Currency Risk Factors in a Recursive Multi-Country Economy

R. Colacito  M.M. Croce  F. Gavazzoni  R. Ready

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Motivation

The literature has identified factor structures in currency returns

- Interest Rates (Lustig, Roussanov, and Verdelhan (2011))
- Macroeconomic quantities (e.g. NFA, Della Corte, Riddiough, and Sarno (2013))
- Persistent Heterogeneity Across Countries (LRV (2011), Hassan and Mano (2014))
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We propose a structural equilibrium model:

1. address simultaneously UIP failure and carry trade
2. unified framework for abovementioned empirical results
Overview

1. N Countries
Overview

1. N Countries

2. Complete markets and recursive preferences.
   - News shocks are priced
Overview

1. N Countries

2. Complete markets and recursive preferences.
   - News shocks are priced

3. **Heterogeneous exposure to global long-run growth news**
   - Provide novel evidence from G-10 countries
   - Captures cross-sectional variation in currency returns
   - Endogenous cross-sectional variation in macro quantities
Literature


*Here:* Unified G-E framework
Literature


  **Here:** Unified G-E framework

- **Growth news in int‘l finance:** among others Colacito and Croce (2011, 2013), Bansal and Shaliastovich (2011), Lewis and Liu (2014), ...

  **Here:** Introduce heterogeneous exposure to global growth shocks
Literature


**Here**: Unified G-E framework

▶ **Growth news in int‘l finance**: *among others* Colacito and Croce (2011, 2013), Bansal and Shaliastovich (2011), Lewis and Liu (2014), ...

**Here**: Introduce heterogeneous exposure to global growth shocks

▶ **Asymmetries/Frictions**: *among others* Backus, Gavazzoni, Telmer, and Zin (2010), Ready, Roussanov, and Ward (2012), Hassan (2013), Gabaix and Maggiori (2013), ...

**Here**: Frictionless recursive risk sharing.
Empirical Motivation:

Heterogeneous Exposure to Global News Shocks
Estimating Persistent Predictable Component in GDP

- Estimate the following system for $i \in \text{G-10 currency countries}$

$$\Delta GDP^i_t = \phi \cdot pd^i_{t-1} + \sigma \cdot x^i_{t-1} + \varepsilon^i_t$$

Short-Run Shock

$$x^i_t = \rho_x \cdot x^i_{t-1} + \varphi_e \cdot \sigma \cdot \varepsilon^i_{x,t}$$

Long-Run Shock

Estimation yields an empirical measure of the persistent component of country growth as in Colacito and Croce (2013) and Bansal et al. (2010).
Estimating Persistent Predictable Component in GDP

- Estimate the following system for \( i \in \text{G-10 currency countries} \)

\[
\Delta GDP^i_t = \phi \cdot pd^i_{t-1} + \sigma \cdot x^i_{t-1} + \varepsilon^i_t
\]

\(\text{Short-Run Shock}\)

\[
x^i_t = \rho_x \cdot x^i_{t-1} + \varphi_e \cdot \sigma \cdot \varepsilon^i_{x,t}
\]

\(\text{Long-Run Shock}\)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>(\phi)</th>
<th>(\rho_x)</th>
<th>(\sigma)</th>
<th>(\varphi_e)</th>
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<tr>
<td>(S.E.)</td>
<td>(0.005)</td>
<td>(0.773)</td>
<td>(0.020)</td>
<td>(0.058)</td>
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</table>

- Estimation yields an empirical measure of the persistent component of country growth as in Colacito and Croce (2013) and Bansal et al. (2010)
Global Risk Exposure

1. Exposure to Global **Short-Run** Risk:

\[
\Delta GDP_t^i = \left(1 + \beta_{\Delta y}^i\right) \cdot \left(\frac{1}{n} \sum_{i=1}^{n} \Delta GDP_t^i\right) + \xi_t^i, \quad \forall i \in \{\text{G10 countries}\}.
\]
Global Risk Exposure

1. Exposure to Global **Short-Run** Risk: No Heterogeneity

\[
\Delta GDP^i_t = \left(1 + \beta^i_{\Delta y}\right) \cdot \left(\frac{1}{n} \sum_{i=1}^{n} \Delta GDP^i_t\right) + \xi^i_t, \quad \forall i \in \{G10 countries\}.
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<tbody>
<tr>
<td>(\beta^i_{\Delta y})</td>
<td>-0.28</td>
<td>-0.18</td>
<td>0.05</td>
<td>-0.12</td>
<td>0.14*</td>
<td>0.61**</td>
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2. Exposure to Global Long-Run Risk:

\[ x^i_t = \left(1 + \beta^i\right) \cdot \left(\frac{1}{n} \sum_{i=1}^{n} x^i_t\right) + \zeta^i_t, \quad \forall i \in \{G-10 countries\}. \]
Global Risk Exposure

