Does capital markets uncertainty affect the business cycle?

- Stock market fluctuations partly reflect changes in the expectations about the underlying real economic activity.
  - Do capital markets also help anticipate movements in the real economy? —An old issue.

- For example, Fama (1990) and Schwert (1990) showed that stock market returns and price-dividend ratios help predict real economic activity.

- So why should we also consider capital markets volatility to predict economic activity?

- We know stock market volatility is higher in bad times than in good times. But if stock market volatility is countercyclical, it might convey information about future economic activity!
Rolling estimates, obtained as \( \sqrt{\frac{\pi}{2}} \sum_{i=1}^{12} \frac{abs(Return_{t+1-i})}{\sqrt{12}} \). Monthly data. Annualized, percent. Shaded areas: NBER recessions.
Avg: 14.18. Avg during expansions: 13.50 (−4%). Avg during recessions: 17.39 (+23%)
Two key issues

• That capital markets uncertainty is countercyclical does not immediately lead to conclude that financial volatility \textit{anticipates} real economic activity. Moreover, correlation is not causation. In general,
  
  – Does aggregate stock market volatility affect investment decisions in the real sector of the economy?
  – Does volatility help predict the business cycle?

• These issues have outstanding policy implications, and are, of course, of immediate concern to corporate decision makers, even in the simple case where a sustained stock volatility merely anticipates, without affecting, the business cycle.
This paper’s results

We find that:

• Financial volatility predicts roughly 30% of after-war economic activity in the United States.

• This number increases to roughly 50% when indicators of financial volatility are used in conjunction with indicators of macroeconomic volatility.

• These findings are robust to the sampling period, and are particularly significant over the Great Moderation era.

• At the heart of our analysis is a notion of volatility based on a *slowly changing measure of returns variability*. This volatility measure captures *long-run uncertainty in capital markets*, and is particularly successful at explaining trends in the economic activity at horizons of six months and one year.
Comparison with some leading indicators

![Graph showing financial volatility and economic activity](Image)
Cross-correlations over the Great Moderation

- Correlation between stock market volatility at $t$ and one year growth at $t+\text{lag}$
- Correlation between the term spread at $t$ and one year growth at $t+\text{lag}$
- Correlation between the corporate spread at $t$ and one year growth at $t+\text{lag}$
Stock volatility and the term spread

• The predicting power of stock market volatility has increased in the last twenty-five years:

  – Over the Great Moderation, stock market volatility explains, *alone*, between 35% and 55% of future real economic activity, at horizons of one and two years.
  – Over the same period, stock volatility has a predictive power that is quite comparable to that of a traditional leading indicator: the term spread.

• In fact, we find that combining the term spread with aggregate stock market volatility leads to a predicting block that anticipates the business cycle reasonably well, delivering quite isolated false signals of economic slowdowns, with no such false signals over the Great Moderation period.
We undertake out-of-sample experiments and submit these findings to reality checks.

In these experiments, developments in the term spread and stock market volatility anticipate all the NBER-dated recessions that are left by the data and our estimation constraints, including the recession episode related to the 2007 subprime crisis.
Plan

1. Why does financial volatility help predict real economic activity?
2. Data, measurement methods and competing predictors
3. In-sample results
4. Out-of-sample experiments
5. Conclusion
Part 1

Why does financial volatility help predict real economic activity?
We consider four explanations

(i) Information-related reasons, not necessarily causality reasons. An example of a production economy and incomplete information
   – correlation

(ii) Time-varying risk premiums
    – correlation

(iii) Uncertainty and irreversible investments
    – causation

(iv) Procyclicality of capital markets and financial distress
    – causation
(i) Production and incomplete information

- Consider the following simple production-based explanation
- Two-period economy. First period: production by a monopolist. In the second period, the producer faces a linear inverse demand,

\[ D^{-1}(Q) = a + \tilde{v} - \lambda Q, \]

for some positive constants \( a \) and \( \lambda \). The variable \( \tilde{v} \) captures a random shock in the demand. We assume that \( \tilde{v} \sim N(0, \sigma^2) \), and that prior to production decisions, the firm observes a signal \( s \) on \( \tilde{v} \),

\[ s = \tilde{v} + \epsilon, \quad \epsilon \sim N(0, \sigma^2). \]

