Financial Amplification of Foreign Exchange Risk Premia

Tobias Adrian, Erkko Etula, Jan Groen
Federal Reserve Bank of New York

Brussels, July 23-24, 2010
Conference on Advances in International Macroeconomics—Lessons from the Crisis
ECFIN/ULB/UBC

1The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.
Financial Market Monitoring

- Are current asset valuations "high" or "low"?
- How do the valuations link to macro fundamentals?
- What are the implications for financial stability?
Systemic Risk in the FX Markets


- Brunnermeier and Pedersen (2009): Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices.

- Korinek (2010): Ties systemic risk in international capital flows explicitly to the welfare losses due to balance sheet constraints of financial institutions.

Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks
Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
  - Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices

Korinek (2010):
- Ties systemic risk in international capital flows explicitly to the welfare losses due to balance sheet constraints of financial institutions

- International macro and leverage dynamics
Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
  - Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices

- Korinek (2010):
Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
  - Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices

- Korinek (2010):
  - Ties systemic risk in international capital flows explicitly to the welfare losses due to balance sheet constraints of financial institutions
Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
  - Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices

- Korinek (2010):
  - Ties systemic risk in international capital flows explicitly to the welfare losses due to balance sheet constraints of financial institutions

Systemic Risk in the FX Markets

- Caballero and Krishnamurthy (2001):
  - Interaction of constraints on the domestic and foreign financial sectors lead to amplification of macroeconomic shocks

- Brunnermeier and Pedersen (2009):
  - Funding liquidity and market liquidity interact, leading to spillovers across financial institutions and excessively volatile asset prices

- Korinek (2010):
  - Ties systemic risk in international capital flows explicitly to the welfare losses due to balance sheet constraints of financial institutions

  - International macro and leverage dynamics
What we do

- Extract the common components of expected U.S. dollar funded carry trade returns via partial least squares regressions

- Estimate foreign exchange risk premia:
  1. Macro fundamentals (real activity and inflation)
  2. Balance sheet quantities ("funding liquidity conditions")
Risk Premium Kernel Density Estimates

![Graph showing kernel density estimates for risk premiums with two distributions: one for Macro Variables Only and another for Macro and Balance Sheet Variables.](image-url)
Amplification

![Amplification Diagram]
Episodes of "Balance Sheet Risk Premium" Compression

1. From 1988 (Louvre Accord) to early 1991 (global downturn)

2. Run-up to the LTCM crisis, between early 1995 and 1998

3. Balance sheet risk premium exhibited a prolonged decline between July 2002 and June 2008

- Each of these episodes of prolonged risk premium compression is followed by a sharp reversal of the balance sheet risk premium in the crisis
Related Literature

1. Violation of UIP (Fama 1984, Engel 1996 among others)


3. Asset pricing implications of funding liquidity risk (Adrian and Shin 2007, Adrian and Etula 2010, Adrian, Moench and Shin 2010)
Outline

1. State Variable Extraction via Partial Least Squares
2. Risk Premium Estimation
3. Implications for Systemic Risk Monitoring
Data

- Monthly data:
  1. Exchange rates,
  2. Macroeconomic fundamentals,

- January 1988 to December 2010
  - Start dictated by the availability of balance sheet data.
Foreign Exchange Return

- Riskless foreign bond holding period rate of return $r_{f,t}^i$.
- U.S. dollar funding is riskless at rate $r_{f,t}^{US}$.
- Spot exchange rate, $\varepsilon_t^i$: number of U.S. dollars that can be bought with one unit of foreign currency $i$.
- The excess return to this strategy is given by:

$$er_{t+1}^i \equiv (1 + r_{f,t}^i) \frac{\varepsilon_{t+1}^i}{\varepsilon_t^i} - (1 + r_{f,t}^{US})$$

- Data from Datastream

Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom
We form six currency portfolios on the basis of the forward premium at the end of each month.

We sort the currencies according to the forward premium *vis-à-vis* the U.S. dollar each month.

Compute the excess return for each of six forward premium portfolios. This provides a way to:

- deal with the unbalanced panel of the currency data
- increase the stability of the risk factor loadings
Panel consists of 44 real activity series, including:

- *Industrial production* data for the United Kingdom, Denmark, France, Germany (both total and excluding construction), Spain, Austria, Belgium, Italy, Luxembourg, Norway, Ireland, Portugal, Taiwan, India, Korea, Malaysia, United States, Japan, and
- *Capacity utilization rate* data for the manufacturing sectors in Japan and the United States,
- *Consumer and business confidence* indicators for the euro area, France, Italy, Netherlands, the European Union, and the United States,
- *Business confidence* indicators for the United Kingdom, Austria, Belgium, Denmark, Luxembourg, Finland, Greece, and Portugal,
- *Consumer confidence* indicator for Spain.

