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Industry Based Equity Premium Forecasts

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Industry based equity premium forecasts

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Abstract

In this paper we used industry indexes to predict the equity premium in the US. We considered several types of predictive models: i) constant coefficients and constant volatility, ii) drifting coefficients and constant volatility, iii) constant coefficients and stochastic volatility and iv) drifting coefficients and stochastic volatility. The models were estimated through the particle learning algorithm, which is suitable for dealing with the problem that an investor faces in practice, given that it allows the investor to revise the parameters as new information arrives. All the models exhibit similar statistical predictive ability, but stochastic volatility models generate slightly higher utility gains.

Resumo

Neste trabalho usamos índices industriais para prever o prémio de risco no EUA. Considerámos vários tipos de modelos de previsão: i) Coeficientes constantes e volatilidade constante, ii) coeficientes variáveis e volatilidade constante iii) coeficientes constantes e volatilidade estocástica e iv) coeficientes variáveis e volatilidade estocástica. Os modelos foram estimados através do algoritmo parameter learning, que replica adequadamente o problema que um investidor enfrenta na prática, dado que permite ao investidor atualizar os parâmetros após a chegada de nova informação. Todos os modelos exibem capacidade de previsão similar ao nível estatístico, mas os modelos de volatilidade estocástica geram ganhos de utilidade ligeiramente superiores.
1. Introduction

The efficient markets hypothesis, characterized by Fama (1965), states that prices fully reflect all the available information. Later, Grossman and Stiglitz (1980) proved that, if the process of information gathering is costly, prices cannot possibly incorporate all the available information. They argue that prices only partially reveal the information because, otherwise, informed investors could not obtain a return that would justify paying the cost of acquiring information. The fact that information is costly and that investors have limited time and resources is closely related to the limited attention hypothesis, according to which investors must choose to analyze only a subset of the available information, because they can not process it all.

One of the most clear episodes that illustrates investors inattention was analyzed by Huberman and Regev (2001). The stock price of EnterMed, a biotechnology company, surged 600% after the New York Times Sunday edition published an article on a potential development of new cancer-curing drugs, even though the article did not reveal any new information. The same news have been published more than five months earlier, in the scientific review Nature, with a much smaller impact on this firm's stock price.

Other authors used slow information diffusion as an explanation for several stock market anomalies. Peng and Xiong (2006), develop a model that contemplates both limited investor attention and overconfidence, and argue that return correlation between firms is higher than fundamental correlation. Hou (2007) shows that slow diffusion of common information causes large firms to lead small firms in the same industry. Menzly and Ozbas (2010) report that industries related through the supply
chain exhibit strong cross-momentum, and Cohen and Frazzini (2008) find that firms' prices do not incorporate immediately the news about other firms that are amongst their main customers. Hong et al. (2007) show that, if investors focus their attention on a subset of all the industries, then returns will exhibit positive cross-momentum. They also provide evidence, using univariate predictive regressions, that industries lead the stock market.

We extend the work of Hong et al. (2007) in two directions: we consider predictive regressions with both drifting parameters and stochastic volatility, and we analyze the out-of-sample predictive ability of industries, through combination forecasts.

Instability in predictive regressions has been reported by several authors. Pettenuzzo and Timmermann (2011) searched for breaks in predictive regressions, based on the dividend yield and the short rate, in the US. They concluded that there is strong evidence of breaks, and that they may have a substantial impact on the optimal asset allocation. Paye and Timmermann (2006) also tested for the presence of breaks in several developed countries, and reached similar results. Henkel et al. (2011) have used a regime-shifting model to predict the equity premia in the G7 countries. They have shown that parameter estimates are different in the two regimes, and that predictability is substantially higher during recessions than during expansionary periods. Dangl and Halling (2012) used a dynamic linear model, which implies gradual coefficients changes, in order to forecast the equity premium in the US. They showed that the model's predictions generate substantial utility gains for an investor with CRRA preferences. Johannes et al. (2014) proposed a model to estimate the relation between the net payout ratio and the equity premium, in the US, that featured both
drifting coefficients and time-varying volatility. They concluded that their model delivers statistically and economically significant out-of-sample utility gains, for a power utility investor, unlike traditional predictive models, with constant parameters and volatility, that generate no benefit for the investor. Rapach et al. (2010) argued that model uncertainty and instability limits the ability on individual predictive models. In order to overcome this problem, they combined the predictions of univariate regressions and concluded that the resulting forecasts were smoother and generated both statistical and economic out-of-sample gains.