- Linear technology \( \Leftrightarrow \) total costs \( C'(Q) = zQ \) for some positive constant \( z \).
- Firm’s managers are risk-neutral, and maximize the value of the firm.
- Safe assets are elastically supplied so as to make the safe interest rate zero.
Possible to show that,

- Production takes place only when the signal $s$ takes a sufficiently favourable cutoff value $\hat{s} \equiv -\frac{a-z}{\theta}$, where $\theta = \frac{n-1}{n}$, and $n$ is the signal-to-noise ratio.

- Stock price $P$, production $Q$ and returns volatility $\text{Vol}$ (say) are all functions of the current signal $s$, and equal

$$P(s) = \frac{\theta^2}{4\lambda} (s - \hat{s})^2 \mathbb{I}_{s > \hat{s}}; \quad Q(s) = \frac{\theta}{2\lambda} (s - \hat{s}) \mathbb{I}_{s > \hat{s}}; \quad \text{and } \text{Vol}(s) = \frac{2\sigma \sqrt{1 - \theta}}{a - z + \theta s},$$

where $\mathbb{I}$ is the indicator function, and where returns volatility is only defined when economic activity takes place, i.e. when $s > \hat{s}$. 
Production and stock prices

Production and signals of economic activity

Stock price and signals of economic activity
Return volatility

Return volatility and signals about future economic activity
### Regressions in a Monte Carlo experiment

<table>
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<tr>
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<th>const</th>
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<th>$R^2$</th>
<th></th>
<th>const</th>
<th>Price</th>
<th>$R^2$</th>
<th></th>
<th>const</th>
<th>Vol</th>
<th>Price</th>
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<tr>
<td>t-stat</td>
<td>100.88</td>
<td>-53.61</td>
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<td></td>
<td>100.16</td>
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<td></td>
<td></td>
<td>153.05</td>
<td>-71.86</td>
<td>14.45</td>
<td></td>
</tr>
</tbody>
</table>

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(ii) Time-varying risk-premiums

Risk premium on the S&P 500, annualized, percent.
Strong evidence of asymmetric risk premiums
The theoretical connection

In economies with rational expectations, stock market volatility is countercyclical because risk premiums (i.e. the compensation investors require to invest in the stock market) change asymmetrically in response to variations in the economic conditions (Mele, 2007).

- That risk premia are countercyclical is a widely known fact.
- But the main message of that paper is not a simple statement that risk premia must be countercyclical to activate countercyclical volatility.
- Rather, the crucial point is that to generate asymmetric-like patterns in returns volatility, risk premia must increase more in bad times than they decrease in good times, just as the empirical evidence suggests.
Economic intuition

Asymmetric risk premiums and countercyclical return volatility
**Uncertainty and irreversible investments**

- Option pricing theory predicts that uncertainty raises the value to wait.

- Bloom (2009) models time-varying uncertainty of business conditions, assuming that total factor productivity has stochastic volatility.
  
  - His model, which includes irreversible investments and nonconvex adjustment costs, predicts that firms freeze investments during uncertain times, as the value to waiting increases in such periods.
  
  - Bloom, Floetotto and Jaimovich (2009) reach a similar conclusion within a calibrated real business cycle model: uncertainty shocks are impulses that generate rich propagation mechanisms.
(iv) Procyclicality of capital markets and financial distress

- In the previous explanations, asset prices (and volatility) respond passively to changes in the economic conditions. But asset price movements can feed back the real economy.

- **Procyclicality.** General idea: in the presence of frictions in financial and credit markets, Modigliani-Miller breaks down. Financial structure of firms matters.

