Appendices

A Appendix Figures

Figure A.1 Comparison of residualized credit spread diff. (EU-US) with un-residualized benchmarks

This figure compares the EU-US residualized credit spread differential (dashed blue) with un-residualized credit spread differentials constructed from Bank of America Merrill Lynch Single A Corporate index (BAML, dotted green) and Barclays Single A Corporate index (solid red). The un-residualized euro minus dollar credit spread differential is constructed by subtracting the dollar-denominated single A aggregate option adjusted spread from euro-denominated single A aggregate option adjusted spread provided by BAML and Barclays.

To construct estimates of residualized credit spread, I estimate the following cross-sectional regression at each date $t$

$$ S_{it} = \alpha_{ct} + \beta_{ft} + \gamma_{mt} + \delta_{rt} + \varepsilon_{it} $$

where $S_{it}$ is the yield spread over the swap curve for bond $i$ that is issued in currency $c$, by firm $f$, with maturity $m$ and rating $r$. The residualized credit spread of euro relative to dollar is defined as $\hat{\alpha}_{eur,t} - \hat{\alpha}_{usd,t}$. Details of the measure’s construction are provided in Section 1.2.
Figure A.2 Additional Controls

This figure presents the credit spread differential between bonds denominated in different currencies relative to US dollar. The solid red line is the residualized credit spread differential constructed based on the procedure in Section 1.2. The dotted blue line is estimated with cross-sectional regressions that controls for the amount outstanding, the age of the bond relative to maturity, and the seniority of the bond in addition to the variables included in Equation 1.
Figure A.3 Low-grade vs high-grade credit spread differential for EUR/USD

This figure presents the credit spread differential between bonds denominated in euro versus dollar for low-grade and high-grade bonds. High grade bonds are defined as bonds with single-A or higher rating by Moody. I estimate the following cross-sectional regression at each date $t$ for low-grade and high-grade bonds separately

$$S_{it} = \alpha_{ct} + \beta_{ft} + \gamma_{mt} + \varepsilon_{it}$$

where $S_{it}$ is the yield spread over the swap curve for bond $i$ that is issued in currency $c$, by firm $f$, and with maturity $m$. The residualized credit spread of currency $c$ relative to dollar is defined as $\hat{\alpha}_{c,t} - \hat{\alpha}_{usd,t}$. Details of the measure’s construction are provided in Section 1.2. Similar graphs for other currencies are presented in Appendix Figure A.4.
Figure A.4 Low-grade vs high-grade credit spread differential in other currencies

This figure presents the credit spread differential between bonds denominated in different currencies relative to US dollar for low-grade and high-grade bonds. High grade bonds are defined as bonds with single-A or higher rating by Moody. I estimate the following cross-sectional regression at each date $t$ for low-grade and high-grade bonds separately

$$S_{it} = \alpha_{ct} + \beta_{ft} + \gamma_{mt} + \varepsilon_{it}$$

where $S_{it}$ is the yield spread over the swap curve for bond $i$ that is issued in currency $c$, by firm $f$, and with maturity $m$. The residualized credit spread of currency $c$ relative to dollar is defined as $\hat{\alpha}_{c,t} - \hat{\alpha}_{usd,t}$. Details of the measure’s construction are provided in Section 1.2.
Figure A.5 Country-specific sovereign spreads and CIP violations

This figure presents country-specific sovereign spreads of bonds with similar characteristics denominated in EUR and USD and CIP deviations for EURUSD. The results are similar to Corradin and Rodriguez-Moreno (2016), which employs a manual matching method in paring bonds of similar qualities issued by the same sovereign issuer.
Figure A.6 Cross-currency basis swap cash flows

This figure decomposes the cash flows of a lend EUR/borrow USD (receive Euribor + basis versus pay $Libor) cross-currency basis swap into two floating-rate notes (FRNs) in EUR and USD. The euro lending cash flows are shown in blue and the dollar borrowing cash flows are shown in red. Upward arrows represent payments and downward arrows represent receivables. An initial exchange of €1 for $1.1 (at the spot FX rate) is made at the swap initiation date. Floating rate coupons based on the Euribor and $Libor reference rates are exchanged every quarter in the interim. A final exchange of the original principal amount (at the initial FX rate) is made at the maturity date. The other counterparty of this swap holds a borrow EUR/lend USD position and the reverse of the cash flows shown below.
This figure presents a comparison of EUR-USD cross-currency basis swaps with short-term reference rates as Euribor and Libor (Red) and Fed Fund Effective rate and overnight Eonia rate from 2009 (when Bloomberg’s overnight-based cross currency swap data begin) to 2015.
Figure A.8 Residualized credit spread differential, CIP deviations, and interest rate differential

This figure presents the residualized credit spread differential (euro minus dollar) and CIP deviations for EURUSD in the top panel and interest rate differential (5-year euro minus dollar interest rate swap differential) in the bottom panel.
Figure A.9 Credit spread differential and CIP violation relative to EUR

This figure presents credit spread differentials \((\alpha_c - \alpha_{EUR})\) and CIP deviations \((r_{c}^{FX \text{ implied}} - r_c)\) relative to EUR for six major funding currencies \((c = AUD, CAD, CHF, GBP, JPY, USD)\). Vertical bars represent the 95% confidence interval for the estimated credit spread differentials constructed using robust standard errors clustered at the firm level. Details of the measures’ construction are provided in Section 1.2 and 2.
Figure A.10 Credit spread differential and CIP violation relative to GBP

This figure presents credit spread differentials \((\alpha_c - \alpha_{GBP})\) and CIP deviations \((r_{c}^{\text{FX implied}} - r_c)\) relative to GBP for six major funding currencies \((c = \text{AUD, CAD, CHF, EUR, JPY, USD})\). Vertical bars represent the 95% confidence interval for the estimated credit spread differentials constructed using robust standard errors clustered at the firm level. Details of the measures’ construction are provided in Section 1.2 and 2.
Figure A.11 Spillover of deviations: orthogonalized impulse responses of deviations and issuance flow for EURUSD

I estimate a first order vector autoregression (VAR) of the form

\[
\begin{bmatrix}
1 \\
a_{bp} \\
a_{cp}
\end{bmatrix}
\begin{bmatrix}
1 \\
b_t \\
c_t
\end{bmatrix}
= B
\begin{bmatrix}
\mu_{t-1} \\
b_{t-1} \\
c_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
\varepsilon_{\mu,t} \\
\varepsilon_{b,t} \\
\varepsilon_{c,t}
\end{bmatrix}
\]

I apply Cholesky Decomposition by ordering the variables as \( \mu, b \) and \( c \). This ordering assumes that issuance responds with a lag to both \( \varepsilon_c \) and \( \varepsilon_b \) shocks, and credit deviation respond with a lag to CIP shocks. The orthogonalized impulse responses to \( \varepsilon_c \) and \( \varepsilon_b \) shocks are graphed below. The choice of lag 1 is selected by Bayesian Information Criteria. 95% confidence intervals are shown in gray.
Figure A.12 Spillover of deviations: partially identified impulse responses of deviations and issuance flow for EURUSD

I estimate a first order vector autoregression (VAR) of the form

\[
\begin{bmatrix}
1 & a_{c\mu} & 1 & a_{cb} \\
a_{b\mu} & a_{bc} & 1
\end{bmatrix}
\begin{bmatrix}
\mu_t \\
c_t \\
b_t
\end{bmatrix}
= B
\begin{bmatrix}
\mu_{t-1} \\
c_{t-1} \\
b_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
\varepsilon_{\mu,t} \\
\varepsilon_{c,t} \\
\varepsilon_{b,t}
\end{bmatrix}
\]