In this paper we estimated equity premium predictive regressions, based on 32 US industries. We considered models with i) constant coefficients and constant volatility, ii) drifting coefficients and constant volatility, iii) constant coefficients and stochastic volatility and iv) drifting coefficients and stochastic volatility. We combined the forecasts of the industries' predictive regressions, for each model type, according to their past performance. The combined forecasts delivered both statistical and economic gains, relative to the predictions based on the historical mean. The models' statistical performance is similar across all model types, but stochastic volatility models generated slightly higher economic gains.

The rest of this paper is organized as follows. Section 2 describes the methodology used in the estimation of the predictive regressions, and the out-of-sample evaluation measures. Section 3 presents the dataset. Section 4 displays our results, and section 5 presents the main conclusions.
2. Methodology

2.1 The model

It is a well known fact that stock returns exhibit conditional stochastic volatility. Besides, past research provides extensive evidence that the relation between the equity premium and a set of commonly used predictive variables is not stable over time. Therefore, we have chosen the following model that contemplates both these features

\[ R_{t+1} = \alpha_t + \beta_0 I_t + \beta_{t+1} I_t + \exp(V_{t+1}/2) \varepsilon_{t+1}^R \]  
\[ I_{t+1} = \alpha_t + \beta_{t+1} I_t + \exp(W_{t+1}/2) \varepsilon_{t+1}^I \]

where \( R_{t+1} \) is the equity premium from the end of month \( t \) to the end of month \( t+1 \), \( I_{t+1} \) is the excess return of the industry over the riskless interest rate, \( V_{t+1} \) and \( W_{t+1} \) are stochastic conditional volatilities for the equity premium and industry equations, respectively, \( \varepsilon_{t+1}^R \) and \( \varepsilon_{t+1}^I \) are standard normal errors with correlation \( \rho \).

Traditional models that attempt to predict the equity premium assume volatility is constant, which implies that all observations have the same weight in the estimation. Stochastic volatility models, underweight observations that correspond to high volatility periods, whose information content is presumably lower. We have chosen a log-stochastic volatility specification (Jacquier et al., 2005), because of its simplicity and its ability to incorporate volatility clusters

\[ V_{t+1} = \alpha_v + \beta_v V_t + \sigma_v \eta_{t+1}^V \]  
\[ W_{t+1} = \alpha_w + \beta_w W_t + \sigma_w \eta_{t+1}^W \]

where \( \eta_{t+1}^V \) and \( \eta_{t+1}^W \) are standard normal independent errors.
We model the time-varying nature of predictability assuming that $\beta_{t+1}$, in equation (1), follows an AR(1) process, as in Johannes et al., 2004

$$\beta_{t+1} = \beta_{\beta} \beta_t + \sigma_{\beta} \varepsilon^\beta_{t+1}$$

(5)

where $\varepsilon^\beta_{t+1}$ is a standard normal independent error.

Equations (1) to (5) characterize the general model, which features both stochastic volatility and drifting coefficients (SV-DC model). We also consider other restricted versions of this model, namely:

- Stochastic volatility and constant coefficients (SV-CC model)- $\beta_{t+1}$ equals zero;

- Constant volatility and drifting coefficients (CV-DC model)- $V_{t+1}$ and $W_{t+1}$ are constant;

- Constant volatility and constant coefficients (CV-CC model)- $V_{t+1}$ and $W_{t+1}$ are constant and $\beta_{t+1}$ equals zero.

2.2 Particle filter

Particle filters are a class of sequential Monte Carlo methods which are particularly suitable for problems that involve sequential parameter and state learning. They approximate a continuous probability distribution by a discrete distribution of weighted draws named particles. Historically, particle filters were used to estimate sequentially an unknown set of state variables, assuming that the parameters were known\(^1\) (for example, the bootstrap filter and the auxiliary particle filter). Later, new methods were developed that can be used to estimate both the state variables and the parameters, such as the Storvik (2002) filter and particle learning (Carvalho et al. 2010)), which we used to estimate equations (1) to (5).