- One well-known mechanism: agency costs make the cost of external funds increase and the availability of funds decrease. So the intertemporal allocation of credit is not optimal - a social planner would make credit allocation countercyclical.
• This procyclicality of credit allocation amplifies small shocks occurring in the real sectors of the economy. For example, the **financial accelerator** hypothesis holds that in bad times, financial intermediaries reduce their funding activities because the value of collaterals is also reduced in bad times.

  – Bernanke, Gertler and Gilchrist (1999) presented a unified view of how agency problems make funding opportunities depend on firms’ collateral values - and so how these financial frictions make financial markets and general macroeconomic conditions intimately related.

• Borio, Furfine and Lowe (2001) explained that the financial accelerator hypothesis may not be the only explanation to play a role. Market participants may also have a misperception of risk.

  – Thus for example, the reason why we observe that the credit/GDP ratio is procyclical can be that financial intermediaries underestimate risk in good
times, and overestimate risk in bad times - thereby lending too much in
good times and too less in bad times.
– This misperception of risk can simply arise because financial intermediaries
may fail to recognize that measures of risk (such as the one we use in this paper) can be very high in bad times as a result of the build-up of risk-taking
behavior in good times, and vice versa.
Financial volatility

- Time varying financial volatility may be at the origins of sizeable distortions in lending and investment decisions.

- In bad times, financial volatility increases. Increased financial volatility makes future collateral values more uncertain. In anticipation of this increased uncertainty, the volume of funds financial intermediaries provide decrease, and their cost increases, thereby exacerbating the current economic conditions.

- This explanation is consistent with the mechanism put forward by Borio, Furfine and Lowe (2001). Indeed, if financial markets are rational and quick processors of information, it may be the case that financial volatility increases precisely towards the end of the build-up of risk-taking behavior in good times, but just enough before an economic downturn.
Part 2

Data, measurement methods and competing predictors
Economic activity

We use monthly data from January 1957 to September 2008, to quantify the predicting power of financial volatility on economic activity through two complementary search strategies.

- First, we predict the growth of industrial production at horizons of three, six, twelve and twenty-four months:

\[ G_{t \rightarrow t+k} = \ln \left( \frac{\text{IP}_{t+k}}{\text{IP}_t} \right), \quad k \in \{3, 6, 12, 24\}, \]

where \( \text{IP}_t \) is the industrial production index as of month \( t \).
Second, we predict probabilities of recessions, by utilizing the NBER-dating series as a recession variable,

\[ \text{Rec}_t \equiv \mathbb{I}_{\text{NBER}_t=1}, \]

which equals one if the US economy is in recession at time \( t \), and zero otherwise.
Volatility

- We use continuously compounded returns to track variations in price indexes. That is, given an asset index and its associated price $P_t$ (such as a bond price index or the S&P 500 index), we define its return as of time $t$ as,

$$R_{t}^{tot} = \ln \frac{P_t + D_t}{P_{t-1}},$$

where $D_t$ is the dividend paid off by the asset index.
We decompose the return $R^{tot}_t$ as,

$$R^{tot}_t = R^p_t + R^d_t$$

where

$$R^p_t \equiv \ln \frac{P/D_t + 1}{P/D_{t-1}} \quad \text{and} \quad R^d_t \equiv \ln \frac{D_t}{D_{t-1}},$$

and where $P/D_t$ is the price-dividend ratio as of time $t$. This decomposition disentangles the returns component due to variation in the payoff from the returns component due to the (possibly rational) reaction of prices to changes in the economic environment.
Finally, we define volatility as a long-run moving average of past absolute returns,

$$\sigma_t^p(\ell) \equiv \sqrt{6\pi} \times \frac{1}{\ell} \sum_{i=1}^{\ell} |R_{t+1-i}^p|,$$  

(1)

where we use the lag $\ell$ to create volatility estimates from past returns. We have experimented Eq. (1) with different values of $\ell$. Our empirical results suggest that the choice of $\ell$ is important. The predictive power of volatility is somehow limited if $\ell$ equals 1 or 2 months, say. But this power increases dramatically for $\ell = 6$ or $\ell = 12$.

- We report results for $\ell = 12$. 

