The Real Exchange Rate, Innovation and Productivity: Heterogeneity, Asymmetries and Hysteresis

Laura Alfaro (HBS and NBER) Alejandro Cuñat (Vienna and CESifo) Harald Fadinger (Mannheim and CEPR) Yanping Liu (Mannheim)

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Motivation

- Aftermath of Global Financial Crisis: renewed the debate of the effects of real exchange rate (RER) movements.
  - Massive inflows to emerging markets (quantitative easing): policymakers from emerging markets concerned about loss of competitiveness.
  - Rich countries: recent concerns about appreciated exchange rates and their impact on manufacturing.
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- Revived interest in different policies:
  - Macro: reserve accumulation and capital controls to limit exchange rate appreciations (Alfaro, Chari, Kanczuk, 2015).
  - Micro: production and export subsidies, tariffs/industrial policy; exchange rates (RER)
Motivation: RER Effects

- Effects of RER depreciation/appreciation far from clear, evidence inconclusive.
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- An extensive empirical literature has focused on characterizing the aggregate effects of RER depreciation (Rodrik, 2008 and references therein).
  - No consensus on the channels: externalities from specialization in tradables/exports, larger aggregate savings…; other effects.
  - Empirical issues: omitted variables, reverse causality, etc. (Woodford, 2008, Henry, 2008).
- Firm-level studies mixed evidence.
- Industrialized countries: muted impact RER depreciations (Berman et al., 2012; Amiti et al., 2014).
- Emerging countries (data constraints): productivity gains associated to imports (Halpern et al., 2015; Gopinath and Neiman, 2014).
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What We do

- We investigate the effects of RER movements on firm productivity, export and import decisions, and innovation
  - Compilation of cross-country firm-level data
- Explore a number of mechanisms and their implications by structurally estimating a dynamic model of R&D choice, exporting and importing.
  - Counterfactuals
What We do: Micro-Level Evidence

- We investigate the effects of RER movements on firm productivity, export and import decisions, and innovation, exploiting cross-country firm-level data.
  - Comprehensive compilation of firm-level data: economic activity, trade status, R&D, currency denomination of debt, etc. (manufacturing sector).
  - Years 2001-2010, ≈ 70 dev. + 23 indust. countries, ≈ 500,000 firms.
    - Administrative Plant-Level Data (Colombia, France, China, Hungary).
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We document empirical evidence on the heterogeneous effects of RER movements on average manufacturing-firm-level outcomes across three regions:

- Emerging Asia, Other Developing (Latin America, Eastern Europe), Industrialized.
Stylized Fact: Regional Heterogeneity in Export and Import Orientation

Emerging Asia firms are relatively more export to import oriented than firms from other emerging countries; industrial-country firms are relatively more balanced.

Table: Import and Export Propensity/Intensity (to Sales) of Manufacturing plants (Computed from census micro data)

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Colombia</th>
<th>Hungary</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export prob.</td>
<td>0.26</td>
<td>0.37</td>
<td>0.35</td>
<td>0.23</td>
</tr>
<tr>
<td>Import prob.</td>
<td>0.17</td>
<td>0.45</td>
<td>0.39</td>
<td>0.20</td>
</tr>
<tr>
<td>Relative export prob.</td>
<td>1.53</td>
<td>0.82</td>
<td>0.90</td>
<td>1.15</td>
</tr>
<tr>
<td>Avg. export intensity (exporters)</td>
<td>0.6</td>
<td>0.10</td>
<td>0.10</td>
<td>0.23</td>
</tr>
<tr>
<td>Avg. import intensity (importers)</td>
<td>0.13</td>
<td>0.14</td>
<td>0.24</td>
<td>0.14</td>
</tr>
<tr>
<td>Relative export intensity</td>
<td>4.62</td>
<td>0.71</td>
<td>0.42</td>
<td>1.64</td>
</tr>
</tbody>
</table>

Similar evidence by region: D&B and World Bank’s Enterprise Survey (no industr.).
Finding: Regional Heterogeneity

- Firm-level Revenue-based Productivity (TFPR) growth and the RER growth rate
  - Positively correlated in Emerging Asia;
  - Negatively correlated in Other Emerging Markets;
  - Uncorrelated in Industrialized Economies.

Figure: I. RER and Firm-level TFPR Growth: 2001-2010
(Binned Scatter Plots; Country-sector, Year FE and Business Cycle Controls)
Finding: Exporters and Importers

- Firm-level revenue-based productivity (TFPR) growth and the RER growth rate:
  - Positively correlated for exporters; negatively correlated for importers.