\(^1\) Lopes and Tsay (2011) provide an excellent review of particle filters in financial econometrics.
The particle learning algorithm requires the computation a set of sufficient statistics, that are deterministically updated, in order to represent the posterior parameter vector. This algorithm can be described as follows

i) Resample \( \left\{ \hat{z}_t^{(i)} \right\}_{i=1}^N \) from \( z_t^{(i)} = (x_t, s_t, \theta)^{(i)} \) with weights \( w_t \propto p(y_{t+1}|z_t^{(i)}) \)

ii) Propagate \( \hat{x}_t^{(i)} \) to \( x_{t+1}^{(i)} \) via \( p(x_{t+1}|\hat{z}_t^{(i)}, y_{t+1}) \)

iii) Propagate sufficient statistics \( s_t^{(i)} = S(s_t^{(i)}, x_t^{(i)}, y_{t+1}) \)

iv) Sample \( \theta^{(i)} \) from \( p(\theta|s_t^{(i)}) \)

where, \( x_t \) is the state vector, \( s_t \) is the sufficient statistics vector, \( y_t \) is the data vector, and \( \theta \) is the parameter vector. For further details about the estimation procedure for equation (1) to (5), see the internet appendix to Johannes et al. (2014).

In order to implement the algorithm described above, we had to define prior parameter and state values. We followed Johannes et al. (2014) and we used the three initial years as a training sample.

2.3 Combination of forecasts

Equity premium forecasts, based on a single predictive variable, are known to be unstable and volatile (Goyal and Welch (2003)), which compromises their out-of-sample performance. Rapach et al. (2010) proposed a new approach that combines predictions from univariate models according to their past performance. They show that this method generates smoother forecasts, that outperform the predictions based on the historical mean. We draw on the approach of Rapach et al. (2010) and combined the equity premium forecasts from the various industries, in order to generate better performing predictions.
Hong et al. (2007) have shown that not all industries incorporate useful information for predicting the equity premium. Therefore, unlike Rapach et al. (2010), we have chosen to restrict the set of industries included in the weighted forecasts, based on their mean-squared forecast error (MSFE).

The procedure we used to generate weighted forecasts was the following:

1- We computed the mean-squared forecast errors for industry $i$, from $t_1$ until the end of the sample

$$\text{MSFE}_t^i = \sum_{s=t_1}^{t-1} (R_{s+1}^i - \hat{R}_{s+1}^i)^2$$ (6)

where $\hat{R}_{s+1}^i$ is the equity premium prediction from industry $i$, for period $s + 1$. The MSFE computation starts at $t_1$, 120 periods (10 years) after the estimation begins, in order to obtain sufficiently reliable parameter estimates.

2- For each period, from $t_2$ ($t_2 = t_1 + 120$ periods) until the end of the sample, we sorted the individual predictions according to the reciprocal of their MSFE. Then, we computed the individual predictions' weights, based on the $N$ best industries ($N=1, 2, 3, 4, 5, 10$ and $15$). When industry $i$ is amongst those $N$ with lowest MSFE at time $t$, its weight in the combined forecast is

$$w_t^i = \frac{1}{\text{MSFE}_t^i} \sum_{n=1}^{N} \left( \frac{1}{\text{MSFE}_t^n} \right)$$ (7)

3- We generated combined predictions. The equity premium combined forecast for $t+1$, based on the best $N$ industries is

$$\hat{R}_{t+1}^N = \sum_{i=1}^{N} w_t^i \hat{R}_{t+1}^i$$ (8)
2.4 Performance evaluation

We used several measures, that complement each other, in order to evaluate the forecasts. We computed the pseudo $R^2$ out-of-sample, which reveals whether the predictions are close to the realized equity premia, in a mean-square sense. The statistical significance of the pseudo R-squared out-of-sample was tested using the MSPE-adjusted statistic. We also computed the utility gain for an investor that used the equity premia predictions based on the model, relative to an investor that based his asset allocation decisions on the historical mean.

The pseudo $R^2$ is

$$R^2_{\text{OOS}} = 1 - \frac{\text{MSFE}^{\text{mod}}}{\text{MSFE}^{\text{mean}}}$$  \hspace{1cm} (9)

where $\text{MSFE}^{\text{mod}}$ is the mean-squared forecast error from the model and $\text{MSFE}^{\text{mean}}$ represents the mean-squared forecast error from the historical mean. Note that the pseudo $R^2$ out-of-sample is positive whenever the model predictions outperform the forecasts based on the historical mean.

