Credit spreads, daily business cycle, and aggregate bond returns predictability

Alexey Ivashchenko
University of Lausanne and Swiss Finance Institute

December, 2017
This paper is about corporate bond spreads:

Credit spread = Risky corporate bond yield − Safe bond yield =

= Expected credit loss + Credit risk premium (Excess bond premium)
This paper is about **corporate bond spreads**:

\[
\text{Credit spread} = \text{Risky corporate bond yield} - \text{Safe bond yield} = \\
\quad = \text{Expected credit loss} + \text{Credit risk premium (Excess bond premium)}
\]

This paper revisits known and establishes novel **forecasting properties of the credit risk premium**.
Paper in a nutshell

Benchmark view

Risk premium is

- big and volatile;
- predicts macro activity.

Collin-Dufresne, Goldstein, and Martin (2001);
Gilchrist and Zakrajšek (2012); De Santis (2017); Nozawa (2017)
Risk premium is

- big and volatile;
- predicts macro activity.

Collin-Dufresne, Goldstein, and Martin (2001); Gilchrist and Zakrajšek (2012); De Santis (2017); Nozawa (2017)

Risk premium is

- much smaller and less volatile;
- does not predict macro;
- predicts bond market returns.

See also: d’Avernas (2017)
Some definitions

- **GZ spread** $S_{i,t}^{GZ}[k]$ of bond $k$ of firm $i$ at time $t$: the difference in YTM between bond $k$ and a risk-free bond with the same coupon schedule priced with ZC curve.
Some definitions

- **GZ spread** $S_{i,t}^{GZ}[k]$ of bond $k$ of firm $i$ at time $t$: the difference in YTM between bond $k$ and a risk-free bond with the same coupon schedule priced with ZC curve.

- **Fitted GZ spread** $\hat{S}_{i,t}^{GZ}[k] = \hat{g}(Z_{i,t,k})$. 
Some definitions

- **GZ spread** $S^{GZ}_{i,t}[k]$ of bond $k$ of firm $i$ at time $t$: the difference in YTM between bond $k$ and a risk-free bond with the same coupon schedule priced with ZC curve.

- **Fitted GZ spread** $\hat{S}^{GZ}_{i,t}[k] = \hat{g}(Z_{i,t},k)$.

- **Excess bond premium** $EBP_{i,t}[k] = S^{GZ}_{i,t}[k] - \hat{S}^{GZ}_{i,t}[k]$. 
Some definitions

- **GZ spread** $S_{i,t}^{GZ}[k]$ of bond $k$ of firm $i$ at time $t$: the difference in YTM between bond $k$ and a risk-free bond with the same coupon schedule priced with ZC curve.
- **Fitted GZ spread** $\hat{S}_{i,t}^{GZ}[k] = \hat{g}(Z_{i,t},k)$.
- **Excess bond premium** $EBP_{i,t}[k] = S_{i,t}^{GZ}[k] - \hat{S}_{i,t}^{GZ}[k]$.
- **Aggregate EBP** at each date $t$, $EBP_t$: cross-sectional mean over $i$ and $k$. 

Data

Bond trades from Enhanced TRACE, bond characteristics from Mergent FISD, firm and equity data from Compustat and CRSP, and daily business cycle measure from the Philly Fed.
**Data**

Bond trades from Enhanced TRACE, bond characteristics from Mergent FISD, firm and equity data from Compustat and CRSP, and daily business cycle measure from the Philly Fed ADS index plot.