I apply a partial identification method by assuming that issuance flow responds with a lag to both \(\varepsilon_c\) and \(\varepsilon_b\) shocks, but \(b\) and \(c\) has no ordering with respect to each other. That is, \(\varepsilon_b\) and \(\varepsilon_c\) can have contemporaneous effects on both \(b\) and \(c\). The orthogonalized impulse responses to \(\varepsilon_c\) and \(\varepsilon_b\) shocks are graphed below. The choice of lag 1 is selected by Bayesian Information Criteria. Confidence intervals at the 95% level using bootstrapped standard errors are shown in gray.
Figure A.13 Term structure of CIP deviations in EURUSD

This figure presents the term structure of CIP deviations in EURUSD. Panel A presents time series of 3 month and 10 year deviations in CIP in EURUSD. Panel B presents the maturity curve of CIP violation on April 21, 2015 (dark blue) and November 1, 2008 (light grey).

Panel A: Time series of short- and long- term CIP deviations

Panel B: CIP maturity curves
Figure A.14 Credit spread differential and Issuance for EUR/USD around Bear Stearns and Lehman downfall

This figure presents credit spread differential and issuance flow from November 2007 to November 2008. The two vertical lines indicate the downfall of Bear Stearns and Lehman Brothers respectively.

Panel A: Credit deviation and CIP deviations

Panel B: Net deviation (credit minus CIP)

Panel C: Net issuance flow (Eurozone to U.S.) in $billions
Figure A.15 Credit spread differential and Issuance for EUR/USD around Eurozone Sovereign Crisis

This figure presents credit spread differential and issuance flow around the time of the Eurozone Sovereign Crisis in 2011-2012. The first vertical line marks May 2011, when wholesale funding conditions rapidly deteriorated. The second vertical line marks June 2012, when Greece elected the pro-austerity New Democracy Party, allaying fears of the country was about to leave the eurozone.

Panel A: Credit spread differential and CIP deviations

Panel B: Net deviation (credit minus CIP)

Panel C: Net issuance flow (Eurozone to U.S.) in $billions
B Appendix Tables
Table B.1 Fed QE response
This table presents responses in treasury yield and credit spreads following Federal Reserve QE announcements using a bootstrap event-study method from Mamaysky (2014). The average response (in bps) in days following Fed QE announcement dates are displayed for the 10 year Treasury, dollar corporate single-A OAS, and credit spread differentials. The OAS spreads are from Bank Of America Merrill Lynch Index. $p$-value in parenthesis indicates the fraction of counterfactual “responses” from random draws in the sample period that are more extreme than the response following the actual QE announcements.

<table>
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<tr>
<th>Days since announcement</th>
<th>10yr Treasury</th>
<th>USD corp A OAS</th>
<th>EUR-USD corp A OAS</th>
<th>GBP-USD corp A OAS</th>
<th>JPY-USD corp A OAS</th>
<th>AUD-USD corp A OAS</th>
</tr>
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<tr>
<td>0</td>
<td>-13.1</td>
<td>-0.7</td>
<td>0.1</td>
<td>1.3</td>
<td>-0.5</td>
<td>2.2</td>
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<td></td>
<td>(0.000)</td>
<td>(0.206)</td>
<td>(0.491)</td>
<td>(0.116)</td>
<td>(0.742)</td>
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<td>5</td>
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<td>4.0</td>
<td>10.1</td>
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<tr>
<td></td>
<td>(0.047)</td>
<td>(0.349)</td>
<td>(0.161)</td>
<td>(0.129)</td>
<td>(0.156)</td>
<td>(0.040)</td>
</tr>
<tr>
<td>15</td>
<td>-6.4</td>
<td>-16.2</td>
<td>10.3</td>
<td>11.6</td>
<td>20.2</td>
<td>35.4</td>
</tr>
<tr>
<td></td>
<td>(0.229)</td>
<td>(0.047)</td>
<td>(0.044)</td>
<td>(0.056)</td>
<td>(0.012)</td>
<td>(0.000)</td>
</tr>
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### Table B.2 Summary statistics
This table presents summary statistics on key variables used in the analysis.

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<th>Mean</th>
<th>S.D.</th>
<th>Min</th>
<th>Max</th>
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<td>Net monthly bilateral issuance/Total issuance (percent)</td>
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<td></td>
<td></td>
<td></td>
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<td>$issPct_{US\rightarrow AU}$</td>
<td>163</td>
<td>2.877</td>
<td>3.733</td>
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<td>22.90</td>
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<td>3.866</td>
<td>3.857</td>
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<td>-0.000781</td>
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<td>28.53</td>
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<tr>
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<td>12.67</td>
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<td>Residualized credit spread relative to US</td>
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<td></td>
<td></td>
<td></td>
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<td>AU</td>
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<td>11.51</td>
<td>-27.56</td>
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<td>19.99</td>
<td>-100.4</td>
<td>3.889</td>
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<tr>
<td>UK</td>
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<td>-7.571</td>
<td>14.17</td>
<td>-85.09</td>
<td>9.730</td>
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<td>JP</td>
<td>151</td>
<td>-29.90</td>
<td>32.07</td>
<td>-118.1</td>
<td>52.34</td>
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<tr>
<td>CIP deviation (5 year) in basis points</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AU</td>
<td>151</td>
<td>17.48</td>
<td>10.30</td>
<td>-9.750</td>
<td>48</td>
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<td>6.945</td>
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<td>34.50</td>
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<td>19.70</td>
<td>-65.50</td>
<td>5.750</td>
</tr>
<tr>
<td>EU</td>
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<td>-18.31</td>
<td>17.84</td>
<td>-66.55</td>
<td>3.040</td>
</tr>
<tr>
<td>UK</td>
<td>151</td>
<td>-7.533</td>
<td>12.19</td>
<td>-64.15</td>
<td>6.500</td>
</tr>
<tr>
<td>JP</td>
<td>151</td>
<td>-35.92</td>
<td>31.76</td>
<td>-99.30</td>
<td>16</td>
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<tr>
<td>Net deviation/effective credit spread differential</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>151</td>
<td>-9.565</td>
<td>12.69</td>
<td>-47.37</td>
<td>37.69</td>
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<td>-27.64</td>
<td>85.32</td>
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<td>JP</td>
<td>151</td>
<td>0.484</td>
<td>22.45</td>
<td>-91.65</td>
<td>86.18</td>
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Table B.3 Broker-dealer leverage and risk tolerance

This table presents the regression of the absolute level of credit and CIP deviations on proxies for collateral haircut and investor risk aversions. Broker-dealer leverage factor is constructed following Adrian, Etula and Muir (2014) using the Flow of Funds data.