We use annual growth rates for industrial production series.
Inflation Panel

- Panel consists of annual consumer price index (CPI) inflation data for 26 economies, i.e., the United States, the United Kingdom, Belgium, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland, Canada, Japan, Finland, Greece, Ireland, Portugal, Spain, Taiwan, Hong Kong, Korea, Malaysia, Pakistan, Philippines, Singapore, Thailand, China.

- We take the 12-month difference in annual (year-on-year) CPI inflation rates.
Aggregate Balance Sheet Components

   - Includes USD CP issued by U.S. and foreign financial institutions with U.S. affiliates.

   - We take the logarithm of the ratio of financial bonds issued relative to non-financial bonds issued each month.

3. Free credit balances at U.S. broker-dealer margin accounts.

4. Debit balances at U.S. broker-dealer margin accounts.
Balance Sheet Variables (Standardized)

- Financial Commercial Paper
- Debit Balances at Broker-Dealer Margin Accounts
- Free Credit Balances at Broker-Dealer Margin Accounts
- Financials Bond Issues Relative to Non-Financials Bond Issues
Partial Least Squares I

- PLS is an efficient factor estimation approach (Groen and Kapetanios, 2008).

- $T \times N$ matrix of $N$ indicator variables $Z = (z'_1 \cdots z'_T)'$ (consisting of real activity, inflation and balance sheet data).

- Standardize $Z$ to have zero mean and unit variance space, resulting in the $T \times N$ matrix $\tilde{Z} = (\tilde{z}'_1 \cdots \tilde{z}'_T)'$.

- PLS uses dominant eigenvector $v$ of the squared covariance between the vector of demeaned dollar-based currency returns and the panel of combined predictor variables:

$$\tilde{Z}' \tilde{e}r \tilde{e}r' \tilde{Z}$$

where $\tilde{e}r = (\tilde{e}r'_1 \cdots \tilde{e}r'_6)'$ with $\tilde{e}r^i = (\tilde{e}r^i_1 \cdots \tilde{e}r^i_T)'$ where $\tilde{e}r^i_t$ is the demeaned excess return on currency $i$. 

Partial Least Squares II

- The common factor from $\tilde{Z}$ relevant for the dollar-based excess returns is then:

$$X_t = (\tilde{v}\tilde{Z}_t)'$$

where $\tilde{v}$ is a transformation of the $N \times 1$ dominant eigenvector $v$ of $\tilde{Z}'\tilde{\epsilon}\tilde{\epsilon}'\tilde{Z}$ such that $||v|| = 1$.

- Then we decompose $X_t$ into a global real activity subfactor $X_t^{real}$, a global inflation subfactor $X_t^{infl}$, and an aggregate U.S. balance sheet subfactor $X_t^{BS}$.

  - we impose a hierarchical factor structure where $X_t$ corresponds to a linear combination of $X_t^{real}$, $X_t^{infl}$, $X_t^{BS}$.

- This is implemented via an iterative process by extracting linear combination of $X$'s that correlate most highly with the common component of the excess currency returns.
Estimated State Variables

Cumulative Average Carry Return

Balance Sheet State Variable

Real Activity State Variable

Inflation State Variable
Asset Pricing Approach

With a pricing kernel $M_{t+1}/M_t$, the expected payoff is:

$$E_t \left[ \frac{M_{t+1}}{M_t} \left( (1 + r^i_{f,t}) \frac{\varepsilon^i_{t+1}}{\varepsilon^i_{t}} - (1 + r^{US^{i}}_{f,t}) \right) \right] = 0$$

Using the definition of covariance, we find the uncovered interest rate parity:

$$\frac{\varepsilon^i_{t+1}}{\varepsilon^i_{t}} = \frac{1 + r^{US^{i}}_{f,t}}{1 + r^i_{f,t}} + \mu^i_t + \zeta^i_{t+1}$$

where $\zeta^i_{t+1}$ denote exchange rate innovations and $\mu^i_t$ is the foreign exchange risk premium:

$$\mu^i_t = -\text{Cov}_t \left[ \frac{M_{t+1}/M_t}{E_t [M_{t+1}/M_t]}, \frac{\varepsilon^i_{t+1}}{\varepsilon^i_{t}} \right]$$
It follows that exchange rate appreciation is due to three components:

\[
\frac{\varepsilon_{t+1}^i}{\varepsilon_t^i} = \frac{1 + r_{f,t}^{US}}{1 + r_{f,t}^i} + \mu_t + \xi_{i,t+1}.
\]

- Exchange Rate Appreciation
- Interest Rate Carry
- FX Risk Premium
- FX Risk
We assume that the pricing kernel $M_{t+1} / M_t$ is exponentially affine in the state variables $X_t$:

$$
\frac{M_{t+1}}{M_t} = \exp \left(-r_t^f - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\nu_{t+1}\right)
$$

$$
\Sigma_t\lambda_t = \lambda_0 + \lambda_1 X_t
$$

where

$$
X_{t+1} = \mu + \phi X_t + \nu_{t+1}.
$$

We further assume that the innovations to state variables are normally distributed with $\nu_{t+1} \sim N(0, \Sigma_t)$. 