Stock volatility as a leading indicator: a preliminary scrutiny

We regress:

\[ \sigma_t(12) = c + \sum_{i \in \{3, 12, 24, 36\}} b_i \sigma_{t-i}(12) + \gamma_1 I_t \in \mathcal{O}(NBER_t=1) + \gamma_2 I_{NBER_t=1} + \nu_t, \]

**Panel A: Full sample, 1957-2008**

<table>
<thead>
<tr>
<th>estimate</th>
<th>( c )</th>
<th>( b_3 )</th>
<th>( b_{12} )</th>
<th>( b_{24} )</th>
<th>( b_{36} )</th>
<th>( \gamma_1 )</th>
<th>( \gamma_2 )</th>
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<tbody>
<tr>
<td>t-stat</td>
<td>7.18</td>
<td>40.10</td>
<td>-6.48</td>
<td>-0.65</td>
<td>-0.98</td>
<td>2.52</td>
<td>5.80</td>
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</tbody>
</table>

**Panel B: 1957-1982**

<table>
<thead>
<tr>
<th>estimate</th>
<th>( c )</th>
<th>( b_3 )</th>
<th>( b_{12} )</th>
<th>( b_{24} )</th>
<th>( b_{36} )</th>
<th>( \gamma_1 )</th>
<th>( \gamma_2 )</th>
</tr>
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<tbody>
<tr>
<td>t-stat</td>
<td>6.19</td>
<td>27.83</td>
<td>-8.85</td>
<td>1.07</td>
<td>-1.91</td>
<td>1.41</td>
<td>5.50</td>
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</table>

**Panel C: 1983-2008**

<table>
<thead>
<tr>
<th>estimate</th>
<th>( c )</th>
<th>( b_3 )</th>
<th>( b_{12} )</th>
<th>( b_{24} )</th>
<th>( b_{36} )</th>
<th>( \gamma_1 )</th>
<th>( \gamma_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-stat</td>
<td>4.76</td>
<td>32.56</td>
<td>-2.28</td>
<td>-1.86</td>
<td>-0.41</td>
<td>3.35</td>
<td>3.36</td>
</tr>
</tbody>
</table>
Predictors

- Financial volatility might be countercyclical, and anticipate the business cycle, because it merely reflects information conveyed by other factors. To assess if financial volatility accounts for additional pieces of information, we need to specify sets of control variables.
Individual predictors

- **Financial Volatility**
  (i) stock market volatility; (ii) volatility of the term spread; (iii) volatility of the corporate spread; (iv) volatility of stock market volatility

- **Macroeconomic Volatility**
  (v) volatility of oil return; (vi) volatility of industrial production growth; (vii) volatility of inflation; (viii) volatility of unemployment rate; (ix) volatility of metal return

- **Traditional Predictors**
  (x) term spread; (xi) corporate spread; (xii) stock returns; (xiii) oil return; (xiv) index of leading indicators, growth; (xv) 3 month interest rate; (xvi) inflation; (xvii) dividend yield; (xviii) lagged industrial production growth
Predicting blocks, main

**Block B1:** Term spread, corporate spread, and 12 month stock market returns

**Block B2:** Term spread, short-term rate

**Block B3:** Stock market volatility, term spread volatility

**Block B4:** Stock market volatility, term spread

**Block B5:** Volatility of stock market volatility, short-term rate

**Block B6:** Volatility of stock market volatility, term spread

**Block B7:** Volatility of stock market volatility, stock market volatility, term spread

**Block B8:** Volatility of stock market volatility, stock market volatility, interaction term, term spread
Predicting blocks, macroeconomic controls

