Dominant-currency pricing and the global spillovers from US shocks

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The views expressed in the paper are those of the authors and not those of the ECB.
Background and motivation

- In which currency are export/import prices sticky?

- Pricing paradigm has important implications for
  - exchange-rate pass-through and expenditure switching
  - spillovers and business cycle co-movement
  - exchange-rate disconnect
  - optimal monetary policy and optimum currency areas
  - international monetary policy coordination
Review of export pricing paradigms

- **Traditional Mundellian international macro model: PCP**
  - Mundell (1963); Fleming (1962); Obstfeld and Rogoff (1995)
  - Export prices sticky in exporter’s currency

- **More recently: LCP**
  - Betts and Devereux (1996, 2000); Engel (2000); Devereux and Engel (2003)
  - Export prices sticky in importer’s currency

- **Even more recently: DCP**
  - Cook and Devereux (2006); Goldberg and Tille (2009); Gopinath (2015)
  - Export prices sticky in one dominant currency, for example US$

- **Example: Relevant FX for ERPT to $^M_P$ under**
  - PCP: Bilateral FX
  - LCP: None
  - DCP: Bilateral US$ FX
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- **Example: Relevant FX for ERPT to $P^M$ under**
  - PCP: Bilateral FX
  - LCP: None
  - DCP: Bilateral US$ FX
This paper

- Test for empirical relevance of DCP
  Gopinath et al. (2019); Zhang (2018)

- Derive testable prediction of DCP from three-country DSGE model:
  \[
  \text{Trade subject to (partial) DCP} \quad \Downarrow \\
  \text{Output spillovers from US$ appreciation are negatively correlated} \\
  \text{with economies’ export/import US$ invoicing share differentials}
  \]

- Confront prediction with the data for up to 45 economies for 1995-2018
Findings

- Output spillovers from US$ appreciation fall with export/import US$ invoicing share differential
- Data consistent with (partial) DCP
- Findings robust to
  - Considering US demand, monetary policy or UIP shocks
  - Accounting for commodity trade
  - Considering EUR invoicing and euro area demand shock spillovers as placebo test
Outline

1 A three-country DSGE model with PCP, LCP and DCP
   - Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2 Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3 Summary and discussion
A three-country DSGE model with PCP, LCP and DCP

- Model structure
- Pure PCP, LCP and DCP
- Partial DCP

Empirical analysis

- Baseline
- Extensions
- Robustness

Summary and discussion
Key elements of the model

- Sticky prices
  - Fractions of exporters price in PCP, LCP and DCP

- Three large, symmetric economies
  - Dominant-currency issuer $D$, think of the US
  - Rest-of-the-world block 1 $E$, think of EMEs
  - Rest-of-the-world block 2 $F$, think of RoW

- And furthermore
  - Central banks respond to inflation and output gap
  - Flexible FX, no capital controls
  - Incomplete financial markets at international level
Overview of model structure: Domestic economy
Overview of model structure: Domestic economy

Domestic Economy

Central Bank

$R_t$

$\Delta CPI_t$

$C_t$

$B_t^*$

Representative Household

Consumption Good Bundler

Final Good Producer

Import Good Bundler

Intermediate Good Producer

Foreign Countries

Price setting

$Y^F_t$

$IM^F_t$

$IM_t(i)$

$Y_t(i)$

$\hat{Y}_t$

$X_t(i)$

Intermediate Good Producer
## Consumption good bundlers parametrisation

<table>
<thead>
<tr>
<th>Country</th>
<th>Share of Consumption Bundle</th>
<th>Parameter</th>
</tr>
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<tbody>
<tr>
<td><strong>EME (E)</strong></td>
<td>Share of EME consumption bundle accounted for by EME final product</td>
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Further Parametrisation
1 A three-country DSGE model with PCP, LCP and DCP
   - Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2 Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3 Summary and discussion
Inducing multilateral US$ appreciation

- Several shocks as candidates for inducing US$ appreciation

- Contractionary US monetary policy shock
  - Very standard both in theory and empirically
  - ...but accounts only for a small share of the variation of the data

- UIP shock
  - Argued to account for a large share of the variation of FX
  - ...but not well understood theoretically and hard to identify empirically

- Positive US demand shock
  - Straightforward to identify and accounts for a large share of the variation of the data

Focus on demand shock, but consider UIP and monetary policy shocks in extensions
Inducing multilateral US$ appreciation

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Effects of a positive US demand shock
Effects of a positive US demand shock

- Under PCP output spillovers are expansionary
  - Expenditure switching in EME and US raises EME net exports vis-à-vis US
  - EME exports additionally benefit from positive demand effect in US
  - No expenditure switching between EME and RoW