Figure: IIa. RER and Firm-level TFPR Growth by Trade Status: 2001-2010
(Binned Scatter Plots; Country-sector-time FE, Trade and MNC Status)

Figure: IIb. RER and Firm-level Changes in R&D probability: 2001-2010
(Binned Scatter Plots; Country-sector-time FE, Trade and MNC Status)
Finding: R&D and Financial Constraints

- Firm-level R&D probability and cash flow are positively correlated;
- Effect stronger for exporters; in emerging markets than in industrialized economies;

Figure: RER and Firm-level Cash flow: 2001-2010 (Binned Scatter Plots)
Micro-Level Evidence: Overview Findings

- Heterogeneous effects of RER movements on average manufacturing firm-level outcomes across three regions.
  - Emerging Asia, RER depreciations associated with:
    1. Faster firm-level TFP (revenue-based), sales and cash flow growth;
    2. Higher probability to engage in R&D and export.
    3. The positive effects on outcomes are concentrated on exporting firms.
    4. Firms importing intermediates are negatively affected.
  - On average negative effects for firms located in other emerging economies (Latin America, Eastern Europe).
    - Most import intensive; foreign currency debt.
  - No significant effects for manufacturing firms in industrialized countries.
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...the existing manufacturing sector generally takes a dim view of exchange rate devaluations and fears such policy (Díaz Alejandro, 1965).
Microeconomic channels through which the RER effects come through.

- Changes in productivity are not the result of externalities but of firms’ deliberate decisions.
  - Exploit structural differences in export and import orientation and financial development across regions.
What We Do: Model-Mechanisms

- **Microeconomic channels** through which the RER effects come through.
  - Changes in productivity are not the result of externalities but of firms’ deliberate decisions.
  - Exploit structural differences in export and import orientation and financial development across regions.
- We structurally estimate a dynamic firm-level model of exporting, importing and R&D investment featuring:
  1. Imported intermediate goods
  2. R&D investment subject to financial constraints.
  3. Market-size effects: cash flow
Microeconomic channels through which the RER effects come through.

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Decompose average TFPR effects: persistent physical productivity effects due to innovation, demand effects, firm-level imports; market-size effect and financial constraint.
Conduct counterfactual simulations of temporary depreciations and appreciations.
What We Do: Simulation

- Conduct counterfactual simulations of temporary depreciations and appreciations.
  - Temporary RER movements can have **persistent** (positive or negative) effects on TFP growth through innovation.
  - **Non-linear** effects.
  - Depreciations/appreciations **asymmetric** effects.
    - Export and import orientations; substitution between domestic and intermediate inputs.
    - Option value of engaging in R&D, hysteresis due to sunk costs; credit constraints; (Baldwin, 1988; Baldwin and Krugman 1989).
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⇒ Firm-level responses aggregate into the **heterogeneous** average effects of real-exchange-rate fluctuations on R&D and productivity growth across regions.
Our analysis is silent on:

- How the RER appreciation/depreciation came about.
- Welfare analysis; Costs of reserve accumulation, inflation, financial repression, tensions/interactions among countries, service sector, etc. (Woodford, 2008; Henry, 2008).
Related Literature

- **Trade, Innovation, and productivity growth**
  - Exports, market size and innovation: Lileeva and Trefler, 2010 (Canada); Bustos, 2011 (Argentina); Aw et al, 2010 (Taiwan); Aghion et al. (France).
  - Imports and productivity: Halpern et al, 2015 (Hungary)
  - Sovereign default-productivity losses: Mendoza and Yue, 2012 (Mexico)

- **Effects of Exchange Rates**
  - Effects of RER movements on rich-country firms: Amiti et al, 2012 (Belgium); Berman et al, 2012 (France), Ekholm et al, 2012 (Norway); Fitzgerald and Haller, 2015 (Ireland)
  - Effects of large devaluations on emerging markets: Verhoogen, 2008 (Mexico); Gopinath and Neiman, 2014 (Argentina)

- **Financial Constraints**
  - Financial constraints and exports: Manova, 2013
  - Financial constraints exporting and R&D: Gorodnichenko and Schnitzer, 2013 (Eastern Europe)
  - Financial constraints and TFP: Midrigan and Xu, 2014 (S. Korea)
Outline

- Introduction
- Empirical Evidence: Stylized Facts
- Theoretical Model
- Estimation Strategy
- Estimation Results
- Counterfactual Experiments
- Robustness
**Sample: Manufacturing Firms**

- **Orbis** (Bureau Van Dijk): 2 CDs + web version
  - Firm-level data of listed and unlisted firms: sales, materials, capital stock, employees, cash flow, R&D expenditure.
  - Years 2001-2010, \( \approx 70 \) dev. + 23 indust. countries, \( \approx 500,000 \) firms.

- **Worldbase** (Dunn and Brad Street): plant-level export and import status, sales, employment for years 2000, 2005, 2007, 2009 (matched with Orbis);

- Detailed **administrative plant-level data**: Colombia, France, China, Hungary (export/import participation and intensities).

