Risk-sharing for the long-run
The gains from financial integration

Ric Colacito    Max Croce

UNC-Chapel Hill
The question

What are the welfare benefits of financial integration?
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- Long standing question in international finance
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- One common finding
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- One common finding
  → The benefits are smaller than 1% of lifetime consumption
What are the welfare benefits of financial integration?

- Long standing question in international finance
- One common finding
  → The benefits are smaller than 1% of lifetime consumption
- Related literature
  - Cole and Obstfeld (1991)
  - van Wincoop (1994)
  - Tesar (1995)
  - Gourinchas and Jeanne (2006)
  - ...
Are we getting this right?

- A general equilibrium model that can explain the joint dynamics of international
  1. prices
  2. quantities
- Specifically
  - High degree of consumption home bias
  - Low int'l correlation of consumption and output
  - Relative smoothness of exchange rates
  - Degree of volatility of SDF's
  - High int'l correlation of returns
  - Lack of correlation between consumption differentials and exchange rates
  - Negative UIP regression slope
  - At least some volatility of Net Exports
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Background

• Bansal and Yaron (2004):
  1. Risk-sensitive agents
  2. Slowly moving predictive component of consumption growth
     can generate volatile stochastic discount factors.
Background

- Bansal and Yaron (2004):
  1. Risk-sensitive agents
  2. Slowly moving predictive component of consumption growth can generate volatile stochastic discount factors.

- Colacito and Croce (2007):
  3. High int’l correlation of long-run risks can generate modestly volatile exchange rates.
This paper

Two additional ingredients:

4. Consumption home bias
5. General equilibrium approach
This paper

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introduce a time-varying distribution of consumption across countries
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This generates:

- incentive to trade (goods and assets)
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introduce a **time-varying distribution of consumption across countries**

This generates:

- incentive to trade (goods and assets)
- asymmetric movements between consumptions differentials and exchange rates
Two additional ingredients:

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introduce a **time-varying distribution of consumption across countries**

This generates:

- incentive to trade (goods and assets)
- asymmetric movements between consumptions differentials and exchange rates
- time varying volatility
Roadmap of the talk

- Setup of the model
- Calibration
- Reconciling international prices and quantities
- What are the benefits of financial integration?
- In progress: predictability?
Preferences

- Agents have risk-sensitive preferences

\[ U_t^i = (1 - \delta) \log C_t^i + \delta \theta \log E_t \exp \left\{ \frac{U_{t+1}^i}{\theta} \right\}, \quad \forall i \in \{h,f\} \]

where \( \theta = 1/(1 - \gamma) \).
Preferences

- Agents have risk-sensitive preferences

\[ U_t^i = (1 - \delta) \log C_t^i + \delta E_t[U_{t+1}^i], \quad \forall i \in \{h,f\} \]

where \( \theta = 1/(1 - \gamma) \). If \( \theta \to -\infty \): time additive case.
Preferences

- Agents have risk-sensitive preferences

\[ U^i_t = (1 - \delta) \log C^i_t + \delta \theta \log E_t \exp \left\{ \frac{U^i_{t+1}}{\theta} \right\}, \quad \forall i \in \{h,f\} \]

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where \( \theta = 1/(1 - \gamma) \).

- Preferences are defined over the consumption aggregate

\[ C_t^h = (x_t^h)^\alpha (y_t^h)^{1-\alpha} \quad \text{and} \quad C_t^f = (x_t^f)^{1-\alpha} (y_t^f)^\alpha \]
Preferences

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• Preferences are defined over the consumption aggregate

\[ C_t^h = (x_t^h)^\alpha (y_t^h)^{1-\alpha} \quad \text{and} \quad C_t^f = (x_t^f)^{1-\alpha} (y_t^f)^\alpha \]

• Consumption home bias: \( \alpha >> 0.5 \).
Endowments

- Endowments' growth is *almost* i.i.d.