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</tr>
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2. Exposure to Global **Long-Run** Risk: Substantial Heterogeneity

\[ x_t^i = \left( 1 + \beta^i \right) \cdot \left( \frac{1}{n} \sum_{i=1}^{n} x_t^i \right) + \zeta_t^i, \quad \forall i \in \{G-10 \text{ countries}\}. \]

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<tr>
<td>( \beta^i )</td>
<td>-0.51***</td>
<td>-0.44***</td>
<td>-0.08</td>
<td>-0.02</td>
<td>0.00</td>
<td>0.08</td>
<td>0.12</td>
<td>0.26**</td>
<td>0.27*</td>
<td>0.33**</td>
</tr>
</tbody>
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Model
Preferences

- N countries
- The utility of country $i$'s agent is

$$V_{i,t} = (1 - \delta) \cdot \frac{C_{i,t}^{1-1/\psi}}{1 - 1/\psi} + \delta \cdot E_t \left[ V_{i,t+1}^{1-\theta} \right]^{\frac{1}{1-\theta}}, \quad \theta = \frac{\gamma - 1/\psi}{1 - 1/\psi}$$
Preferences

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- News are independently priced

$$M_{i,t+1} = \delta \left( \frac{C_{i,t+1}}{C_{i,t}} \right)^{-\frac{1}{\psi}} E_t \left[ \frac{U_{i,t+1}^{1-\gamma}}{U_{i,t+1}^{1-\gamma}} \right]^{\frac{1/\psi - \gamma}{1 - \gamma}}$$
Preferences

- **N countries**

- The utility of country $i$'s agent is
  \[
  V_{i,t} = (1 - \delta) \cdot \frac{C_{i,t}^{1 - 1/\psi}}{1 - 1/\psi} + \delta \cdot E_t \left[ V_{i,t+1}^{1-\theta} \right]^{\frac{1}{1-\theta}}, \quad \theta = \frac{\gamma - 1/\psi}{1 - 1/\psi}
  \]

- News are independently priced
  \[
  M_{i,t+1} = \delta \left( \frac{C_{i,t+1}}{C_{i,t}} \right)^{-\frac{1}{\psi}} \left( \frac{U_{i,t+1}^{1-\gamma}}{E_t \left[ U_{i,t+1}^{1-\gamma} \right]} \right)^{\frac{1/\psi - \gamma}{1-\gamma}}
  \]

- Consumption bundle:
  \[
  C_t^i = (x_{i,t}^i)^\alpha \prod_{j \neq i} (x_{j,t}^j)^{\frac{1-\alpha}{N-1}}
  \]
Endowments

- Endowment for country $i$ is

$$
\log X_t^i = \mu_x + \log X_{t-1}^i + z_{i,t-1} - \tau \ EC_t + \varepsilon_{i,t}^X
$$
Endowments

- Endowment for country $i$ is
  \[ \log X_t^i = \mu_x + \log X_{t-1}^i + z_{i,t-1} - \tau \; EC_t + \epsilon_{i,t}^X \]

- $z_{i,t}$'s are small predictable components
  \[ z_{i,t} = \rho_i z_{i,t-1} + \epsilon_{i,t}^z \]
Endowments

- Endowment for country $i$ is
  \[
  \log X_t^i = \mu_x + \log X_{t-1}^i + z_{i,t-1} - \tau \ EC_t + \varepsilon_{i,t}^X
  \]

- $z_{i,t}$’s are small predictable components
  \[
  Z_{i,t} = \rho_i Z_{i,t-1} + \varepsilon_{i,t}^Z
  \]

- Long-run shocks can be decomposed into a “global” component and a “local” component
  \[
  \varepsilon_{i,t}^Z = (1 + \beta_{i,t-1}^z)\varepsilon_{global,t}^z + \varepsilon_{i,t}^\tilde{z}
  \]

- $\beta_{i,t}^z$ is modeled as a “nearly permanent” AR(1)
Complete Markets

- Financial Markets are complete
- The budget constraint for agent $i$ can be written as

$$
\sum_{j=1}^{N} p_{j,t} x_{j,t} + \int_{\zeta^{t+1}}^{} A_{i,t+1}(\zeta^{t+1}) Q_{t+1}(\zeta^{t+1}) = A_{i,t} + p_{i,t} X_{i,t}
$$