The MSPE-adjusted statistic, proposed by Clark and West (2007), is an approximately normal modified version of McCraken (2007) MSE-F statistic, which is used to test the null hypothesis that the unrestricted model MSPE is equal to the restricted model MSPE, against the one-sided alternative hypothesis that the former MSPE is lower than the later. The most convenient way to implement this test is to compute

$$\hat{f}_t = \left( R_t - \overline{R}_t^{\text{mean}} \right)^2 - \left[ \left( R_t - \overline{R}_t^{\text{mean}} \right)^2 - \left( \overline{R}_t^{\text{mean}} - \overline{R}_t^{\text{mod}} \right)^2 \right]$$  \hspace{1cm} (10)
where $R_t^{\text{mod}}$ is the equity premium prediction at month t, based on the model, and $R_t^{\text{mean}}$ is the equity premium prediction at month t, based on the historical mean. The MSPE-adjusted statistic is computed by regressing $\hat{f}_t$ on a constant, and using the resulting t-statistic for a zero coefficient. The null hypothesis of equal predictive ability is rejected, at the 5% confidence level, if the t-statistic exceeds 1.645 (one-sided test).

The previous performance evaluation measures are statistical in nature, and do not necessarily bear a direct relation with the benefits of forecasting the equity premium for an investor. In order to assess the economic value of the predictions, we compute the utility gains for a mean-variance investor, who incorporates the models' predictions in his investment decisions. We assume that the investor can choose between two types of investments, stock market and the riskless asset and, as in Campbell and Thompson (2008), we consider that the fraction of wealth invested in equities can neither exceed 150% nor fall below 0% (no short-selling).

A mean-variance investor with coefficient of relative risk aversion $\gamma$, who forecasts the equity premium using the historical average, will invest a fraction $w_t^{\text{mean}}$ of his wealth in equities, at each month t

$$w_t^{\text{mean}} = \frac{1}{\gamma} \frac{R_t^{\text{mean}}}{\sigma_{t+1}^{2}}$$

where $\hat{\sigma}_{t+1}$ is estimate of standard deviation of stock returns based on historical data.

Over the out-of-sample period, an investor that follows this strategy obtains an average utility

$$\hat{v}^{\text{mean}} = \hat{\mu}^{\text{mean}} - \frac{1}{2}\gamma\hat{\sigma}_{\text{mean}}^{2}$$
where $\hat{\mu}_{\text{mean}}$ and $\hat{\sigma}_{\text{mean}}^2$ represent the sample average and variance, respectively, over the out-of-sample period, for the portfolio formed using only information about the historical mean.

The optimal portfolio weight for an investor that bases his investment decisions on the predictive model are

$$w_{\text{mod}}^t = \frac{1}{\gamma \hat{\sigma}_{N,t+1}^2} \frac{R_{t+1}}{\gamma \hat{\sigma}_{N,t+1}^2}$$

(13)

where $\hat{\sigma}_{N,t+1}^2$ is the combination of the standard deviation estimates, for period $t+1$, from the $N$ best models, with weights given by equation (7). This investor obtains an average utility, over the out-of-sample period given by

$$\hat{\psi}_{\text{mod}} = \hat{\mu}_{\text{mod}} - \frac{1}{2} \gamma \hat{\sigma}_{\text{mod}}^2$$

(14)

where $\hat{\mu}_{\text{mod}}$ and $\hat{\sigma}_{\text{mod}}^2$ are the sample average and variance, respectively, over the out-of-sample period, for the portfolio formed using the predictive model.

The net average benefit per month for an investor who uses the predictive model is

$$\Delta U = \hat{\psi}_{\text{mod}} - \hat{\psi}_{\text{mean}}$$

(16)

and can be interpreted as the average monthly fee that an investor would be willing to pay to have access to the model's forecasts.

3. Data

We obtained monthly returns to the 38 value-weighted industries, from the Kenneth French website, for the period between July 1927 and December 2013. We had to exclude six industries due to missing data, namely, agriculture, forestry and
fishing, sanitary services, steam supply, irrigation systems, public administration and other. We also extracted from this website the one month treasury bill rate (risk free rate) and the excess return, over the risk free rate, on the market value-weighted return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ (equity premium).