Sample period is from Oct’2004 to Dec’2014. Number of unique bonds/firms is 4627/760. Total number of bond-days observations is 1.99 mln. Median number of bonds in sample per day is 826.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Min</th>
<th>Pctl(25)</th>
<th>Median</th>
<th>Pctl(75)</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size, mln USD</td>
<td>594.71</td>
<td>549.50</td>
<td>1</td>
<td>282</td>
<td>500</td>
<td>750</td>
<td>15,000</td>
</tr>
<tr>
<td>Time to maturity, years</td>
<td>8.80</td>
<td>7.81</td>
<td>1.00</td>
<td>3.28</td>
<td>5.90</td>
<td>10.06</td>
<td>30.43</td>
</tr>
<tr>
<td>Age, years</td>
<td>5.72</td>
<td>4.95</td>
<td>0.00</td>
<td>2.05</td>
<td>4.22</td>
<td>7.84</td>
<td>49.66</td>
</tr>
<tr>
<td>Duration, years</td>
<td>6.19</td>
<td>4.10</td>
<td>0.94</td>
<td>3.02</td>
<td>5.03</td>
<td>8.00</td>
<td>19.64</td>
</tr>
<tr>
<td>Coupon rate, pct.</td>
<td>6.06</td>
<td>1.74</td>
<td>0.45</td>
<td>5.10</td>
<td>6.15</td>
<td>7.20</td>
<td>15.00</td>
</tr>
<tr>
<td>Credit rating</td>
<td>8.49</td>
<td>3.28</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Trades per bond per day</td>
<td>6.18</td>
<td>12.33</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1,861</td>
</tr>
<tr>
<td>Yield to maturity, pct.</td>
<td>5.07</td>
<td>2.82</td>
<td>0.19</td>
<td>3.22</td>
<td>5.09</td>
<td>6.27</td>
<td>39.42</td>
</tr>
<tr>
<td>Spread, pct.</td>
<td>2.38</td>
<td>2.41</td>
<td>0.05</td>
<td>1.04</td>
<td>1.68</td>
<td>2.86</td>
<td>35.00</td>
</tr>
<tr>
<td>Return, pct. per day</td>
<td>0.02</td>
<td>1.61</td>
<td>-11.77</td>
<td>-0.55</td>
<td>0.01</td>
<td>0.59</td>
<td>11.23</td>
</tr>
<tr>
<td>Distance-to-default (DD)</td>
<td>0.67</td>
<td>0.34</td>
<td>0.01</td>
<td>0.40</td>
<td>0.63</td>
<td>0.89</td>
<td>5.03</td>
</tr>
<tr>
<td>Amihud measure</td>
<td>0.60</td>
<td>1.06</td>
<td>0.00</td>
<td>0.03</td>
<td>0.21</td>
<td>0.68</td>
<td>8.87</td>
</tr>
</tbody>
</table>
GZ spread: daily and monthly

Daily measure

Monthly measures

- Monthly mean of daily measure
- Monthly last of daily measure
- Original GZ monthly
Panel model for spreads

- The panel of credit spreads in *Gilchrist and Zakrajšek (2012)* is fitted with a linear model:

\[
\log\left( S_{it}^{GZ}[k] \right) = \beta \cdot DD_{it} + (\text{Proxies for recovery rate and liquidity}) + \\
+ (\text{Call option adjustment}) + \\
+ (\text{Industry and rating FE}) + \epsilon_{it}[k]
\]
Panel model for spreads

- The panel of credit spreads in Gilchrist and Zakrajšek (2012) is fitted with a linear model:

\[
\log \left( S_{it}^{GZ}[k] \right) = \beta \cdot DD_{it} + \text{(Proxies for recovery rate and liquidity)} + \\
+ \text{(Call option adjustment)} + \\
+ \text{(Industry and rating FE)} + \epsilon_{it}[k]
\]

- I add two additional factors:

\[
\log \left( S_{it}^{GZ}[k] \right) = \beta \cdot DD_{it} + \text{(Proxies for recovery rate and liquidity)} + \\
+ \text{(Call option adjustment)} + \\
+ \gamma \cdot ADS_{t} + \eta \cdot LIQ_{it}[k] + \\
\text{Daily business cycle and price impact} + \\
+ \text{(Industry and rating FE)} + \epsilon_{it}[k]
\]
### Fitted models for spreads: full sample