<table>
<thead>
<tr>
<th></th>
<th>credit dev. [c]</th>
<th>cip dev. [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>levfac $\gamma^{-1}$</td>
<td>-4.916</td>
<td>-1.755</td>
</tr>
<tr>
<td></td>
<td>[-3.40]</td>
<td>[-2.26]</td>
</tr>
<tr>
<td>vix $\tau^{-1}$</td>
<td>0.932</td>
<td>0.499</td>
</tr>
<tr>
<td></td>
<td>[4.15]</td>
<td>[3.25]</td>
</tr>
<tr>
<td>_cons</td>
<td>17.83</td>
<td>18.37</td>
</tr>
<tr>
<td></td>
<td>[8.70]</td>
<td>[8.09]</td>
</tr>
<tr>
<td>N</td>
<td>288</td>
<td>906</td>
</tr>
<tr>
<td></td>
<td>[0.21]</td>
<td>[2.40]</td>
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<tr>
<td></td>
<td>288</td>
<td>906</td>
</tr>
</tbody>
</table>
Table B.4 Currency basis: Issuance and leverage impact

This table presents contemporaneous regressions of monthly changes in 10-year currency basis (CIP deviations) on net bilateral issuance flow (column 1), one-way issuance flows (columns 2 and 3), net bilateral issuance flow interacting with broker-dealer leverage (column 4), leverage-weighted net bilateral issuance flow (column 5), and net bilateral issuance flow controlling for contemporaneous change in log exchange rate (column 6). Net bilateral issuance flow, $\text{Iss}^{EU\rightarrow US}_t$, is defined as the amount of debt issuance by European firms in USD minus the amount of debt issuance by U.S. firms in EUR. Broker-dealer leverage is calculated from the Federal Reserve Flow of Funds, $\frac{\text{Total Financial Assets}^{BD}_t}{\text{Total Financial Liabilities}^{BD}_t}$. Leverage-weighted issuance flow is defined by $\text{IssLW}^{EU\rightarrow US}_t = \frac{\text{Iss}^{EU\rightarrow US}_t}{\text{BDLev}_t}$. Observations are monthly from 2002-2015. $t$-statistics are reported in brackets.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<tr>
<td>$\Delta \text{basis10yr}_t$</td>
<td>0.198</td>
<td>1.494</td>
<td>0.192</td>
<td>[3.72]</td>
<td>[2.15]</td>
<td>[3.94]</td>
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<td>$\text{IssEUtoUS}_t$</td>
<td>0.294</td>
<td>-0.0924</td>
<td>[-0.59]</td>
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<td></td>
<td></td>
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<td>$\text{IssUSToEU}_t$</td>
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<td>[-1.31]</td>
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<tr>
<td>$\ln \text{BDLev}_t$</td>
<td>-0.389</td>
<td>[-1.88]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Iss}^{EU\rightarrow US}_t \cdot \ln \text{BDLev}_t$</td>
<td>5.794</td>
<td>[4.05]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta e$</td>
<td>57.30</td>
<td>[5.78]</td>
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<td>cons</td>
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<td>1.915</td>
<td>-0.231</td>
<td>-0.244</td>
</tr>
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<td>164</td>
<td>164</td>
<td>164</td>
<td>164</td>
<td>164</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.079</td>
<td>0.083</td>
<td>0.010</td>
<td>0.099</td>
<td>0.092</td>
<td>0.237</td>
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</table>
Table B.5 Price impact of monthly issuance flow on currency basis

This table presents contemporaneous regressions of monthly changes in 10-year basis swap levels (CIP deviations) on bilateral and one-way issuance flows. Net bilateral issuance flow is defined as the amount of debt issuance by foreign firms in dollar minus the amount of debt issuance by U.S. firms in the foreign currency. Leverage-weighted issuance flow is defined by

\[ IssLW_{t}^{F \rightarrow US} = \frac{Iss_{t}^{F \rightarrow US}}{BDLev_{t}} \]

where BDLev_{t} is the U.S. broker-dealer leverage calculated from the Federal Reserve Flow of Funds. \( D_{post07} \) is a dummy indicating the period after the onset of the financial crisis starting in 2008. Sample observations are restricted to months with non-zero net bilateral issuance flow. Panel A presents the impact of monthly issuance flows on currency basis. Panel B presents the impact of monthly issuance flows weighted by broker-dealer leverage. \( t \)-statistics are reported in brackets.

### Panel A: Monthly Issuance flows

<table>
<thead>
<tr>
<th></th>
<th>EUR Δbasis10yr_t</th>
<th>GBP Δbasis10yr_t</th>
<th>JPY Δbasis10yr_t</th>
<th>AUD Δbasis10yr_t</th>
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<tr>
<td>Iss_{t}^{F \rightarrow US}</td>
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<td></td>
<td>[4.07]</td>
<td>[1.32]</td>
<td>[2.46]</td>
<td>[1.90]</td>
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<tr>
<td>IssFtoUS_{t}</td>
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<td>0.0729</td>
<td>0.497</td>
<td>0.220</td>
</tr>
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<td>[3.60]</td>
<td>[1.00]</td>
<td>[2.31]</td>
<td>[1.52]</td>
</tr>
<tr>
<td>IssUStoF_{t}</td>
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<td>-0.218</td>
<td>-0.368</td>
<td>-0.608</td>
</tr>
<tr>
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<td>[-1.88]</td>
<td>[-0.97]</td>
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</tr>
<tr>
<td>( D_{post07} )</td>
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<td>-0.799</td>
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<tr>
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<tr>
<td>cons</td>
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<tr>
<td>N</td>
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<td>R-sq</td>
<td>0.096</td>
<td>0.077</td>
<td>0.022</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>EUR Δbasis10yr_t</td>
<td>GBP Δbasis10yr_t</td>
<td>JPY Δbasis10yr_t</td>
<td>AUD Δbasis10yr_t</td>
</tr>
<tr>
<td>Iss_{t}^{F \rightarrow US}</td>
<td>6.638</td>
<td>3.811</td>
<td>11.88</td>
<td>8.209</td>
</tr>
<tr>
<td></td>
<td>[4.47]</td>
<td>[2.10]</td>
<td>[2.57]</td>
<td>[2.34]</td>
</tr>
<tr>
<td>IssFtoUS_{t}</td>
<td>8.519</td>
<td>3.472</td>
<td>13.31</td>
<td>7.017</td>
</tr>
<tr>
<td></td>
<td>[4.16]</td>
<td>[1.90]</td>
<td>[2.43]</td>
<td>[1.99]</td>
</tr>
<tr>
<td>IssUStoF_{t}</td>
<td>-4.110</td>
<td>-5.026</td>
<td>-11.34</td>
<td>-15.83</td>
</tr>
<tr>
<td></td>
<td>[-1.88]</td>
<td>[-1.75]</td>
<td>[-1.11]</td>
<td>[-1.25]</td>
</tr>
<tr>
<td>( D_{post07} )</td>
<td>-1.145</td>
<td>-1.080</td>
<td>-0.231</td>
<td>-0.930</td>
</tr>
<tr>
<td></td>
<td>[-1.65]</td>
<td>[-1.54]</td>
<td>[-0.34]</td>
<td>[-1.88]</td>
</tr>
<tr>
<td>cons</td>
<td>0.573</td>
<td>-0.862</td>
<td>0.778</td>
<td>0.743</td>
</tr>
<tr>
<td></td>
<td>[1.14]</td>
<td>[-1.62]</td>
<td>[1.19]</td>
<td>[1.69]</td>
</tr>
<tr>
<td>N</td>
<td>159</td>
<td>159</td>
<td>159</td>
<td>159</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.114</td>
<td>0.100</td>
<td>0.022</td>
<td>0.009</td>
</tr>
</tbody>
</table>
C Cross-currency basis as CIP deviation

Cross-currency basis $B$ is defined as the fair exchange of $\$\text{Libor}$ vs foreign Libor $+B$. Figure A.6 illustrates the cashflow of a cross-currency basis swap.

