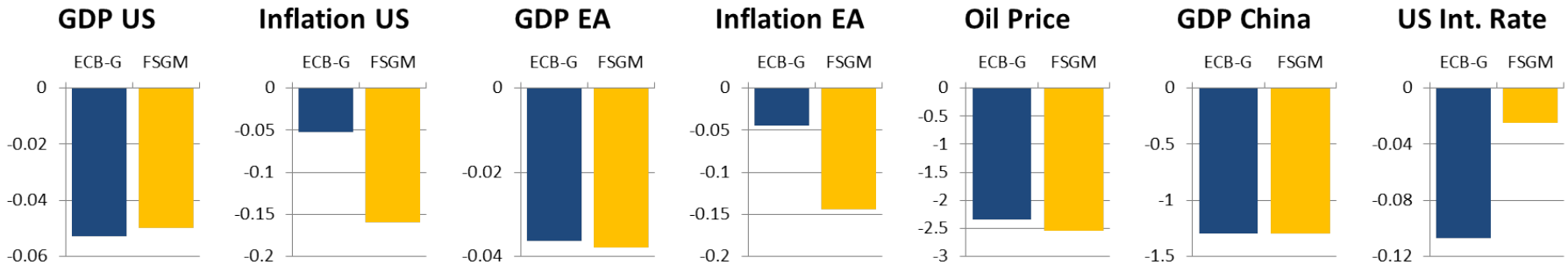
Source: Dizioli, Hunt, and Maliszewski 2016.
Note: This scenario considers a gradual slowdown in China's GDP growth over a five year period. This slowdown is assumed to be driven by weaker productivity growth, and leaves the level of real GDP five percent lower than it would have been if no slowdown occured.

Comparison with IMF's global model: FSGM

Oil price shock[1]