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-DD_{it}$</td>
<td>0.765***</td>
<td>0.543***</td>
<td>0.537***</td>
<td>0.633***</td>
<td>0.443***</td>
<td>0.434***</td>
</tr>
<tr>
<td>(0.034)</td>
<td>(0.030)</td>
<td>(0.030)</td>
<td>(0.054)</td>
<td>(0.050)</td>
<td>(0.049)</td>
<td></td>
</tr>
<tr>
<td>$\log(DUR_{it}[k])$</td>
<td>0.097***</td>
<td>0.109***</td>
<td>0.099***</td>
<td>0.061***</td>
<td>0.068***</td>
<td>0.055***</td>
</tr>
<tr>
<td>(0.010)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.021)</td>
<td>(0.020)</td>
<td>(0.019)</td>
<td></td>
</tr>
<tr>
<td>$-\log(PAR_{it}[k])$</td>
<td>-0.073***</td>
<td>-0.073***</td>
<td>-0.068***</td>
<td>-0.038**</td>
<td>-0.043***</td>
<td>-0.038**</td>
</tr>
<tr>
<td>(0.012)</td>
<td>(0.011)</td>
<td>(0.011)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td></td>
</tr>
<tr>
<td>$\log(CPN_{i}[k])$</td>
<td>0.631***</td>
<td>0.554***</td>
<td>0.554***</td>
<td>0.626***</td>
<td>0.563***</td>
<td>0.560***</td>
</tr>
<tr>
<td>(0.020)</td>
<td>(0.019)</td>
<td>(0.018)</td>
<td>(0.068)</td>
<td>(0.063)</td>
<td>(0.062)</td>
<td></td>
</tr>
<tr>
<td>$\log(AGE_{it}[k])$</td>
<td>0.005</td>
<td>0.021***</td>
<td>0.016***</td>
<td>0.042</td>
<td>0.064***</td>
<td>0.061**</td>
</tr>
<tr>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.027)</td>
<td>(0.024)</td>
<td>(0.024)</td>
<td></td>
</tr>
<tr>
<td>$CALL_{i}[k]$</td>
<td>0.034*</td>
<td>0.038**</td>
<td>0.041**</td>
<td>0.406*</td>
<td>0.564**</td>
<td>0.584**</td>
</tr>
<tr>
<td>(0.020)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.233)</td>
<td>(0.234)</td>
<td>(0.231)</td>
<td></td>
</tr>
<tr>
<td>$ADSt$</td>
<td>-0.247***</td>
<td>-0.243***</td>
<td>-0.235***</td>
<td>-0.231***</td>
<td>-0.235***</td>
<td>-0.231***</td>
</tr>
<tr>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td></td>
</tr>
<tr>
<td>$LIQ_{it}[k]$</td>
<td>0.037***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.039***</td>
</tr>
<tr>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.002)</td>
</tr>
</tbody>
</table>

Industry FE YES YES YES YES YES YES
Credit rating FE YES YES YES YES YES YES
Call adjustment NO NO NO YES YES YES
Adjusted R² 0.719 0.780 0.783 0.745 0.788 0.791

**Note:**  
* p<0.1; ** p<0.05; *** p<0.01

Sample period is from Oct 1, 2004 to Dec 31, 2014. Number of unique bonds/firms is: 4636/762. Total number of bond-days observations is 2032455.

Standard errors are clustered in both the firm (i) and the time (t) dimensions.
GZ spread: actual and explained by models

Model 4

Model 6
Macro forecasting power of EBP

Consider a nowcasting model:

\[
\nabla^h Y_{t+h} = \alpha + \sum_{i=1}^{p} \beta_i \nabla Y_{t-i} + \gamma_1 RFF_t + \gamma_2 TS_t + \gamma_3 \hat{S}_{t}^{GZ} + \gamma_4 EBP_t + \epsilon_{t+h}.
\]

Fitted GZ spread and EBP
Macro forecasting power of EBP

Consider a nowcasting model:

\[ \nabla^h Y_{t+h} = \alpha + \sum_{i=1}^{p} \beta_i \nabla Y_{t-i} + \gamma_1 RFF_t + \gamma_2 TS_t + \gamma_3 \hat{S}^{GZ}_t + \gamma_4 EBP_t + \epsilon_{t+h}. \]

Fitted GZ spread and EBP

Apply it on horizon \( h = 6 \) months:

<table>
<thead>
<tr>
<th></th>
<th>Industrial production</th>
<th>Unemployment rate</th>
<th>Payroll employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>–</td>
<td>M4</td>
<td>M6</td>
</tr>
<tr>
<td>Real Fed funds rate</td>
<td>1.02 (0.71)</td>
<td>0.48 (0.43)</td>
<td>1.08 (0.70)</td>
</tr>
<tr>
<td>Term spread</td>
<td>−1.65** (0.76)</td>
<td>−0.71 (0.61)</td>
<td>−1.69** (0.71)</td>
</tr>
<tr>
<td>GZ spread</td>
<td>−2.58*** (0.91)</td>
<td>0.83*** (0.10)</td>
<td>−1.09*** (0.06)</td>
</tr>
<tr>
<td>Fitted GZ</td>
<td>−0.78 (0.81)</td>
<td>−2.92*** (1.09)</td>
<td>0.57*** (0.16)</td>
</tr>
<tr>
<td>EBP</td>
<td>−4.77**** (1.24)</td>
<td>−1.55 (1.29)</td>
<td>0.99*** (0.20)</td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>0.50</td>
<td>0.57</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Note: * \( p < 0.1 \); ** \( p < 0.05 \); *** \( p < 0.01 \)