- Under LCP output spillovers are expansionary but muted
  - Muted expenditure switching in EME and US
  - EME exports still benefit from positive demand effect in US
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  - Expenditure switching in EME and RoW such that bilateral net exports are unchanged
Effects of a positive US demand shock

- GDP EMEs
- GDP RoW
- GDP US
- Export Price:
  - US to EMEs in EME currency
  - RoW to EMEs in EME currency
  - US to RoW in RoW currency
  - RoW to US in $
- Export Price:
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- Export Price EMEs to US in $
- GDP RoW
- Export Price US to RoW in RoW currency
- Export Price EMEs to RoW in RoW currency
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- Export Price RoW to US in $

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PDP - LCP - DCP
Effects of a positive US demand shock

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A three-country DSGE model with PCP, LCP and DCP

1. Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2. Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3. Summary and discussion
US$ invoicing shares

Note: Data taken from Gopinath (2015). Includes intra-euro area trade in case of euro area economies.
Effects of a positive US demand shock under \textit{partial} DCP

- Most plausibly, only fraction of exports is subject to PCP or DCP

- Consider a \textit{partial} DCP world in which
  - trade with US is subject to DCP
  - for non-US trade, a fraction $\delta_i (1 - \delta_i)$ of country $i$ exporters price in DCP (PCP)

- Country $i$ exports and imports in general not affected equally by FX changes
  - Examine spillovers across different export/import DCP share configurations
  - Define EME (non-US) export/import DCP share differential

\[
\Delta_E \equiv \delta_E^F - \delta_E^I
\]

\hspace{1cm} Share of EME exports to RoW subject to DCP \hspace{1cm} Share of EME imports from RoW subject to DCP
Effects of a positive US demand shock under partial DCP

- Most plausibly, only fraction of exports is subject to PCP or DCP

- Consider a partial DCP world in which
  - trade with US is subject to DCP
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- Country $i$ exports and imports in general not affected equally by FX changes
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- Share of EME exports to RoW subject to DCP
- Share of EME imports from RoW subject to DCP
Effects of a positive US demand shock under *partial DCP*

- Most plausibly, only fraction of exports is subject to PCP or DCP
- Consider a *partial DCP* world in which
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  - for non-US trade, a fraction $\delta_i (1 - \delta_i)$ of country $i$ exporters price in DCP (PCP)
- Country $i$ exports and imports in general not affected equally by FX changes
  - Examine spillovers across different export/import DCP share configurations
  - Define EME (non-US) export/import DCP share differential

\[
\Delta_E \equiv \left( \delta^F_E \right) - \left( \delta^E_F \right)
\]

- Share of EME exports to RoW subject to DCP
- Share of EME imports from RoW subject to DCP

(1)
Effects of a positive US demand shock under *partial* DCP

- Most plausibly, only fraction of exports is subject to PCP or DCP

- Consider a *partial DCP* world in which
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  - for non-US trade, a fraction $\delta_i (1 - \delta_i)$ of country $i$ exporters price in DCP (PCP)

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Effects of a positive US demand shock under *partial* DCP

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Overview of model structure: Partial DCP
Intermediate goods producers parametrisation for $\Delta_E \equiv \delta_E^F - \delta_F^E = 0$

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Effects of a positive US demand shock under partial DCP

GDP EMEs

GDP RoW

Export Price
RoW to EMEs in EME currency

Export Price
EMEs to RoW in RoW currency

Symmetric X-M DCP shares ($\Delta E = 0$)
Effects of a positive US demand shock under partial DCP

- When $\Delta_E = \delta^E_F - \delta^E_F = 0$
  - EME exports to and imports from RoW equally subject to DCP (and PCP)
  - Spillovers to EME are a combination of those from pure DCP and pure PCP

- When $\Delta_E = \delta^E_F - \delta^E_F > 0$
  - EME exports to RoW more strongly affected by DCP effects than imports
  - US$ appreciation reduces EME exports to RoW by more than imports
  - $\Delta_E > 0$ implies smaller spillovers from positive US demand shock

- When $\Delta_E = \delta^E_F - \delta^E_F < 0$
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  - $\Delta_E < 0$ implies larger spillovers from positive US demand shock
Intermediate goods producers parametrisation for $\Delta_E \equiv \delta^F_E - \delta^E_F > 0$

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Effects of a positive US demand shock under partial DCP

GDP EMEs

GDP RoW

Export Price
RoW to EMEs in EME currency

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EMEs to RoW in RoW currency

Symmetric X-M DCP shares ($\Delta E = 0$) - $\Delta E > 0$
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Intermediate goods producers parametrisation for $\Delta_E \equiv \delta^F_E - \delta^E_F < 0$

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Effects of a positive US demand shock under partial DCP