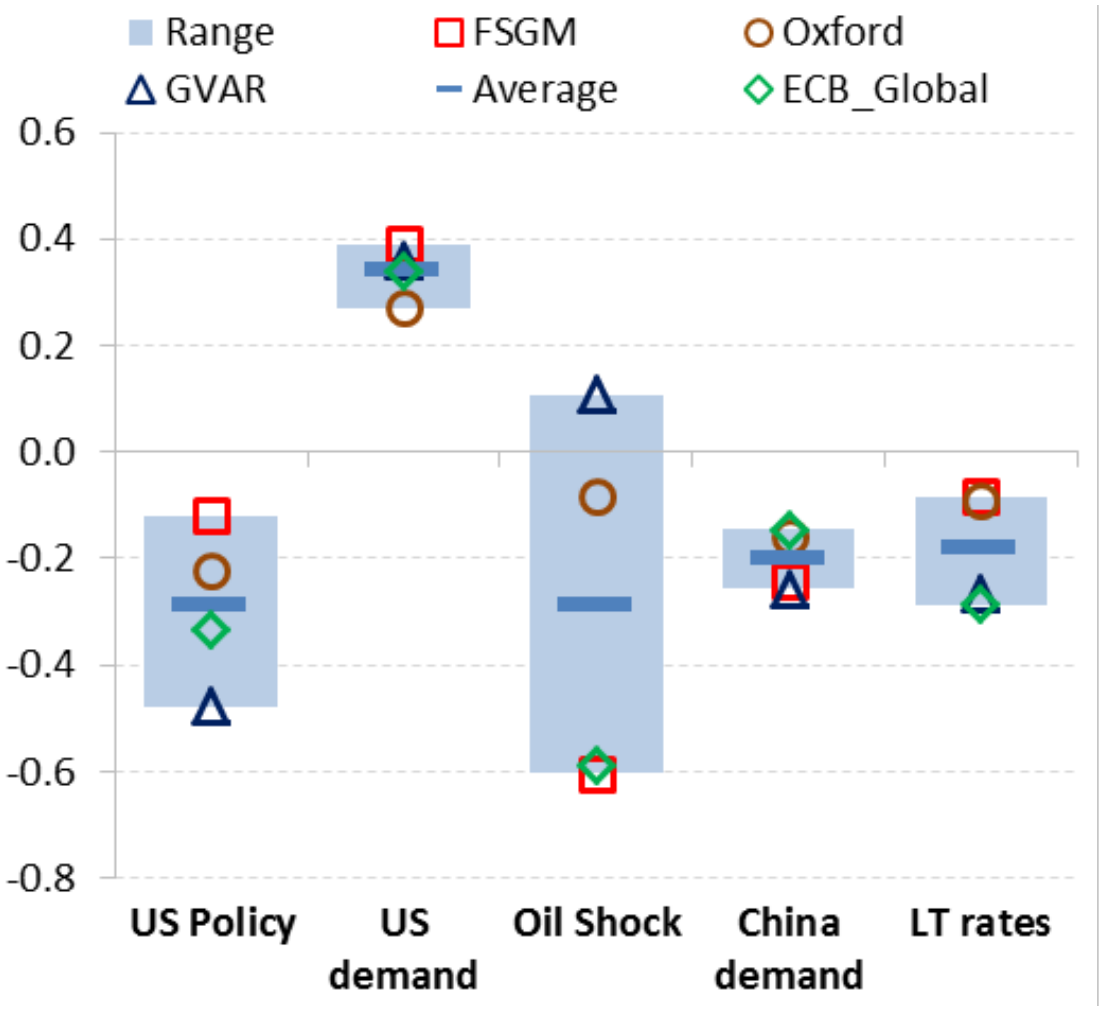


China slowdown



[1]Note: First year percentage deviations from steady state. Interest rates are in basis points while GDP and inflation are expressed in year-on-year changes

Comparison with other models - global effects



Next steps

ECB-Global can be used on a case-by-case approach
Next Steps and Applications:

- Introduce further country heterogeneity (from literature \ empirical estimates)
- Further scenarios: Global secular slowdown; rising long-rates; appreciation of US dollar; EME confidence shock, etc.
- Draft Working Paper

Subsequent Steps:

- Increase structure \ country coverage
- Estimation of key parameters \ shock decomposition

Thank you!

List of Countries in OP

Saudi Arabia
Venezuela
Oman
Qatar
United Arab Emirates
Norway
Ecuador
Nigeria
Angola
Russia
Iran
Kuwait
Libya
Gabon
Equatorial Guinea
Bahrain
Kazakhstan

IS Curve

IS Curve:

$$\begin{aligned}\widehat{ci}_{ea,t} = \alpha_{ea}^{ci,ci}\, E_t\widehat{ci}_{ea,t+1} + \left(1-\alpha_{ea}^{ci,ci}\right)\widehat{ci}_{ea,t-1} \\ - \alpha_{ea}^{ci,r^3}\left(\widehat{r}_{ea,t}^{3} + \widehat{\varpi}_{ea,t}\right) + \alpha_{ea}^{ci,q}\,\widehat{q}_{ea,t} \\ + \alpha_{ea}^{ci,ci}\left(E_t\Delta\overline{y}_{ea,t+1}^{cpi} - \Delta\overline{y}_{ea}^{cpi,ss}\right) \\ - \left(1-\alpha_{ea}^{ci,ci}\right)\left(\Delta\overline{y}_{ea,t}^{cpi} - \Delta\overline{y}_{ea}^{cpi,ss}\right) + \xi_{ea,t}^{ci}\end{aligned}$$

Phillips Curve

Phillips:

$$\widehat{\pi}_t^{PPI,EA} = \widehat{\pi}_t^{T,EA} + \beta^{EA}\,\alpha^{\pi,\pi,EA}\left(E_t\widehat{\pi}_{t+1}^{PPI,EA} - E_t\widehat{\pi}_{t+1}^{T,EA}\right) + \frac{1-\alpha^{\pi,\pi,EA}}{\beta^{EA}}\left(\widehat{\pi}_{t-1}^{PPI,EA} - \widehat{\pi}_t^{T,EA}\right) + \left(1-\alpha^{\pi,\pi,EA}\right)\left(E_t\widehat{\pi}_{t+1}^{T,EA} - \widehat{\pi}_t^{T,EA}\right) + \alpha^{\pi,mc,EA}\,\widehat{mc}_t^{EA} - \xi_t^{\pi,EA}$$