- Worldbank **exporter dynamics database**: entry and exit rates into/from exporting.

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**Other data:** Fraction of firms performing R&D: OECD innovation scoreboard.

**Other Controls:** real GDP growth (PWT 8.0), inflation (IMF GDP deflators)

**Robustness:** Currency composition of debt: World Bank Enterprise survey, Salomão and Valera (2007); IADB Firms' Balance Sheet project.
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- Potential *omitted variable bias* (positive aggregate supply (demand) shocks should positively (negatively) correlate with RER) ⇒ control for GDP growth, inflation.
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- **Strategy I:** Trade-weighted RERs:
  - Omitted variable bias: control for country-time fixed effects (aggregate shocks to manuf. sector); *country-sector-time FE*.
  - Endogeneity of trade-weighted RER: (i) pre-sample trade weights; (ii) each of the 163 manufacturing sectors: negligible weight in aggregate price level.
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- **Strategy II:** IV exploiting (i) exogenous fluctuations in world commodity prices interacted with (pre-sample) trade weights; (ii) world capital flows interacted with financial account openness.
Reduced-form evidence: RER and firm-level outcomes

\[ \Delta \log(Y_{it}) = \beta_0 + \sum_{r \in R} \beta_r \Delta \log(e_{ct}) l_r + \beta_2 X_{ct} + \delta_{sc} + \delta_t + u_{ict}, \]

- **Dependent variable (firm(i)-time(t)-level):**
  1. revenue-based TFP (TFPR) growth rate, from value added;
  2. revenue-based TFP growth rate, from gross output;
  3. sales growth rate;
  4. cash flow growth rate;
  5. change of an indicator variable for R&D (linear probability model.);
  6. growth rate of entry rate into exporting at the country-time level (new exporters/total exporters).

- **Aggregate RER varies at the country(c)-time(t) level.**
- **\(l_r\) dummy for country \(c\) belonging to region \(r\); \(\delta_{sc}\): sector-country fixed effect; \(\delta_t\): time fixed effect; vector \(X_{ct}\): business-cycle controls (real GDP growth rate and the inflation rate).**
- **Cluster standard errors at the country level.**
### Changes in aggregate RER and firm-level outcomes

<table>
<thead>
<tr>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ log TFPR_{VA, it}</td>
<td>Δ log TFPR_{GO, it}</td>
<td>Δ log sales_{it}</td>
<td>Δ log c. f._{it}</td>
<td>Δ R&amp;D prob._{it}</td>
<td>Δ log export entry rate_{ct}</td>
</tr>
<tr>
<td>Δ log e_{ct} ×</td>
<td>0.239***</td>
<td>0.120***</td>
<td>-0.105**</td>
<td>-0.762***</td>
<td>-0.557</td>
<td>0.0196</td>
</tr>
<tr>
<td>emerging East Asia_{c}</td>
<td>(0.0895)</td>
<td>(0.0198)</td>
<td>(0.216)</td>
<td>(0.114)</td>
<td>(0.095)</td>
<td>(0.207)</td>
</tr>
<tr>
<td>Δ log e_{ct} ×</td>
<td>-0.546***</td>
<td>-0.105**</td>
<td>-0.762***</td>
<td>-0.557</td>
<td>0.16</td>
<td>0.063</td>
</tr>
<tr>
<td>other emerging_{c}</td>
<td>(0.185)</td>
<td>(0.0426)</td>
<td>(0.274)</td>
<td>(0.414)</td>
<td>(0.125)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>Δ log e_{ct} ×</td>
<td>0.0196</td>
<td>-0.031</td>
<td>-0.282</td>
<td>-0.319**</td>
<td>-0.168</td>
<td>-0.275</td>
</tr>
<tr>
<td>industrialized_{c}</td>
<td>(0.103)</td>
<td>(0.0309)</td>
<td>(0.217)</td>
<td>(0.126)</td>
<td>(0.149)</td>
<td>(0.274)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,333,986</td>
<td>1,333,986</td>
<td>1,275,606</td>
<td>772,970</td>
<td>148,367</td>
<td>392</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.057</td>
<td>0.038</td>
<td>0.103</td>
<td>0.024</td>
<td>0.016</td>
<td>0.107</td>
</tr>
<tr>
<td>Country-sector FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Time FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Business cycle</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

- Results are robust to:
  - trade-weighted RERs with country-time FE
  - excluding years of global financial crisis
  - 3-year changes (annualized)
  - IV estimates
### Import and Export Participation by region: World Enterprise Survey

<table>
<thead>
<tr>
<th></th>
<th>Emerging Asia</th>
<th>Other Emerging</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.33</td>
</tr>
<tr>
<td>Avg. export intensity</td>
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<td>Avg. import intensity</td>
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</tr>
</tbody>
</table>

