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## Equity premium predictions with adaptive macro indexes

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Equity Premium Predictions with Adaptive Macro Indexes

Jennie Bai

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## **Equity Premium Predictions with Adaptive Macro Indexes**

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### **Abstract**

Fundamental economic conditions are crucial determinants of equity premia. However, commonly used predictors do not adequately capture the changing nature of economic conditions and hence have limited power in forecasting equity returns. To address the inadequacy, this paper constructs macro indexes from large data sets and adaptively chooses optimal indexes to predict stock returns. I find that adaptive macro indexes explain a substantial fraction of the short-term variation in future stock returns and have more forecasting power than both the historical average of stock returns and commonly used predictors. The forecasting power exhibits a strong cyclical pattern, implying the ability of adaptive macro indexes to capture time-varying economic conditions. This finding highlights the importance of using dynamically measured economic conditions to investigate empirical linkages between the equity premium and macroeconomic fundamentals.

Key words: adaptive macro index, forecasting

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# 1 Introduction

Empirical studies increasingly cast doubt on the forecasting power of price-based predictors of equity returns. The literature in this area has documented numerous problems,<sup>1</sup> including small-sample bias with highly persistent predictors,<sup>2</sup> poor out-of-sample performance,<sup>3</sup> and unstable forecasting relationships.<sup>4</sup> One potential reason for their weak performance is that fixed financial predictors fail to capture time-varying economic conditions sufficiently. Nevertheless, fundamental economic forces are crucial determinants of equity premia in the financial markets.<sup>5</sup> The challenge thus far has been to find a way to capture changing fundamental conditions that affect equity returns.

This paper answers the challenge in two ways. First, I construct macro indices from a large number of economic series as quantitative descriptions of economic conditions. Second, I design an adaptive procedure to choose optimal indices for equity premium predictions. Using this procedure, I find that adaptively selected macro indices are able to predict equity premia. Trading strategies based on these indices significantly and consistently outperform a buy-and-hold strategy benchmark under varying assumptions of transaction costs and risk tolerance. Furthermore, I connect these indices to economic sectors, comparing *ex ante* and *ex post* forecasting. The results provide new evidence that four sectors – interest rates, price indices, housing, and employment – are particularly relevant in predicting the equity premium.

Given the deficiency of financial predictors, previous papers (for example, Lettau and Ludvigson [2001], Piazzesi, Schneider and Tuzel [2007] and Gomes, Kogan and Yogo [2007]) have attempted to explore alternative predictors involving macroeconomic series.<sup>6</sup> Common to all these papers is a focus on a small set of predictors based on theoretical models. From an academic viewpoint, the use of model-based predictors facilitates an understanding of specific

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<sup>1</sup>Campbell and Thompson (2007) and Cochrane (2007a) provide excellent surveys of this literature.

<sup>2</sup>Examples are Nelson and Kim (1993), Stambaugh (1999), Ang and Bekaert (2007), Ferson, Sarkissian and Simin (2003), and Valkanov (2003). A number of recent papers discuss alternative econometric methods for conducting valid inference, such as Cavanagh, Elliott and Stock (1995), Polk, Thompson and Vuolteenaho (2006), Lewellen (2004), Torous, Valkanov and Yan (2004), Campbell and Yogo (2006), and Elias (2005).

<sup>3</sup>Goyal and Welch (2007) have systematically investigated most predictors used in the literature and concludes that, except for equity-issuing activity, current predictors hardly have meaningful and robust predictive power on the equity premium. Additional contributions include Bossaerts and Hillion (1999), and Butler, Grullon and Weston (2005). See also Campbell and Thompson (2007), and Cochrane (2007b) for different interpretations of the out-of-sample evidence.

<sup>4</sup>Viceira (1996) and Paye and Timmermann (2006) report evidence that counters the hypothesis of constant coefficient in the forecasting regression. Lettau and Nieuwerburgh (2007) analyze structural shifts in the mean of the dividend-price ratio. Pastor and Stambaugh (2001) use Bayesian methods to estimate structural breaks in the equity premium.

