Macroeconomic Volatility and External Imbalances

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Causes and Macroeconomic Consequences of Uncertainty
Dallas Fed, October 2013
Motivation

The size and durability of the imbalances that characterize the world economy today reflect a myriad of different forces: from differences in actual and potential growth rates, the degree of openness of financial and product markets, the type of exchange rate regime in place, the borrowing requirements of the sovereign, the degree of financial market development, the extent of the official safety nets, to differences in attitudes toward risk and expectations about the future. The interactions of these forces are complex and vary over time. And this limits our capacity to judge the sustainable level of imbalances.

Tim Geithner, 2006
Contributions

- Study new *observable* determinant of evolution of external imbalances: *time varying macro risk* (volatility/uncertainty)
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- Empirically
  - Document relation between changes in imbalances and changes in macro risk
Contributions

- Study new *observable* determinant of evolution of external imbalances: *time varying macro risk (volatility/uncertainty)*

- Empirically
  - Document relation between changes in imbalances and changes in macro risk

- Theoretically/quantitatively
  - Develop simple consumption/saving/investment open economy model with time varying macro risk
  - Model quantitatively captures the relationship between risk and imbalances in the data
  - Importance of open economy in recent literature on "volatility" shocks

- Overall
  - Macro risk major determinant of external imbalances
Sample

- Largest subset of OECD countries for which could find long quarterly macro series consistent across countries and time: 20 countries, 1970.1-2012.4
Variables of interests

- Macroeconomic volatility (risk): Standard deviation of quarterly real GDP growth over a 10 yrs window, relative to average volatility of other countries in sample
- Imbalances: NFA position (include all assets and liabilities) / GDP over the same window
Risk and NFA: the data, 1970-2012

- Net foreign asset position
- Relative volatility

Relative standard deviation of GDP growth (%)

% of GDP

Relative volatility

Year

Relative standard deviation of GDP growth (%)

% of GDP

Relative volatility

Year
Risk and NFA: empirical issues

• Data suggest changes in NFA associated with changes in macro risk
• Potential issues
  • Common trend or factors (globalization, great moderation)
  • Third factors driving both independently (i.e. good policies at the same lower risk and NFA)
  • Measurement of Risk
  • Length and structure of windows (short v/s long run)
## Table 1: Volatility and External Imbalances

<table>
<thead>
<tr>
<th>Dependent variable is Net Foreign Assets</th>
<th>(i)</th>
<th>(ii)</th>
<th>(iii)</th>
<th>(iv)</th>
<th>(v)</th>
<th>(vi)</th>
<th>(vii)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatility of GDP Growth</td>
<td>18.62***</td>
<td>17.22***</td>
<td>17.22***</td>
<td>17.33***</td>
<td>15.14***</td>
<td>15.59***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.812)</td>
<td>(4.876)</td>
<td>(4.471)</td>
<td>(5.757)</td>
<td>(5.023)</td>
<td>(4.848)</td>
<td></td>
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<tr>
<td>Average GDP Growth</td>
<td>-5.790</td>
<td>-4.745</td>
<td>-5.810</td>
<td>-6.924</td>
<td>-2.569</td>
<td>-10.72</td>
<td></td>
</tr>
<tr>
<td>Average Inflation</td>
<td>1.802</td>
<td>3.710*</td>
<td>4.030*</td>
<td>3.225</td>
<td>2.544</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.686)</td>
<td>(2.028)</td>
<td>(2.300)</td>
<td>(2.270)</td>
<td>(2.595)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatility of Inflation</td>
<td>-0.904</td>
<td>-2.299</td>
<td>-2.000</td>
<td>-1.698</td>
<td>-0.699</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.540)</td>
<td>(3.528)</td>
<td>(3.207)</td>
<td>(3.232)</td>
<td>(3.344)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(4.419)</td>
<td>(4.960)</td>
<td>(5.102)</td>
<td>(5.502)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Financial Openness 1</td>
<td>-0.698</td>
<td>-0.101</td>
<td>0.551</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.003)</td>
<td>(4.200)</td>
<td>(4.542)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Financial Openness 2</td>
<td>2.123</td>
<td>1.148</td>
<td>1.729</td>
<td></td>
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<tr>
<td></td>
<td>(4.386)</td>
<td>(3.843)</td>
<td>(3.833)</td>
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<tr>
<td>Trade Openness</td>
<td></td>
<td></td>
<td></td>
<td>-54.06</td>
<td>-50.56</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(66.78)</td>
<td>(67.79)</td>
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</tr>
</tbody>
</table>

N: 662, 662, 662, 646, 633, 633, 633
adj. $R^2$: 0.814, 0.814, 0.815, 0.820, 0.796, 0.801, 0.790

Robust standard errors in parentheses account for clustering at the country level.