\[
\Delta \log X_t = \mu_x + z_{1,t-1} + \varepsilon_{x,t} \\
\Delta \log Y_t = \mu_y + z_{2,t-1} + \varepsilon_{y,t}
\]

where \( z_{1,t} \) and \( z_{2,t} \) are small, predictable components

\[
 z_{1,t} = \rho_1 z_{1,t-1} + \varepsilon_{1,t} \\
 z_{2,t} = \rho_2 z_{2,t-1} + \varepsilon_{2,t}
\]
Complete Markets

- Home country is endowed with $X_t$
- Foreign country is endowed with $Y_t$
Complete Markets

- Home country is endowed with $X_t$
- Foreign country is endowed with $Y_t$
- Two country specific budget constraints

\[
x^h_t + p_t y^h_t + \int_{\zeta^{t+1}} Q^h (\zeta^{t+1}) A^h_{t+1} (\zeta^{t+1}) = X_t + A^h_t \quad [\text{Home}]
\]
\[
x^f_t + p_t y^f_t + \int_{\zeta^{t+1}} Q^f (\zeta^{t+1}) A^f_{t+1} (\zeta^{t+1}) = p_t Y_t + A^f_t \quad [\text{Foreign}]
\]

- Market clearing: $A^h_t + A^f_t = 0$
Planner’s problem

Efficient allocations are the solution to the planner’s problem

\[
\text{choose } \{x^h_t, x^f_t, y^h_t, y^f_t\}_{t=0}^{+\infty}
\]

\[
\text{to max } Q = \mu U^h_0 + (1 - \mu) U^f_0
\]

\[
\text{s.t. } x^h_t + x^f_t = X_t
\]

\[
y^h_t + y^f_t = Y_t, \quad \forall t \geq 0
\]

→ \(\mu\) and \(1 - \mu\) correspond to an initial distribution of assets
Allocations

Time Additive Preferences

Let \( k = \frac{\alpha}{1-\alpha} \):

\[
\begin{align*}
  x^h_t &= \frac{k}{1+k} X_t, \\
  y^h_t &= \frac{1}{k+1} Y_t, \\
  x^f_t &= \frac{1}{1+k} X_t, \\
  y^f_t &= \frac{k}{k+1} Y_t
\end{align*}
\]
Let \( k = \frac{\alpha}{1-\alpha} \):

\[
\begin{align*}
  x^h_t &= \frac{kS_t}{1 + kS_t} X_t, \\
  y^h_t &= \frac{S_t}{k + S_t} Y_t, \\
  x^f_t &= \frac{1}{1 + kS_t} X_t, \\
  y^f_t &= \frac{k}{k + S_t} Y_t
\end{align*}
\]

where

\[
S_t = S_{t-1} \frac{\delta \exp \left\{ \frac{U^h_t}{\theta} \right\}}{E_{t-1} \exp \left\{ \frac{U^h_t}{\theta} \right\}} \bigg/ \frac{\delta \exp \left\{ \frac{U^f_t}{\theta} \right\}}{E_{t-1} \exp \left\{ \frac{U^f_t}{\theta} \right\}}
\]
Consumption growth

Time Additive Preferences

\[ \Delta c^h_t = \alpha \Delta x_t + (1 - \alpha) \Delta y_t \]

\[ \Delta c^f_t = (1 - \alpha) \Delta x_t + \alpha \Delta y_t \]
Consumption growth

Risk Sensitive Preferences

\[
\Delta c^h_t = \Delta c^h_{t,TA} + \lambda^h cs_{t-1} + \lambda^h cs^2_{t-1} + \lambda^h s (s_{t-1}) \varepsilon_t \\
\Delta c^f_t = \Delta c^f_{t,TA} + \lambda^f cs_{t-1} + \lambda^f cs^2_{t-1} + \lambda^f s (s_{t-1}) \varepsilon_t
\]
Consumption growth