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RoW to EMEs in EME currency

GDP RoW

Export Price
EMEs to RoW in RoW currency

Symmetric X-M DCP shares ($\Delta_E = 0$) – $\Delta_E > 0$ – $\Delta_E < 0$
Effects of a positive US demand shock under partial DCP

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- When \( \Delta E = \delta_E^F - \delta_E^E > 0 \)
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  - US$ appreciation reduces EME exports to RoW by *more* than imports
  - \( \Delta_E > 0 \) implies *smaller* spillovers from positive US demand shock

- When \( \Delta E = \delta_E^F - \delta_E^E < 0 \)
  - EME exports to RoW *less* strongly affected by DCP effects than imports
  - US$ appreciation reduces EME exports to RoW by *less* than imports
  - \( \Delta_E < 0 \) implies *larger* spillovers from positive US demand shock
Testable prediction of partial DCP

Non-US trade subject to partial DCP

\[\downarrow\]

Output spillovers from US$ appreciation are \textit{negatively correlated}

with economies’ export/import DCP share differentials
Bringing the prediction of partial DCP to the data

- DC *pricing* shares are not observed, only US$ *invoicing* shares are

- But not necessarily true that export prices are **sticky** in the invoicing currency

  Gopinath and Rigobon (2008); Fitzgerald and Haller (2014); Friberg and Wilander (2008)

- Make the assumption

  *Exports are invoiced in the currency in which they are sticky*

- DCP hypothesis and testable prediction modify to

  *Non-US trade subject to partial DCP ∧ prices sticky in the invoicing currency*

  ↓

  *Output spillovers from US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials*

- What about the null hypothesis $H_0$?
Bringing the prediction of partial DCP to the data

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- DCP hypothesis and testable prediction modify to
  
  \[ \text{Non-US trade subject to partial DCP} \land \text{prices sticky in the invoicing currency} \]
  \[ \Downarrow \]
  \[ \text{Output spillovers from US$ appreciation are negatively correlated} \]
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- What about the null hypothesis \( H_0 \)?
Bringing the prediction of partial DCP to the data

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- Make the assumption

  *Exports are invoiced in the currency in which they are sticky*.

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  \[ \text{Non-US trade subject to partial DCP} \land \text{prices sticky in the invoicing currency} \]

  \[ \Downarrow \]

  *Output spillovers from US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials*.

- What about the null hypothesis $H_0$?
Bringing the prediction of partial DCP to the data

- DC *pricing* shares are not observed, only US$ *invoicing* shares are.

- But not necessarily true that export prices are **sticky** in the invoicing currency. Gopinath and Rigobon (2008); Fitzgerald and Haller (2014); Friberg and Wilander (2008).

- Make the assumption
  
  *Exports are invoiced in the currency in which they are sticky*.

- DCP hypothesis and testable prediction modify to

  \[ \text{Non-US trade subject to partial DCP} \land \text{prices sticky in the invoicing currency} \]

  \[ \Downarrow \]

  *Output spillovers from US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials*.

- What about the null hypothesis \( H_0 \)?
Effects of a positive US demand shock with partial PCP/LCP

GDP EMEs

Export Price
RoW to EMEs in EME currency

GDP RoW

Export Price
EMEs to RoW in RoW currency

Symmetric X-M LCP shares ($\Delta^{LCP}_E = 0$) - $\Delta^{LCP}_E > 0$ - $\Delta^{LCP}_E < 0$

FX responses
Summary of the predictions from the model

- **DCP hypothesis:**
  
  *Non-US trade subject to partial DCP ∧ prices sticky in the invoicing currency*  
  ↓
  
  *Output spillovers from US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials*

- **Null hypothesis:**
  
  *Non-US trade subject to partial PCP/LCP ∨ invoicing unrelated to pricing currency*  
  ↓
  
  *Output spillovers from US$ appreciation are uncorrelated with economies’ export/import US$ invoicing share differentials*
Summary of the predictions from the model

- **DCP hypothesis:**
  
  \[\text{Non-US trade subject to partial DCP } \land \text{ prices sticky in the invoicing currency}\]

  \[\Downarrow\]

  Output spillovers from US$ appreciation are \textit{negatively correlated} with economies’ export/import US$ invoicing share differentials

- **Null hypothesis:**

  \[\text{Non-US trade subject to partial PCP/LCP } \lor \text{ invoicing unrelated to pricing currency}\]

  \[\Downarrow\]

  Output spillovers from US$ appreciation are \textit{uncorrelated} with economies’ export/import US$ invoicing share differentials
Model predictions *qualitatively* robust

- Trade in intermediate inputs, capital, sticky wages, financial frictions
- Variation of parametrisation in Monte Carlo
- Features proposed in the literature explaining variation in ERPT
  - Strategic complementarities in price setting
  - Local distributors
  - Non-tradable goods
1 A three-country DSGE model with PCP, LCP and DCP
   - Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2 Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3 Summary and discussion
A three-country DSGE model with PCP, LCP and DCP
  - Model structure
  - Pure PCP, LCP and DCP
  - Partial DCP