<sup>5</sup>Equity risk premia are closely related to economic conditions. Equity returns seem to be high at business cycle troughs and low at peaks. In line with the pioneering work by Ferson and Merrick (1987), Fama and French (1989), researchers suggest that predictors of excess returns should be correlated with economic conditions. Lettau and Ludvigson (2005) summarize the literature and point out that we should expect to “find evidence from predictive regressions of excess returns on macroeconomic variables over business cycle horizons.”

<sup>6</sup>Lettau and Ludvigson (2001) use “cay”, a measure of the consumption-wealth ratio; Piazzesi, Schneider and Tuzel (2007) employ the housing-expenditure ratio; Gomes, Kogan and Yogo (2007) use the ratio of durables to nondurables consumption.

aspects of the economic mechanism. From an investor’s viewpoint, however, these predetermined variables may not be enough to capture all information required in decision making.

Taking an investor’s position, this paper examines broad economic conditions by constructing macro indices from a large number of economic series, which is in line with the dynamic factor method by Stock and Watson (2002a, 2002b). These macro indices distinguish themselves for the ability to synthesize multidimensional information inherent in economic conditions. As noted in Ludvigson and Ng (2007a), the use of macro indices “eliminates the arbitrary reliance on a small number of exogenous predictors.” Indeed, anecdotal evidence suggests that investors monitor and analyze literally hundreds of data series. Since macro indices can consistently cover a broad range of economic conditions, they are more likely to span an investor’s unobservable information set. Applications of macro indices abound in the macroeconomic literature,<sup>7</sup> but are rarely found in the empirical finance literature. The only exceptions, as far as I know, are Ludvigson and Ng (2007a, 2007b) and Emanuel (2006).<sup>8</sup> This paper contributes to the literature with a new application in real-time equity premium predictions.

Also attempting to address the deficiency of financial predictors, Lettau and Nieuwerburgh (2007) allow for dynamic shifts in the mean of financial ratios (for example, dividend-price ratios) and show that adjusted predictors reconcile some of the controversy regarding return predictability. Their adjustment, however, is impossible in real-time prediction since investors cannot observe future data. This paper instead designs an adaptive prediction process based on macro indices for the real-time equity premium prediction. Adaptability is important since a fixed set of predictors, even using information from a large number of sources, may not accurately reflect investors’ learning processes.

In related work, Pesaran and Timmermann (1995) develop a recursive method to select optimal predictors over time according to a predetermined criterion. This paper incorporates their idea of dynamic modeling with two important modifications. First, I use an out-of-sample criterion for model selection and show that such a criterion increases the likelihood of a successful forecast than in-sample criteria. Second, I extend their base set from a few predictors to high-dimensional economic variables. In doing so, the adaptive prediction procedure captures time-varying economic conditions and allows for a time-varying forecasting relationship between equity returns and macro indices.

Applying this procedure to the CRSP value-weighted index over the one-month Treasury bill, I find that adaptively selected macro indices explain a substantial fraction of the short-term variation in future excess returns. Adaptive forecasts conditional on macro indices

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<sup>7</sup>Growing empirical evidence suggests that a large set of macroeconomic variables may in fact be crucial to properly capture the economy’s dynamics. For example, Stock and Watson (1999, 2002a) and Forni, Hallin, Lippi and Reichlin (2000) find that macro indices lead to considerable improvements over small scale vector autoregressive models. Bernanke and Boivin (2003), Bernanke, Boivin and Elias (2005), and Giannone, Reichlin and Sala (2004) show that the large information set appears to matter empirically to model monetary policy. Boivin and Giannoni (2006) incorporate the dynamic factor approach to estimate dynamic stochastic general equilibrium models.

<sup>8</sup>Ludvigson and Ng (2007) use the dynamic factor method to analyze the empirical risk-return relationship. Ludvigson and Ng (2006) adopt the same method to examine the bond risk premia. Emanuel (2006) applies the factor method to forecast the bond yield curve.

generate smaller prediction errors than both unconditional forecasts using the historical average<sup>9</sup> and the conditional forecasts based on many popular predictors (such as financial ratios, traditional business cycle proxies and other individual macroeconomic series).<sup>10</sup> The superior predictive power of adaptive macro indices have persisted over the past three decades, even in the late 1990s when stock return predictability becomes particularly challenging. Moreover, the accuracy of forecasts both in magnitude and in sign exhibits a strong cyclical pattern: the predictive power of indices (measured by the difference of prediction errors from the benchmark, the prevailing mean) decreases before recessions and lately rebounds during recessions. Timing ability (measured by the percentage of correct forecasting signs) shares the same pattern.