Define the following variables:

- $Z_T$: Domestic zero rate
- $Z_T^*$: Foreign zero rate
- $R$: Dollar par swap rate
- $R^*$: Foreign par swap rate
- $S$: Spot currency exchange rate at time 0. Dollar per 1 unit of foreign currency. e.g. EURUSD
- $F_T$: Forward currency exchange rate at time 0
- $T$: Maturity
- $B$: A swap of 3-month dollar Libor is fair against 3-month foreign Libor $+B$

Without CIP deviation, the forward exchange rate can be expressed as

$$F = S \frac{(1 + Z)^T}{(1 + Z^*)^T}.$$ 

A simplified definition of CIP deviation can be expressed as $\Delta$ in the following equation

$$F = S \frac{1 + r}{1 + r^* - \Delta}.$$ 

Using a replication portfolio similar in methodology as Tuckman and Porfirio (2003), I show that

$$F_* = \frac{S_0}{(1 + Z^*)^T} \left( 1 + B \frac{(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T} \right)^{-1}.$$ 

Consider the following replicating portfolio for a cross-currency basis swap

Positive=Receive, Negative=Pay
<table>
<thead>
<tr>
<th>Transaction</th>
<th>t0 ($)</th>
<th>Interim ($)</th>
<th>T ($)</th>
<th>t0 (F)</th>
<th>Interim (F)</th>
<th>T (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rec. Euribor + ( B ) vs pay $Libor cross-currency swap</td>
<td>( +S_0 )</td>
<td>( -S_0L_t )</td>
<td>( -S_0 )</td>
<td>( -1 )</td>
<td>( L_t^* + B )</td>
<td>( +1 )</td>
</tr>
<tr>
<td>Spot FX</td>
<td>( -S_0 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( +1 )</td>
</tr>
<tr>
<td>Foreign: Pay fixed/rec. floating par swap in amount ( \frac{B}{R^*} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( B/R^<em>[L_t^</em> - R^*] )</td>
</tr>
<tr>
<td>Foreign: Pay floating zero coupon swap (ZCS) in amount ( 1 + \frac{R^*}{R} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( -L_t^* \left[1 + \frac{B}{R^<em>}\right] \left[1 + \frac{B}{R^</em>}\right] [1 + Z^*]^T - 1 )</td>
</tr>
<tr>
<td>Dollar: Rec. floating ZCS in amount ( S_0 )</td>
<td>( S_0L_t )</td>
<td>( -S_0 \left[(1 + Z)^T - 1\right] )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sell foreign fwd. of in amount ( \frac{S_0(1+Z)^T}{F} )</td>
<td>( \frac{S_0(1+Z)^T}{F} )</td>
<td></td>
<td></td>
<td></td>
<td>( -\frac{S_0(1+Z)^T}{F} )</td>
<td></td>
</tr>
</tbody>
</table>

Setting the foreign cash flow in time \( T \) equal to 0, we get

\[
\left(1 + \frac{B}{R^*}\right) \left[(1 + Z^*)^T - 1\right] + 1 = \frac{S_0(1 + Z)^T}{F}
\]

\[
(1 + Z^*)^T + \frac{B}{R^*} \left[(1 + Z^*)^T - 1\right] = \frac{S_0(1 + Z)^T}{F}
\]

\[
1 + \frac{B}{R^* (1 + Z^*)^T} = \frac{S_0(1 + Z)^T}{F (1 + Z^*)^T}
\]

\[
F = \frac{S_0(1 + Z)^T}{(1 + Z^*)^T} \left(1 + \frac{B}{R^* (1 + Z^*)^T}\right)^{-1}
\]

\[
F_{d/f} = \frac{S_{d/f}(1 + Z)^T}{(1 + Z^*)^T} \left(1 + PV^*[B]\right)^{-1}
\]

Now relating this to the simplified definition

\[
F = S \frac{(1 + Z)^T}{(1 + Z^* - \Delta)^T}
\]
We set the two relations equal to each other and obtain

\[
\frac{1}{(1 + Z^* - \Delta)^T} = \frac{1}{(1 + Z^*)^T} \left[ 1 + \frac{B(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T} \right]^{-1}
\]

\[
(1 + Z^* - \Delta)^T = \left[ 1 + \frac{B(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T} \right] (1 + Z^*)^T
\]

LHS can be Taylor approximated around \( B = 0 \) as \((1 + Z^*)^T + T (1 + Z^*)^{T-1} B\), therefore

\[
(1 + Z^*)^T + T (1 + Z^*)^{T-1} \Delta \approx \left[ 1 + X \frac{(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T} \right] (1 + Z^*)^T
\]

\[
\frac{T \Delta}{1 + Z^*} \approx -B \frac{(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T}
\]

\[
\Delta \approx -B \left[ \frac{(1 + Z^*)^T - 1}{R^* (1 + Z^*)^T} \right] \frac{1 + Z^*}{T}
\]

With the definition of a swap \( R^* = \frac{1-(1+Z^*)^{-T}}{\sum_{t=1}^{T}(1+z_{0,t}^*)^T} \), we get

\[
\Delta \approx -B \left[ \sum_{t=1}^{T} (1 + Z_{0,t}^*)^{-t} \right] \frac{1 + Z^*}{T}
\]

Suppose zero rate for different maturities are constant, \( Z_{0,t} = Z_{0,T} = z \), i.e. the zero curve is flat (this also implies flat swap curve). Generally zero curves are upward sloping. Assuming a flat curve bias the discount factor to be smaller, thus making a more conservative estimation. Then the PV becomes

\[
\sum_{t=1}^{T} (1 + z^*)^{-t} = -\frac{(z^* + 1)^{-T} - 1}{z^*}
\]

and \( \Delta \) becomes

\[
\Delta \approx -PV \frac{1 + z^*}{T} - B
\]

\[
\approx \left[ \frac{(z^* + 1)^{-T} - 1}{z^* T} \right] B
\]

\[
\approx - \left[ 1 + \frac{1}{2} (1 - T) z^* + 1/6(T^2 - 1) (z^*)^2 \right] B
\]

where the last line applies 3rd order Taylor approximation.
D Extended model

D.1 Credit markets

In this static model, there are two credit markets: the euro-denominated corporate bond market and the dollar-denominated corporate bond market, and three main credit market players: active local investors in Europe, active local investor in the U.S. and a representative firm that has access to both debt markets.

Local investors I impose the assumption that the active local investors are restricted to investments in their home currency. U.S. active investors specialize in the investment of corporate bonds denominated in dollars. They borrow at the domestic short rate, \( r_U \), and purchase bonds with a promised net yield of \( Y_U \). With fixed probability \( \pi \), the bonds default and lose \( L \) in value. The payoff of the bonds has a variance of \( V_C \), which is treated as an exogenous constant in the model for tractability\(^ {25} \). Investors have a mean-variance preference with risk tolerance \( \tau_i \) and choose investment amount \( X_U \) to solve the following

\[
\max_{X_U} \left[ X_U \left( (1 - \pi) Y_U - \pi L - r_U \right) - \frac{1}{2\tau_i} X_U^2 V_C \right] 
\]  

which has the solution

\[
X_U = \tau_i \frac{(1 - \pi) Y_U - \pi L - r_U}{V_C}.
\]  

Similarly, the European credit investors are constrained to invest in euro-denominated bonds. For simplicity, assume that the default probability, loss given default and payoff variance are the same for bonds in both markets\(^ {26} \). European credit investors have a demand of

\[
X_E = \tau_i \frac{(1 - \pi) Y_E - \pi L - r_E}{V_C}.
\]

Exogenous credit demand shocks In addition, I introduce idiosyncratic demand shocks of \( \epsilon_U \) in dollar bonds and \( \epsilon_E \) in euro bonds. These shocks are exogenous to the model and perhaps represent demand shocks that originate from Quantitative Easing or preferred-habitat investors with inelastically demands such as pension funds, insurance companies and endowments. The sources of exogenous shocks are discussed in Section 4.