Empirical analysis
  - Baseline
  - Extensions
  - Robustness

Summary and discussion
Estimation of spillovers from US demand shocks

- Two-country VAR models

\[ x_t = A(L)x_{t-1} + P\epsilon_t, \quad x_t \equiv (x'_{us,t}, s^usd_t, x'_{it})', \quad x_{jt} \equiv (y_{jt}, \pi_{jt}, i_{jt})', \quad j \in \{us, i\} \]  \hspace{1cm} (2)

- Estimated for up to 45 AEs and EMEs for 1995q1 to 2018q3

- BVAR estimation using BEAR toolbox, uninformative priors

- Identify US demand, monetary policy, supply and UIP shocks using sign restrictions

<table>
<thead>
<tr>
<th></th>
<th>( y_{us,t} )</th>
<th>( \pi_{us,t} )</th>
<th>( i_{us,t} )</th>
<th>( s^usd_t )</th>
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<tr>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>US monetary policy shock</td>
<td>$-$</td>
<td>$-$</td>
<td>+</td>
<td>+</td>
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<tr>
<td>US cost-push shock</td>
<td>$-$</td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td>UIP/global risk shock</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>$-$</td>
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</table>
Country sample, baseline $N = 41$

<table>
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<tr>
<th>Region</th>
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<td>AUS, AUT, BEL, CAN, CHE, CYP, DEU, DNK, ESP, FIN, FRA, GBR, ISL, IRL, ITA, JPN, LUX, NLD, NOR, PRT, SWE</td>
</tr>
<tr>
<td>EM Europe</td>
<td>BGR, CZE, EST, HRV, HUN, LTU, LVA, POL, ROU, SVK, SVN, UKR</td>
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<td>EM Asia</td>
<td>IDN, IND, KOR, PAK, THA</td>
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<td>EM Latin America</td>
<td>ARG, COL, BRA</td>
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<tr>
<td>EM Middle East and Africa</td>
<td>DZA, ISR, MAR, TUR</td>
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</table>
Estimates of the output spillovers from a positive US demand shock

Two-year averages of estimates of output spillovers from a positive US demand shock
Recall the predictions from DCP in the structural model

- DCP hypothesis:

  \[
  \text{Non-US trade subject to partial DCP} \land \text{prices sticky in the invoicing currency} \quad \downarrow \\
  \text{Output spillovers from US$ appreciation are} \\
  \text{negatively correlated} \\
  \text{with economies’ export/import US$ invoicing share differentials}
  \]

- Null hypothesis:

  \[
  \text{Non-US trade subject to partial PCP/LCP} \lor \text{invoicing unrelated to pricing currency} \quad \downarrow \\
  \text{Output spillovers from US$ appreciation are} \\
  \text{uncorrelated} \\
  \text{with economies’ export/import US$ invoicing share differentials}
  \]
Recall the predictions from DCP in the structural model

- **DCP hypothesis:**
  \[
  \text{Non-US trade subject to partial DCP} \land \text{prices sticky in the invoicing currency} \implies \text{Output spillovers from US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials}
  \]

- **Null hypothesis:**
  \[
  \text{Non-US trade subject to partial PCP/LCP} \lor \text{invoicing unrelated to pricing currency} \implies \text{Output spillovers from US$ appreciation are uncorrelated with economies’ export/import US$ invoicing share differentials}
  \]
Non-US trade US$ invoicing share differential

Note: Data from Gopinath (2015), ECB, Ito et al. (2016) for JPN, Devereux et al. (2017) for CAN, and Lafarguette and Mehl (2018) for MAR.
Empirical analysis

Baseline

Relationship between US$ invoicing share differentials and spillovers

Box plots
Relationship between US$ invoicing share differentials and spillovers
Empirical analysis

Baseline

Relationship between US$ invoicing share differentials and spillovers

- Of course we need to consider additional controls, as economies
  - are not equally exposed to bilateral demand effects from US
  - are differentially open to trade multilaterally
  - do not all feature flexible exchange rates

- Run regressions

  \[ \Delta \hat{y}_i = \alpha + \beta \cdot \Delta_{i,\text{nonus}}^{US} + \gamma' z_i + \eta_i, \quad (3) \]

  where \( \Delta \hat{y}_i \) is the average output spillover over the first two years

- \( \eta_i \) captures differences in spillovers that stem from other structural differences of economies (substitution elasticities, price stickiness,..)
Empirical analysis

Relationship between US$ invoicing share differentials and spillovers

- Of course we need to consider additional controls, as economies
  - are not equally exposed to bilateral demand effects from US
  - are differentially open to trade multilaterally
  - do not all feature flexible exchange rates

- Run regressions

\[ \Delta \hat{y}_i = \alpha + \beta \cdot \Delta_{i,\text{nonus}} + \gamma' z_i + \eta_i, \]  

where \( \Delta \hat{y}_i \) is the average output spillover over the first two years

- \( \eta_i \) captures differences in spillovers that stem from other structural differences of economies (substitution elasticities, price stickiness,..)