Finally, to test the real-world economic significance of these adaptive predictions, I examine the profitability of trading portfolios under two investment strategies: 100% stock/bond allocation and a utility-based dynamic portfolio allocation. In both cases, investment strategies exploiting the adaptive forecasts yield greater profits when compared with a buy-and-hold strategy in the market portfolio. The 100% stock/bond switching portfolios earn significantly higher returns over various subperiods with moderate transaction costs. The utility-based portfolios exhibits poor performance due to frequent trading and they make profits only under zero transaction costs and a high tolerance of risk.

The approach in this paper uses time-varying combinations of a large number of variables. It is therefore not immediately clear what specific economic forces contribute to the predictability of returns over time. To overcome this obstacle, I compare several types of forecasts using different information sets. In *ex post* forecasting, I construct indices using the entire sample, and study the performance of each index with fixed weights. The second principal component (F2) stands out with both a relatively good in-sample and simulated out-of-sample performance.<sup>11</sup> In *semi ex post* forecasting, I recursively construct indices using only the historical information available for each month, and I consistently choose the “same” index (principal components with the same order) and study the performance of each index with dynamic loadings. F2 and F5 outperform all other indices. In *ex ante* forecasting, I recursively construct indices using only the historical information available for each month, I sequentially choose indices (principal components with different orders) and I study the performance of adaptive macro indices. Again, F2 and F5 remain the most frequently selected predictors in the adaptive forecasting. Decomposing these indices and projecting them onto each economic sector, I show that the economic fundamentals that contribute most to equity premium prediction are interest rates, price indices, housing and employment.

The paper proceeds as follows. The next section sets up the adaptive prediction process,

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<sup>9</sup>The unconditional forecast is equal to the regression of excess returns on a constant.

<sup>10</sup>Fama and French (1989) show how dividend-price ratios, term spreads and default spreads forecast stock and bond returns. Since this seminal paper, these three variables have become representatives of business cycle proxies in empirical finance literature. The individual macroeconomic series include the growth rate of industrial production and the consumer price index.

<sup>11</sup>Here I use the same criteria advocated by Goyal and Welch (2007). A good predictor should satisfy three rules: 1) both a significant in-sample and a reasonably good out-of-sample performance over the entire sample period; 2) it should have a general upward trend in the graph of  $\Delta SSE$ , the difference in cumulative prediction errors from the benchmark of historical average; and 3) an upward drift that remains positive over the past several decades.

introduces the special model selection criterion and presents empirical predictability results. Section 3 assesses the economic significance of real-time forecasting. I then move on to explore the connection between ex ante and ex post forecasting in Section 4. A robustness check follows in Section 5 and I discuss directions for future research in Section 6.

## 2 Forecasts of Equity Returns

### 2.1 The Adaptive Prediction Process

In this paper I consider an agnostic investor who has no strong beliefs in any particular model, but who trusts in the time-varying inference drawn from her information set. The evolution of forecasting models over time may reflect an investor’s learning process or the changing nature of the underlying economic conditions. The use of an adaptive prediction procedure explicitly accounts for the continuous uncertainty an investor faces in real time. The advantage of adaptive prediction is that all possible models are constantly re-estimated and re-evaluated in order to reflect an investor’s search for the optimal predictive relation based solely on the historical information.

In related work, Pesaran and Timmermann (1995) develop a recursive method to select optimal predictors over time according to a predetermined in-sample criterion. This paper incorporates their idea of dynamic modeling with two important modifications. First, I separate the model selection period from the in-sample estimation period and select an optimal model based on its out-of-sample performance. In Section 5, I show that such an out-of-sample criterion increase the likelihood of a successful forecast than in-sample criteria. Second, I extend their base set from a few predictors to high-dimensional economic variables. In doing so, the adaptive prediction procedure captures time-varying economic conditions and allows for a time-varying forecasting relationship between equity returns and macro indices.