- $p_{i,t}$ is the price of good $i$ ($p_1 = 1$)
- $A_{i,t}(\zeta^{t})$ is country $i$’s claims to time $t$ consumption of good $X_1$
- $Q_{t+1}(\zeta^{t+1})$ gives the price of one unit of time $t + 1$ consumption of good $X_1$ contingent on the realization of $\zeta^{t+1}$ at time $t + 1$.
- In equilibrium, $\sum_i A_{i,t} = 0$ and $\sum_i x_{i,t}^j = X_{j,t}, \forall t$. 
Allocations

- Country $i$ consumption of its own good is

$$x_{i,t}^i = \left(1 + \frac{1 - \alpha}{\alpha(N-1)} \sum_{j \neq i} \frac{S_{j,t}}{S_{i,t}}\right)^{-1} X_{i,t},$$

- Country $i$ consumption of good $j$ is

$$x_{i,t}^j = \frac{1 - \alpha}{\alpha} \frac{1}{N-1} \frac{S_{j,t}}{S_{i,t}} x_{i,t}^i,$$

where

$$S_{j,t} = S_{j,t-1} \cdot \frac{SDF_{j,t}}{SDF_{1,t}} \cdot \left(\frac{C_{j,t}/C_{j,t-1}}{C_{1,t}/C_{1,t-1}}\right)$$
Results
No Heterogeneous Exposure - Takeaways

1. **UIP failure and carry trade are distinct phenomena**
   - Symmetric setup delivers UIP failure but no carry trade
     - UIP failure: heterogenous *local* shocks
     - HML: heterogenous exposure to *global* news shocks
No Heterogeneous Exposure - Takeaways

1. **UIP failure and carry trade are distinct phenomena**
   - Symmetric setup delivers UIP failure but no carry trade
     - UIP failure: heterogenous *local* shocks
     - HML: heterogenous exposure to *global* news shocks

2. **Risk-sharing measures:** $V(FX)$ and $Corr(C, C^*)$.
   - Bilateral measures are misleading when news shocks are priced.
Heterogeneous Exposure: Endowments

- Simulate 5 countries to create heterogeneous exposure to long-run shocks

\[
x_t^i = \left(1 + \beta^i\right) \cdot \left(\frac{1}{n} \sum_{i=1}^{n} x_t^i\right) + \zeta_t^i
\]

LR Endowment Beta w.r.t Global LR Shock
Heterogeneous Exposure: Endowments

- Simulate 5 countries to create heterogeneous exposure to long-run shocks

\[ x_t^i = (1 + \beta^i) \cdot \left( \frac{1}{n} \sum_{i=1}^{n} x_t^i \right) + \zeta_t^i \]

- Endowment exposure to global short-run innovations

\[ \Delta GDP_t^i = (1 + \beta_{\Delta y}^i) \cdot \left( \frac{1}{n} \sum_{i=1}^{n} \Delta GDP_t^i \right) + \xi_t^i \]
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to median base country

![Graph showing LR Endowment Beta w.r.t Global LR Shock]

1. Construct "portfolios" w.r.t. to median base country.
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to median base country

![LR Endowment Beta w.r.t Global LR Shock](image)

- Cross section of Interest Rates

![Mean Interest Rates (Annual %)](image)
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to median base country

\[ \Delta e^j_t = \log M_{j,t} - \log M_{3,t} \]  
\[ \epsilon^{z}_{global,t} \]
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to \textit{median} base country

\[
\Delta e^j_t = \log M_{j,t} - \log M_{3,t} \quad \text{to } \epsilon^z_{global,t}
\]
Heterogeneous Exposure: Interest and Exchange Rates

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\[
\Delta e^j_t = \log M_{j,t} - \log M_{3,t} \quad \text{to} \quad \epsilon_{\text{global},t}^{\uparrow}
\]

- Cross section of Interest Rates
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to median base country

- Cross section of Interest Rates

- Exposure of $\Delta e^j_t = \log M_{j,t} \downarrow - \log M_{3,t} \downarrow \rightarrow \epsilon^z_{global,t} \uparrow$
Heterogeneous Exposure: Interest and Exchange Rates

- Construct “portfolios” w.r.t. to median base country

- Cross section of Interest Rates

- Exposure of $\Delta e^j_t = \log M_{j,t} - \log M_{3,t}$ to $\epsilon^z_{global,t}$
Heterogeneous Exposure: Carry and Factor Structure

- Construct “portfolios” w.r.t. to median base country

- Carry trade returns in Model
Heterogeneous Exposure: Carry and Factor Structure

