The ECB-Global Model for spillover analysis
European Central Bank

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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:

GDP shares

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

**GLOBAL ECONOMY**
(US, Japan, UK, China, Rest of the World, OP)

- **1. DOMESTIC ECONOMY**
  - IS-curve: Domestic demand,
  - Phillips curve: Inflation

- **2. GOVERNMENT**
  - Gov. spending and revenues (debt, output gap)
  - Gov. debt dynamics (output growth, fiscal deficit, interest rate on gov. debt)

- **3. CENTRAL BANK**
  - Taylor rule: interest rate
  - China augmented with changes in nominal exchange rate. Reserve requirement as an additional monetary policy tool.

- **4. FINANCIAL SECTOR**
  - Interbank spread (spillovers)
  - Bank lending tightness (spillovers)
  - Sovereign risk spread (spillovers)
  - Equity prices (spillovers)
  - UIP: Exchange rate (spillovers)

**OIL SECTOR**
(Endogenous oil demand)

**REAL spillovers: trade**

**EURO AREA**

**REAL spillovers: oil**
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.
Propagation channels of global spillovers

**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)

- → revision/improvement of some equations
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

- RER EU/USD
- Oil imports US
- Total imports US
- Non-oil imports US
- Total export US
- Risk premium US
- Bank lending tightness US
- Equity prices US
- Interbank market rate spread US
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

- Output gap OP
- CPI inflation OP
- RER OP
- Aggregate demand OP
- Nominal policy rate OP
- Gov. spending OP
- Tot. exp. OP
- Tot. imp. OP
- Oil prices

- Yellow: 0
- Orange: 0.2
- Red: 0.4
- Black: baseline
Response of oil importers

Implies different global response

Output gap US

Output gap EA

Output gap JA

Output gap UK

Output gap CH

Output gap OP

Output gap RW

Global Output

Global Output (excl.OP)
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)

1. China: Real GDP
2. Global Real GDP
3. Global Real Price of Oil and Metals
4. Real GDP
5. Real GDP
6. Real GDP

Source: Dizio, 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 occurred.
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

The graph compares different models in terms of their response to various shocks. The models include Range, FSGM, Oxford, GVAR, and ECB_Global. The x-axis represents different types of shocks: US Policy, US demand, Oil Shock, China demand, and LT rates. The y-axis shows the magnitude of the effect.
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:

\[ \bar{c}_{e,a,t} = \alpha_{e,a}^{c_i,c_i} E_t \bar{c}_{e,a,t+1} + (1 - \alpha_{e,a}^{c_i,c_i}) \bar{c}_{e,a,t-1} \]

\[ - \alpha_{e,a}^{c_i,r^3} (\bar{r}_{e,a,t}^3 + \bar{\omega}_{e,a,t}) + \alpha_{e,a}^{c_i,q} \bar{q}_{e,a,t} \]

\[ + \alpha_{e,a}^{c_i,c_i} \left( E_t \Delta \bar{y}_{e,a,t+1} - \Delta \bar{y}_{e,a,ss} \right) \]

\[ - (1 - \alpha_{e,a}^{c_i,c_i}) \left( \Delta \bar{y}_{e,a,t} - \Delta \bar{y}_{e,a,ss} \right) + \xi_{e,a,t} \]
Phillips Curve

Phillips:

\[
\hat{\pi}^{PPI,EA}_t = \hat{\pi}^{T,EA}_t + \beta^{EA} \alpha^{\pi,\pi,EA} \left( E_t \hat{\pi}^{PPI,EA}_{t+1} - E_t \hat{\pi}^{T,EA}_{t+1} \right) \\
+ \frac{1 - \alpha^{\pi,\pi,EA}}{\beta^{EA}} \left( \hat{\pi}^{PPI,EA}_{t-1} - \hat{\pi}^{T,EA}_t \right) \\
+ \left( 1 - \alpha^{\pi,\pi,EA} \right) \left( E_t \hat{\pi}^{T,EA}_{t+1} - \hat{\pi}^{T,EA}_t \right) \\
+ \alpha^{\pi,mc,EA} \hat{mc}_t^{EA} - \xi^{\pi,EA}_t
\]

Marginal costs:

\[
\hat{mc}_{ea,t} = \alpha^{mc,y}_{ea} y^{ppi}_{ea,t} + \alpha^{mc,\pi^{ppi}}_{ea} \left\{ \alpha^{mc,oil}_{ea} \left( \hat{Q}_{ea,t} + \hat{p}^{oil}_t - \hat{p}^{ry}_{ea,t} \right) \right. \\
+ (1 - \alpha^{mc,oil}_{ea}) \left[ \omega_{ea,us}^{II} \left( \hat{Q}_{ea,t} \hat{p}^{ry}_{us,t} - \hat{p}^{ry}_{ea,t} \right) + \omega_{ea,rw}^{II} \left( \hat{Q}_{ea,t} - \hat{Q}_{op,t} + \hat{p}^{ry}_{op,t} - \hat{p}^{ry}_{ea,t} \right) \right] \}
\]
\[ \hat{\varsigma}_{ea,t} = \alpha_{\varsigma ea, \varsigma b} \cdot \left[ \varphi_{\varsigma ea} \left( \omega_{\varsigma ea,us} \hat{\varsigma}_{us,t} + \omega_{\varsigma ea,op} \hat{\varsigma}_{op,t} \right) \right] \\
+ \left( 1 - \alpha_{\varsigma ea, \varsigma b} \right) \cdot \left( \alpha_{\varsigma ea, lag} \hat{\varsigma}_{ea,t-1} - \alpha_{\varsigma ea, \hat{y} \hat{y}_{ea,t}} \right) + \xi_{\varsigma ea,t}, \]