Data plots for control variables
Relationship between US$ invoicing share differentials and spillovers

- Of course we need to consider additional controls, as economies
  - are not equally exposed to bilateral demand effects from US
  - are differentially open to trade multilaterally
  - do not all feature flexible exchange rates

- Run regressions

\[ \Delta \hat{y}_i = \alpha + \beta \cdot \Delta US^\$,nonus + \gamma'z_i + \eta_i, \]  

where \( \Delta \hat{y}_i \) is the average output spillover over the first two years

- \( \eta_i \) captures differences in spillovers that stem from other structural differences of economies (substitution elasticities, price stickiness,..)
## Baseline regression results

<table>
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<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-US trade rel. to GDP</td>
<td>0.001</td>
<td>0.001*</td>
<td>0.210*</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.09)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Trade with US rel. to GDP</td>
<td>0.004**</td>
<td>0.004**</td>
<td>0.228**</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Exchange rate flexibility against USD</td>
<td>0.114**</td>
<td>0.128***</td>
<td>0.530***</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Non-US exports USD invoicing share</td>
<td>-0.004***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-US imports USD invoicing share</td>
<td>0.004**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
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<tr>
<td>Non-US X/M USD invoicing share differential</td>
<td>-0.004***</td>
<td>-0.303***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.52</td>
<td>0.53</td>
<td>0.53</td>
</tr>
<tr>
<td>Observations</td>
<td>41</td>
<td>41</td>
<td>41</td>
</tr>
</tbody>
</table>

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Unconditional and conditional scatterplots
A three-country DSGE model with PCP, LCP and DCP
- Model structure
- Pure PCP, LCP and DCP
- Partial DCP

Empirical analysis
- Baseline
- Extensions
- Robustness

Summary and discussion
Extensions

- Can test for the empirical relevance of DCP using spillovers from all shocks that appreciate US$ multilaterally, including US monetary policy and UIP shocks.

- A large share of US$ invoicing relates to commodity trade, but commodity prices are typically believed to not be sticky in US$; is there DCP beyond commodity trade?

- Consider spillovers from euro area demand shock and EUR invoicing as placebo test.
US monetary policy shock spillovers under partial DCP

GDP EMEs

GDP RoW

Export Price
RoW to EMEs in EME currency

Export Price
EMEs to RoW in RoW currency

- Symmetric X-M DCP shares (Δ_E = 0) - Δ_E > 0 - Δ_E < 0
UIP shock spillovers under partial DCP

GDP EMEs

Export Price
RoW to EMEs in EME currency

GDP RoW

Export Price
EMEs to RoW in RoW currency

Symmetric X-M DCP shares ($\Delta_E = 0$) - $\Delta_E > 0$ - $\Delta_E < 0$
### US monetary policy and UIP shock spillovers

<table>
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<th>Monetary policy</th>
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<th>UIP</th>
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<td>(1) SRs</td>
<td>(2) IV</td>
<td>(3) SRs</td>
<td>(4) IV</td>
<td>(5) SRs</td>
<td>(6) IV</td>
</tr>
<tr>
<td>Non-US trade rel. to GDP</td>
<td>0.001*</td>
<td>0.003*</td>
<td>0.000</td>
<td>0.001</td>
<td>0.003***</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.09)</td>
<td>(0.08)</td>
<td>(0.59)</td>
<td>(0.17)</td>
<td>(0.00)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Trade with US rel. to GDP</td>
<td>0.004**</td>
<td>-0.002</td>
<td>-0.004</td>
<td>-0.005***</td>
<td>-0.004</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.69)</td>
<td>(0.13)</td>
<td>(0.00)</td>
<td>(0.11)</td>
<td>(0.60)</td>
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<tr>
<td>Exchange rate flexibility against USD</td>
<td>0.128***</td>
<td>0.181*</td>
<td>-0.059</td>
<td>-0.047</td>
<td>-0.112*</td>
<td>0.329***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.08)</td>
<td>(0.46)</td>
<td>(0.20)</td>
<td>(0.06)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Non-US X/M USD invoicing share differential</td>
<td>-0.004***</td>
<td>-0.012**</td>
<td>-0.003*</td>
<td>-0.003***</td>
<td>-0.002</td>
<td>-0.011***</td>
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<tr>
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<td>(0.00)</td>
<td>(0.02)</td>
<td>(0.10)</td>
<td>(0.01)</td>
<td>(0.11)</td>
<td>(0.00)</td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.53</td>
<td>0.26</td>
<td>-0.01</td>
<td>0.17</td>
<td>0.21</td>
<td>0.39</td>
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<td>Observations</td>
<td>41</td>
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</tbody>
</table>

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Extensions

- Can test for the empirical relevance of DCP using spillovers from all shocks that appreciate US$ multilaterally, including US monetary policy and UIP shocks.