Suppose that at time  $t = N - m$ , an investor constructs an information set including an array of  $K$  macroeconomic variables with  $N - m$  time-series observations. As with Stock and Watson (2002b), the investor uses principal component analysis and decomposes the information set into  $K$  factors,

$$X_t = \Lambda Z_t = \lambda_1 z_{1,t} + \lambda_2 z_{2,t} + \cdots + \lambda_K z_{K,t}, \quad (1)$$

where  $X_t$  is the panel of economic variables assumed to cover the investor’s information set,  $z_{i,t}$  ( $i = 1, \dots, K$ ) are principal components of the panel data ordered by their ranks in explaining the variance,<sup>12</sup> and  $\lambda_i$  is the loadings on the individual series.

The investor then defines a universe of parsimonious models based on in-sample estimations,<sup>13</sup>

$$r_t = a_i + b_i z_{i,t-1} + \epsilon_t, \quad i = 1, \dots, K, \quad (2)$$

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<sup>12</sup> $z_1$  explains the most of the variance and it has the biggest eigenvalue.

<sup>13</sup>Since factors  $z_i$  are mutually orthogonal by construction, it is sufficient for an investor to consider only univariate predictive regression. A regression with multiple factors has the same explanatory power as the sum of each individual factor. The explanatory power from different factors does not overlap.

Two stage estimation usually involves the error-in-variable problem. But Bai and Ng (2005) show that the pre-estimation of the factors  $z_t$  does not affect the consistency of the second-stage parameter estimates. Moreover they prove that the least squares estimates from factor-augmented forecasting regressions are  $\sqrt{T}$  consistent and

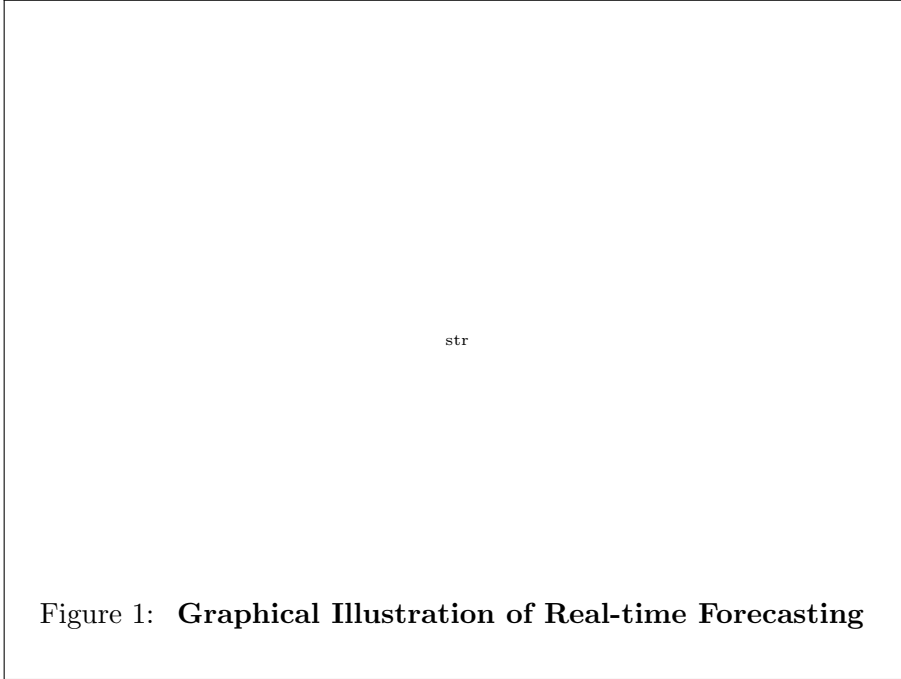


Figure 1: **Graphical Illustration of Real-time Forecasting**

and chooses the optimal model according to a predefined selection criterion. In other words, the investor treats all models under consideration as equally likely. Choosing a particular model at time  $t$  does not necessarily restrict the model choice at subsequent periods. Such a treatment is different from typical dynamic factor models proposed by Stock and Watson (2002a, 2002b), in the sense that this procedure does not restrict the base set of predictors to be the first few principal components. Instead, the investor seek an optimal predictor from all principal components.