**Table:** Import and export propensity/intensity of manufacturing plants from Worldbank’s 2016 Enterprise Survey. Emerging Asia is defined as developing East Asia and South Asia; other emerging economies are defined as Eastern Europe and Latin America.
Trade Status

\[
\Delta \log(Y_{ic,t}) = \beta_0 + \sum_{r \in R, T \in \text{exp, imp}} \beta_{Tr} \Delta \log(e_{c,t}) I_{T} I_{r} + \sum_{r \in R, T \in \text{exp, imp}} I_{T} I_{r} + \delta_{cst} + u_{ic,t}
\]

- Interact effect of RER with firm-level trade status (exporter, importer; multinational):
  - Include country-sector-time FE \((\delta_{cst})\).
- To avoid endogeneity of the trade status, we keep the firms’ trade status fixed over the sample period (equal to the trade status in the first period we observe it).
## Aggregate RER and Firm-Level Outcomes

**Table: Aggregate RER and firm-level outcomes by firm’s trade status**

<table>
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<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \log e_{ct} \times ) emerging Asia ( _c \times ) exporter ( _f )</td>
<td>0.197**</td>
<td>0.030</td>
<td>0.135***</td>
<td>0.243***</td>
<td>0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.075)</td>
<td>(0.019)</td>
<td>(0.036)</td>
<td>(0.035)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>( \Delta \log e_{ct} \times ) emerging Asia ( _c \times ) importer ( _f )</td>
<td>-0.157***</td>
<td>-0.016**</td>
<td>-0.099***</td>
<td>-0.123**</td>
<td>-0.101***</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.008)</td>
<td>(0.024)</td>
<td>(0.049)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>( \Delta \log e_{ct} \times ) emerging Asia ( _c \times ) multinational ( _f )</td>
<td>-0.005</td>
<td>0.019</td>
<td>-0.088***</td>
<td>-0.096</td>
<td>-0.049*</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.019)</td>
<td>(0.015)</td>
<td>(0.059)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>( \Delta \log e_{ct} \times ) other emerging ( _c \times ) exporter ( _f )</td>
<td>0.394**</td>
<td>0.087**</td>
<td>0.333***</td>
<td>1.162***</td>
<td>0.167***</td>
</tr>
<tr>
<td></td>
<td>(0.159)</td>
<td>(0.036)</td>
<td>(0.079)</td>
<td>(0.281)</td>
<td>(0.029)</td>
</tr>
<tr>
<td>( \Delta \log e_{ct} \times ) other emerging ( _c \times ) importer ( _f )</td>
<td>-0.251</td>
<td>-0.074</td>
<td>0.005</td>
<td>-0.803***</td>
<td>-0.119</td>
</tr>
<tr>
<td></td>
<td>(0.177)</td>
<td>(0.046)</td>
<td>(0.102)</td>
<td>(0.203)</td>
<td>(0.072)</td>
</tr>
<tr>
<td>( \Delta \log e_{ct} \times ) other emerging ( _c \times ) multinational ( _f )</td>
<td>-0.027</td>
<td>-0.083**</td>
<td>0.382</td>
<td>0.502*</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>(0.127)</td>
<td>(0.040)</td>
<td>(0.248)</td>
<td>(0.292)</td>
<td>(0.024)</td>
</tr>
</tbody>
</table>

- **Observations**: 511,061 511,061 481,733 313,856 35,151
- **R-squared**: 0.094 0.076 0.16 0.063 0.116
- **Country-sector-time FE**: YES YES YES YES YES
- **Firm status controls**: YES YES YES YES YES
- **Cluster**: Country Country Country Country Country

- **Industrialized**: smaller/insignificant.
Financial constraints and R&D Decisions

\[ I_{RDit} = \beta_0 + \beta_1 \text{fin. dev.}_c + \beta_2 \log(c.f.)_it + \beta_3 \log(c.f.)_it \times \text{fin. dev.}_c + \beta_4 X_{ict} + \nu_{it}, \]

- \( I_{RDit} \): indicator that equals one if firm \( i \) performs R&D in year \( t \); \( \log(c.f.)_{it} \) is the firm’s cash flow (in logs); \( \text{fin. dev.}_c \) is a measure of country-level financial development (private credit/GDP).

- Controls: employment and capital stock (in logs), the inflation rate and the real growth rate of GDP.