- A large share of US$ invoicing relates to commodity trade, but commodity prices are typically believed to not be sticky in US$; is there DCP beyond commodity trade?

- Consider spillovers from euro area demand shock and EUR invoicing as placebo test.
### Controlling for the importance of commodity trade

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>WDI</th>
<th>Boz et al.</th>
<th>Rauch</th>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>Non-US trade rel. to GDP</td>
<td>0.001*</td>
<td>0.001**</td>
<td>0.001*</td>
<td>0.001*</td>
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<tr>
<td></td>
<td>(0.09)</td>
<td>(0.05)</td>
<td>(0.06)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Trade with US rel. to GDP</td>
<td>0.004**</td>
<td>0.004*</td>
<td>0.004</td>
<td>0.004*</td>
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<tr>
<td></td>
<td>(0.03)</td>
<td>(0.09)</td>
<td>(0.14)</td>
<td>(0.08)</td>
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<tr>
<td>Exchange rate flexibility against USD</td>
<td>0.128***</td>
<td>0.132***</td>
<td>0.118***</td>
<td>0.136***</td>
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<td>(0.00)</td>
<td>(0.00)</td>
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<td>(0.00)</td>
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<tr>
<td>Non-US X/M USD invoicing share differential</td>
<td>-0.004***</td>
<td>-0.006***</td>
<td>-0.005**</td>
<td>-0.004**</td>
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<td></td>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
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<tr>
<td>Share of commodity in total exports</td>
<td>0.002</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.19)</td>
<td>(0.90)</td>
<td>(0.73)</td>
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<td>Share of commodity in total imports</td>
<td>0.002</td>
<td>0.002</td>
<td>-0.000</td>
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<td></td>
<td>(0.46)</td>
<td>(0.55)</td>
<td>(0.89)</td>
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<td>Commodity export/import share differential</td>
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<td>0.001</td>
<td>-0.000</td>
<td>0.001</td>
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<td>(0.36)</td>
<td>(0.87)</td>
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<td>Adjusted R-squared</td>
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<td>0.53</td>
<td>0.53</td>
<td>0.52</td>
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<td>Observations</td>
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Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Controlling for the importance of commodity trade
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- Can test for the empirical relevance of DCP using spillovers from all shocks that appreciate US$ multilaterally, including US monetary policy and UIP shocks.

- A large share of US$ invoicing relates to commodity trade, but commodity prices are typically believed to not be sticky in US$; is there DCP beyond commodity trade?

- Consider spillovers from euro area demand shock and EUR invoicing as placebo test.
EUR DCP as placebo test

Expect much weaker evidence for DCP for the case of the EUR, as

- EUR not used remotely as much as the US dollar in third-country trade
- Do not expect DCP effects in response to shocks that appreciate the EUR
Trade with the euro area/US and EUR/US$ invoicing
Estimated output spillovers from a positive EA demand shock

Two-year averages of estimates of output spillovers from a positive EA demand shock
EUR DCP as placebo test

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Only Europe†</th>
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<tbody>
<tr>
<td></td>
<td>(1)</td>
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<td>Non-EA trade rel. to GDP</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.80)</td>
<td>(0.83)</td>
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<td>Trade with EA rel. to GDP</td>
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<td></td>
<td>(0.28)</td>
<td>(0.15)</td>
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<tr>
<td>Exchange rate flexibility against EUR</td>
<td>0.192</td>
<td>0.178**</td>
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<td>(0.10)</td>
<td>(0.05)</td>
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<tr>
<td>Exports EUR invoicing share</td>
<td>-0.013</td>
<td>-0.001</td>
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<tr>
<td></td>
<td>(0.22)</td>
<td>(0.90)</td>
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<td>Imports EUR invoicing share</td>
<td>0.015</td>
<td>0.010</td>
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<td></td>
<td>(0.22)</td>
<td>(0.39)</td>
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<tr>
<td>X/M EUR invoicing share differential</td>
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<td>-0.013</td>
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<td></td>
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<td>(0.21)</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.03</td>
<td>0.08</td>
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<tr>
<td>Observations</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Robust standard errors.