\[ \hat{\omega}_{ea,t} = \alpha_{\omega ea, blt} \cdot \hat{blt}_{ea,t} + \alpha_{\omega ea, \varsigma g} \cdot \hat{\varsigma}_{ea,t} \]
Normal:

\[
\hat{r}_{ea,t} + \hat{\omega}_{ea,t} - \left( \hat{r}_{us,t} + \hat{\omega}_{us,t} - \alpha_{ea}^{nfa} \cdot \hat{nfa}_{ea,t} \right) = E_t \hat{Q}_{ea,t+1} - \hat{Q}_{ea,t}
\]  

(1)

China

\[
\theta_{ch}^{uip} \left[ \hat{r}_{ch,t}^3 + \hat{\omega}_{ch,t} + E_t \hat{\pi}_{ch,t+1}^{cpi} - \left( \hat{r}_{us,t}^3 + \hat{\omega}_{us,t} + E_t \hat{\pi}_{us,t+1}^{cpi} + \hat{nfa}_{ch,t} \alpha_{ch}^{nfa} \right) \right]
\]

\[+ \left( 1 - \theta_{ch}^{uip} \right) \left( \Delta \bar{Q}_{ch,t} - \Delta \bar{Q}_{ch}^{ss} \right) = E_t \hat{Q}_{ch,t+1} - \hat{Q}_{ch,t} + E_t \hat{\pi}_{ch,t+1}^{cpi} - \hat{\pi}_{us,t+1}^{cpi} + \xi_{ch,t}^{uip},
\]

where:

\[
\Delta \bar{Q}_{t}^{CH} = \Delta \bar{Q}_{t}^{CH,SS} + \xi_{t}^{Q}
\]
China’s Reserve requirement ratio

China:

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

The “equilibrium reserve requirement” evolves as

\[ \Delta \hat{rrr}_t^{CH} = \alpha^{rrr,CH} \Delta \hat{rrr}_{t-1}^{CH} + \hat{rrr}^{SS,CH} \left(1 - \alpha^{rrr,CH}\right) + \varepsilon_t^{\Delta rrr,CH}, \]
\[ (2) \]

This equation appears only for China.
China Taylor rule and Domestic Absorption

China Taylor rule:

$\hat{i}_{t}^{CH} = \alpha_{is,is,CH} \hat{i}_{t-1}^{CH} + \left(1 - \alpha_{is,is,CH}\right) \left[\hat{\pi}_{t}^{T,CH} + \alpha_{is,\pi^{T},CH} \left(\hat{\pi}_{t}^{CPI,CH} - \hat{\pi}_{t}^{T,CH}\right) + \alpha_{is,y,CH} \hat{y}_{t}^{PPI,CH}\right]$

$+ \alpha_{is,\Delta S,CH} \left(\Delta S_{t}^{CH} - \Delta \bar{S}^{CH}\right) + \varepsilon_{t}^{rrr,CH} + \varepsilon_{t}^{is,CH},$

- Responds to changes in $S$ and to shocks in $RRRRR$

China’s Domestic absorption:

$\hat{d}_{a_{t}}^{CH} = \alpha_{da,da,CH} \hat{d}_{a_{t+1}}^{CH} + \hat{d}_{a_{t-1}}^{CH} \left(1 - \alpha_{da,da,CH}\right)$

$- \left(\hat{r}^{3}_{t}^{CH} + \hat{r}^{p}_{t}^{CH}\right) \alpha_{da,r3,CH}$

$+ \alpha_{da,q,CH} \hat{q}_{t}^{CH} + \alpha_{da,da,CH} \left(\Delta \bar{y}_{t+1}^{CPI,CH} - \Delta \bar{y}^{CPI,SS}\right)$

$- \left(1 - \alpha_{da,da,CH}\right) \left(\Delta \bar{y}_{t}^{CPI,CH} - \Delta \bar{y}^{CPI,SS}\right) - \hat{r}_{t}^{RRR} CH \alpha_{da,rrr,CH} + \xi_{t}^{da,CH}$
0 = \omega_{ea}^{oil} \cdot (\hat{Q}_{ea,t} + \hat{p}_t^{oil}) + \\
\quad + (1 - \omega_{ea}^{oil})\alpha_{ea}^H \cdot \hat{p}_{ea,t}^{r_y} + (1 - \omega_{ea}^{oil})(1 - \alpha_{ea}^H) \times \\
\quad \times \left[ \omega_{ea,us}^{M_{nonoil}} (\hat{Q}_{ea,t} + \hat{p}_{us,t}^{r_y}) + \omega_{ea,op}^{M_{nonoil}} (\hat{Q}_{ea,t} - \hat{Q}_{op,t} + \hat{p}_{op,t}^{r_y}) \right].
Exchange rate

\[ Q_{ea,us} = \frac{S_{ea,us} \times P_{us}}{P_{ea}}, \quad Q_{ch,us} = \frac{S_{ch,us} \times P_{us}}{P_{ch}} \Rightarrow Q_{ea,ch} = \frac{Q_{ea,us}}{Q_{ch,us}} \]

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

where \( \omega_i \) are the bilateral export shares.