Whereas most studies use in-sample model selection criteria based on the predictive regression (2), I introduce an out-of-sample criterion: the *predictive least squares principle*, which is based on a predictor’s forecasting performance in a simulated out-of-sample period. The model selection period is a moving window with a length of  $m$ -months. In this period, the investor records prediction errors for all macro indices by comparing their forecasts with realized returns.

At the end of the training period  $t = N$ , the investor choose an index with the smallest cumulative prediction errors in previous  $m$ -months and use it to predict the one-month-ahead excess market return at the first point of the trading period,  $t = N+1$ . Meanwhile, the investor transforms the predicting result into trading strategies that bring profits or losses, depending on the realization of the true market return (Section 3 presents investment strategies).

Figure 1 illustrates this adaptive prediction process. All stages of the adaptive prediction process re-occur on a monthly basis via a rolling window framework. Macro indices are also reconstructed each month via a recursive window starting from the beginning of the sample. For example, the first investment decision made at  $t = N$ , is based on an estimation during the in-sample period of  $[1, N - m]$  and a model selection in the training period of  $[N - m + 1, N]$ . For the second investment decision, the corresponding estimation period is  $[1, N - m + 1]$ ; the

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asymptotically normal. Stock and Watson (2002b) provide both theoretical arguments and empirical evidence that factors using estimated principal components are consistent even in the face of temporal instability in the individual time series used to construct the factors. The reason is that such instability may “average out” in the construction of common factors if the instability is sufficiently dissimilar from one to the next.



training period is  $[N - m + 2, N + 1]$ .

## 2.2 Model Selection Criterion

A key step in the adaptive prediction process is to choose the optimal predictor according to a predefined selection criterion. Conventional measures such as  $R^2$ , Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are calculated only from the in-sample information. Thus they have limitations as guides for finding an optimal indicator in forecasting future excess returns. Bossaerts and Hillion (1999) show that the use of these in-sample criteria fails to find sufficient out-of-sample predictability.

In this paper I introduce an out-of-sample model selection criterion, *predictive least squares* (PLS), advocated by Rissanen (1986) and Wei (1992). The PLS principle selects the optimal forecasting model  $M_i$  which minimizes the cumulative squared prediction errors in the training period:

$$M_i: \text{PLS}(z_i) = \sum_{t=N-m}^N \left[ r_t - (\hat{a}_{i,t-1} + \hat{b}_{i,t-1} z_{i,t-1}) \right]^2, \quad i = 1, \dots, K \quad (3)$$

where  $(\hat{a}_{i,t-1}, \hat{b}_{i,t-1})$  is estimated from the predictive regression using only historical information up to time  $t-1$ . The PLS principle is consistent with the main purpose of real-time forecasting: finding a predictor with the least prediction errors. Models selected in this way intuitively tend to have a good performance in the second out-of-sample trading period.

Another potential benefit of PLS is its natural link to the information-based criteria. Define  $\epsilon_t(N) = r_t - (\hat{a}_{i,t-1} + \hat{b}_{i,t-1} z_{i,t-1})$  and  $e_t = r_t - (\hat{a}_{i,t-1} + b_{i,t-1} z_{i,t})$ , we can decompose PLS into two terms:

$$\sum_{t=N-m}^N e_t^2 = \underbrace{\sum_{t=1}^N \epsilon_t^2(N) - \sum_{t=1}^{N-m} \epsilon_t^2(N-m)}_{\text{goodness of fit}} + \underbrace{\sum_{t=N-m}^N z'_{i,t} \Sigma_{z_{i,t}} z_{i,t} e_t^2}_{\text{penalty}}. \quad (4)$$

Recall that the in-sample period is from  $t = 1$  to  $N-m$  and the training period is from  $N-m+1$  until  $N$ . The estimation of  $b_N$  uses only information in the in-sample period and  $\epsilon_t(N)$  is the fitting error of the predictive regression. As with the information-based criteria, the first two terms in the formula (4) can be viewed as the measure of the goodness of fit; the third one as a penalty that reflects the complexity of the model.

## 2.3 Data and Empirical Implementation

The equity premium is measured by the end-of-month return of the CRSP value-weighted index in excess of the one-month Treasury Bill rate. All variables in this paper are at a monthly frequency covering the period from January 1960 to November 2006, for a total of 563 observations.