**Table 1**

Descriptive statistics for the 32 industries' monthly returns and for the equity premium (EP), in %.

| Industry | Average | Std. | Max | Min |
|----------|---------|------|-----|-----|
| Mines    | 0.66    | 7.49 | 33.48 | -34.32 |
| Oil      | 0.94    | 7.82 | 41.05 | -27.57 |
| Stone    | 0.83    | 7.94 | 55.23 | -35.22 |
| Cnstr    | 0.79    | 9.55 | 67.27 | -38 |
| Food     | 0.72    | 4.84 | 32.43 | -27.94 |
| Smoke    | 0.86    | 5.83 | 33.33 | -25.32 |
| Txtls    | 0.70    | 7.76 | 59.03 | -33.19 |
| Aprl     | 0.74    | 8.43 | 90.01 | -33.16 |
| Wood     | 0.85    | 7.71 | 42.73 | -34.38 |
| Chair    | 0.87    | 10.11 | 91.68 | -46.51 |
| Paper    | 0.79    | 7.07 | 70.37 | -31.5 |
| Print    | 0.63    | 7.09 | 53.4 | -30.36 |
| Chems    | 0.76    | 5.66 | 47.79 | -31.31 |
| Ptrlm    | 0.83    | 5.99 | 39.02 | -29.95 |
| Rubbr    | 0.925   | 8.78 | 100.37 | -35.7 |
| Lethr    | 0.70    | 6.70 | 41.34 | -29.82 |
| Glass    | 0.71    | 7.43 | 50.36 | -31.83 |
| Metal    | 0.65    | 8.53 | 80.7 | -33.1 |
| MtlPr    | 0.70    | 6.24 | 39.97 | -28.48 |
| Machn    | 0.81    | 7.25 | 50.2 | -33.73 |
| Elctr    | 0.79    | 8.01 | 59.38 | -34.65 |
| Cars     | 0.82    | 7.35 | 71.63 | -34.23 |
| Instr    | 0.72    | 5.82 | 27.81 | -30.79 |
| Manuf    | 0.64    | 7.67 | 60.14 | -35.26 |
| Trans    | 0.63    | 7.20 | 65.35 | -34.52 |
| Phone    | 0.53    | 4.77 | 30.79 | -21.59 |
| TV       | 0.98    | 7.27 | 29.62 | -29.58 |
| Utils    | 0.60    | 5.59 | 42.82 | -32.88 |
| Whlsl    | 0.63    | 7.31 | 59.17 | -44.63 |
| Rtail    | 0.74    | 6.02 | 42.21 | -30.32 |
| Money    | 0.73    | 6.89 | 59.75 | -39.62 |
| Srvc     | 0.78    | 7.85 | 51.95 | -39.29 |
| EP       | 0.64    | 5.42 | 37.93 | -29.07 |
Table 1 presents descriptive statistics for the equity premium and for the excess return, over the risk free rate, for all the industries. The average monthly equity premium is 0.64%, and the average excess returns for the industries ranges between 0.53% (phone) and 0.93% (rubber). The equity premium standard deviation is 5.42%, and is higher for most industries, reaching 10.11% for chair. The last two columns shows that monthly excess returns are widely disperse, as was expected, given that our sample includes the great depression. The highest monthly excess return across all the industries is 100.37% for rubber, and the lowest reaches -46.51% (chair).

4. Results

We present the main results in three separate subsections. In the first one, we consider the full sample results. In the second subsection, we analyze the results in three subsamples of approximately equal length. Finally, in the last subsection, we compare the predictors' performance in expansion and recession periods.

4.1 Full sample

Table 2 exhibits the pseudo R-squared out-of sample for combinations of forecasts, based on four different models (CV-CC, CV-DC, SV-CC and SV-DC). All the models considered have statistically significant predictive ability, with pseudo R-square often higher than 1%. Models with constant volatility perform slightly better than stochastic volatility models. The best result overall is obtained for the combination of the two best industries, based on the model with constant coefficients and constant volatility. It is noticeable that forecasts based on the weighted average of a small number of industries (four or less) outperform predictions that use many industries. In
particular, predictions that combine all the industries underperform the best forecast by more than 1%.