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   - Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2 Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3 Summary and discussion
Robustness

- **Alternative country samples**
  - Drop individual or groups of economies (FIN/HRV, AUS/NOR, financial centers)
  - Add economies with interpolated data, small economies (<1 million population)

- **Alternative VAR specifications**
  - Minnesota priors, 8/5-variable VAR, impact dummies, SOE assumption
  - Sample period 1995-2007
  - Average IRFs over one/three/four years, panel with all horizons

- **Alternative regression specifications**
  - Controlling for financial spillover channels
  - Inference based on bootstrap
## Alternative country samples

<table>
<thead>
<tr>
<th></th>
<th>(1) Baseline</th>
<th>(2) -FIN/HRV</th>
<th>(3) -AUS/NOR</th>
<th>(4) -(2) and (3)</th>
<th>(5) -Fin. centers</th>
<th>(6) Small N</th>
<th>(7) Large N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-US trade rel. to GDP</td>
<td>0.001**</td>
<td>0.001**</td>
<td>0.001**</td>
<td>0.001**</td>
<td>0.001</td>
<td>0.001*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.05)</td>
<td>(0.04)</td>
<td>(0.03)</td>
<td>(0.14)</td>
<td>(0.05)</td>
<td>(0.54)</td>
</tr>
<tr>
<td>Trade with US rel. to GDP</td>
<td>0.004**</td>
<td>0.005**</td>
<td>0.004*</td>
<td>0.005**</td>
<td>0.003</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.01)</td>
<td>(0.07)</td>
<td>(0.03)</td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.48)</td>
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<tr>
<td>Exchange rate flexibility against USD</td>
<td>0.128***</td>
<td>0.120***</td>
<td>0.104***</td>
<td>0.102**</td>
<td>0.127***</td>
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<td>Non-US X/M USD invoicing share differential</td>
<td>-0.004***</td>
<td>-0.003***</td>
<td>-0.007***</td>
<td>-0.006**</td>
<td>-0.005***</td>
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Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Robustness

- Alternative country samples
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  - Controlling for financial spillover channels
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### Alternative VAR specifications

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<td>0.001**</td>
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<td>0.001*</td>
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<td>0.112***</td>
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<td>-0.003***</td>
<td>-0.004***</td>
<td>-0.004**</td>
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Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
## Alternative IRF definitions

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<td>Trade with US rel. to GDP</td>
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<td>0.005**</td>
<td>0.005*</td>
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<td>Non-US X/M USD invoicing share differential</td>
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<td>-0.003***</td>
<td>-0.005***</td>
<td>-0.005**</td>
<td>-0.004**</td>
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Robust standard errors. Panel regression includes horizon dummies and Driscoll-Kraay robust standard errors.

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## Controlling for heterogeneous exposure to financial spillovers

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<td>0.001</td>
<td>0.001*</td>
<td>0.000</td>
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<td>0.002</td>
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<td>0.095***</td>
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<td>-0.005***</td>
<td>-0.005***</td>
<td>-0.005***</td>
<td>-0.006***</td>
<td>-0.005***</td>
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<td>USD foreign liabilities/GDP</td>
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<td>0.006**</td>
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<td>Share of USD foreign liabilities</td>
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Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Inference based on bootstrap

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<td>Adjusted R-squared</td>
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1 A three-country DSGE model with PCP, LCP and DCP
   - Model structure
   - Pure PCP, LCP and DCP
   - Partial DCP

2 Empirical analysis
   - Baseline
   - Extensions
   - Robustness

3 Summary and discussion
Summary

- Provide new evidence on the importance of DCP in global trade

- Derive theoretical prediction regarding the role of DCP for spillovers from US shocks from a three-country NK DSGE model:
  
  *If partial DCP is empirically relevant, spillovers from multilateral US$ appreciation are negatively correlated with economies’ export/import US$ invoicing share differentials*

- Confront this prediction with the data
  - Estimate US shock spillovers from two-country VARs for up to 45 economies
  - Regress spillover estimates on export/import US$ invoicing share differentials

- Export/import US$ invoicing share differential indeed negatively correlated with spillovers from US shocks that appreciate the US$
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A three-country DSGE model with PCP, LCP and DCP

- Model structure
- Pure PCP, LCP and DCP
- Partial DCP

Empirical analysis

- Baseline
- Extensions
- Robustness

Summary and discussion
## Parametrisation

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<td>$\psi_f$</td>
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<td>Calvo probability for prices</td>
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<td>Demand Shock persistence</td>
<td>$\rho^\beta$</td>
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<td>Disutility of labour</td>
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<td>Central bank inflation sensitivity</td>
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<td>Sensitivity of foreign interest rates to NFA</td>
<td>$\mu$</td>
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Robustness of prediction to trade in intermediate production inputs