Risk Sensitive Preferences

\[
\Delta c^h_t = \Delta c^h_{t,TA} + \lambda^h c s_{t-1} + \lambda^h c c s^2_{t-1} + v^h (s_{t-1}) g(\epsilon_{1,t}, \epsilon_{2,t}, \epsilon_{x,t}, \epsilon_{y,t})
\]

\[
\Delta c^f_t = \Delta c^f_{t,TA} + \lambda^f c s_{t-1} + \lambda^f c c s^2_{t-1} + v^f (s_{t-1}) g(\epsilon_{1,t}, \epsilon_{2,t}, \epsilon_{x,t}, \epsilon_{y,t})
\]

1. Contemporaneous response to long-run shocks
Consumption growth

Risk Sensitive Preferences

\[
\Delta c^h_t = \Delta c^{h,TA}_t + \lambda^h c s_{t-1} + \lambda^h c c s_{t-1}^2 + v^h(s_{t-1}) g(\varepsilon_{1,t}, \varepsilon_{2,t}, \varepsilon_{x,t}, \varepsilon_{y,t})
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\]

1. Contemporaneous response to long-run shocks
2. Endogenous stochastic volatility
Stochastic Discount Factors

- With Risk-sensitive preferences

\[
m^i_{t+1} = \log \frac{\partial U^i_{t+1}}{\partial C^i_{t+1}} + \frac{\partial U^i_t}{\partial C^i_t} = \log \delta - \Delta c^i_{t+1} + \log \frac{\exp \left\{ U^i_{t+1} / \theta \right\}}{E_t \exp \left\{ U^i_{t+1} / \theta \right\}}, \quad \forall i \in \{h,f\}
\]

- With Time-additive preferences

\[
m^i_{t+1} = \log \delta - \Delta c^i_{t+1}, \quad \forall i \in \{h,f\}
\]
Stochastic Discount Factors

- With Risk-sensitive preferences

\[ m^h_{t+1} - E_t[m^h_{t+1}] = g^h(s_t e^1_{t+1}, s_t e^2_{t+1}, s_t e^x_{t+1}, s_t e^y_{t+1}) \]

\[ m^f_{t+1} - E_t[m^f_{t+1}] = g^f(s_t e^1_{t+1}, s_t e^2_{t+1}, s_t e^x_{t+1}, s_t e^y_{t+1}) \]

- With Time-additive preferences

\[ m^i_{t+1} = \log \delta - \Delta c^i_{t+1}, \quad \forall i \in \{h,f\} \]
Stochastic Discount Factors

- With Risk-sensitive preferences

\[
m_{t+1}^h - E_t[m_{t+1}^h] = g^h(s_t \varepsilon_{t+1}, s_t \varepsilon_{t+1}^2, s_t \varepsilon_{t+1}^x, s_t \varepsilon_{t+1}^y)
\]

\[
m_{t+1}^f - E_t[m_{t+1}^f] = g^f(s_t \varepsilon_{t+1}, s_t \varepsilon_{t+1}^2, s_t \varepsilon_{t+1}^x, s_t \varepsilon_{t+1}^y)
\]

- With Time-additive preferences

\[
m_{t+1}^i = \log \delta - \Delta c_{t+1}^i, \quad \forall i \in \{h,f\}
\]
Exchange Rates

• By no arbitrage

\[ E_t \left[ M_{t+1}^f R_{t+1}^f \right] = 1 = E_t \left[ M_{t+1}^h \frac{e_{t+1}}{e_t} R_{t+1}^f \right] \]
Exchange Rates

By no arbitrage

\[ E_t \left[ M_{t+1}^f R_{t+1}^f \right] = 1 = E_t \left[ M_{t+1}^h \frac{e_{t+1}}{e_t} R_{t+1}^f \right] \]
Exchange Rates