**Table 2**  
Pseudo R-squared out-of-sample for the models with constant coefficients and constant volatility (CV-CC), drifting coefficients and constant volatility (CV-DC), constant coefficients and stochastic volatility (SV-CC) and drifting coefficients and stochastic volatility (SV-DC), based on the best industry (1), combinations of 2, 3, 4, 5, 10, 15 best industries, and all the industries (All), in %. The last three rows display the average, maximum and minimum pseudo R-squared out-of-sample for the predictions based on the individual industries (in %).  
a- significant at 1%, b- significant at 5% c- significant at 10%

|       | CV-CC  | CV-DC  | SV-CC  | SV-DC  |
|-------|--------|--------|--------|--------|
| 1     | 1.8\(^a\) | 1.78\(^a\) | 1.52\(^a\) | 1.36\(^a\) |
| 2     | 1.98\(^a\) | 1.74\(^a\) | 1.79\(^a\) | 1.79\(^a\) |
| 3     | 1.75\(^a\) | 1.9\(^a\)  | 1.49\(^a\) | 1.27\(^a\) |
| 4     | 1.6\(^a\)  | 1.78\(^a\) | 1.49\(^a\) | 1.60\(^a\) |
| 5     | 1.65\(^a\) | 1.8\(^a\)  | 1.24\(^a\) | 1.5\(^a\)  |
| 10    | 1.44\(^a\) | 1.34\(^a\) | 1.02\(^a\) | 1.21\(^a\) |
| 15    | 1.2\(^a\)  | 1.13\(^a\) | 0.83\(^a\) | 1.01\(^a\) |
| All   | 0.52\(^c\) | 0.5\(^c\)  | 0.49\(^c\) | 0.51\(^b\) |
| Average| 0.1    | 0.01    | -1.55   | -0.29   |
| Maximum| 1.23   | 1.22    | 1.30    | 1.45    |
| Minimum| -1.87  | -1.65   | -10.8   | -2.82   |

The bottom three rows of table 2 display the average, maximum and minimum pseudo R-squared out-of-sample for the individual industries. It is clear that combinations of forecast, based on the past MSFE, outperform the predictions from a single industry.

Table 3 presents the average net annualized utility gains, for an investor with coefficient of relative risk aversion equal to 3. All the models generate sizable utility gains, with gains as high as 5%. Generally, weighted forecasts based on only a few industries provide higher utility gains than predictions based on a large number of industries. Stochastic volatility models also tend to deliver higher utility gains than constant volatility models, due to the fact that the former are able to time market
volatility and reduce the fraction of wealth invested in stocks during high volatility periods.

Table 3
Utility gains for the models with constant coefficients and constant volatility (CV-CC), drifting coefficients and constant volatility (CV-DC), constant coefficients and stochastic volatility (SV-CC) and drifting coefficients and stochastic volatility (SV-DC), based on the best industry (1), combinations of 2, 3, 4, 5, 10, 15 best industries, and all the industries (All), in %.

|       | CV-CC | CV-DC | SV-CC | SV-DC |
|-------|-------|-------|-------|-------|
| 1     | 2.78  | 2.78  | 5.38  | 2.35  |
| 2     | 2.54  | 2.35  | 5.03  | 3.77  |
| 3     | 2.40  | 2.40  | 4.89  | 3.36  |
| 4     | 2.30  | 2.32  | 1.09  | 3.93  |
| 5     | 2.23  | 2.39  | 4.12  | 3.47  |
| 10    | 1.97  | 1.90  | 3.77  | 3.38  |
| 15    | 1.7   | 1.67  | 3.35  | 3.41  |
| All   | 1.1   | 0.98  | 2.04  | 2.38  |

Figure 1
The top panel exhibits the difference between the fraction of wealth invested in stocks according to the constant coefficients and stochastic volatility model and the constant coefficients and constant volatility models, for combined predictions based on the 5 best industries, during the last 20 years. The bottom panel shows the squared monthly equity premium.
Figure 1 aims to illustrate this phenomenon. The top panel exhibits the difference between the fraction of wealth invested in stocks according to the constant coefficients and stochastic volatility model and the constant coefficients and constant volatility models, for combined predictions based on the 5 best industries, during the last 20 years. The bottom panel shows the squared monthly equity premium. It is clear that the investment strategy, driven by the stochastic volatility model, allocates a smaller fraction of wealth to the stock market during the turbulent periods comprised between 1999 and 2002, and after the recent financial crisis. In the remaining low volatility periods, the investment in the stock market is higher for the stochastic volatility model.