\(^ {25} \)A Bernoulli default distribution with probability \( \pi \), loss-given-default \( L \) and promised yield \( Y_U \) implies that \( V_C = \pi (1 - \pi) (Y_U + L)^2 \). The solution to the investors’ problem would contain a quadratic root. To keep the model tractable, \( V_C \) is assumed to be an exogenous constant.

\(^ {26} \)Given common default probability \( \pi \) and loss-given-default \( L \), payoff variance \( V_C \) of euro-denominated and dollar-denominated bonds can only be the same if the promised yields \( Y_U \) and \( Y_E \) are also identical. With a small difference in \( Y_U \) and \( Y_E \) in comparison to \( L \), \( V_C \) is assumed to be the same for both markets.
**Firm** The representative global firm needs to issue a fixed debt amount $D$. The firm chooses a share $\mu$ of the debt to be issued in dollar at a cost of $Y_U$. The reminder $1 - \mu$ of the debt is issued in euro promising a coupon of $Y_E$. The firm is a price taker, and its decision is analyzed in Section D.3.

**Market clearing conditions** in the dollar and euro credit market are

\[
X_U + \epsilon_U = \mu D \\
X_E + \epsilon_E = (1 - \mu) D.
\]

Combining the demand equations with the market clearing conditions and applying first-order taylor approximation for $\pi$ around 0, we can write the difference in promised yield between euro and dollar bonds as a credit spread difference, $c$, and a risk-free rate difference, $\rho$.

\[
Y_E - Y_U = \underbrace{\frac{V_C}{\tau_i} ((1 - 2\mu) D - \epsilon_C)}_{c} + \underbrace{(r_E - r_U)}_{\rho}.
\]

where $\epsilon_C \equiv \epsilon_E - \epsilon_U$ is the relative idiosyncratic euro credit demand. The credit spread differential, $c$, is a function of dollar issuance share $\mu$, local investor risk preference $\tau_i$, payoff variance $V_C$ and relative credit demand shock. $c$ represent a price discrepancy of credit risk since the default probability and loss given default are identical across the two markets.

The cross-currency issuer has limited ability to influence the relative credit spread. If it chooses all of its debt to be issued in euro instead of dollar, i.e. $\mu = 0$, then the relative credit spread in euro would widen as a result of the additional debt supply. The issuer’s impact is limited, however, by the size of its total debt issuance $D$ given the restriction that $\mu \in [0, 1]$.

**D.2 Currency swap market**

Next, I describe the dynamics of the currency swap market. There are two main players in this market: currency swap traders and issuers.

**Currency swap traders** Currency swap traders choose amount of capital to devote to either CIP deviations, denoted as $b$, or alternate investment opportunity with profit of $f(I)$, where $I$ is the amount of investment. $b$ is defined in the same way as in Section 3. When $b$ is positive, the FX-implied euro funding rate is high relative to the actual euro funding
rate. Therefore, FX swap traders simultaneously lend out euro and borrow dollar through purchasing dollar in the spot market and selling dollar in the forward market. They enter into a swap size of $s$, where $s > 0$ when the trader is lending out euro. When $b$ is negative, the FX-implied euro funding rate is low, and FX swap trader borrows in euro and lends in dollar by entering into a swap position with $s < 0$.

The arbitrageur has to set aside a haircut $H$ when it enters the swap transaction to arbitrage CIP violation. Following Garleanu and Pedersen (2011), the amount of haircut is assumed to be proportional to the size $s$ of the swap position, $H = \gamma |s|$. Therefore, the capital devoted towards alternative investment is $I = W - \gamma |s|$. Swap traders has total wealth $W$ and solve the following

$$\max_s bs + f(W - \gamma |s|)$$

which generates the intuitive result that the expected gain from conducting a unit of additional CIP arbitrage is equal to marginal profitability of the alternative investment, $b = sign[s] \gamma f'(W - \gamma |s|)$. A simple case is when the alternative investment activity is quadratic, $f(I) = \phi_0 I - \frac{1}{2} \phi I^2$. In this case, $b = sign[s] \gamma (\phi_0 - \phi W + \gamma \phi |s|)$.

I make an additional simplifying assumption that CIP deviation $b$ disappears when there is no net demand for swaps, but as soon as there is net demand for swaps, $b$ becomes non-zero. This assumption is equivalent to stating $\frac{\partial b}{\partial \phi} = W$, which means that arbitrageur has just enough wealth $W$ to take advantage of all positive-NPV investment opportunities in the alternative project $f(I)$. Simplifying with this assumption remove the constant intercept term in the equation above for $b$, and we obtain that CIP deviation is proportional to swap trader position,

$$b = \phi \gamma^2 s.$$ 

This model of swap traders is analogous to that of Ivashina, Scharfstein, and Stein (2015) which modeled the outside alternative activity with a log functional form.

**Firm** The same representative firm from the credit market also engages in FX swap transactions as a price taker. The issuer has a desired dollar funding ratio of $m$ and euro funding ratio of $1 - m$. This target could represent the firm’s operational exposures in different currencies. For instance, AT&T would have $m = 1$ since its operations in entirely in the U.S. The issuer thus has an exchange rate exposure of $(m - \mu)$ given its choice of dollar issuance share $\mu$. It chooses a hedging ratio $h \in [0, 1]$ for a total amount of hedged foreign issuance $(m - \mu) hD$. From the perspective of a U.S.-based issuer with $m = 1$, e.g. AT&T, the hedging amount $(1 - \mu) hD$ is positive and represents the issuer’s dollar borrowing via the FX market. AT&T buys dollar in the spot market for conversion of euro issuance proceed
into dollars and sells dollar in the forward market for future repayment of debt. The currency swap trader must hold the opposite position, that is, lending dollar to AT&T by selling dollar in the spot market and buying dollar in the forward market.

**Exogenous FX swap demand** In addition, there is a source of exogenous shock \( \epsilon_F \) that represent other non-issuance-related use of FX-swaps. One source of \( \epsilon_F \) shock in recent period has emanated from regulatory changes. For instance, U.S. money market reform has reduced the availability of wholesales dollar funding to foreign banks and increased their reliance on funding via currency swaps (Pozsar 2016). Other sources of exogenous shocks are discussed in Section 4.

**Equilibrium** Market clearing condition of the FX swap market implies that the equilibrium level of CIP deviation satisfies

\[
 b = -\gamma^2 \phi \left( D (m - \mu) h + \epsilon_F \right)
\]

The negative sign arise since the swap trader take the opposite position of the hedging demand. Equation 16 provides several intuitive comparative statics. First, CIP deviation \( b \) is proportional to the total amount of hedging demand \( D (m - \mu) h + \epsilon_F \). \( b \) is negative when there is a net hedging demand for borrowing dollar/lending euro, that is when \( D (m - \mu) h + \epsilon_F > 0 \). This can occur if the issuer has a dollar funding shortfall, \( m > \mu \), e.g. AT&T issues a fraction of its bond in euro but has its entire funding need in U.S. dollar, and therefore needs to borrow dollar/lend euro via the FX market. On the other hand, \( b \) is positive when the net hedging demand is for borrowing euro/lending dollar. Second, more stringent haircut requirements \( \gamma \) intensifies the impact of hedging demand for either positive or negative deviations.