Same for 3m and 12m
Bi-variate VARs for ADS and EBP

EBP of Model 4

EBP of Model 6
Predictive content of the EBP in *Gilchrist and Zakrajšek (2012)* hinges on the information about business cycle and liquidity states;
Predictive content of the EBP in *Gilchrist and Zakrajšek (2012)* hinges on the information about business cycle and liquidity states;

Both are tractable with readily available daily proxies;
Predictive content of the EBP in *Gilchrist and Zakrajšek (2012)* hinges on the information about business cycle and liquidity states;

Both are tractable with readily available daily proxies;

EBP orthogonal to business cycle state has much less (if any) forecasting power;
Predictive content of the EBP in *Gilchrist and Zakrajšek (2012)* hinges on the information about business cycle and liquidity states;

Both are tractable with readily available daily proxies;

EBP orthogonal to business cycle state has much less (if any) forecasting power;

**Probably, one does not really need spreads to forecasts macro.**
Nozawa (2017) shows that under some mild assumptions about recovery rates one can derive Campbell-Shiller decomposition for corporate bonds and by iterating it forward obtain:

\[ S_t = \mathbb{E}_t \left[ \sum_{1}^{\infty} \rho^{i-1} r_{t+i}^e \right] + \mathbb{E}_t \left[ \sum_{1}^{\infty} \rho^{i-1} l_{t+i} \right] + \text{Const.} \]

- Risk premium
- Expected credit loss
Nozawa (2017) shows that under some mild assumptions about recovery rates one can derive Campbell-Shiller decomposition for corporate bonds and by iterating it forward obtain:

$$S_t = \mathbb{E}_t \left[ \sum_{i=1}^{\infty} \rho^{i-1} r_{t+i}^e \right] + \mathbb{E}_t \left[ \sum_{i=1}^{\infty} \rho^{i-1} l_{t+i} \right] + \text{Const.}$$

In this spirit, consider a return forecasting model:

$$R_{t:t+h} = \alpha + \beta R_{t-h:t} + \gamma_1 LVL_t + \gamma_2 SLP_t + \gamma_3 CRV_t + \gamma_4 \hat{S}_t^{GZ} + \gamma_5 EBP_t + \epsilon_{t+h}.$$ 

I will apply it to corporate bond market returns (Barclays IG corporate bond index).
Forecasting market returns with EBP correlated with the business cycle

- Returns:
  - Returns\(_{t-1}\):
  - Level:
  - Curvature:
  - Fitted GZ spread:
  - EBP:

Horizon in days

Context | Daily EBP | Forecasting macro | Forecasting returns | Investment strategy | Results
---|---|---|---|---|---

Forecasting market returns with EBP orthogonal to the business cycle

Same with VIX

Same with d(VIX)
‘Real-time’ EBP measurement

Expanding samples are used to estimate real-time EBP.
Coefficients on real-time EBP in cumulative 50-day return forecasting

Expanding samples are used in real-time EBP and expected returns estimations.
Setup for the market-timing strategy

An investor has an amount of money $W$ under management at the end of week $t$. She can take one of the following three positions for the week $t + 1$:

- stay away from the corporate bond market and invest $W$ in risk-free securities only;
- follow the market and invest $W$ in the index ETF;
- borrow a certain fraction $\alpha > 0$ of $W$ at the risk-free rate, and invest $(1 + \alpha)W$ in the index ETF.
Setup for the market-timing strategy

An investor has an amount of money $W$ under management at the end of week $t$. She can take one of the following three positions for the week $t + 1$:

- stay away from the corporate bond market and invest $W$ in risk-free securities only;
- follow the market and invest $W$ in the index ETF;
- borrow a certain fraction $\alpha > 0$ of $W$ at the risk-free rate, and invest $(1 + \alpha)W$ in the index ETF.

How will she forecast returns?