The base set of forecasting variables comprises 100 macroeconomic variables. Following Stock and Watson (2002a, 2005), I chose this panel to represent broad sectors of U.S.

economic conditions: real output, unemployment and employment, wages, housing, foreign exchange rates, money and credit aggregates, interest rates, inventories and orders, price indices, consumption, and consumer expectation.<sup>14</sup> The series are transformed so as to insure stationarity. In addition, the transformed data are standardized prior to index construction and estimation. All economic series are from the Global Insights Basic Economics Database. A detailed description of the data and its transformation is given in Appendix A.1.

To facilitate the comparison, I adopted ten monthly variables in Goyal and Welch (2007) as the control predictors, including price-dividend ratios, price-earnings ratios, dividend payout, book-to-market ratios, long term government bond returns, inflation measured by Consumer Price Index (all urban consumers), net issuing activity, term spread, default spread and default payout. Their explicit definitions are given in Appendix A.2. The contrast set of forecasting variables does not include *cay*, the consumption wealth ratios proposed by Lettau and Ludvigson (2001), because the construction of *cay* uses forward-looking information, which is impossible in real-time forecasting. The base set also excludes the investment to capital ratios proposed by Cochrane (1991), since this variable is not available at the monthly frequency.

With constructed indices, investors can easily implement the adaptive prediction procedure: estimate the linear prediction models, select the optimal model using the PLS principle and then compute a one-month-ahead forecast. The first in-sample estimation is based on monthly observations over the period 1960:1 to 1974:12. Other estimations occur recursively with the same start. The year 1960 was chosen as the start of the estimation sample since reliable monthly measures for most macroeconomic time series were not available until the late 1950s.<sup>15</sup> Also, a number of studies have suggested the possibility that stock returns may have varied systematically over the business cycles in the early 1960s. The year 1975 was chosen as the start of the out of sample since the oil shock of 1973-1975 probably improved the significance of predictability for many models, as pointed out by Goyal and Welch (2007). Excluding the oil shock recession from the out-of-sample period increases the credibility of a predictive model.

The length of the training period is an ad hoc choice. There is a tradeoff between the length and the quality of the model selection. A long rolling window has more statistical power. But a short rolling window easily captures the dynamic changes of economic conditions and hence an optimal predictor selected under a short window tends to reflect the most recent information. Motivated by real-time forecasting, this paper adopts a 24-month rolling window under which an investor may switch more frequently from one model to another in response to newly obtained information. For a robustness check, I also conduct the same experiment by choosing an optimal predictor according to their performance in previous 12, 18, 30, 36, 42,

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<sup>14</sup>Strictly speaking, variables in the interest rate sector (bond yields) are not pure macroeconomic variables. But interest rates are important indicators of monetary policy and hence are included here to capture specific information of economic conditions. For a robustness check, I also construct macro indices and redo the experiment without using interest rate variables. I find that the resulting macro indices still have significant predictive power. Detailed results are available from the author on request.

<sup>15</sup>Many macroeconomic series became available after World War II. But the data immediately after the war were volatile due to the unusually intensive re-construction. To obtain reliable macro data, I take a rather conservative stand and commence with the estimation at the beginning of 1960.

and 48 months. The results are not significantly different.<sup>16</sup>

## 2.4 Empirical Results

### A. Real-time Out-of-Sample Performance

Figure 2 illustrates the out-of-sample performance for monthly predictive regressions in real time. Similar to Goyal and Welch (2007), the performance is measured by the difference in the cumulative squared prediction errors between the benchmark (a forecast equal to the historical average excess return measured at each time-point) and the prediction model (a forecast based on a single predictor with the smallest cumulative prediction errors in the previous 24 months). Panel A displays the results using adaptive macro indices; Panel B displays the results using the same adaptive procedure with the application to ten commonly used predictors, summarized in Goyal and Welch (2007).

The graph of cumulative prediction error difference ( $\Delta$ SSE) offers special advantages in displaying forecasting performance. First, it provides a continuous evaluation of forecasting performance over the whole out-of-sample period. Its complete records avoid biased judgement based on only single time-point evaluation. In contrast, common practice in the literature conducts out-of-sample tests based solely on the ending point estimate for a fixed sample period, though a good ending cannot guarantee the goodness of the whole process. Second, the time-series pattern of the graph allows for recognizing months with a good, or a bad, performance. An increase in a line indicates better performance of the testing prediction model, whereas a decrease in a line suggests better performance of the benchmark. A good month means that the  $\Delta$ SSE at that month is included in an upward trend along the line. Finally, the graph is invariant to the choice of the out-of-sample period (though it does affect the in-sample estimation results).