- Depending on the specification, we include different fixed effects (country and sector, country-sector or firm).
### R&D, credit constraints and financial development

<table>
<thead>
<tr>
<th></th>
<th>(1) R&amp;D prob.(_{it})</th>
<th>(2) R&amp;D prob.(_{it})</th>
<th>(3) R&amp;D prob.(_{it})</th>
<th>(4) R&amp;D prob.(_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>financial development(_c)</td>
<td>0.589***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log(cash flow)(_{ft})</td>
<td>0.044***</td>
<td>0.04***</td>
<td>0.052***</td>
<td>0.015***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>log(cash flow)(_{ft}) × financial development(_c)</td>
<td>-0.028***</td>
<td>-0.028***</td>
<td>-0.032***</td>
<td>-0.004***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.250</td>
<td>0.338</td>
<td>0.375</td>
<td>0.790</td>
</tr>
<tr>
<td>Observations</td>
<td>117,403</td>
<td>117,394</td>
<td>117,142</td>
<td>108,826</td>
</tr>
</tbody>
</table>

- Time FE: YES
- Sector FE: NO
- Country FE: NO
- Sector-country FE: NO
- Firm FE: NO
- Cluster: Firm

Financial development is measured as log(cash flow) × financial development, with R-squared ranging from 0.250 to 0.790, and observations ranging from 117,142 to 108,826.
R&D Sensitivity, credit constraints and financial development

\[ l_{iRD,t} = \beta_0 \sum_{i=1}^{4} \beta_1 i \log(cashflow)_{i,t} \times size_i + \sum_{i=1}^{4} \beta_2 i \log(cashflow)_{i,t} \times size_i \times fin.dev.c + \beta_4 X_{iC,t} + \nu_{i,t}, \]

<table>
<thead>
<tr>
<th></th>
<th>(1) R&amp;D prob.(_{it})</th>
<th>(2) R&amp;D prob.(_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \log(cash \ flow)_{1f} \times )</td>
<td>0.015</td>
<td>0.008</td>
</tr>
<tr>
<td>size quartile 1(_f)</td>
<td>(0.019)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{2f} \times )</td>
<td>0.035**</td>
<td>0.018</td>
</tr>
<tr>
<td>size quartile 2(_f)</td>
<td>(0.0153)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{3f} \times )</td>
<td>0.052***</td>
<td>0.048***</td>
</tr>
<tr>
<td>size quartile 3(_f)</td>
<td>(0.005)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{4f} \times )</td>
<td>0.056***</td>
<td>0.059***</td>
</tr>
<tr>
<td>size quartile 4(_f)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{f} \times )</td>
<td>-0.0001</td>
<td>-0.0001</td>
</tr>
<tr>
<td>size quartile 1(_f) \times credit(_c)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{2f} \times )</td>
<td>-0.0002*</td>
<td>-0.0001</td>
</tr>
<tr>
<td>size quartile 2(_f) \times credit(_c)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{3f} \times )</td>
<td>-0.0002***</td>
<td>-0.0002***</td>
</tr>
<tr>
<td>size quartile 3(_f) \times credit(_c)</td>
<td>(0.00004)</td>
<td>(0.00004)</td>
</tr>
<tr>
<td>( \log(cash \ flow)_{4f} \times )</td>
<td>-0.0002***</td>
<td>-0.0002***</td>
</tr>
<tr>
<td>size quartile 4(_f) \times credit(_c)</td>
<td>(0.00002)</td>
<td>(0.00002)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor</th>
<th>YES</th>
<th>YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time/Firm FE/B.C.</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Sector FE</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Country FE</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Sector-country FE</td>
<td>NO</td>
<td>YES</td>
</tr>
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</table>
## Foreign Debt Shares by Region

<table>
<thead>
<tr>
<th></th>
<th>(1) foreign debt share</th>
<th>(2) foreign debt share</th>
</tr>
</thead>
<tbody>
<tr>
<td>emerging Asia$_c$</td>
<td>10.61*** (0.338)</td>
<td>4.820*** (0.462)</td>
</tr>
<tr>
<td>emerging Asia$_c$ × exporter$_f$</td>
<td>18.21*** (0.876)</td>
<td></td>
</tr>
<tr>
<td>emerging Asia$_c$ × importer$_f$</td>
<td>0.433 (0.626)</td>
<td></td>
</tr>
<tr>
<td>other emerging$_c$</td>
<td>19.09*** (0.386)</td>
<td>14.15*** (0.581)</td>
</tr>
<tr>
<td>other emerging$_c$ × exporter$_f$</td>
<td>24.90*** (1.073)</td>
<td></td>
</tr>
<tr>
<td>other emerging$_c$ × importer$_f$</td>
<td>-0.919 (0.759)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>14,554</td>
<td>14,554</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.201</td>
<td>0.271</td>
</tr>
<tr>
<td>Cluster</td>
<td>Firm</td>
<td>Firm</td>
</tr>
</tbody>
</table>
Summary of stylized facts

- Firms in emerging Asia: real depreciations are associated with faster revenue-based productivity growth, faster sales growth, faster growth of cash flow, higher probability to engage in R&D, and higher export entry rates.