- frequency alignment: weekly returns on the left, $N$ latest daily predictors one week prior on the right (EBP, past returns, etc.);
- selection and shrinkage by LASSO.
Training sample: 2009–2010
## Performance of the strategy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Market</td>
<td>Strategy</td>
</tr>
<tr>
<td>Mean excess return</td>
<td>0.21</td>
<td>0.33</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.75</td>
<td>0.88</td>
</tr>
<tr>
<td>Sharpe ratio</td>
<td>0.28</td>
<td>0.37</td>
</tr>
<tr>
<td>Information ratio</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Max. excess return</td>
<td>2.46</td>
<td>2.80</td>
</tr>
<tr>
<td>Min. excess return</td>
<td>-1.66</td>
<td>-2.48</td>
</tr>
</tbody>
</table>
Summary

This paper:¹

- Estimated credit risk premium on the daily frequency;

¹Full paper is available at http://www.ivasche.com
Summary

This paper:

- Estimated credit risk premium on the daily frequency;
- Demonstrated that the forecasting power of credit risk premium for macroeconomic activity is due to the link with aggregate business risk and bond liquidity risk;

1Full paper is available at http://www.ivasche.com
Summary

This paper:¹

- Estimated credit risk premium on the daily frequency;
- Demonstrated that the forecasting power of credit risk premium for macroeconomic activity is due to the link with aggregate business risk and bond liquidity risk;
- Showed that the risk premium orthogonal to the business cycle state starts to forecast bond returns out-of-sample;

¹Full paper is available at http://www.ivasche.com
Summary

This paper:\(^1\)

- Estimated credit risk premium on the daily frequency;
- Demonstrated that the forecasting power of credit risk premium for macroeconomic activity is due to the link with aggregate business risk and bond liquidity risk;
- Showed that the risk premium orthogonal to the business cycle state starts to forecast bond returns out-of-sample;
- Used this forecasting power to construct a profitable market-timing strategy.

\(^1\)Full paper is available at [http://www.ivasche.com](http://www.ivasche.com)
In the Merton (1974) model firm’s default probability at time $t$ is determined by:

$$
\mathbb{P}[V_A \leq D] = \Phi(-DD) = \Phi(d_1) = \Phi \left( - \frac{\log \left( \frac{V_A}{D} \right) + (r - \frac{\sigma_A^2}{2})(T - t)}{\sigma_A \sqrt{T - t}} \right),
$$

where $V_A$ is the value of firm’s assets, $D$ is the default threshold, $\sigma_A$ is the volatility of $V_A$, $T - t$ is the time to maturity, $r$ is the discount rate, $\Phi(\cdot)$ is the standard normal c.d.f., and $V_A$ and $\sigma_A$ are determined by:

$$
0 = V_A \Phi(d_1) - \exp \{-r(T - t)\} D \Phi(d_2) - V_E,
$$

$$
0 = \frac{V_A}{V_E} \Phi(d_1) \sigma_A - \sigma_E,
$$

where $d_2 = d_1 - \sigma_A \sqrt{T - t}$, and $V_E$ and $\sigma_E$ are correspondingly the value of the firm’s equity and its volatility (these parameters are observed).
Appendix: ADS index as of fall 2016
Appendix: Number of bonds in sample per day
## Appendix: Forecasting macro on 3m and 12m horizon

### Industrial production vs. Real Fed funds rate, Term spread, GZ spread, and EBP

<table>
<thead>
<tr>
<th></th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Fed funds rate</td>
<td>0.51</td>
<td>0.23</td>
<td>0.56</td>
<td>0.06</td>
<td>0.07*</td>
<td>0.05</td>
<td>-0.09*</td>
<td>-0.09**</td>
<td>-0.09*</td>
<td></td>
</tr>
<tr>
<td>(0.36)</td>
<td>(0.21)</td>
<td>(0.42)</td>
<td>(0.05)</td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Term spread</td>
<td>-0.90*</td>
<td>-0.39</td>
<td>-0.94**</td>
<td>0.04</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.07</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>(0.47)</td>
<td>(0.33)</td>
<td>(0.50)</td>
<td>(0.06)</td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.06)</td>
<td>(0.04)</td>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GZ spread</td>
<td>-1.84***</td>
<td>0.54***</td>
<td>0.66***</td>
<td>-0.70</td>
<td>-2.18***</td>
<td>0.46***</td>
<td>0.60***</td>
<td>-0.59***</td>
<td>-0.74***</td>
<td></td>
</tr>
<tr>
<td>(0.40)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitted GZ</td>
<td>-0.70</td>
<td>-2.18***</td>
<td>0.46***</td>
<td>0.60***</td>
<td>-0.59***</td>
<td>-0.74***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.54)</td>
<td>(0.35)</td>
<td>(0.08)</td>
<td>(0.04)</td>
<td>(0.11)</td>
<td>(0.06)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EBP</td>
<td>-2.85***</td>
<td>-0.82</td>
<td>0.59***</td>
<td>0.33***</td>
<td>-0.70***</td>
<td>-0.46***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.60)</td>
<td>(0.66)</td>
<td>(0.07)</td>
<td>(0.10)</td>
<td>(0.07)</td>
<td>(0.08)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Adjusted R^2