- By no arbitrage

$$
\log \frac{e_{t+1}}{e_t} = \log M_{t+1}^f - \log M_{t+1}^h
$$
Exchange Rates

- By no arbitrage

\[
\log \frac{e_{t+1}}{e_t} = \log M_{t+1}^f - \log M_{t+1}^h
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- Stochastic Discount Factors are highly volatile...
Exchange Rates

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\log \frac{e_{t+1}}{e_t} = \log M_{t+1}^f - \log M_{t+1}^h
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- Stochastic Discount Factors are highly volatile...
- they ought to be highly correlated as well!
Exchange Rates

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\]

• Stochastic Discount Factors are highly volatile...
• they ought to be highly correlated as well!
• How?
Exchange Rates

- By no arbitrage

\[
\log \frac{e_{t+1}}{e_t} = \log M_{t+1}^f - \log M_{t+1}^h
\]

- Stochastic Discount Factors are highly volatile...
- they ought to be highly correlated as well!
- How? 
- Long-Run risks are highly correlated
Net Export/Output

- Definition

\[
\frac{NX^h_t}{X_t} = \frac{X^f_t - pY^h_t}{X_t}
\]
Net Export/Output

- Definition

\[
\frac{NX_t^h}{X_t} = \frac{X_t^f - pY_t^h}{X_t}
\]

- With Time additive preferences

\[
\frac{NX_t^h}{X_t} = 0
\]
Net Export/Output

- Definition

\[
\frac{NX_t^h}{X_t} = \frac{X_t^f - pY_t^h}{X_t}
\]

- With Risk-Sensitive preferences

\[
\frac{NX_t^h}{X_t} = \frac{1 - S_t}{1 + kS_t}
\]

where

\[
S_t = f(\varepsilon_t^1, \varepsilon_t^2, \varepsilon_t^x, \varepsilon_t^y)
\]
Net Export/Output

- **Definition**

\[
\frac{NX_t^h}{X_t} = \frac{X_t^f - pY_t^h}{X_t}
\]

- **With Risk-Sensitive preferences**

\[
\frac{\partial \frac{NX_t^h}{X_t}}{\partial S_t} < 0
\]

where

\[
S_t = f(\varepsilon_t^1, \varepsilon_t^2, \varepsilon_t^x, \varepsilon_t^y)
\]

\[
<<0 \quad \gg0
\]
## Calibration

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu$</td>
<td>Mean Output growth</td>
<td>0.165%</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Std. dev. of idiosyncratic output growth</td>
<td>0.540%</td>
</tr>
<tr>
<td>$\sigma_x$</td>
<td>Std. dev. of long-run output growth</td>
<td>4%</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Degree of consumption home bias</td>
<td>0.980</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Subjective discount factor</td>
<td>0.998</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Risk Aversion</td>
<td>7</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Persistence of long-run risks</td>
<td>0.988</td>
</tr>
<tr>
<td>$\rho_{12}$</td>
<td>Correlation of long-run risks</td>
<td>.9</td>
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<tr>
<td>$\rho_{xy}$</td>
<td>Correlation of short-run risks</td>
<td>0</td>
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Correlation of Long-Run Risks: methodology

Methodology:

- Define GDP as sum of consumption and Net Export
- For each country: regress $\Delta GDP$ on lagged $\Delta c$, $pd$, $cy$
- Use projection as measure of long-run risks
- Apply to US and UK
Long-Run Risks

→ Using all NX

\[ \rho_{12} = 0.46 \]

\[ \rho_{12} = 0.70 \]
Long-Run Risks

→ Using all NX
Long-Run Risks

→ Using only bilateral NX
Long-Run Risks

→ Using only bilateral NX
## Results: quantities

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<td>$\sigma(\Delta y)$</td>
<td>1.92</td>
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<td>2.57</td>
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<tr>
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<td>0.37</td>
<td>0.34</td>
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<td>0.81</td>
<td>2.38</td>
<td>3.39</td>
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<td>$ACF_1 (NX/Y)$</td>
<td>0.85</td>
<td>0.81</td>
<td>0.69</td>
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Results: prices