**Block B9:** Volatilities of: oil return, industrial production growth, inflation, metal return

**Block B10:** Oil return, index of leading indicators (growth), inflation, dividend yield
Part 3

In-sample results
Linear regressions

For each predicting horizon \( k \in \{3, 6, 12, 24\} \), we regress industrial production growth on to the previous predicting variables or blocks:

\[
G_{t \to t+k} = \alpha^k + \sum_{j=1}^{P_i} \sum_{\text{lag} \in \{0, l_1^k, \ldots, l_4^k\}} \beta^k_{j} (\text{lag}) \cdot \text{Regressor}_j (t - \text{lag}) + \text{Error} (t + k),
\]

where \( P_i \) is the number of regressors, and \( \alpha^k, \{\beta^k_{j} (\text{lag})\}_{\text{lag} \in \{0, l_1^k, \ldots, l_4^k\}} \) are the parameters to be estimated.
## Individual predictors

### Panel A: Full sample, 1957-2008

<table>
<thead>
<tr>
<th>Predictors</th>
<th>3m</th>
<th>6m</th>
<th>1Y</th>
<th>2Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 = stock market volatility</td>
<td>0.01</td>
<td>0.02</td>
<td>0.06</td>
<td>0.11</td>
</tr>
<tr>
<td>P2 = volatility of the term spread</td>
<td>0.06</td>
<td>0.09</td>
<td>0.14</td>
<td>0.17</td>
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<tr>
<td>P3 = volatility of the corporate spread</td>
<td>0.09</td>
<td>0.14</td>
<td>0.21</td>
<td>0.28</td>
</tr>
<tr>
<td>P4 = volatility of stock market volatility</td>
<td>0.14</td>
<td>0.21</td>
<td>0.29</td>
<td>0.37</td>
</tr>
<tr>
<td>P5 = volatility of oil return</td>
<td>0.22</td>
<td>0.31</td>
<td>0.34</td>
<td>0.43</td>
</tr>
<tr>
<td>P6 = volatility of industrial production index</td>
<td>0.27</td>
<td>0.36</td>
<td>0.38</td>
<td>0.47</td>
</tr>
<tr>
<td>P7 = volatility of inflation</td>
<td>0.33</td>
<td>0.43</td>
<td>0.45</td>
<td>0.68</td>
</tr>
<tr>
<td>P8 = volatility of unemployment rate</td>
<td>0.38</td>
<td>0.50</td>
<td>0.53</td>
<td>0.80</td>
</tr>
<tr>
<td>P9 = volatility of metal return</td>
<td>0.39</td>
<td>0.51</td>
<td>0.57</td>
<td>0.83</td>
</tr>
<tr>
<td>P10 through P18</td>
<td>0.61</td>
<td>0.75</td>
<td>0.85</td>
<td>0.92</td>
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</tbody>
</table>

### Panel B: 1957-1982

<table>
<thead>
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<th>Predictors</th>
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<th>6m</th>
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<th>2Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 = stock market volatility</td>
<td>0.01</td>
<td>0.01</td>
<td>0.04</td>
<td>0.09</td>
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<tr>
<td>P2 = volatility of the term spread</td>
<td>0.05</td>
<td>0.08</td>
<td>0.14</td>
<td>0.18</td>
</tr>
<tr>
<td>P3 = volatility of the corporate spread</td>
<td>0.09</td>
<td>0.15</td>
<td>0.24</td>
<td>0.32</td>
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<tr>
<td>P4 = volatility of stock market volatility</td>
<td>0.26</td>
<td>0.42</td>
<td>0.55</td>
<td>0.63</td>
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<tr>
<td>P5 = volatility of oil return</td>
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<td>0.63</td>
<td>0.70</td>
<td>0.74</td>
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<tr>
<td>P6 = volatility of industrial production index</td>
<td>0.55</td>
<td>0.70</td>
<td>0.73</td>
<td>0.75</td>
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<tr>
<td>P7 = volatility of inflation</td>
<td>0.61</td>
<td>0.76</td>
<td>0.78</td>
<td>0.89</td>
</tr>
<tr>
<td>P8 = volatility of unemployment rate</td>
<td>0.60</td>
<td>0.77</td>
<td>0.81</td>
<td>0.92</td>
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<td>P9 = volatility of metal return</td>
<td>0.62</td>
<td>0.78</td>
<td>0.85</td>
<td>0.92</td>
</tr>
<tr>
<td>P10 through P18</td>
<td>0.72</td>
<td>0.86</td>
<td>0.94</td>
<td>0.97</td>
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### Panel C: 1983-2008