All regressions include a constant, country and year fixed effects.
Measuring Risk differently

Use GARCH(1,1) and estimate

\[ y_t = \rho y_{t-1} + \varepsilon_t \]
\[ \sigma_{\varepsilon,t} = \beta_1 \sigma_{\varepsilon,t-1} + \beta_2 \varepsilon_{t-1}^2 \]

where \( y_t \) is real GDP growth
GARCH volatility

Est. from GARCH  Rolling window
## Table 2: Volatility and External Imbalances - Alternative Measures and Sample

Dependent variable is Net Foreign Assets<sup>a</sup>

<table>
<thead>
<tr>
<th></th>
<th>(i)</th>
<th>(ii)</th>
<th>(iii)</th>
<th>(iv)</th>
<th>(v)</th>
<th>(vi)</th>
<th>(vii)</th>
<th>(viii)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vol. GDP Growth (5 yrs)</td>
<td>14.83***</td>
<td>14.41***</td>
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<td></td>
<td>(4.395)</td>
<td>(4.753)</td>
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<tr>
<td>Av. GDP Growth (5 yrs)</td>
<td></td>
<td></td>
<td>-2.613</td>
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<td>(5.737)</td>
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<tr>
<td>Vol. GDP Growth (7 yrs)</td>
<td></td>
<td></td>
<td></td>
<td>16.65***</td>
<td>15.73***</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td>(4.105)</td>
<td>(4.627)</td>
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<tr>
<td>Av. GDP Growth (7 yrs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5.171</td>
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<td></td>
<td></td>
<td>(7.222)</td>
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<tr>
<td>Vol. GDP Growth (from GARCH)</td>
<td></td>
<td></td>
<td></td>
<td>14.02***</td>
<td>14.61***</td>
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<td></td>
<td>(4.841)</td>
<td>(4.858)</td>
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<tr>
<td>Av. GDP Growth (1 yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.966</td>
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<td></td>
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<td></td>
<td></td>
<td>(2.198)</td>
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<td></td>
<td>(5.609)</td>
<td>(6.386)</td>
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</tr>
<tr>
<td>Av. GDP Growth (1985-2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.626</td>
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<td></td>
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<td></td>
<td></td>
<td>(12.05)</td>
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</tbody>
</table>

<sup>a</sup> Net foreign asset position in each specification is computed on the same window used for computing volatility.

Robust standard errors in parentheses account for clustering at the country level.

All regressions include a constant, country and year fixed effects.
Quantitative summary

- A 0.5% change in relative macro-risk (in the medium-long run, experienced by most countries) associated with change in NFA/Y between 7% and 8%
Why should volatility affect imbalances?

- **Consumption**: If international risk-sharing incomplete changing relative volatility affects relative precautionary motive, relative “risk adjusted" rate of time preference", increases scope for international inter-temporal trade, leads to imbalances
Why should volatility affect imbalances?

- **Consumption**: If international risk-sharing incomplete changing relative volatility affects relative precautionary motive, relative “risk adjusted" rate of time preference", increases scope for international inter-temporal trade, leads to imbalances

- **Investment**: Changing relative volatility change international allocation of capital, leads to imbalances
The goal

• Write simple open economy model which allows
The goal

- Write simple open economy model which allows
  - Quantification of these effects
  - Understanding of how these effects depend on structural features of economy
Model overview

- Two countries, one good
- Macro volatility driven by country specific TFP shocks, with time varying volatility
- Competitive factor markets and full risk sharing within a country (repr. agent)
- Potential menu of assets traded internationally
- Agents choose consumption and international assets portfolios
- Firms choose investment
Households

\[
\max_{c_{it}, l_{it}, \lambda_{it}, \lambda_{1t}^F, b_{1t}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(c_{it}, l_{it})
\]

\[
c_{1t} + b_{1t} + \lambda_{1t} p_1 + \lambda_{1t}^F p_{2t} \\
\leq l_{1t} w_{1t} + \lambda_{1t} (d_{1t} + p_{1t}) + \lambda_{1t-1}^F (d_{2t} + p_{2t}) + b_{1t-1} R_{t-1}
\]

\[
\lambda_{10}, \lambda_{10}^F, b_{10} \text{ given}
\]
Firms

\[
\max_{l_{it}, k_{it}, x_{it}} \sum_{t=1}^{\infty} d_{it} Q_{it}
\]

s.t.

