Economic Uncertainty and the Relative Price of SPX Put Options

Marcelo Bianconi and Marco Sammon

Tufts University & Federal Reserve Bank of Boston

marcelo.bianconi@tufts.edu
marco.sammon@bos.frb.org

February 22, 2015
Economic Uncertainty and Relative Put Prices

Marcelo Bianconi and Marco Sammon

Calculation of Relative Price

Alternative Measures of Uncertainty

Predictive Accuracy of Uncertainty Measures

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work

Time Series of Relative Put Price

Relative Price of SPX Put Options

- 30 Day Monthly Average
- 60 Day Monthly Average
- 90 Day Monthly Average
Comparing End of Month and Monthly Average

Relative Price of SPX Put Options

- 60 Day Relative Put Price (EOD)
- 60 Day Monthly Average
Uncertainty Measures in the Literature

Some well known uncertainty measures include:

- Economic Policy Uncertainty Index [Bloom et al. 2013]
- Macro Uncertainty [Jurado et al. 2013] (JLN)
- VIX Index [CBOE 2009]
- Implied Volatility from [Black and Scholes 1973]
- Realized Volatility of Stock Returns

Bloom index is news based, JLN based on common unforecastable component in macroeconomic series, VIX is computed from OTM calls/puts, implied volatility is calculated numerically by inverting the Black Scholes formula and realized volatility is calculated as the standard deviation of returns.
Uncertainty Measures in the Literature

Many series seem to capture similar information:

![Common Uncertainty Measures Graph]

All variables standardized
In addition to measures in the literature, several fixed income quantities are used to predict uncertainty:

- TED Spread
- BBB Spread
- Slope of Yield Curve

Note: Some series are available daily, while others are computed monthly. To merge the two types, we tried using end-of-month data, as well as monthly averages of daily data.
Uncertainty Measures in the Literature

Fixed Income Uncertainty

Slope = 10 Year Yield − 3 Month Yield

Economic Uncertainty and Relative Put Prices
Marcelo Bianconi and Marco Sammon

Calculation of Relative Price

Alternative Measures of Uncertainty

Predictive Accuracy of Uncertainty Measures

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work
Relation to Our Previous Work

This paper is related *Implied Volatility and the Risk-Free Rate of Return in Options Markets (with Scott MacLachlan)* [Bianconi et al. 2015]:

- We used option-implied volatility to forecast the VIX
- Implied volatility calculated with a varying risk-free rate was better for forecasting the VIX than traditional implied volatility (as measured by the Diebold-Mariano test)
- The relative put price is easier to compute than implied volatility, as it only requires the price of one option and doesn’t rely on numerical solutions
We use Theil’s U test to evaluate forecast accuracy with different measures of uncertainty. We obtain out-of-sample predictions by running regressions of the following form:

\[ \text{Vol}_t = \alpha + \sum_{i=1}^{m} \beta_i \text{Vol}_{t-i} + \sum_{i=1}^{n} \gamma_i X_{t-i} \]

Where \( \text{Vol} \) is the standard deviation of S&P 500 returns over the next three months and \( X \) is the uncertainty measure of interest.

Note: Lags for each covariate were selected using the Akaike information criterion.
Theil’s U

Of all the univariate tests, the EOM 60 day relative price has the smallest test statistic.

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Theil’s U</th>
<th>RP Price</th>
<th>Theil’s U</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.559675</td>
<td>30 AVG</td>
<td>0.52341</td>
</tr>
<tr>
<td>VIX</td>
<td>0.509049</td>
<td>60 AVG</td>
<td>0.509461</td>
</tr>
<tr>
<td>TED Spread</td>
<td>0.559419</td>
<td>90 AVG</td>
<td>0.555401</td>
</tr>
<tr>
<td>JLN 3m</td>
<td>0.517557</td>
<td>30 EOM</td>
<td>0.541269</td>
</tr>
<tr>
<td>Bloom</td>
<td>0.55175</td>
<td>60 EOM</td>
<td>0.429091</td>
</tr>
<tr>
<td>All AVG</td>
<td>0.302637</td>
<td>90 EOM</td>
<td>0.541329</td>
</tr>
<tr>
<td>All EOM</td>
<td>0.315993</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EOM - End of month, AVG - Monthly Average
All AVG has all covariates, as well as all monthly average relative put prices
All EOM has all covariates, as well as all end of month relative put prices
Macroeconomic Variables of Interest

We analyze the relationship between several important macroeconomic series and our relative price measure:

- Real GDP Growth
- Potential GDP
- Non-Residential Fixed Investment
- Residential Investment