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<td>1.21</td>
<td>1.18</td>
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<td>$corr(r^f_h, r^f_f)$</td>
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<td>14.5</td>
<td>11.90</td>
</tr>
<tr>
<td>$E(r^f)$</td>
<td>2.71</td>
<td>1.07</td>
</tr>
<tr>
<td>$\sigma(r^f)$</td>
<td>1.21</td>
<td>1.18</td>
</tr>
<tr>
<td>$corr(r^f_{h}, r^f_f)$</td>
<td>0.87</td>
<td>0.67</td>
</tr>
<tr>
<td>$corr(\Delta c^h_t − \Delta c^f_t, \Delta e_t)$</td>
<td>-0.19</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
Results: prices

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>US</td>
</tr>
<tr>
<td>$\sigma(m)$</td>
<td>36%</td>
<td>$\geq$30%</td>
</tr>
<tr>
<td>$\sigma(\Delta e)$</td>
<td>14.5</td>
<td>11.90</td>
</tr>
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</tr>
<tr>
<td>$\text{corr}(\Delta c^h_t - \Delta c^f_t, \Delta e_t)$</td>
<td>-0.19</td>
<td>-0.02</td>
</tr>
<tr>
<td>$\beta_{UIP}$</td>
<td>-3.5</td>
<td>-0.98</td>
</tr>
</tbody>
</table>
The benefits of Financial Integration

- A model with portfolio autarky
  \[\Rightarrow\] Welfare loss of a ban to trade of assets
The benefits of Financial Integration

- A model with portfolio autarky
  → Welfare loss of a ban to trade of assets

- Calibrate the model with autarky to 50’s and 60’s
Portfolio autarky

- Home country is endowed with $X_t$
- Foreign country is endowed with $Y_t$
- Two country specific budget constraints

$$x^h_t + p_t y^h_t = X_t \quad [\text{Home}]$$
$$x^f_t + p_t y^f_t = p_t Y_t \quad [\text{Foreign}]$$

- Trade is balanced in every period
Equilibrium with portfolio autarky

- Consumption

\[ \Delta c_{t,aut}^h = \alpha \Delta x_t + (1 - \alpha) \Delta y_t \]
\[ \Delta c_{t,aut}^f = (1 - \alpha) \Delta x_t + \alpha \Delta y_t \]

- Exchange rates

\[ e_t = y_t - x_t \]

- Net Exports

\[ \frac{NX_t^h}{X_t} = 0 \]
What are the benefits of financial integration?

- Constant fraction of consumption that makes agents indifferent between
  - living in autarky
  - living in complete markets
What are the benefits of financial integration?

- Constant fraction of consumption that makes agents indifferent between
  - living in autarky
  - living in complete markets

- Benefits when:
  1. Long-run risks are shut down: 2.26%
What are the benefits of financial integration?

- Constant fraction of consumption that makes agents indifferent between
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- Benefits when:
  1. Long-run risks are shut down: 2.26%
  2. Long-run risks are turned on: 4.39%
What are the benefits of financial integration?

- Constant fraction of consumption that makes agents indifferent between
  - living in autarky
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- Benefits when:
  1. Long-run risks are shut down: 2.26%
  2. Long-run risks are turned on: 4.39%

- What were the gains in the 50s-60s?
What are the benefits of financial integration?

• Constant fraction of consumption that makes agents indifferent between
  • living in autarky
  • living in complete markets

• Benefits when:
  1. Long-run risks are shut down: 2.26%
  2. Long-run risks are turned on: 4.39%

• What were the gains in the 50s-60s?
  \[ \text{corr}(\varepsilon^1_t, \varepsilon^2_t) = 0.5 \]
Back in the day...

Without long-run risks
Back in the day...

Without long-run risks
Back in the day...

With long-run risks
Back in the day...