- Other emerging markets (Latin America and Eastern Europe): real depreciations have a significantly negative effect on firm-level outcomes.

- Industrialized countries: real depreciations have no significant effects.

- Exporters: positively affected by real depreciations; firms importing intermediates: negatively impacted.

- Firms in emerging Asia: less likely to import, less import intensive, higher export intensity than firms in other regions. Firms in other emerging economies: most likely to import and most import intensive.

- Firms' R&D choice depends on the level of cash flow; the more so the less developed local financial markets are.

- Firms in other emerging economies are most exposed to foreign currency borrowing, followed by firms from emerging Asia.
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Model: Setup

- Small open economy: foreign variables exogenous.
- Focus on manufacturing sector.
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- Heterogeneous monopolistic firms producing a single variety of the manufacturing good, $Y_{it} = \exp(\omega_{it}) K_{it}^{\beta_k} L_{it}^{\beta_l} M_{it}^{\beta_m}$.
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- Firms choose whether to invest in R&D; affects their future productivity, \( \omega_{it} \).
- R&D: intangible investment, subject to sunk costs \( f_{RD,0} \) (in the period the firm starts innovating) and fixed costs \( f_{RD} \) (in other periods it innovates).
  - R&D cannot be used as collateral (borrowing constraints);
  - Only firms with operating profits larger than the sunk costs can finance R&D.
  - Firms can borrow at most \( \theta \) of current profits;
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  - R&D cannot be used as collateral (borrowing constraints);
  - Only firms with operating profits larger than the sunk costs can finance R&D.
  - Firms can borrow at most \( \theta \) of current profits;
- RER fluctuations change cash flow and affect thereby the behavior of firms, follow an AR(1) process; \( \log(e_t) = \gamma_0 + \gamma_1 \log(e_{t-1}) + \nu_t \).
Model: Setup (cont.)

- Consumers’ preferences over manufacturing varieties \( i \):

\[
D_{T,t} = \left( \int_{i \in \Omega_T} d_i^{\sigma-1} di + \int_{i \in \Omega_T^*} d_i^{\sigma-1} di \right)^{\frac{\sigma}{\sigma-1}},
\]

- \( \Omega_T \) and \( \Omega_T^* \): sets of domestically produced and imported varieties.
Model: Setup (cont.)

- Consumers’ preferences over manufacturing varieties $i$:
  \[
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  \]

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- Firms self-select into exporting their output and/or importing materials; per-period fixed costs $f_m$ and $f_x$, i.i.d. random draws.

[Note: The mathematical expressions and text have been reproduced accurately from the original document.]
Consumers’ preferences over manufacturing varieties $i$:

$$D_{T,t} = \left( \int_{i \in \Omega_T} d_{it}^{\sigma-1} \, di + \int_{i \in \Omega_T^*} d_{it}^{\sigma-1} \, di \right)^{\frac{\sigma}{\sigma-1}},$$

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Domestic ($X_{it}$) and imported ($X_{it}^*$) intermediates: imperfect substitutes, $\epsilon > 1$:

$$M_{it} = \left[ (B^* X_{it}^*)^{\frac{\epsilon}{\epsilon-1}} + X_{it}^{\frac{\epsilon}{\epsilon-1}} \right]^{\frac{\epsilon-1}{\epsilon}}$$

Firm importing inputs: $P_{Mt} = P_{Xt} \left[ 1 + \left( A e_t^{-1} \right)^{\frac{\epsilon-1}{1-\epsilon}} \right]^{\frac{1}{1-\epsilon}}$; $A \equiv B^* / P_{Xt}^*$: quality-adjusted relative cost of imported intermediates (RER, quality, and imperfect substitution).
Model: Setup (cont.)

- Consumers’ preferences over manufacturing varieties $i$:
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- Firm $i$ chooses one among four different “regimes”, which characterize the following per-period profit function:
  \[ \Pi_{it} = \max \left[ \Pi_{it}^{(x,m)} - f_x - f_m, \Pi_{it}^{(x,0)} - f_x, \Pi_{it}^{(0,m)} - f_m, \Pi_{it}^{(0,0)} \right] \]
R&D and Financial Constraints

- Innovation raises productivity, subject to sunk costs $f_{RD,0}$ (in the period the firm starts innovating) and fixed costs $f_{RD}$ (in other periods it innovates).
  - $\omega_{it} = \alpha_0 + \alpha_1 \omega_{it-1} + \alpha_2 l_{iRD,t-1} + u_{it}$;
  - $l_{iRD,t-1}$: indicator for innovation in $t-1$; $\alpha_2$: return to innovation.
Innovation raises productivity, subject to sunk costs $f_{RD,0}$ (in the period the firm starts innovating) and fixed costs $f_{RD}$ (in other periods it innovates).