Quarterly data interpolated to monthly using cubic spline
### Testing Granger Causality

Does variable on vertical axis Granger Cause variable on horizontal axis (p-values):

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>0.0720</td>
<td>0.0000</td>
<td>0.7506</td>
<td>0.0866</td>
</tr>
<tr>
<td>TED</td>
<td>0.0283</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.8037</td>
</tr>
<tr>
<td>Bloom</td>
<td>0.0682</td>
<td>0.5091</td>
<td>0.3056</td>
<td>0.3603</td>
</tr>
<tr>
<td>JLN 3M</td>
<td>0.8867</td>
<td>0.0000</td>
<td>0.4333</td>
<td>0.8023</td>
</tr>
<tr>
<td>30 EOM</td>
<td>0.0794</td>
<td>0.0000</td>
<td>0.2455</td>
<td>0.1126</td>
</tr>
<tr>
<td>30 AVG</td>
<td>0.0693</td>
<td>0.0000</td>
<td>0.8002</td>
<td>0.0557</td>
</tr>
<tr>
<td>60 EOM</td>
<td>0.0951</td>
<td>0.0000</td>
<td>0.3613</td>
<td>0.6392</td>
</tr>
<tr>
<td>60 AVG</td>
<td>0.0820</td>
<td>0.0000</td>
<td>0.8159</td>
<td>0.0574</td>
</tr>
<tr>
<td>90 EOM</td>
<td>0.2097</td>
<td>0.0000</td>
<td>0.4978</td>
<td>0.1296</td>
</tr>
<tr>
<td>90 AVG</td>
<td>0.2373</td>
<td>0.0000</td>
<td>0.7181</td>
<td>0.0806</td>
</tr>
</tbody>
</table>

Note: Lags for each covariate were selected using the Akaike information criterion.

Macroeconomic series were exception - only one lag was used.

Null hypothesis is absence of Granger Causality.
## Testing Granger Causality

Does variable on vertical axis Granger Cause variable on horizontal axis (p-values):

<table>
<thead>
<tr>
<th></th>
<th>VIX</th>
<th>TED</th>
<th>Bloom</th>
<th>JLN 3M</th>
<th>30 EOM</th>
<th>30 AVG</th>
<th>60 EOM</th>
<th>60 AVG</th>
<th>90 EOM</th>
<th>90 AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real GDP</td>
<td>0.0000</td>
<td>0.0279</td>
<td>0.0755</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0006</td>
<td>0.0000</td>
<td>0.0006</td>
<td>0.0002</td>
</tr>
<tr>
<td>Real Pot. GDP</td>
<td>0.1458</td>
<td>0.7082</td>
<td>0.0015</td>
<td>0.0651</td>
<td>0.0216</td>
<td>0.1746</td>
<td>0.0024</td>
<td>0.1055</td>
<td>0.0253</td>
<td>0.0781</td>
</tr>
<tr>
<td>Real Non-Res. Invest.</td>
<td>0.0217</td>
<td>0.3296</td>
<td>0.6084</td>
<td>0.0440</td>
<td>0.0157</td>
<td>0.0182</td>
<td>0.0094</td>
<td>0.0222</td>
<td>0.0032</td>
<td>0.0136</td>
</tr>
<tr>
<td>Real Res. Invest.</td>
<td>0.1169</td>
<td>0.0070</td>
<td>0.8597</td>
<td>0.0031</td>
<td>0.1609</td>
<td>0.0170</td>
<td>0.4560</td>
<td>0.0390</td>
<td>0.1860</td>
<td>0.0524</td>
</tr>
</tbody>
</table>

Null hypothesis is absence of Granger Causality
Relationship between Relative Put Price and GDP

Uncertainty and GDP

- Blue line: Ch. Potential GDP
- Red line: Ch. GDP
- Green line: 60 Day Relative Put Price (EOD)
Cross Correlation

X-Corr of VIX Index (EOD) and Real GDP Growth

-20 -10 0 10 20
Lag

-1.00 -0.50 0.00 0.50 1.00

-1.00 -0.50 0.00 0.50 1.00
Cross Correlation

X-Corr of Bloom Uncertainty Index and Real GDP Growth
Cross Correlation

X-Corr of Macro Uncertainty for h = 3 month ahead as computed as in Jurad

Calculation of Relative Price
Alternative Measures of Uncertainty
Predictive Accuracy of Uncertainty Measures
Impact of Uncertainty on Macroeconomy and Interest Rates
Conclusions and Future Work
Economic Uncertainty and Relative Put Prices