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<th>2Y</th>
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</thead>
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<tr>
<td>P1 = stock market volatility</td>
<td>0.12</td>
<td>0.23</td>
<td>0.35</td>
<td>0.55</td>
</tr>
<tr>
<td>P2 = volatility of the term spread</td>
<td>0.23</td>
<td>0.37</td>
<td>0.50</td>
<td>0.70</td>
</tr>
<tr>
<td>P3 = volatility of the corporate spread</td>
<td>0.26</td>
<td>0.40</td>
<td>0.55</td>
<td>0.75</td>
</tr>
<tr>
<td>P4 = volatility of stock market volatility</td>
<td>0.33</td>
<td>0.49</td>
<td>0.60</td>
<td>0.79</td>
</tr>
<tr>
<td>P5 = volatility of oil return</td>
<td>0.44</td>
<td>0.59</td>
<td>0.70</td>
<td>0.84</td>
</tr>
<tr>
<td>P6 = volatility of industrial production index</td>
<td>0.43</td>
<td>0.59</td>
<td>0.71</td>
<td>0.86</td>
</tr>
<tr>
<td>P7 = volatility of inflation</td>
<td>0.46</td>
<td>0.64</td>
<td>0.73</td>
<td>0.87</td>
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<tr>
<td>P8 = volatility of unemployment rate</td>
<td>0.49</td>
<td>0.71</td>
<td>0.85</td>
<td>0.92</td>
</tr>
<tr>
<td>P9 = volatility of metal return</td>
<td>0.50</td>
<td>0.73</td>
<td>0.88</td>
<td>0.94</td>
</tr>
<tr>
<td>P10 through P18</td>
<td>0.60</td>
<td>0.86</td>
<td>0.95</td>
<td>0.97</td>
</tr>
</tbody>
</table>
Volatility loadings

3 month prediction, 1957–1982

3 month prediction, 1957–2008

3 month prediction, 1983–2008

6 month prediction, 1957–1982

6 month prediction, 1957–2008

6 month prediction, 1983–2008

1 year prediction, 1957–1982

1 year prediction, 1957–2008

1 year prediction, 1983–2008

2 year prediction, 1957–1982

2 year prediction, 1957–2008

2 year prediction, 1983–2008

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### Predicting blocks

**Panel A: Full sample, 1957-2008**

<table>
<thead>
<tr>
<th>Predicting block</th>
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<th>6m</th>
<th>1Y</th>
<th>2Y</th>
</tr>
</thead>
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<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>B1</td>
<td>0.27</td>
<td>0.28</td>
<td>0.38</td>
<td>0.41</td>
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<tr>
<td>B2</td>
<td>0.17</td>
<td>0.27</td>
<td>0.38</td>
<td>0.39</td>
</tr>
<tr>
<td>B3</td>
<td>0.17</td>
<td>0.09</td>
<td>0.13</td>
<td>0.18</td>
</tr>
<tr>
<td>B4</td>
<td>0.12</td>
<td>0.15</td>
<td>0.24</td>
<td>0.32</td>
</tr>
<tr>
<td>B5</td>
<td>0.18</td>
<td>0.28</td>
<td>0.39</td>
<td>0.38</td>
</tr>
<tr>
<td>B6</td>
<td>0.10</td>
<td>0.15</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>B7</td>
<td>0.15</td>
<td>0.19</td>
<td>0.28</td>
<td>0.38</td>
</tr>
<tr>
<td>B8</td>
<td>0.23</td>
<td>0.29</td>
<td>0.37</td>
<td>0.40</td>
</tr>
</tbody>
</table>