GDP EMEs

Export Price
US to EMEs in EME currency

Export Price
RoW to EMEs in EME currency

GDP RoW

Export Price
US to RoW in RoW currency

Export Price
EMEs to RoW in RoW currency

GDP US

Export Price
EMEs to US in $

Export Price
RoW to US in $

- Symmetric X-M DCP shares ($\Delta_E = 0$) - $\Delta_E > 0$ - $\Delta_E < 0$
Robustness of prediction to sticky wages, capital, financial frictions
Robustness of prediction to alternative parameterisations

- Draw parameter values from uniform distribution spanning range of values considered in the literature

- Calculate difference between EME impact spillover for $\Delta E > 0$ and $\Delta E < 0$

- Repeat for $R = 1000$ replications and plot distribution of difference

Parameters considered

- Intertemporal elasticity of substitution $\sigma_c \in [0.5, 4]$
- Demand elasticity for domestic and foreign final goods $\psi_f \in [0.75, 4]$
- Demand elasticity for differentiated intermediates $\psi_i \in [1.1, 3]$
- Calvo parameters for price stickiness $\theta_p \in [0.65, 0.85]$
Spillover differential across Monte Carlo replications

Difference in EME real GDP impact response for $\Delta E > 0$ and $\Delta E < 0$
Appendix 79/73

Estimates of the output spillovers from a positive US demand shock

Baseline sample (57% of non-US world GDP)

Maximum Sample (82% of non-US world GDP)

(incl. CHN, DZA, ISL, LUX, MEX, MLT, MYS, NZL, PAK, PER, RUS, ZAF)
US$ invoicing

![Export US$ invoicing share](image)

![Import US$ invoicing share](image)

Note: Data for euro area economies includes intra-euro area trade.
Obtaining non-US invoicing share differentials

\[
\Delta_{i, nonus}^{us} \triangleq \frac{X_{i, nonus}^{us} - M_{i, nonus}^{us}}{X_{i, nonus}^{us} - M_{i, nonus}^{us}} = \frac{X_{i, nonus}^{us} - X_{i, us}^{us}}{X_{i, nonus}^{us} - M_{i, us}^{us}} = \frac{X_{i, nonus}^{us} - X_{i, us}^{us}}{M_{i, nonus}^{us} - M_{i, us}^{us}}
\]

\[
= \left( \delta_i^{x,us} - \delta_i^{x,us} \cdot s_i^{x,us} \right) \cdot 1 \frac{1}{1 - s_i^{x,us}} - \left( \delta_i^{m,us} - \delta_i^{m,us} \cdot s_i^{m,us} \right) \cdot 1 \frac{1}{1 - s_i^{m,us}}
\]

(4)

where
- \(\delta_i^{\ell,us}\) are taken from Gopinath (2015) and the ECB
- \(\delta_i^{\ell,us}\) from Gopinath et al. (2010) if available and otherwise assumed to be unity
- \(s_i^{\ell,us}\) from the IMF DoTS
Some words of caution on trade invoicing data

- Trade invoicing data in general patchy
- Data put together in a sequence of papers by different authors
- Data in general not consistent across countries
  - Goods and services trade
  - Time periods covered
  - Customs data or surveys
- For US: Assumption that all trade with US is invoiced in US$ problematic for some economies (bilateral US invoicing shares based on confidential BLS data only reported for a few countries in Gopinath et al. (2010))
- For euro area: Assumption that all intra-euro area is invoiced in EUR is unlikely to be accurate
Relationship between US$ invoicing share differentials and spillovers
Data plots for control variables

Non-US trade/GDP

Trade with US/GDP

Exchange rate flexibility

Trading-partner exchange rate flexibility
Descriptive statistics

<table>
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<tr>
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<td>Two-year real GDP response</td>
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<td>Non-US trade rel. to GDP</td>
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<td>Exchange rate flexibility against USD</td>
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Baseline regression results for AEs and EMEs

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<th>(1) Baseline</th>
<th>(2) EMEs</th>
<th>(3) AEs</th>
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<tbody>
<tr>
<td>Non-US trade rel. to GDP</td>
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<td>(0.60)</td>
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<td>-0.001</td>
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<td>Adjusted R-squared</td>
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<td>Observations</td>
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Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Baseline regression results for AEs and EMEs
## US monetary policy shock spillovers

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<td>-0.004</td>
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<td>Non-US exports USD invoicing share</td>
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<tr>
<td>Non-US imports USD invoicing share</td>
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<td>0.001**</td>
<td>0.000***</td>
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<td></td>
<td>(0.70)</td>
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<td></td>
<td>(0.10)</td>
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<tr>
<td>Adjusted R-squared</td>
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</table>

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Unconditional and conditional scatterplots

Two-year real GDP response vs. X/M EUR invoicing share differential.