Marcelo Bianconi and Marco Sammon

Calculation of Relative Price

Alternative Measures of Uncertainty

Predictive Accuracy of Uncertainty Measures

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work
Cross Correlation

X-Corr of 30 Day Monthly Average and Real GDP Growth

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work
Cross Correlation

X-Corr of 60 Day Relative Put Price (EOD) and Real GDP Growth

Lag
Cross Correlation

X-Corr of 60 Day Monthly Average and Real GDP Growth
Cross Correlation

X-Corr of 90 Day Relative Put Price (EOD) and Real GDP Growth
Term Structure

Yield on Treasury Bills with different maturities:

- 3 Month
- 1 Year
- 5 Year
- 10 Year
Testing Granger Causality

<table>
<thead>
<tr>
<th></th>
<th>3 Month</th>
<th>1 Year</th>
<th>5 Year</th>
<th>10 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0135</td>
<td>0.2418</td>
</tr>
<tr>
<td>TED</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0316</td>
<td>0.0026</td>
</tr>
<tr>
<td>Bloom</td>
<td>0.0329</td>
<td>0.0055</td>
<td>0.0025</td>
<td>0.0016</td>
</tr>
<tr>
<td>JLN 3M</td>
<td>0.0010</td>
<td>0.0001</td>
<td>0.2410</td>
<td>0.4683</td>
</tr>
<tr>
<td>30 EOM</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.1299</td>
<td>0.3707</td>
</tr>
<tr>
<td>30 AVG</td>
<td>0.0003</td>
<td>0.0009</td>
<td>0.0887</td>
<td>0.4145</td>
</tr>
<tr>
<td>60 EOM</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0031</td>
<td>0.0808</td>
</tr>
<tr>
<td>60 AVG</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0157</td>
<td>0.2799</td>
</tr>
<tr>
<td>90 EOM</td>
<td>0.0005</td>
<td>0.0029</td>
<td>0.1735</td>
<td>0.1257</td>
</tr>
<tr>
<td>90 AVG</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0307</td>
<td>0.3143</td>
</tr>
</tbody>
</table>

Note: Lags for each covariate were selected using the Akaike information criterion

Null hypothesis is absence of Granger Causality
Testing Granger Causality

<table>
<thead>
<tr>
<th>Null hypothesis is absence of Granger Causality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does variable on vertical axis Granger Cause variable on horizontal axis (p-values):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>VIX</th>
<th>TED</th>
<th>Bloom</th>
<th>JLN 3M</th>
<th>30 EOM</th>
<th>30 AVG</th>
<th>60 EOM</th>
<th>60 AVG</th>
<th>90 EOM</th>
<th>90 AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Month</td>
<td>0.8314</td>
<td>0.0000</td>
<td>0.0002</td>
<td>0.0003</td>
<td>0.8637</td>
<td>0.9926</td>
<td>0.5411</td>
<td>0.8783</td>
<td>0.9577</td>
<td>0.8410</td>
</tr>
<tr>
<td>1 Year</td>
<td>0.4819</td>
<td>0.0019</td>
<td>0.0003</td>
<td>0.0083</td>
<td>0.1167</td>
<td>0.6276</td>
<td>0.0336</td>
<td>0.4252</td>
<td>0.1074</td>
<td>0.5917</td>
</tr>
<tr>
<td>5 Year</td>
<td>0.9384</td>
<td>0.1403</td>
<td>0.0004</td>
<td>0.0583</td>
<td>0.1599</td>
<td>0.9778</td>
<td>0.0625</td>
<td>0.9485</td>
<td>0.0344</td>
<td>0.5449</td>
</tr>
<tr>
<td>10 Year</td>
<td>0.9374</td>
<td>0.0205</td>
<td>0.0002</td>
<td>0.0590</td>
<td>0.3387</td>
<td>0.5820</td>
<td>0.1083</td>
<td>0.9094</td>
<td>0.7042</td>
<td>0.7070</td>
</tr>
</tbody>
</table>
Relationship between T-Bill Yields and Relative Put Price
Cross Correlation

X-Corr of VIX Index (EOD) and 3M T-Bill Yield
Cross Correlation

X-Corr of Bloom Uncertainty Index and 3M T-Bill Yield
Economic Uncertainty and Relative Put Prices

Marcelo Bianconi and Marco Sammon

Calculation of Relative Price

Alternative Measures of Uncertainty

Predictive Accuracy of Uncertainty Measures

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work

Cross Correlation

X-Corr of Macro Uncertainty for h = 3 month ahead as computed as in Jurado
Cross Correlation

X-Corr of 30 Day Relative Put Price (EOD) and 3M T-Bill Yield
Cross Correlation

X-Corr of 30 Day Monthly Average and 3M T-Bill Yield
Economic Uncertainty and Relative Put Prices