With long-run risks
Portfolio autarky and the 50s-60s

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data US</th>
<th>Data UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma (\Delta y)$</td>
<td>1.92</td>
<td>1.68</td>
<td>3.28</td>
</tr>
<tr>
<td>$ACF_1 (\Delta y)$</td>
<td>0.43</td>
<td>0.45</td>
<td>-0.32</td>
</tr>
<tr>
<td>$\sigma (\Delta c)$</td>
<td>1.88</td>
<td>1.12</td>
<td>1.69</td>
</tr>
<tr>
<td>$ACF_1 (\Delta c)$</td>
<td>0.43</td>
<td>0.36</td>
<td>0.20</td>
</tr>
<tr>
<td>$corr (\Delta y^h, \Delta y^f)$</td>
<td>-0.11</td>
<td>-0.38</td>
<td></td>
</tr>
<tr>
<td>$corr (\Delta c^h, \Delta c^f)$</td>
<td>-0.07</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>$\sigma (NX/Y)$</td>
<td>0</td>
<td>0.88</td>
<td>1.97</td>
</tr>
<tr>
<td>$ACF_1 (NX/Y)$</td>
<td>-</td>
<td>0.42</td>
<td>0.13</td>
</tr>
<tr>
<td>$\sigma (m)$</td>
<td>38%</td>
<td>$\geq 30%$</td>
<td></td>
</tr>
<tr>
<td>$\sigma (\Delta e)$</td>
<td>3.28</td>
<td>4.39</td>
<td></td>
</tr>
<tr>
<td>$E (r^f)$</td>
<td>2.71</td>
<td>0.66</td>
<td>0.88</td>
</tr>
<tr>
<td>$\sigma (r^f)$</td>
<td>1.21</td>
<td>0.89</td>
<td>0.87</td>
</tr>
<tr>
<td>$corr (r^f_h, r^f_f)$</td>
<td>0.50</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>
Predictability?

\( S_t \) should forecast the cross-section of int’l excess returns

\[
\begin{align*}
    r_{c,t}^j &= \beta_0 + \beta_1 s_{t-1} + \epsilon_t, \quad \forall j = \{h,f\}
\end{align*}
\]
Predictability?

$S_t$ should forecast the cross-section of int’l excess returns

$$r_{c,t}^j = \beta_0 + \beta_1 s_{t-1} + \varepsilon_t, \quad \forall j = \{h,f\}$$

Testable implications:

- forecastability through Net Exports
- forecastability through relative wealth-consumption ratios
Predictability?

\( S_t \) should forecast the cross-section of int’l excess returns

\[
\begin{align*}
  r_{c,t}^j &= \beta_0 + \beta_1 s_{t-1} + \varepsilon_t, \\
  \forall j &= \{h,f\}
\end{align*}
\]

Testable implications:

- forecastability through Net Exports
- forecastability through relative wealth-consumption ratios

Empirical questions:

- which returns?
- which Net Exports?
- how do we measure the wealth-consumption ratio?
Concluding Remarks

1. A general equilibrium model
2. Can account for
   - exchange rates dynamics
   - behavior of int’l returns
   - joint distribution of prices and quantities
3. Large welfare benefits
4. Forecastability of cross-section of int’l returns?
Stochastic Discount Factors

• With Risk-sensitive preferences

\[ m^h_{t+1} - E_t[m^h_{t+1}] = g^h(s_t \varepsilon^1_{t+1}, s_t \varepsilon^2_{t+1}, s_t \varepsilon^x_{t+1}, s_t \varepsilon^y_{t+1}) < 0 \]

\[ m^f_{t+1} - E_t[m^f_{t+1}] = g^f(s_t \varepsilon^1_{t+1}, s_t \varepsilon^2_{t+1}, s_t \varepsilon^x_{t+1}, s_t \varepsilon^y_{t+1}) < 0 \]

• With Time-additive preferences

\[ m^i_{t+1} = \log \delta - \Delta c^i_{t+1}, \quad \forall i \in \{h,f\} \]