4.2 Subsamples

In this subsection we analyze the results in three different subsamples. The first subsample ranges from 9/1950 and 12/1953, the second one is comprised between 1/1974 and 12/1993, and the final one covers the period between 1/1994 and 12/2013.

Table 4

Pseudo R-squared out-of-sample for the models with constant coefficients and constant volatility (CV-CC), drifting coefficients and constant volatility (CV-DC), constant coefficients and stochastic volatility (SV-CC) and drifting coefficients and stochastic volatility (SV-DC), based on the best industry (1), combinations of 2, 3, 4, 5, 10, 15 best industries, and all the industries (All), in %. In each cell, the first value corresponds to the period from 9/1950 to 12/1973, the second value corresponds to the period from 1/1974 to 12/1993, and the last values corresponds to the period from 1/1994 to 12/2013.

|        | CV-CC     | CV-DC     | SV-CC     | SV-DC     |
|--------|-----------|-----------|-----------|-----------|
| 1      | 1.46⁰/2.23⁰/1.50⁰ | 3.01⁰/1.83⁰/0.84 | 2.19⁰/1.50⁰/1.05⁰ | 0.21/1.59/1.83⁰ |
| 2      | 2.01⁰/2.30⁰/1.54⁰ | 2.10⁰/2.11⁰/1.00 | 2.80⁰/2.03⁰/0.76 | 1.50⁰/2.33⁰/1.32⁰ |
| 3      | 1.81⁰/2.10⁰/1.24⁰ | 2.47⁰/2.26⁰/1.04 | 2.19⁰/1.44⁰/1.00 | 1.18/1.74⁰/0.76 |
| 4      | 1.69⁰/1.91⁰/1.13⁰ | 2.27⁰/2.11⁰/1.00 | 1.94⁰/1.52⁰/1.09 | 1.48⁰/1.84⁰/1.36⁰ |
| 5      | 1.69⁰/1.94⁰/1.24⁰ | 2.13⁰/2.10⁰/1.19⁰ | 1.26⁰/1.36⁰/1.06 | 2.01⁰/1.32⁰/1.33⁰ |
| 10     | 1.87⁰/1.57⁰/0.93 | 1.61⁰/1.44⁰/0.99 | 1.21⁰/1.11⁰/0.74 | 1.63⁰/1.07⁰/1.04⁰ |
| 15     | 1.51⁰/1.20⁰/0.94 | 1.48⁰/1.11⁰/0.86 | 0.94⁰/0.98⁰/0.95 | 1.31⁰/0.87⁰/0.93⁰ |
| All    | 0.89⁰/0.40⁰/0.37 | 0.75/0.45/0.35 | 0.13/0.87/0.27 | 0.71/0.51/0.35 |
Table 4 exhibits the pseudo R-squared out-of-sample for the three subsamples. All the R-squared are positive, which indicates that the models outperform predictions based on the historical mean. The evidence of predictive ability is stronger in subsamples one and two than in the last one but, even in the last 20 years, there is evidence of predictability at the 10% level. Even though the results are similar for the different models, the model that features constant coefficients and volatility presents the best overall performance.

Table 5 shows the annualized utility gains for each subsample. Almost all the models deliver positive gains, except the SV-CC model, for the 4 best industries. The economic benefits generated by the constant volatility models are higher during the middle subsample, and the gains for the stochastic volatility models are higher in the first part of the sample. Overall, stochastic volatility models tend to generate higher gains.

|       | CV-CC   | CV-DC   | SV-CC   | SV-DC   |
|-------|---------|---------|---------|---------|
| 1     | 2.02/3.65/2.67 | 2.60/3.89/1.86 | 7.45/3.82/4.81 | 2.75/1.41/2.87 |
| 2     | 1.98/3.71/1.95 | 1.84/3.53/1.69 | 7.34/4.03/3.67 | 5.45/2.68/3.14 |
| 3     | 1.79/3.18/2.24 | 1.97/3.28/1.93 | 7.27/3.28/4.05 | 5.48/2.13/2.42 |
| 4     | 1.64/3.15/2.12 | 1.84/3.19/1.93 | 3.82/-1.63/1.05 | 2.83/2.73/3.18 |
| 5     | 1.52/2.99/2.18 | 1.80/3.15/1.93 | 5.99/2.55/3.77 | 5.69/1.69/2.97 |
| 10    | 1.52/2.73/1.68 | 1.39/2.45/1.85 | 5.51/2.44/3.62 | 6.02/1.61/2.53 |
| 15    | 1.34/2.13/1.62 | 1.26/2.07/1.70 | 4.96/2.05/3.00 | 5.95/1.40/2.84 |
| All   | 0.91/1.27/1.11 | 0.76/1.15/1.02 | 3.03/1.28/1.78 | 4.94/0.33/1.82 |