<table>
<thead>
<tr>
<th></th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
<th>M4</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>0.61</td>
<td>0.68</td>
<td>0.64</td>
<td>0.76</td>
<td>0.76</td>
<td>0.79</td>
<td>0.89</td>
<td>0.89</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>M6</td>
<td>0.68</td>
<td>0.64</td>
<td>0.76</td>
<td>0.79</td>
<td>0.89</td>
<td>0.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

* p<0.1; ** p<0.05; *** p<0.01
Appendix: Forecasting returns with EBP and VIX

![Graphs showing the relationship between returns, horizon, and EBP and VIX parameters.](image)

- **Returns**: Shows the evolution of returns over different horizons.
- **Curvature**: Displays the curvature parameter over time.
- **VIX**: Illustrates the volatility index over the horizon.
- **Level**: Presents the level parameter over the forecast horizon.
- **Slope**: Demonstrates the slope parameter over the horizon.
- **Fitted GZ spread**: Shows the fitted GZ spread over the forecast horizon.
- **EBP**: Displays the EBP parameter over the horizon.

*Horizon in days: 0 18 36 54 72 90*
Appendix: Forecasting returns with only stationary series

Back to main
Appendix: correlations between EBP and other asset pricing factors

<table>
<thead>
<tr>
<th></th>
<th>EBP</th>
<th>BM</th>
<th>DRF</th>
<th>CRF</th>
<th>LRF</th>
<th>SM</th>
<th>SMB</th>
<th>HML</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBP</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td>0.06**</td>
<td>0.28***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRF</td>
<td>-0.08**</td>
<td>-0.36***</td>
<td>0.08**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRF</td>
<td>-0.36***</td>
<td>0.08**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRF</td>
<td>0.05*</td>
<td>0.20***</td>
<td>0.47***</td>
<td>-0.06*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>-0.01</td>
<td>-0.28***</td>
<td>0.03</td>
<td>0.41***</td>
<td>-0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMB</td>
<td>0.00</td>
<td>-0.08***</td>
<td>0.00</td>
<td>0.14***</td>
<td>-0.02</td>
<td>0.33***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HML</td>
<td>0.01</td>
<td>-0.14***</td>
<td>0.00</td>
<td>0.18***</td>
<td>-0.02</td>
<td>0.44***</td>
<td>0.09***</td>
<td></td>
</tr>
<tr>
<td>UMD</td>
<td>-0.03</td>
<td>0.09***</td>
<td>-0.04</td>
<td>-0.17***</td>
<td>-0.01</td>
<td>-0.38***</td>
<td>-0.05*</td>
<td>-0.59***</td>
</tr>
</tbody>
</table>

(a) Daily frequency with daily rebalancing.

<table>
<thead>
<tr>
<th></th>
<th>EBP</th>
<th>BM</th>
<th>DRF</th>
<th>CRF</th>
<th>LRF</th>
<th>SM</th>
<th>SMB</th>
<th>HML</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBP</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td>0.14</td>
<td>0.47***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRF</td>
<td>-0.22*</td>
<td>-0.04</td>
<td>-0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRF</td>
<td>0.03</td>
<td>0.04</td>
<td>0.37***</td>
<td>-0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRF</td>
<td>-0.01</td>
<td>-0.14</td>
<td>0.03</td>
<td>-0.13</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>0.13</td>
<td>0.02</td>
<td>-0.13</td>
<td>-0.09</td>
<td>0.19*</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMB</td>
<td>0.15</td>
<td>-0.17</td>
<td>-0.16</td>
<td>-0.20*</td>
<td>0.11</td>
<td>0.56***</td>
<td></td>
<td>-0.05</td>
</tr>
<tr>
<td>HML</td>
<td>-0.27**</td>
<td>-0.05</td>
<td>0.03</td>
<td>0.03</td>
<td>-0.01</td>
<td>-0.41***</td>
<td>0.10</td>
<td>-0.50***</td>
</tr>
<tr>
<td>UMD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Monthly frequency with monthly rebalancing.

Table: DRF, CRF, and LRF are default, credit, and liquidity bond factors from Bai, Bali, and Wen (2016). BM is the bond market, SM is the stock market, SMB, HML, and UMD, are small-minus-bus, high-minus-low, and momentum Fama-French stock pricing factors.

* p < 0.1, ** p < 0.05, *** p < 0.01. Back to main