\[
d_{it} = A_{it} l_{it}^{1-\alpha} k_{it}^\alpha - w_{it} l_{it} - x_{it}
\]

\[
k_{it} = (1 - \delta) k_{it-1} + x_{it} - \phi k_{it-1} \left[ \frac{x_{it}}{k_{it-1}} - \delta \right]^2
\]

\[k_{i0}\] given
Shocks

\[
\begin{bmatrix}
\log A_{1t} \\
\log A_{2t}
\end{bmatrix} = \begin{bmatrix}
\rho & \psi \\
\psi & \rho
\end{bmatrix}\begin{bmatrix}
\log A_{1t-1} \\
\log A_{2t-1}
\end{bmatrix} + \begin{bmatrix}
V_{1t}\varepsilon_{1t} \\
V_{2t}\varepsilon_{2t}
\end{bmatrix}
\]

\[V_{it} = (1 - \rho_V) + \rho_V V_{it-1} + \eta_{it}\]

\[
\begin{bmatrix}
\varepsilon_{1t} \\
\varepsilon_{2t}
\end{bmatrix} \xrightarrow{\text{}} N(0, \Sigma_{\varepsilon}), \quad \begin{bmatrix}
\eta_{1t} \\
\eta_{2t}
\end{bmatrix} \xrightarrow{\text{}} N(0, \Sigma_{\eta})
\]
Equilibrium

\[ c_{1t} + x_{1t} + c_{2t} + x_{2t} = y_{1t} + y_{2t} \]
\[ b_{1t} + b_{2t} = 0 \]
\[ \lambda_{1t} + \lambda^{F}_{2t} = 0, \quad \lambda_{2t} + \lambda^{F}_{1t} = 0 \]
International diversification

We impose

\[
\begin{align*}
\lambda_{10} &= \lambda_{1t} = \lambda_{2t} = \lambda \quad \text{for every } t \\
\lambda^{F}_{10} &= \lambda^{F}_{1t} = \lambda^{F}_{2t} = 1 - \lambda \quad \text{for every } t
\end{align*}
\]

- \(\lambda = 1\) model is equivalent to Baxter and Crucini (1995): standard incomplete markets.
- \(\lambda < 1\) more international risk diversification
Key parameters

- Preferences

\[ U(c, l) = \frac{1}{1 - \sigma} \left[ c^\mu (1 - l)^{1-\mu} \right]^{1-\sigma} \quad \text{Standard} \]

\[ = \frac{1}{1 - \sigma} \left( c - \frac{1}{v} l^\nu \right)^{1-\sigma} \quad \text{GHH} \]
Key parameters

- Preferences

\[
U(c, l) = \frac{1}{1 - \sigma} \left[ c^\mu (1 - l)^{1 - \mu} \right]^{1 - \sigma} \quad \text{Standard}
\]

\[
= \frac{1}{1 - \sigma} \left( c - \frac{1}{v} l^\nu \right)^{1 - \sigma} \quad \text{GHH}
\]

- Process for TFP and Volatility shocks
Key parameters

- Preferences

\[ U(c, l) = \frac{1}{1 - \sigma} \left[ c^\mu(1 - l)^{1-\mu} \right]^{1-\sigma} \quad \text{Standard} \]

\[ = \frac{1}{1 - \sigma} \left( c - \frac{1}{\nu} l^\nu \right)^{1-\sigma} \quad \text{GHH} \]

- Process for TFP and Volatility shocks
- International diversification, \( 1 - \lambda \)
Qualitative results

- Increase in volatility leads to accumulation of external position
  - For all plausible preferences
  - For all plausible levels of international diversification
  - Size of the effect very sensitive to persistence of shocks
The impact of a volatility shock (Standard preferences)
The impact of a volatility shock (GHH preferences)
Quantitative results