Table 5
Utility gains for the models with constant coefficients and constant volatility (CV-CC), drifting coefficients and constant volatility (CV-DC), constant coefficients and stochastic volatility (SV-CC) and drifting coefficients and stochastic volatility (SV-DC), based on the best industry (1), combinations of 2, 3, 4, 5, 10, 15 best industries, and all the industries (All), in %. In each cell, the first value corresponds to the period from 9/1950 to 12/1973, the second value corresponds to the period from 1/1974 to 12/1993, and the last values corresponds to the period from 1/1994 to 12/2013.
4.3 Expansions and recessions

Rapach et al. (2010) and Neely et al. (2014), among others, have shown that equity premium predictability, based on a wide set of traditional predictive variables, is strong during recessions and absent in expansions. In this subsection we tested if our industry based equity premium forecasts exhibit the same pattern. We split the sample in recession and expansion periods, according to NBER data. Tables 6 and 7 present the pseudo R-squared out-of-sample and the annualized utility gains, respectively, for each subsample.

Table 6

Predictability is strong in recessions for all the models, with R-squared values often exceeding 5%. In contrast, there is no evidence that any of the models considered is able to forecast the equity premium during expansionary periods. The models that feature stochastic volatility and drifting coefficients do not seem to have a higher predictive ability than the basic model (CV-CC). Therefore, there seems to be no advantage in using more complicated models, that require the estimation of a higher number of parameters, if we are only interested in their statistical performance.
Table 7
Utility gains for the models with constant coefficients and constant volatility (CV-CC), drifting coefficients and constant volatility (CV-DC), constant coefficients and stochastic volatility (SV-CC) and drifting coefficients and stochastic volatility (SV-DC), based on the best industry (1), combinations of 2, 3, 4, 5, 10, 15 best industries, and all the industries (All), in %. In each cell, the first value corresponds to expansions and the second one to recessions.

|      | CV-CC     | CV-DC     | SV-CC     | SV-DC     |
|------|-----------|-----------|-----------|-----------|
| 1    | 1.8/7.45  | 1.64/8.33 | 4.71/8.4  | 0.95/9.29 |
| 2    | 1.47/7.75 | 1.22/7.91 | 4.37/8.01 | 2.64/9.25 |
| 3    | 1.31/7.73 | 1.22/8.13 | 4.28/7.53 | 2.3/8.45  |
| 4    | 1.19/7.73 | 1.18/7.92 | 0.04/4.19 | 2.96/8.57 |
| 5    | 1.15/7.49 | 1.29/7.76 | 3.69/5.89 | 2.67/7.22 |
| 10   | 0.97/6.79 | 0.83/7.07 | 3.29/5.79 | 2.87/5.55 |
| 15   | 0.73/6.37 | 0.67/6.53 | 2.93/5.05 | 3.09/4.62 |
| All  | 0.3/4.89  | 0.22/4.53 | 1.51/4.35 | 2.33/2.15 |

Table 7 reveals that the combined forecast generates positive utility gains, both in recessions and expansions. However, the economic benefit of the predictions is clearly superior in recessions, with gains as high as 9.29%. Stochastic volatility models deliver higher gains in both subsamples relative to constant volatility models.

5. Concluding remarks

In this paper we have shown that industries can be used to predict the equity premium. Moreover, combination of forecasts based on the past performance of the individual industries’ predictions deliver utility gains, for a mean-variance investor. Predictability is lower during the last subsample, which was expected, given that the cost of acquiring information has decreased. Grossman and Stiglitz (1980) argue that when the cost of acquiring information decreases, the fraction of investors who decide to be informed is higher, and prices become more informative.

We also found that predictability is strong during recessions, and absent during expansion. This predictability pattern, that has also been reported in previous studies, deserves further research.
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