One additional insight on the role of the issuer in the above setup is that debt issuer hedging demand \( D (m - \mu) h \) does not have to have the same sign as other exogenous hedging demand, \( \epsilon_F \). If \( \epsilon_F \) has the opposite sign as and larger in magnitude than the issuer demand, the issuer would incur an additional benefit (instead of cost) through hedging. In this case, the firm would contribute to the elimination of CIP deviation and act as a provider of liquidity in the currency forward market.

**D.3 The Firm’s Problem**

Putting it all together, I describe the firm’s optimization problem and first order conditions. The representative firm has a mean-variance preference and wants to minimize the total cost of issuance while avoiding exchange rate volatility. It chooses fraction \( \mu \) of the debt to be
issued in dollar and hedging ratio $h$ to minimize the total financing cost. Dollar debt carries a promised yield of $Y_U$, and the remainder are issued in euro at a yield of $Y_E \equiv Y_U + c + \rho$. I assume for simplicity that Uncovered Interest Rate Parity holds\(^{27}\), therefore the difference of unhedged funding cost between issuing in EUR and USD is $c$. However, unhedged issuance that deviate from the firm’s desired funding needs exposure it to exchange rate variance $V_F$ and incurs a cost on the portion of unhedged currency exposure\(^{28}\). Since $D(m - \mu)$ is the currency mismatch and $1 - h$ fraction of this mismatch is unhedged, the cost due to FX volatility is $\frac{1}{2\tau_F} D^2 (m - \mu)^2 (1 - h)^2 V_F$. FX hedging imposes an adjustment to debt servicing cost equal to the amount of hedging need $(m - \mu) h$ multiplied by the per-unit price of hedging $b$, which is the deviation from CIP.

Given the above setup, the firm solves

$$
\min_{\mu, h} D \begin{bmatrix}
\mu Y_U & (1 - \mu)(Y_U + c) & (m - \mu) hb & \frac{1}{2\tau_F} D (m - \mu)^2 (1 - h)^2 V_F
\end{bmatrix}. \tag{17}
$$

Cross-currency issuers are taken to be a representative firm that is a price taker in the credit and FX swap markets. That is, there can be many other identical firms of total measure one solving the same optimization problem. Their debt issuance in each market determines the bond yields and currency swap levels but they take the equilibrium prices as given when solving their optimizing problem.

We first analyze the partial equilibrium solution in the firm’s problem before considering the general equilibrium in section (D.4). The firm’s first order conditions are

$$
\mu^* = m + \frac{\tau_F(c - bh^*)}{D(h^* - 1)^2 V_F} \tag{18}
$$

and

$$
h^* = 1 + \frac{\tau_F b}{(m - \mu^*) D V_F}. \tag{19}
$$

Equation 18 says that the issuer has a natural inclination to issue a fraction $m$ of the total debt in dollar to obtain the optimal capital structure. With credit market frictions, dollar

\(^{27}\)The assumption of UIP can be relaxed without changing the main results involving CIP violation.

\(^{28}\)The incentive to hedge volatile cashflows can be rationalized in the framework of costly external finance and firm’s incentive to keep sufficient internal funds available to take advantage of attractive investment opportunities (Froot, Scharfstein, and Stein 1992).
issuance share increases in the relative euro credit spread $c$. That is, if AT&T’s euro credit spread were wide relative to dollar, then it is more incentivized to issue in dollar. Similarly, segmentation in the FX market also affect the equilibrium share of issuance in dollar. When the cost of borrowing dollar in the FX market is large, $b < 0$, AT&T is reluctant to issue in euro and engage in the swapping of proceeds to dollar, therefore dollar issuance ratio $\mu^*$ is high.

Equation 19 expresses the optimal hedging ratio in terms of the optimal share of dollar issuance. I impose the assumption that the issuer cannot make a pure exchange rate bet, thus $h \in [0, 1]$. When there is a dollar financing shortfall ($m > \mu^*$), hedging is incomplete ($h < 1$) if there is a costly CIP deviation for borrowing dollar via the FX market ($b < 0$). Similarly, when there is a euro financing shortfall $m < \mu^*$, hedging is incomplete when it is costly to borrow euro via the FX market ($b > 0$). Furthermore, hedging ratio approaches unity when the firm has zero risk tolerance $\tau_F$, large amount of issuance-driven FX exposure $(m - \mu^*) D$, or when FX volatility is high. In sum, hedging is incomplete when it is costly and more complete when the firm is averse to large risks.

D.4 Perfect alignment of deviation

Rewriting equations (14), (16), (18), and (19), we have four equilibrium conditions and four endogenous variables ($b$, $c$, $\mu$, $h$) summarized again below:

- Credit spread difference (euro minus dollar credit spreads)

\[ c = \frac{V_C}{\tau_i} \left( (1 - 2\mu) D + \varepsilon_C \right) \]  
\[ (14) \]

- CIP violation (FX-implied minus actual euro funding rate)

\[ b = -\gamma^2 \phi \left( D (m - \mu) h + \varepsilon_F \right) \]  
\[ (16) \]

- Issuance share in dollar

\[ \mu = m + \frac{\tau_F (c - bh)}{D(h - 1)^2 V_F} \]  
\[ (18) \]

- Hedging ratio

\[ h = 1 + \frac{\tau_F b}{(m - \mu) DV_F} \]  
\[ (19) \]

The first two equations represent equilibrium conditions that determine the price deviations in the FX and credit markets. The last two equations are FOCs from the firm’s
issuance and hedging decisions. Two types of shocks are exogenous to the system: credit demand shock $\varepsilon_C$ (positive indicates relative demand for euro credit) and FX swap demand shock $\varepsilon_F$ (positive indicates dollar-borrowing demand).

We can solve the model and obtain the general equilibrium solutions for $c$, $b$, $\mu$, and $h$. We analyze the solution for $c$ and $b$, and especially focuses on the shock terms.

$$c = b = - (\varepsilon_C + 2\varepsilon_F + D(2m - 1))$$  \hspace{1cm} (20)

where $\Lambda$ is a positive constant, $\Lambda = D\gamma^2\phi V_C V_F / (2\gamma^2\phi V_C \tau_F + 2V_C V_F + \gamma^2\phi V_F \tau_i)$

- $c$ and $b$ have perfect correlation and identical magnitude
- $c$ and $b$ can be individually large
- Relative credit demand for euro bonds $\varepsilon_C$ and demand for swapping into dollar (buy dollar spot/sell dollar forward) $\varepsilon_F$ both make $c$ and $b$ more negative: $\frac{\partial c}{\partial \varepsilon_C} = \frac{\partial b}{\partial \varepsilon_C} < 0$ and $\frac{\partial c}{\partial \varepsilon_F} = \frac{\partial b}{\partial \varepsilon_F} < 0$

D.5 Imperfect alignment of deviations

In the earlier section, I introduced the model to show a simple case of perfect alignment between the two deviations. Next, I explore more realistic case in which there are imperfect alignment. Since the firm integrates the two deviations, there must be some frictions that prevent the firms from completely aligning the two deviations.

$$\min_{\mu, h} \begin{bmatrix} -\mu c \\ \text{credit spread diff.} \end{bmatrix} + \frac{1}{\tau_C} (m - \mu)^2 + (m - \mu) hb + \frac{1}{2\tau_F} D (m - \mu)^2 (1 - h)^2 V_F$$

- $\frac{1}{\tau_C} (m - \mu)^2$ comes from refinancing risk due to the concentration of bond ownership (Boermans 2016), or collateral constraints for hedging (Rampini and Viswanathan 2010)
  - Loosely speaking, $\tau_C$ represent balance sheet strength
Partial equilibrium; FOC condition for $\mu^*$

$$\mu^* = m + \tau_x (c - b)$$ (22)

$h^*$ is the same as before.