- $\omega_{it} = \alpha_0 + \alpha_1 \omega_{it-1} + \alpha_2 I_{iRD,t-1} + u_{it}$;
- $I_{iRD,t-1}$: indicator for innovation in $t-1$; $\alpha_2$: return to innovation.

Financial constraint: in each period the innovation fixed/sunk cost has to be proportional to current profits.

$$I_{iRD,t} \left[ f_{RD,0} (1 - I_{iRD,t-1}) + f_{RD} I_{iRD,t-1} \right] \leq \theta \epsilon_{i,t} \Pi_{i,t} (\omega_{i,t}, e_t)$$

- $\theta \in [1, \bar{\theta}]$ quality of financial system; $\epsilon_{i,t}$ is an i.i.d. shock.
R&D and Financial Constraints

- Innovation raises productivity, subject to sunk costs $f_{RD,0}$ (in the period the firm starts innovating) and fixed costs $f_{RD}$ (in other periods it innovates).
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  - $I_{iRD,t-1}$: indicator for innovation in $t-1$; $\alpha_2$: return to innovation.

- Financial constraint: in each period the innovation fixed/sunk cost has to be proportional to current profits.
  \[ l_{iRD,t} [f_{RD,0} (1 - l_{iRD,t-1}) + f_{RD} l_{iRD,t-1}] \leq \theta \epsilon_{i,t} \Pi_{i,t} (\omega_{i,t}, e_t) \]
  - $\theta \in [1, \bar{\theta}]$ quality of financial system; $\epsilon_{i,t}$ is an i.i.d. shock.

- The firm chooses an infinite sequence of R&D decisions $l_{iRD,t}$ that maximizes the value function subject to the financial constraint for R&D.
  \[ V_{i,t} (s_{i,t}) = \max_{l_{iRD,t}} \left\{ \Pi_{i,t} (\omega_{i,t}, e_t) - [f_{RD,0} (1 - l_{iRD,t-1}) + f_{RD} l_{iRD,t-1}] + \beta E_t V_{i,t+1} (s_{i,t+1} | l_{iRD,t} = 1, s_{i,t}) \right\} \]
  - $\beta = (1 + r)^{-1}$
Summary: Timing Decisions

1. Observe $s_{i,t} = (\omega_{i,t}, e_t, l_{iRD,t-1})$.
2. Observe the realizations of $f_x$ and $f_m$.
3. Choose variables inputs $(M_{i,t}, L_{i,t}, K_{i,t})$, export status $l_{ix,t}$ and import status $l_{im,t}$.
4. Observe realization of cash-flow shock $\epsilon_{i,t}$ and R&D fixed costs $f_{RD,0}$, and $f_{RD}$.
5. Make R&D decision $l_{iRD,t}$. 
Construct revenue-based productivity as:

\[ tfpr_{it} \equiv r_{it} - \hat{\beta}_l l - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} = [\hat{\beta}_0 + \bar{\omega}_{it} + \bar{\epsilon}_{it} + \hat{\beta}_m \bar{a}_{it} - \hat{\beta}_m \log P_{Xst}] + g_{it} \left( D_{T,t}, D_{T,t}^*, e_t \right). \]

In the model \( \frac{\partial E(tfpr_{i,t})}{\partial \log e_t} \) can be decomposed as:

\[ \beta_1 \equiv \frac{\partial E(tfptr_{i,t})}{\partial \log e_t} = \bar{\alpha}_2 \frac{\partial \text{Prob}(I_{tRD,t-1} = 1)}{\partial \log e_t} + \hat{\beta}_m \frac{\partial E(\bar{a}_{i,t})}{\partial \log e_t} + \frac{\partial E(g_{i,t}(D_{T,t}, D_{T,t}^*, e_t))}{\partial \log e_t} \]

1. Innovation channel: financial constraints effect.
2. Importing channel: extensive (probability to import) and intensive margin (import intensity).
3. Change in demand: demand/exporters (extensive and intensive).
Parameter calibration/estimation strategy consists of several steps:

1. Calibrate parameters $\sigma$ (elasticity of demand; 4), $\varepsilon$ (subst. elasticity of intermediates; 4) and $r$ (interest rate; 0.05-industrialized and 0.10-emerging).

2. For a given elasticity of demand $\sigma$, parameters $\alpha_0$, $\alpha_1$, $\alpha_2$, (stochastic process for log-productivity), and output elasticities, $\beta_l$, $\beta_k$, $\beta_m$: obtained from model-consistent estimation of the production function (following De Loecker, 2011; Halpern et al, 2015).

3. The parameters ruling the stochastic process of the RER ($\gamma_0$, $\gamma_1$, $\sigma_v^2$): obtained by estimating the AR(1) process specified for log $(e_t)$.