Marginal costs:

$$\widehat{mc}_{ea,t} = \alpha_{ea}^{mc,y}\widehat{y}_{ea,t}^{ppi} + \alpha_{ea}^{mc,\pi^{ppi}}\left\{\alpha_{ea}^{mc,oil}\left(\widehat{Q}_{ea,t} + \widehat{p}_t^{oil} - \widehat{p}_{ea,t}^{ry}\right) + (1-\alpha_{ea}^{mc,oil})\left[\omega_{ea,us}^{II}\left(\widehat{Q}_{ea,t}\widehat{p}_{us,t}^{ry} - \widehat{p}_{ea,t}^{ry}\right) + \omega_{ea,rw}^{II}\left(\widehat{Q}_{ea,t} - \widehat{Q}_{op,t} + \widehat{p}_{op,t}^{ry} - \widehat{p}_{ea,t}^{ry}\right)\right]\right\}.$$

Equations Interbank Spread and Risk Premium

$$\widehat{\varsigma}^{b}_{ea,t} = \alpha^{\varsigma^b,\varsigma^b}_{ea} \cdot \left[\varphi^{\varsigma^b}_{ea}\left(\omega^{F}_{ea,us}\widehat{\varsigma^{b}}_{us,t} + \omega^{F}_{ea,op}\widehat{\varsigma}^{b}_{op,t}\right)\right] + \left(1-\alpha^{\varsigma^b,\varsigma^b}_{ea}\right)\cdot\left(\alpha^{\varsigma^b,lag}_{ea}\widehat{\varsigma}^{b}_{ea,t-1} - \alpha^{\varsigma^b,\widehat{y}}_{ea}\widehat{y}_{ea,t}\right) + \xi^{\varsigma^b}_{ea,t},$$

$$\widehat{\varpi}_{ea,t} = \alpha^{\varpi,blt}_{ea}\cdot\widehat{blt}_{ea,t} + \alpha^{\varpi,\varsigma^g}_{ea}\cdot\widehat{\varsigma}^{g}_{ea,t}$$

UIP

Normal:

$$\widehat{r}^{3}_{ea,t} + \widehat{\varpi}_{ea,t} - \left(\widehat{r}^{3}_{us,t} + \widehat{\varpi}_{us,t} - \alpha^{nfa}_{ea} \cdot \widetilde{nfa}_{ea,t}\right) = E_t \widehat{Q}_{ea,t+1} - \widehat{Q}_{ea,t} \tag{1}$$

China

$$\theta^{uip}_{ch}\left[\widehat{r}^{3}_{ch,t} + \widehat{\varpi}_{ch,t} + E_t\widehat{\pi}^{cpi}_{ch,t+1} - \left(\widehat{r^{3}}_{us,t} + \widehat{\varpi}_{us,t} + E_t\widehat{\pi}^{cpi}_{us,t+1} - \widetilde{nfa}_{ch,t}\,\alpha^{nfa}_{ch}\right)\right]$$
$$+\left(1-\theta^{uip}_{ch}\right)\left(\Delta\overline{Q}_{ch,t} - \Delta\overline{Q}^{ss}_{ch}\right) = E_t\widehat{Q}_{ch,t+1} - \widehat{Q}_{ch,t} + E_t\widehat{\pi}^{cpi}_{ch,t+1} - \widehat{\pi}^{cpi}_{us,t+1} + \xi^{uip}_{ch,t},$$

where:

$$\Delta\overline{Q}^{CH}_{t} = \Delta\overline{Q}^{CH,SS} + \xi^{Q}_{t}$$

China's Reserve requirement ratio

China:

$$\begin{aligned}\widehat{rrr}_t^{CH} &= \rho^{rrr,EA}\,\widehat{rrr}_{t-1}^{CH} \\ &+ \left(1-\rho^{rrr,EA}\right)\left[\alpha^{rrr,y,CH}\widehat{y}_t^{PPI,CH} + \alpha^{rrr,\pi,CH}(E_t\widehat{\pi}_{t+3}^{CPI,EA} - \widehat{\pi}_t^{T,CH})\right] \\ &+ \varepsilon_t^{rrr,CH} + \alpha^{rrr,\varepsilon^{is},CH}\varepsilon_t^{is,CH}.\end{aligned}$$