Examining the general equilibrium solution yield additional implications. The solution can be best written in matrix form,

$$
\begin{pmatrix}
  c \\
  b \\
  c - b \\
  \mu
\end{pmatrix}
= \Lambda
\begin{bmatrix}
  -(\tau_x \gamma^2 \phi V_F D + \gamma^2 \phi \tau_F + V_F) V_C & -2\gamma^2 \phi \tau_x V_F D \\
  -\tau_x \gamma^2 \phi V_F D V_C & -\gamma^2 \phi (2\tau_x V_F D + \tau_i) V_F \\
  -(\gamma^2 \phi \tau_F + V_F) V_C & \gamma^2 \phi \tau_i V_F \\
  -\tau_x (\gamma^2 \phi \tau_F + V_F) V_C & \tau_x \gamma^2 \phi \tau_i V_F
\end{bmatrix}
\begin{pmatrix}
  \varepsilon_C \\
  \varepsilon_F
\end{pmatrix} + \text{const.}
$$

(23)

where

$$\Lambda = \left[ \gamma^2 \phi (\tau_F (2D_V C \tau_x + \tau_i) + D_V F \tau_i \tau_x) + V_F (2D_V C \tau_x + \tau_i) \right]^{-1}$$

**Proposition 5.** (The alignment of deviations) When firms are relatively unconstrained by capital structure considerations, $\tau_x \gg 0$, the credit spread differential and CIP deviations respond similarity to shocks to either credit or FX swap demand, $\frac{\partial c}{\partial \varepsilon_C} \approx \frac{\partial b}{\partial \varepsilon_C}$ and $\frac{\partial c}{\partial \varepsilon_F} \approx \frac{\partial b}{\partial \varepsilon_F}$. The two deviations also has similar magnitude, $c \approx b$. When firms are completely unconstrained in capital structure, $\lim_{\tau_x \to \infty} c = \lim_{\tau_x \to \infty} b$.

As we have already seen in Equation 23, the two violations share common loadings on $\varepsilon_F$ and $\varepsilon_C$ shocks. Rewriting the comparative statics of the violations with respect to the shocks, we have

$$
\frac{\partial c}{\partial \varepsilon_C} = \frac{\partial b}{\partial \varepsilon_C} + \frac{1}{\tau_x} \frac{\partial \mu}{\partial \varepsilon_C}
$$

and

$$
\frac{\partial c}{\partial \varepsilon_F} = \frac{\partial b}{\partial \varepsilon_F} + \frac{1}{\tau_x} \frac{\partial \mu}{\partial \varepsilon_F}.
$$

When the issuer is completely unrestricted in the choice of issuance currency, the two deviations are perfectly aligned in response to shocks, i.e. $\lim_{\tau_x \to \infty} \frac{\partial c}{\partial \varepsilon_C} = \lim_{\tau_x \to \infty} \frac{\partial b}{\partial \varepsilon_C}$ and $\lim_{\tau_x \to \infty} \frac{\partial c}{\partial \varepsilon_F} = \lim_{\tau_x \to \infty} \frac{\partial b}{\partial \varepsilon_F}$. Empirically, the two time series have a high level of correlation but not perfectly correlated. This indicates that issuers have a $\tau_x$ that is high but not infinite.

**Proposition 6.** (The co-movement of cross-currency issuance with net deviation) $\text{Sign} \left[ \frac{\partial \mu}{\partial \varepsilon} \right] = \text{Sign} \left[ \frac{\partial (c-b)}{\partial \varepsilon} \right]$ and $\text{Sign} \left[ \frac{\partial \mu}{\partial m} \right] = -\text{Sign} \left[ \frac{\partial (c-b)}{\partial m} \right]$. Dollar issuance ratio $\mu$ is positively correlated to the net deviation $c - b$ when shocks originate from the demand for credit or FX
forward. $\mu$ is **negatively** correlated to $c - b$ when shocks originate from exogenous changes in the desired issuance currency mix $m$ (**supply** shocks).

Suppose AT&T is thinking of expanding into Europe and needs raise funding in EUR. Effectively, its dollar target funding ratio $m$ is dropped. When it attempt to raise fund in EUR, it does so by both issuing in EUR and swapping dollar issuance into EUR. With more euro issuance, it’s dollar funding ratio $\mu$ is dropped. Issuing in Euro increases its euro credit spread, so $c$ is higher. Borrowing euro via FX swap increases the borrowing cost of euro, that is $b$ increases, however, this increase is less than the increase in $c$ since transmission of shock is imperfect. Therefore $\frac{\partial c - b}{\partial (-m)} > 0$ while $\frac{\partial \mu}{\partial (-m)} < 0$. I show this in general equilibrium in the appendix.

**Proposition 7.** *(The cross-section of issuance-based arbitrage)* $\frac{\partial^2 \mu}{\partial c \partial \tau_X} < 0$, $\frac{\partial^2 \mu}{\partial e \partial \tau_X} > 0$, and $\frac{\partial^2 (c - b)}{\partial e \partial \tau_X} < 0$. Firms with stronger balance sheet (higher $\tau_X$) respond more aggressively to demand shocks in credit and FX, and their firm-specific net deviation is less responsive to shocks.

**Proposition 8.** *(The balance sheet of financial intermediary)* $\frac{\partial c}{\partial \gamma} < 0$, $\frac{\partial b}{\partial \gamma} < 0$. When haircut for swap traders $\gamma$ is high, both deviations are more responsive to demand shocks. The effect on net deviation is ambiguous, depending on the source of the shock.

**Proposition 9.** *(The amount of capital available for arbitrage use)* $\frac{\partial (c - b)}{\partial c} > 0$, $\frac{\partial (c - b)}{\partial e} < 0$. The impact of shocks on the net deviation is smaller when total amount of debt issuance is high.

This follows the intuition that when issuers are able to provide enough cross-market arbitrage capital, the FX funding and credit markets become more integrated.

**Proposition 10.** *(Risk and risk tolerance)* $\frac{\partial c}{\partial V_C} < 0, \frac{\partial b}{\partial V_C} < 0$, $\frac{\partial c}{\partial \tau_F} > 0$, and $\frac{\partial b}{\partial \tau_F} > 0$. With higher payoff variance $V_C$, exchange rate variance $V_F$ or lower risk tolerances $\tau_F$ and $\tau_i$, the impact of demand shocks on credit spread differential and CIP violations are amplified.

\[
\frac{\partial (c - b)}{\partial m} = -2\gamma^2 \phi \tau_F BV_C - 2BV_C V_F \\
\frac{\partial \mu}{\partial m} = \gamma^2 \phi \tau_i V_F B + \tau_i V_F + \tau_i \gamma^2 \phi \tau_F
\]
This is because when the credit markets have perfectly elastic supply curves, credit demand shocks are unable to make a dent in the relative price of credit in the first place; therefore, no misalignment is created. Similarly, the FX shock misalignment term \( \frac{1}{\tau_x} \frac{\partial \mu}{\partial \varepsilon_F} \) converges to zero as either FX arbitrageur’s risk tolerance or issuer’s tolerance for exchange rate volatility approach infinity. That is, when FX arbitrageur or issuer provides perfectly elastic supply of FX swaps, \( \varepsilon_F \) shocks would not make an impact on CIP, thus, no misalignment between \( c \) and \( b \) is created. Case studies of exogenous credit shock and FX funding shock.