**Panel B: 1957-1982**

<table>
<thead>
<tr>
<th>Predicting block</th>
<th>3m</th>
<th>6m</th>
<th>1Y</th>
<th>2Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>0.17</td>
<td>0.09</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>B1</td>
<td>0.32</td>
<td>0.40</td>
<td>0.56</td>
<td>0.49</td>
</tr>
<tr>
<td>B2</td>
<td>0.27</td>
<td>0.43</td>
<td>0.61</td>
<td>0.66</td>
</tr>
<tr>
<td>B3</td>
<td>0.18</td>
<td>0.18</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>B4</td>
<td>0.21</td>
<td>0.35</td>
<td>0.50</td>
<td>0.38</td>
</tr>
<tr>
<td>B5</td>
<td>0.29</td>
<td>0.46</td>
<td>0.64</td>
<td>0.74</td>
</tr>
<tr>
<td>B6</td>
<td>0.25</td>
<td>0.35</td>
<td>0.47</td>
<td>0.47</td>
</tr>
<tr>
<td>B7</td>
<td>0.28</td>
<td>0.45</td>
<td>0.60</td>
<td>0.53</td>
</tr>
<tr>
<td>B8</td>
<td>0.41</td>
<td>0.50</td>
<td>0.65</td>
<td>0.55</td>
</tr>
</tbody>
</table>

**Panel C: 1983-2008**

<table>
<thead>
<tr>
<th>Predicting block</th>
<th>3m</th>
<th>6m</th>
<th>1Y</th>
<th>2Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>0.18</td>
<td>0.08</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>B1</td>
<td>0.41</td>
<td>0.31</td>
<td>0.40</td>
<td>0.47</td>
</tr>
<tr>
<td>B2</td>
<td>0.25</td>
<td>0.33</td>
<td>0.42</td>
<td>0.46</td>
</tr>
<tr>
<td>B3</td>
<td>0.25</td>
<td>0.40</td>
<td>0.54</td>
<td>0.72</td>
</tr>
<tr>
<td>B4</td>
<td>0.26</td>
<td>0.47</td>
<td>0.57</td>
<td>0.68</td>
</tr>
<tr>
<td>B5</td>
<td>0.11</td>
<td>0.10</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>B6</td>
<td>0.15</td>
<td>0.21</td>
<td>0.26</td>
<td>0.27</td>
</tr>
<tr>
<td>B7</td>
<td>0.26</td>
<td>0.48</td>
<td>0.63</td>
<td>0.78</td>
</tr>
<tr>
<td>B8</td>
<td>0.26</td>
<td>0.48</td>
<td>0.63</td>
<td>0.79</td>
</tr>
</tbody>
</table>
Probabilities of recession

B1: term spread, corp. spread, stock mkt returns
B2: term spread, short-term rate
B3: stock mkt volatility, term spread volatility
B4: stock market volatility, term spread
B5: volatility of stock mkt volatility, short-term rate
B6: volatility of stock market volatility, term spread
B7: vol of stock vol, stock vol, term spread
B8: vol of stock vol, stock vol, interaction, term spread
Part 4

Out-of-sample experiments
• Rolling estimates with estimation window equal to $M = 120$ months or $90$ months. Needed to cope with the non-stationarity of the data
  
  – For example, we showed, in sample, that a structural break in the linkages between financial volatility and the business cycle, occurred around the inception of the Great Moderation.
  – Yet with Probit models, we need wider windows, given that NBER recessions are “rare,” and use $M = 360$ months.

• Let $e_{t,k}^i$ be any predicting error as of time $t$, arising out-of-sample, using the predicting block $i$ at forecasting horizon $k$. 
• **Unconditional predictive ability.** We use the standard Diebold-Mariano (1995) test, relying on:

\[
\bar{d}_{T,k}^{i,j} = \frac{1}{T} \sum_{t=1}^{T} \left( |\varepsilon_{t,k}^i| - |\varepsilon_{t,k}^j| \right).
\]

• **Conditional predictive ability.** We use Giacomini-White testing strategy. Let

\[
\Delta \varepsilon_{t+1,k}^{i,j} \equiv |\varepsilon_{t,k}^i| - |\varepsilon_{t,k}^j|.
\]