Empirical Implementation II

With this notation, we use Stein's lemma to express the FX risk premium as:

\[
\mu_t = -\text{Cov}_t \left[ \frac{M_{t+1}/M_t}{E_t [M_{t+1}/M_t]}, \frac{\varepsilon_{t+1}^i}{\varepsilon_t^i} \right] \\
= \text{Cov}_t \left[ \nu_{t+1}, \frac{\varepsilon_{t+1}^i}{\varepsilon_t^i} \right] \Sigma_t^{-1} (\lambda_0 + \lambda_1 X_t).
\]

It follows that the pricing equation reduces to:

\[
\frac{\varepsilon_{t+1}^i}{\varepsilon_t^i} = \frac{1 + r_{f,t}^{US}}{1 + r_{f,t}^i} + \beta_t^{ii} (\lambda_0 + \lambda_1 X_t) + \tilde{\varepsilon}_{t+1}^i,
\]

where \( \beta_t^{ii} = \text{Cov}_t \left[ \nu_{t+1}, \frac{1/\varepsilon_{t+1}^i}{1/\varepsilon_t^i} \right] \Sigma_t^{-1}. \)
The exchange rate risk $\xi_{t+1}$ can further be decomposed into a systematic component $\beta_i^{ii} \nu_{t+1}$, and an idiosyncratic component $e_i^{t+1}$, such that:

\[
\frac{\varepsilon_i^{t+1}}{\varepsilon_i^t} = \frac{1 + r_{US}^t}{1 + r_{f,t}^i} - \beta_i^{ii} \nu_{t+1} + \beta_i^{ii} (\lambda_0 + \lambda_1 X_t) + e_i^{t+1}.
\]

- FX Appreciation
  - Carry

\[
\text{FX Risk Premia} + \text{Systematic FX Risk} + \text{Idiosyncratic FX Risk}
\]
We next investigate the extent to which the state variables determine the FX risk premium.

We define the systematic FX risk as the unforecastable part of the return to an equal-weighted carry portfolio:

\[ v_{t+1} = r_{t+1}^{EW} - E_t \left[ \tilde{r}_{t+1}^{EW} | 1, r_t^{EW}, X_t \right] , \]

We estimate cross-sectional model by way of three-step OLS regressions applied to the cross-section of 6 carry portfolios (see Adrian and Moench, 2008).

For simplicity, we estimate constant betas for each portfolio \( i \).
Risk Premium of the Equal Weighted Carry Portfolio

![Graph showing foreign exchange returns and risk premium over time from 1990 to 2010. The x-axis represents the years in a monthly format (1990m1 to 2010m1), and the y-axis represents the risk premium and foreign exchange returns. The graph indicates fluctuations in both metrics over time.]

- Foreign Exchange Returns
- Risk Premium
Risk Premium of Macro and Balance Sheet Variables

![Graph showing risk premium over time for macro and balance sheet variables.](image)
Amplification
Risk Premium Kernel Density Estimates

Macro Variables Only
Macro and Balance Sheet Variables

Figure:
Implications for Financial Stability Monitoring

Systemic risk regulators:

- Monitor the evolution of risk in the financial system,
- Develop models to detect the buildup of potential vulnerabilities, and
- Formulate appropriate policies.

This paper presents a methodology to measure the risk premium associated with the dynamics of intermediary balance sheets, which in turn is an indicator for the buildup of systemic risk.

- We document that the financial intermediary balance sheet variables amplify the volatility of the FX risk premium relative to the risk premium due to macro fundamentals.
FX Volatility and the Balance Sheet Risk Premium

- FX volatility is an indicator of risk
- Episodes of systemic financial instability are usually accompanied with high FX volatility
- However, high FX volatility does not necessarily correspond to systemic risk.
FX Volatility and the Balance Sheet Risk Premium

![Graph showing standardized log FX volatility and standardized balance sheet risk premium over time from 1990 to 2010. The graph plots the data with blue and red lines, indicating volatility and risk premium, respectively.]

- **Y-axis**: Standardized Log FX Volatility
- **X-axis**: Time (1990m1 to 2010m1)

Legend:
- Blue line: Standardized Log FX Volatility
- Red line: Standardized Balance Sheet Risk Premium
Conclusion

- We document that the presence of balance sheet variables substantially amplifies the volatility of estimated foreign exchange risk premiums.

- This finding is in line with theories of systemic risk that argue that balance sheet constraints lead to excess volatility of exchange rates and asset prices more generally.

- The methodology that we develop can be used for quantitative surveillance systems to monitor financial stability.