- Construct “portfolios” w.r.t. to median base country

![LR Endowment Beta w.r.t Global LR Shock](image1)

- Carry trade returns in Model

![Mean Portfolio Returns (Annual %)](image2)

- Lustig, Roussanov, and Verdelhan (2011) in Model

![Return Beta w.r.t HML Factor](image3)
CRRA case

- Interest Rate portfolio sorts with CRRA preferences
NFA, FX, and Interest Rates
Average Interest Rates and NFA

- Model: High $\beta^z_i \rightarrow$ low $r^i_f$ and positive $NFA_i$
Average Interest Rates and NFA

- Model: High $\beta_i^z \rightarrow$ low $r_f^i$ and positive $NFA_i$

- Precautionary savings at work
Volatilities

- Model: High $|\beta_i^z|$ $\rightarrow$ high $\sigma(\Delta e_i)$ and high $\sigma(NFA_i)$

- Risk sharing at work
Conditional Responses
Model: NFA and Exchange Rate

- Response to a positive global long-run shock

High beta  Low beta

$\Delta GDP$
Model: NFA and Exchange Rate

- Response to a positive global long-run shock

High beta    Low beta

\[ \Delta \text{GDP} \]

\[ \text{NFA} \]
Model: NFA and Exchange Rate

- Response to a positive global long-run shock

![Graphs showing the response of Delta GDP, NFA, and Delta e to high and low beta scenarios.](image)

- High beta
- Low beta
Data: NFA

\[
\frac{NFA_{i,t}}{GDP_{i,t}} = \alpha_{i}^{NFA} + \lambda_{i}^{NFA} \cdot Z_{global,t} + \xi_{i,t}
\]
Data: NFA

\[
\frac{NFA_{i,t}}{GDP_{i,t}} = \alpha_i^{\text{NFA}} + \lambda_i^{\text{NFA}} \cdot z_{\text{global},t} + \xi_{i,t}
\]
Data: NFA

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\frac{NFA_{i,t}}{GDP_{i,t}} = \alpha_i^{NFA} + \lambda_i^{NFA} \cdot z_{global,t} + \xi_{i,t}
\]
**Data: Exchange Rate**

\[
\Delta e_{i,t} = \alpha_i^{FX} + \lambda_i^{FX} \cdot \Delta z_{global,t} + \xi_i,t, 
\]
Data: Exchange Rate

\[ \Delta e_{i,t} = \alpha_i^{FX} + \lambda_i^{FX} \cdot \Delta z_{global,t} + \xi_i,t, \]
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\[ \Delta e_{i,t} = \alpha_i^{FX} + \lambda_i^{FX} \cdot \Delta z_{global,t} + \xi_{i,t}, \]
Robustness: Currency Portfolios

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Exchange Rate</th>
<th></th>
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<th>Net Foreign Assets</th>
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<tbody>
<tr>
<td>Low $\beta_i^z$</td>
<td>-26.52</td>
<td>-26.52</td>
<td>-27.51</td>
<td>-27.51</td>
<td>384.03</td>
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<tr>
<td></td>
<td>(16.05)</td>
<td>(16.05)</td>
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<td>Medium $\beta_i^z$</td>
<td>-23.85</td>
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<td>-27.31</td>
<td>-52.15</td>
<td>-46.44</td>
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<td>(9.35)</td>
<td>(12.06)</td>
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<td>(55.67)</td>
<td>(1.95)</td>
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<tr>
<td>High $\beta_i^z$</td>
<td>-67.16</td>
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<td>-84.88</td>
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<td>-154.46</td>
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<td>Y</td>
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<tr>
<td>Exclude US</td>
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<td>Y</td>
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<tr>
<td>Control local shocks</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
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- Results are robust to the exclusion of specific countries and controlling for local shocks
Conclusion
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1. Novel empirical evidence on heterogenous exposure to global news shocks
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2. GE model with (i) recursive preferences, (ii) multiple countries, and (iii) heterogenous exposure to global news shocks
   → Unified framework for several phenomena.
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   Consistent with data, High news exposure countries have:
   - Low interest rates
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- Positive NFA positions
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    - Low interest rates
    - Safe currencies
    - Positive NFA positions
    - More volatile NFA and FX

    (same for low risk exposure countries)
Conclusion

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   → Unified framework for several phenomena.

   Consistent with data, High news exposure countries have:
   - Low interest rates
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   - Positive NFA positions
   - More volatile NFA and FX

   (same for low risk exposure countries)

3. Future research: investment flows, interplay with frictions