The "equilibrium reserve requirement" evolves as

$$\Delta\overline{rrr}_t^{CH} = \alpha^{\overline{rrr},CH}\,\Delta\overline{rrr}_{t-1}^{CH} + \overline{rrr}^{SS,CH}\left(1-\alpha^{\overline{rrr},CH}\right) + \varepsilon_t^{\Delta\overline{rrr},CH}, \qquad (2)$$

This equation appears only for China

China Taylor rule and Domestic Absorption

China Taylor rule:

$$\begin{aligned}\widehat{is}_t^{CH} =& \alpha^{is,is,CH}\,\widehat{is}_{t-1}^{CH} \\ &+\left(1-\alpha^{is,is,CH}\right)\left[\widehat{\pi}_t^{T,CH}+\alpha^{is,\pi^T,CH}\left(\widehat{\pi}_t^{CPI,CH}-\widehat{\pi}_t^{T,CH}\right)+\alpha^{is,y,CH}\widehat{y}_t^{PPI,CH}\right. \\ &\left.+\alpha^{is,\Delta S,CH}\left(\Delta S_t^{CH}-\Delta\overline{S}^{CH}\right)+\varepsilon_t^{rrr,CH}+\varepsilon_t^{is,CH},\right.\end{aligned}$$

- Responds to changes in S and to shocks in RRRR

China's Domestic absorption:

$$\begin{aligned}\widehat{da}_t^{CH} &= \alpha^{da,da,CH}\,\widehat{da}_{t+1}^{CH}+\widehat{da}_{t-1}^{CH}\left(1-\alpha^{da,da,CH}\right) \\ &-\left(\widehat{r3}_t^{CH}+\widehat{rp}_t^{CH}\right)\alpha^{da,r3,CH} \\ &+\alpha^{da,q,CH}\,\widehat{q}_t^{CH}+\alpha^{da,da,CH}\left(\Delta\overline{y}_{t+1}^{CPI,CH}-\Delta\overline{y}^{CPI,SS}\right) \\ &-\left(1-\alpha^{da,da,CH}\right)\left(\Delta\overline{y}_t^{CPI,CH}-\Delta\overline{y}^{CPI,SS}\right)-\widehat{rrr}_t^{CH}\,\alpha^{da,rrr,CH}+\xi_t^{da,CH}\end{aligned}$$

Consumer Price Index

$$
\begin{aligned}
0 = \varpi_{ea}^{oil} \cdot \left(\widehat{Q}_{ea,t} + \widehat{p}_t^{oil} \right) + \\
+ (1 - \varpi_{ea}^{oil}) \alpha_{ea}^{H} \cdot \widehat{p}_{ea,t}^{ry} + (1 - \varpi_{ea}^{oil})(1 - \alpha_{ea}^{H}) \times \\
\times \left[\omega_{ea,us}^{M^{nonoil}} \left(\widehat{Q}_{ea,t} + \widehat{p}_{us,t}^{ry} \right) + \omega_{ea,op}^{M^{nonoil}} \left(\widehat{Q}_{ea,t} - \widehat{Q}_{op,t} + \widehat{p}_{op,t}^{ry} \right) \right] .
\end{aligned}
$$

Exchange rate

$$Q_{ea,us} = \frac{S_{ea,us} \times P_{us}}{P_{ea}}, \quad Q_{ch,us} = \frac{S_{ch,us} \times P_{us}}{P_{ch}} \longrightarrow Q_{ea,ch} = \frac{Q_{ea,us}}{Q_{ch,us}}$$

$$REER_{ea} = \sum_{i \in \{countries\}} \omega_i Q_{ea,i}$$

where ω_i are the bilateral export shares.