- Choose parameters of shock process to match relevant cross sectional moments

<table>
<thead>
<tr>
<th>Name</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business Cycle Statistics</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Dev. of GDP Growth</td>
<td>1.13%</td>
<td>0.95%</td>
</tr>
<tr>
<td>Relative St. Dev. of Consumption to GDP Growth</td>
<td>0.94</td>
<td>0.98</td>
</tr>
<tr>
<td>Relative St. Dev. of Investment to GDP Growth</td>
<td>3.27</td>
<td>3.52</td>
</tr>
<tr>
<td>St. Dev. of Change in Net-Exports-to-GDP Ratio</td>
<td>1.12%</td>
<td>0.82%</td>
</tr>
<tr>
<td><strong>Other Moments</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Dev. of Relative Volatility (de-meaned)</td>
<td>0.30%</td>
<td>0.36%</td>
</tr>
<tr>
<td>Persistence of Relative Volatility</td>
<td>0.87</td>
<td>0.96</td>
</tr>
<tr>
<td>St. Dev. of NFA (de-meaned)</td>
<td>14.5%</td>
<td>16.0%</td>
</tr>
</tbody>
</table>

<sup>a</sup> Each standard deviation is computed as average standard deviation on quarterly data across countries. 
<sup>b</sup> Recall that relative volatility and net foreign asset position are computed at yearly frequency. Moreover we consider 10 year windows. County-specific effects are purged by subtracting average relative volatility and net foreign assets by country in the de-meaned statistics. Persistence in turn is computed by estimating an AR(1) on relative volatility with country fixed effects.

Note finally that, since we are interested in capturing the effect of changes in volatilities, we do not numerically compute equilibria of this model using standard linearization based methods, as, using such methods, individuals' and firms' decision rules are independent from second moments of the shocks. We instead compute decision rules using third order approximation methods, as the third order is necessary to capture the impact of changes of variance on agents decision rules.
Result 1. Model captures well the observed relation between Risk and NFA

<table>
<thead>
<tr>
<th>Window</th>
<th>V</th>
<th>VG</th>
<th>V</th>
<th>VG</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 years</td>
<td>21.82***</td>
<td>19.05***</td>
<td>20.14</td>
<td>(6.610)</td>
</tr>
<tr>
<td></td>
<td>(5.938)</td>
<td>-12.06</td>
<td>19.11</td>
<td>(9.964)</td>
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<tr>
<td></td>
<td></td>
<td>18.12***</td>
<td>-16.92</td>
<td>(5.899)</td>
</tr>
<tr>
<td></td>
<td>(4.899)</td>
<td>-9.75</td>
<td>18.21</td>
<td>(9.130)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.22***</td>
<td>-18.22</td>
<td>(9.336)</td>
</tr>
<tr>
<td>10 years</td>
<td>18.62***</td>
<td>14.83***</td>
<td>18.15</td>
<td>(3.812)</td>
</tr>
<tr>
<td></td>
<td>(4.876)</td>
<td>-5.79</td>
<td>17.02</td>
<td>(9.336)</td>
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<tr>
<td></td>
<td></td>
<td>14.41***</td>
<td>-13.50</td>
<td>(4.753)</td>
</tr>
<tr>
<td>5 years</td>
<td>14.83***</td>
<td>14.83***</td>
<td>14.29</td>
<td>(4.395)</td>
</tr>
<tr>
<td></td>
<td>(4.753)</td>
<td>-2.61</td>
<td>13.52</td>
<td>(5.737)</td>
</tr>
</tbody>
</table>

"V" denotes regressions of net foreign asset position on volatility of GDP growth, "VG" denotes regressions on volatility and average GDP growth. All regressions on the real world data include a constant, country and year fixed effects. All regressions on simulated data include a constant and country fixed effects. The regressor in this case is relative volatility of GDP growth, which delivers results comparable to including year fixed effects and using plain volatility of GDP growth at the same time.

- Result 2. First we compute the cross sectional standard deviation of net foreign asset position (after controlling for country and time fixed effects) in the data and then we assess how much of this cross sectional dispersion can be reproduced by the model.
Result 2. How important are risk shocks?

- Eliminating risk shock from model reduce standard deviation of NFA from 16% to 13%
- Risk shocks not fundamental
- Relation between risk and NFA driven also by realized (ex post) not ex-ante risk
- Essential element is the persistence of shocks
- If shocks not persistent model generates no relation between risk and NFA. NFA movements dominated by intertemporal borrowing/lending and not by precautionary motives.
Conclusions

- Data and theory suggest time-varying country-specific macroeconomic volatility is an important factor to understand evolution of external imbalances
- This is consistent with the importance of precautionary motive in driving imbalances
- Imbalances not good or bad per se, reflect underlying macroeconomic conditions/policies