4. Rest of the model’s parameters ($f_x$, $f_m$, $f_{RD,0}$, $f_{RD}$, $D$, $D^*$, $\theta$, $\sigma_u^2$): estimated by using an indirect inference approach that matches model and data statistics.
## Estimated Parameters and Model Fit: Emerging Asia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Values (S.E.)</th>
<th>Moments</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_x$</td>
<td>log export fixed cost, mean</td>
<td>7.98 (0.01) (11th pctile of exporters' sales)</td>
<td>R&amp;D probability</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>$f_{RD,0}$</td>
<td>log R&amp;D sunkcost, mean</td>
<td>13.38 (1.63) (17.6 pct. of avg. R&amp;D benefit)</td>
<td>Export probability</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>$f_{RD}$</td>
<td>log R&amp;D fixed cost, mean</td>
<td>9.06 (1.25) (0.24 pct. of avg. R&amp;D benefit)</td>
<td>Export/sales Ratio, mean</td>
<td>0.60</td>
<td>0.64</td>
</tr>
<tr>
<td>$f_m$</td>
<td>import fixed cost, mean</td>
<td>7.99 (0.04) (5th pctile of importers' sales)</td>
<td>Import probability</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>$A$</td>
<td>quality of imported intermediates</td>
<td>0.72 (0.01)</td>
<td>Import/sales ratio</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>$D_T$</td>
<td>log domestic demand</td>
<td>5.56 (0.01)</td>
<td>Mean firm size (log revenue)</td>
<td>6.6</td>
<td>6.7</td>
</tr>
<tr>
<td>$D_T^*$</td>
<td>log foreign demand</td>
<td>6.53 (0.01)</td>
<td>Sd, firm size (log revenue)</td>
<td>3.23</td>
<td>3.19</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>persistence, productivity</td>
<td>0.86 (0.003)</td>
<td>(<em>Dynamic moments</em>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_u$</td>
<td>sd, innovation of productivity</td>
<td>0.44 (0.006)</td>
<td>R&amp;D, continuation prob.</td>
<td>0.90</td>
<td>0.86</td>
</tr>
<tr>
<td>$\theta$</td>
<td>credit constraint</td>
<td>15 (23.97)</td>
<td>R&amp;D, start prob.</td>
<td>0.06</td>
<td>0.04</td>
</tr>
</tbody>
</table>

## Estimated parameters: Other Emerging Economies, Industrialized

Alfaro, Cuñat, Fadinger, Liu
## Elasticity of TFPR w.r.t RER, Decomposition

<table>
<thead>
<tr>
<th>Region</th>
<th>Innovation (R&amp;D)</th>
<th>Imports</th>
<th>Demand</th>
<th>Total Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerging Asia</td>
<td>0.013</td>
<td>-0.055</td>
<td>0.266</td>
<td>0.21</td>
</tr>
<tr>
<td>Other emerging</td>
<td>0.009</td>
<td>-0.207</td>
<td>0.051</td>
<td>-0.15</td>
</tr>
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</tr>
</tbody>
</table>
Counterfactual Exercises

- Yearly depreciation of 5% for five years followed by sudden re-appreciation (25%).
- Depreciation/appreciation: unanticipated.
- Other cases: Yearly depreciation of 2.5%; appreciation 5% for five years followed by sudden re-appreciation.
Persistent effects: changes in physical productivity from changes in innovation (R&D) after the temporary depreciation are more long-lasting.

**Figure:** A.1 Unexpected real depreciation of 25%: Emerging East Asia
Persistent effects: changes in physical productivity from changes in innovation (R&D) after the temporary depreciation are more long-lasting.

**Figure:** A.2 Unexpected real depreciation of 25%: Emerging East Asia (left), Other Emerging (right)
Counterfactual: TFP Growth Time Paths for the Average Firm–Different Regions

- Relatively short-lived real depreciation: heterogeneous effects

Figure: A.3 Time path TFP growth against RER growth rate (25% RER depreciation)
Counterfactual: Temporary Depreciation/Appreciation, Emerging East Asia

- Non-linear and asymmetric effects.

Figure: B. Unexpected Real Depreciation (25%, 12.5%) and Appreciation (25%), Emerging East Asia
Additional Results and Robustness Checks

- RER and firm level outcomes: depreciations and appreciations
- Foreign-currency borrowing
- Non-targeted moments
- Return to R&D
- Elasticity of demand; interest rates
- Sensitivity parameters/specifications
Conclusions

- The effects of RER changes on firm-level outcomes vary across economies according to a number of features: export orientation, dependence on imports of intermediates (integration GVC), financial development.
- Explain micro channels of heterogeneous aggregate effects of RER changes on firm-level outcomes across countries.
- Temporary RER changes have very persistent effects on TFP growth and innovation.
- RER changes effects: asymmetric, non-linear.
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Future Work:

Services; Interactions

Implications for policy