### E Case studies

This section showcase two case studies that are illustrative of the impact of credit shock and FX funding shock on the equilibria. These cases highlight the model’s central predictions as well as its shortcomings. I construct net issuance flow between the Eurozone and the U.S. aggregated at the monthly level and residualized credit spread time series at the daily interval.

Precisely estimated event studies are inappropriate in this context for a number of reasons. First, cross-market arbitrage capital are slow moving, and therefore the transmission of shock from one market to another can take a long time to complete and the statistical power of tests are low for longer horizons. This point is analyzed in a model of market segmentation and slow moving capital by Greenwood, Hanson, and Liao (2015). Second, major policy announcements events are anticipated well in-advance, reducing the surprise contained in the announcements. For instance, most QE announcements are highly anticipated and priced by market participants before the event date. Gradualism in monetary policy can also induce rational agents to react strongly to the initial policy adjustment and price in subsequent adjustments in monetary policy that are inertial (Stein and Sunderam 2016). Third, the data in this context is especially unsuited for precisely estimated impacts upon an event. In the quantity data, the cross-currency debt issuance time series is especially lumpy given the large day-to-day idiosyncrasies to how many large issuances are placed on the market. Issuers also tend to avoid anticipated events that would cause market volatility. I aggregate the data at the monthly level to smooth the impact of any single issuance, although large one-off issuance can still have a sizable contribution to the monthly number. In the price data, the credit spread differential time series are formed by point estimates of cross-sectional regressions in each date. The 95% confidence interval is generally tight in the range of 10 basis points, but can be as large as over 50 basis points during the peak of the crisis. Therefore it would inappropriate to conduct a standardized event study.
While these case studies fall short of event studies, they non-the-less highlight key elements of the model predictions.

E.1 U.S. Credit Crunch and Bear Stearns downfall

I first begin with an analysis of a possible shock to the credit market. Figure A.14 presents the two LOOP violations and the monthly net issuance flow around the time of Bear Stearns’ collapse and the onset of the Financial Crisis. The two vertical lines indicate the collapse of Bear Stearns and Lehman Brothers respectively. I focus more on Bear Stearns for two reasons. One, while the collapse of Bear Stearns had significant impacts on the financial market, there were no pervasive halting of trading and liquidity provision in the fixed income and derivatives market as there were after Lehman’s collapse. Lehman’s bankruptcy closed down its broker-dealer operation overnight and left all of its counter parties exposed to sizable unmatched risks. Therefore, observed prices in credit and FX derivatives might have reflected the severe draw back in liquidity and supply rather than just reflect swaps demand. Relating to the model developed above, Lehman’s collapse might have coincided with both a shock in $\varepsilon_C$ and in $\varepsilon_F$ as counter parties frantically search to replace their unmatched book exposure immediately following the ceasing of Lehman’s broker-dealers, and there might have been substantial shifts in the risk tolerance of swap arbitrageurs, $\tau_s$. In contrast, Bear Stearns’ downfall might be more representative of a shock in $\varepsilon_C$ alone, as sentiments regarding dollar credit was affected without simultaneous shocks to CIP. Two, the collapse of Bear Stearns was more unexpected relative to that of Lehman Brothers. Bear Stearns’ stock price was as high as $68$ a share on March 11, 2008, the week prior to it agreed to be bought out by JP Morgan the firm at the price of $2$ a share on March 17, 2008.\(^{30}\) In comparison, Lehman’s collapse, although a large shock to the world, was followed a prolonged deterioration in its stock price from around $20$ per share in the beginning of 2008 to $10$ a share on September 12, 2008, the Friday before its filing of bankruptcy.

As Panel A of Figure A.14 shows, the residualized dollar credit spread widened (euro spread tightened) in March 2008. This tightening of the relative euro residualized credit spread was reversed over the course of the next few months, but dollar credit largely remained underpriced relative to euro credit over the summer. On the other hand, CIP deviation did not show much response initially upon Bear Stearns’ collapse but drifted downwards more gradually over the summer. Panel B shows that the net deviation (credit minus CIP) dropped to a low around -30 bps around the time of Bear’s downfall as the gap between credit and CIP widened during this period. Panel C shows that large net issuance flow from U.S. to Europe

\(^{30}\)A revised deal of $10$ a share was struck on March 24, 2008 as a class action was filed on behalf of shareholders challenging the original terms of the acquisition.
ensued in March and continued for several months until July. This is suggestive that more U.S. firms decided to issue in Europe, as the credit condition in the U.S. was unfavorable. Their debt-related hedging might have contributed to the more gradual downward drift of CIP violations, which also made their hedging (buy euro forward) more costly.

E.2 Eurozone Sovereign Crisis circa 2011-2012

Next, I present a plausible FX funding shock that directly affected CIP deviation and indirectly affected the credit market. Concerns over European sovereign debt begin to surface in 2009 and intensified in the early part of 2011. While this initially started as concerns regarding the credit worthiness of European banks, it soon became large shock in the CIP market. In May 2011, large outflows in money mutual fund that are exposed to Eurozone banks led to a shrinkage of dollar funding for these banks. Chernenko and Sunderam (2014) document that the total money-fund holdings of Eurozone bank paper declined by 37%, from $453 billion to $287 billion, between May and August of 2011. The shrinkage of the dollar funding market meant that Eurozone banks with dollar operations needed to rely on the FX funding market to swap their euro funding base into dollar, and this created direct price pressure on CIP deviation (Ivashina, Scharfstein, and Stein 2015).

Figure A.15 presents the two LOOP violations and the monthly net issuance flow during the Eurozone Sovereign Crisis in 2011-2012. Panel A shows that the 5-year CIP deviation widened from around -15 bps in early May to -70 bps by January 2012. A negative CIP means that the FX implied euro funding rate was lower than the actual euro funding rate, and this implies that it is costly to borrow dollar/lending euro through the FX funding market. As the Eurozone banks were mainly interested in replacing its short-term funding, the widening in CIP for short maturities was even more striking. Figure A.13 shows that the 3-month CIP widened to as much as -125 bps. As Panel B shows, the widening of CIP raised the net deviation of credit minus CIP, resulting in an overall higher cost of issuing bonds in the U.S.

Panel C shows that net issuance flow that were previously tilted towards European firms issuing in the U.S. declined dramatically from over $12 billion in April 2011 to close to zero over the reminder of the year. The net issuance flow, however, did not reverse direction. That is, there were few U.S. firms attempting to issue in Euro to take advantage of the net deviation. This perhaps indicates that firms were reluctant to place large issuance in euro given uncertainties regarding the future of the euro. Global credit investors likely also shared the firms’ concerns when deciding on the arbitrage opportunity. As a result of the slowness and reluctance in arbitrage capital deployment, the residualized credit spread only gradually
declined over this period as Panel A shows.