Regress \(\Delta \varepsilon_{t+1,k}^{i,j}\) on some vector of variables \(h_{t,k}^{i,j}\), deemed to explain the failure of equal conditional predictive ability stemming from any two blocks:

\[
\Delta \varepsilon_{t+1,k}^{i,j} = \delta_{k}^{i,j} \cdot h_{t,k}^{i,j} + u_{t+1,k}^{i,j}, \quad t = M - 1, \ldots, N - k, \tag{1}
\]

where for any two predicting blocks \(i\) and \(j\), and predicting horizon \(k\), \(\delta_{k}^{i,j}\) is a vector of constants, and, finally, \(u_{t+1,k}^{i,j}\) is a residual term.
• In Monte Carlo experiments, Giacomini and White show that test has both reasonable size and power, once \( h_{t,k}^{i,j} = [1 \ \Delta \epsilon_{t,k}^{i,j}]^\top \). We make this choice.

• The GW test can be used to implement an adaptive decision rule for selecting a predictive block over the others, thus exploiting the best conditional predictive power of any block. We report the frequency at which we reject block \( i \) for block \( j \), over the entire out-of-sample period,

\[
\frac{1}{N - M - 1} \sum_{t=M-1}^{N-1} \mathbb{I}(E_N(\Delta \epsilon_{N+1,k}^{i,j}) > 0) \approx \frac{1}{N - M - 1} \sum_{t=M-1}^{N-1} \mathbb{I}(\hat{\delta}_k^{i,j} \cdot h_{t,k}^{i,j} > 0),
\]

where \( \mathbb{I} \) is the indicator function.
Linear predictions

Out-of-sample predictions of 6 month growth made by volatility variables, [5%, 95%] cross-sectional predicting percentiles

Out-of-sample predictions of 0 month growth made by volatility variables and the term spread, [5%, 95%] cross-sectional predicting percentiles
Financial Volatility and Real Economic Activity

Probit, out-of-sample, coincident

B1: term spread, corp. spread, stock mkt returns

B2: term spread, short-term rate

B3: stock mkt volatility, term spread volatility

B4: stock market volatility, term spread

B5: volatility of stock mkt volatility, short-term rate

B6: volatility of stock market volatility, term spread

B7: vol of stock vol, stock vol, term spread

B8: vol of stock vol, stock vol, interaction, term spread

November 2010
Probit, out-of-sample, six-month projections

B1: term spread, corp. spread, stock mkt returns

B2: term spread, short-term rate

B3: stock mkt volatility, term spread volatility

B4: stock market volatility, term spread

B5: volatility of stock mkt volatility, short-term rate

B6: volatility of stock market volatility, term spread

B7: vol of stock vol, stock vol, term spread

B8: vol of stock vol, stock vol, interaction, term spread
A tale of two recessions

average probability forecasts: the first 6 months in the 2007 recession

average probability forecasts: 2007 recession

average probability forecasts: the first 6 months in the 2001 recession

average probability forecasts: 2001 recession
Conclusion

• If financial volatility is countercyclical, it might encode information about the development of the business cycle.

• Our conclusion, based on an array of measurement methods, is that stock volatility does indeed help predict the business cycle.
  - We rely on predictions of both industrial production growth and NBER-dated recessions, utilizing in-sample projections and submitting our findings to reality checks and other out-of-sample experiments.
  - We control the significance of these predicting relations, by looking at alternative predicting blocks of economic activity, which include:
    (i) traditional leading indicators
    (ii) financial variables such as the term spread or the corporate spread
(iii) additional volatility variables, such as the volatility of the term spread, the volatility of stock market volatility or the volatility of real aggregates.

- We find that combining stock volatility with the term spread leads to a predicting block of economic activity, which tracks, and anticipates, the business cycle reasonably well. For instance, this predicting block would have considerably helped predict at least the last three recessions, with no “false positive” signals.

- While we have outlined a few theoretical explanations for these findings, we still lack a systematic explanation of them.

- The next challenging step is to integrate financial volatility into a plausible propagation mechanism that includes realistically calibrated asset prices.