Crash Risk in Currency Returns

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Which types of risk affect currency returns?

AUD

CHF

GBP

JPY
Summary of findings

- The excess return in log is ($S_t$ per one unit of foreign currency)

\[ y_{t+1} = s_{t+1} - s_t - (r_t - \tilde{r}_t) \]

- Three types of jumps:
  1. Variance: probability is affected by the variance itself
  2. USD depreciation (up): probability is affected by the US interest rate
  3. USD appreciation (down): probability is affected by the foreign interest rate

- Jumps in FX coincide with major macro and political news
- Jumps in variance do not coincide ⇒ “economic uncertainty”
- Jumps contribute 25%, on average, to the total currency risk; can be as high as 40%
- A 21-country dollar index retains these properties
- A small-scale option valuation exercise suggests that jump risk is priced
## Basic properties of excess currency returns

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Skewness</th>
<th>Kurtosis</th>
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</thead>
<tbody>
<tr>
<td><strong>AUD</strong></td>
<td>Return</td>
<td>0.0186</td>
<td>0.74</td>
<td>-0.38</td>
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<tr>
<td></td>
<td>(\Delta \sqrt{IV})</td>
<td>0.0109</td>
<td>3.76</td>
<td>0.90</td>
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<tr>
<td><strong>CHF</strong></td>
<td>Return</td>
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<td>0.72</td>
<td>0.11</td>
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<td>(\Delta \sqrt{IV})</td>
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<tr>
<td><strong>GBP</strong></td>
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<td>0.61</td>
<td>-0.23</td>
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<td>(\Delta \sqrt{IV})</td>
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<td><strong>JPY</strong></td>
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<tr>
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<td>(\Delta \sqrt{IV})</td>
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<td><strong>SPX</strong></td>
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<tr>
<td></td>
<td>(\Delta \sqrt{VIX})</td>
<td>0.0089</td>
<td>5.89</td>
<td>0.50</td>
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</table>
Time-varying skewness

AUD

CHF

GBP

JPY
Risks and expected excess returns

- Excess returns are:

\[ y_{t+1} = E_t(y_{t+1}) + \text{shocks} \]

- Most research is focused on \( E_t(y_{t+1}) \), e.g.,
  - UIP implies that \( E_t(y_{t+1}) = 0 \)
  - Bilson-Fama-Tryon regressions find \( E_t(y_{t+1}) = \alpha + \beta(r_t - \tilde{r}_t) \)
  - More recent studies find other factors affecting \( E_t(y_{t+1}) \)

- Where do these factors come from? \( \text{cov}(m, \text{shocks}) \)

- We focus on careful modelling of the shocks

- Our findings should be useful for both GE and factor-based models of risk premiums
The Preferred Model

\[ y_{t+1} = \mu_t + v_t^{1/2} w_{t+1}^s + z_{t+1}^u - z_{t+1}^d \]

\[ v_{t+1} = (1 - \nu) v + \nu v_t + \sigma_v v_t^{1/2} w_{t+1}^v + z_{t+1}^v \]  
\[ \text{corr}(w_{t+1}^s, w_{t+1}^v) = \rho \]

\[ h_t^u = h_0 + h_r r_t, \quad h_t^d = h_0 + h_r \tilde{r}_t, \quad h_t^v = h_0^V + h_v v_t, \]  
\[ \text{jump intensities} \]

\[ z_t^{u,d} \sim \text{Exp}(\theta), \quad z_t^v \sim \text{Exp}(\theta_v) \]  
\[ \text{jump sizes} \]

\[ \mu_t = \mu_0 + \mu_r (r_t - \tilde{r}_t) + \nu v_t \]

- Treat IV as a biased and noisy signal about \( \nu \):
  \[ IV_t = \alpha_{iv} + \beta_{iv} v_t + \text{noise} \]

- Implications:
  - On average, 1.3 to 2.6 jumps in variance per year; average jump size increases vol by 20% to 40%
  - On average, 0.4 to 1.3 jumps in currencies per year; average jumps size is 1.2% to 1.6%
  - Third cumulant \( \kappa_3(t) (s_{t+1} - s_t) = 6\theta^3 h_r (r_t - \tilde{r}_t) \)
JPY excess returns, estimated states, jump intensities

(a) Excess return

(b) Volatility

(c) Jumps in excess return

(d) Jumps in volatility
## Summary of announcements associated with jumps

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Contribution to total risk

- What is total risk?
- Variance, skewness, kurtosis, etc. capture different aspects of risk
- We use entropy (a.k.a. generalised variance):
  \[ L_t(S_{t+n}/S_t) = \log E_t(e^{s_{t+n}-s_t}) - E_t(s_{t+n} - s_t) \]
- Intuition:
  \[ L_t = \kappa_2(s_{t+n} - s_t)/2! + \kappa_3(s_{t+n} - s_t)/3! + \kappa_4(s_{t+n} - s_t)/4! + \ldots, \]
  where \( \kappa_j \) is the \( j \)th cumulant of \( s_{t+n} - s_t \)
Decomposition of entropy
Index of currencies

- The LRV dollar index fits nicely into our framework
  - 21 currency pairs against USD: Euro-zone, AUD, CAD, CHF, DKK, GBP, JPY, NOK, NZD, and SEK
  - First principal component of at-the-money IV’s for each country as a very noisy signal about variance

- The diagnostics select the same model

Details:
- Variance level declines as compared to bilateral FX rates
- Jumps are less frequent
- The relative importance is unchanged: jumps contribute 25%-30% to overall risk (entropy)
Index excess returns, estimated states, jump intensities

(a) Excess return

(b) Volatility

(c) Jumps in excess return

(d) Jumps in volatility
The jump risk is massive. Is it priced?

The index results suggest that it should be priced.

One natural source to measure jump risk premiums is the FX option market.

We conduct a simple calibration exercise using representative volatility smiles.
Implied Volatility
Interesting challenges for theory

- What is the structure of fundamental shocks?
  - Jump probabilities are affected by interest rates – cannot assume this

- What are jumps – disasters or something else?

- Probabilities of jumps in FX vs variance are different in economically meaningful way
  - There is a clear need to distinguish risk from economic uncertainty
Summary

- We study risks in currency returns

- We find that
  - Both normal and jump risks are important
  - Jump risks are time-varying
  - Jumps in FX can be linked to news. Jumps in vol cannot
  - Jumps are not idiosyncratic
  - Option prices suggest priced jump risk