Marcelo Bianconi and Marco Sammon

Calculation of Relative Price

Alternative Measures of Uncertainty

Predictive Accuracy of Uncertainty Measures

Impact of Uncertainty on Macroeconomy and Interest Rates

Conclusions and Future Work

Cross Correlation

X-Corr of 60 Day Relative Put Price (EOD) and 3M T-Bill Yield
Cross Correlation

X-Corr of 60 Day Monthly Average and 3M T-Bill Yield
Cross Correlation

X-Corr of 90 Day Relative Put Price (EOD) and 3M T-Bill Yield
Cross Correlation

X-Corr of 90 Day Monthly Average and 3M T-Bill Yield
Impulse Response Functions

We include all term structure information in the fitted value for 3-Month T-bill yield with a regression of the following form:

\[ 3MYield_t = \alpha + \sum_{i=1}^{a} \beta_i 3MYield_{t-i} + \sum_{i=1}^{b} \gamma_i 1YRYield_{t-i} + \sum_{i=1}^{c} \psi_i 5YRYield_{t-i} + \sum_{i=1}^{d} \phi_i 10YRYield_{t-i} \]

We set \( a = b = c = d = 1 \), but it is also possible to select the appropriate lags using the AIC.
30 Day Relative Put Price

**30 Price, Real Ch. GDP**

![Graph](varbasic, _30_price, g_rgdp_a)

Graphs by irfname, impulse variable, and response variable

**30 Price, Real Ch. Non-Res. Invest.**

![Graph](varbasic, _30_price, g_rprinv_a)

Graphs by irfname, impulse variable, and response variable

**30 Price, Real Ch. Res. Invest**

![Graph](varbasic, _30_price, g_rprinv_a)

Graphs by irfname, impulse variable, and response variable

**30 Price, Real Ch. Pot. GDP**

![Graph](varbasic, _30_price, _3month_bill_hat)

Graphs by irfname, impulse variable, and response variable
60 Day Relative Put Price

**60 Price, Real Ch. GDP**

Graphs by irfname, impulse variable, and response variable

**60 Price, Real Ch. Non-Res. Invest.**

Graphs by irfname, impulse variable, and response variable

**60 Price, Real Ch. Res. Invest**

Graphs by irfname, impulse variable, and response variable

**60 Price, Fitted 3-M T-Bill Yield**

Graphs by irfname, impulse variable, and response variable
Impulse Response Functions

90 Day Relative Put Price

90 Price, Real Ch. GDP
varbasic, _90_price, g_rgdp_a
Graphs by irfname, impulse variable, and response variable

90 Price, Real Ch. Non-Res. Invest.
varbasic, _90_price, g_rprinv_a
Graphs by irfname, impulse variable, and response variable

90 Price, Real Ch. Res. Invest
varbasic, _90_price, g_prnrinv_a
Graphs by irfname, impulse variable, and response variable

90 Price, Fitted 3-M T-Bill Yield
varbasic, _90_price, _3month_bill_hat
Graphs by irfname, impulse variable, and response variable
Realized volatility is the standard deviation of S&P 500 returns over the previous 3 months.
Realized volatility is the standard deviation of S&P 500 returns over the previous 6 months.
Realized volatility is the standard deviation of S&P 500 returns over the previous 12 months.
Summary of Findings

We develop a measure of uncertainty that is:

• Easy to compute
• Superior for forecasting realized volatility
• Useful for forecasting macroeconomic series such as GDP
• Applicable to many areas of future research
Avenues for Future Research

- Use an G/ARCH model to estimate the volatility process
- Test forecasting ability at different frequencies (Daily, Weekly, Monthly, Quarterly)
- Obtain a longer time series with more recessions to ensure the robustness of our uncertainty measure
- Forecast stock volatility for individual companies - especially before earnings announcements or other corporate events
- Use dimension reduction techniques to distill out principal components for forecasting volatility
- Experiment with data filtering techniques, including exponential moving average
References

Bianconi, MacLachlan and Sammon (2015)
Implied Volatility and the Risk-Free Rate of Return in Options Market
North American Journal of Economics and Finance

Jurado, Ludvigson and Ng (2013)
Measuring Uncertainty
NBER Working Paper

Baker, Bloom and Davis (2013)
Measuring Economic Policy Uncertainty
Chicago Booth Research Paper

Black and Scholes (1973)
The Pricing of Options and Corporate Liabilities
Journal of Political Economy

Chicago Board Options Exchange, Incorporated (2009)
CBOE Volatility Index - VIX
White Paper
Questions