The first impression on the graph in Panel A is a positive  $\Delta$ SSE line over the entire out-of-sample period, which means that the macro index prediction model generates smaller cumulative prediction errors and hence is superior to the benchmark for the period of January 1977 to December 2005. In addition, the  $\Delta$ SSE line tends to increase in general, suggesting an increasing difference in prediction errors between the benchmark and the prediction model. The  $\Delta$ SSE line edges upward from the beginning of 1977, increases substantially in the early 1980s, but then starts to shake up and down until the early 1990s. During the 1990 recession, the predictive power of the macro indices, as measured by  $\Delta$ SSE, jumps by approximately 70% and then grows steadily until 1998. After the tumultuous period of 1998-1999, the  $\Delta$ SSE line rebounds to a new peak and remains stable until the end of 2005.

Another striking pattern of the out-of-sample performance is its tight correlation with the business cycles. The predictive power of macro indices decreases before the recessions but rebounds quickly during them. As evidenced in the graph, the  $\Delta$ SSE line has three sharp downward drifts in the period 1986:02 - 1986:10 (before the 1987 stock market crash), the period 1989:07 - 1990:02 (before the 1990-91 recession) and the period 1998:02 - 1998:09 (before the “bubble period” of 1999-2001). With each decline, a corresponding upward drift is

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<sup>16</sup>Detailed results are available from the author on request.

Panel A: Macro Indices

observed during the recession or market downturns. This phenomenon in turn indicates that macro indices are suitable predictors for excess stock returns since macro indices sufficiently describe economic conditions.

Important information of the real-time forecasting performance is also provided in Table 1, which displays the statistical results using three measures: the out-of-sample R-square statistics ( $R_{oos}^2$ ), the difference of the root-mean-squared-error statistics ( $\Delta RMSE$ ), and the  $F$ -statistics for the test of equal forecast accuracy (MSE-F).<sup>17</sup> The benchmark is the unconditional forecast equal to the historical average. The alternative is the conditional forecast using adaptively selected predictors: macro indices in Panel A and financial predictors in Panel B. During each out-of-sample month, investors choose a predictor from the macroeconomic or financial base set, which has the smallest cumulative prediction errors in previous 24-months. All calculations are based on the adaptive prediction process described in Section 2.1.

As shown in Panel A of Table 1, adaptive macro indices robustly predict excess stock returns for the whole sample of 1977:1 to 2005:12, with a 2.7% out-of-sample  $R^2$  and a 9.66 MSE-F value which is 99% statistically significant. For both subperiods of 1980-1989 and 2001-2005, the  $F$  statistics are both significant above the 90% level: 2.11 for the 1980s and 3.51 for the 2000s. These numbers confirm that the conditional forecasts based on adaptive macro indices have smaller prediction errors and hence are superior to the unconditional forecasts based on the historical average.

The subperiod 1990-1999 has a  $R^2$  value of 1.10, but the  $F$ -statistic (1.33) is not statistically significant, suggesting that adaptive macro indices have a seemingly unimproved forecasting power. However, these numbers only reveal the predictability information at a single point, that is December 1999; it hides the time-series pattern of predictability over the course of the 1990s. As shown in the  $\Delta SSE$  graph in Figure 2, the low  $\Delta RMSE$  number at 1999:12 is due to the sharp drop of predictability during the bubble period 1998-1999. Macro indices do have steadily increasing predictive power from the beginning of 1990 to the beginning of 1998. This example demonstrates that it is important to use the cumulative-prediction-error-difference graph to evaluate out-of-sample performance.

In sharp contrast, the adaptive forecasts of excess returns based on financial/accounting ratios (Panel B) have much higher prediction errors than the benchmark. For either the full out-of-sample period or for three subperiods, the  $R_{oos}^2$  are all negative as are the  $F$ -statistics. These results are consistent with the findings in Goyal and Welch (2007), who show that commonly used predictors in the current literature have a poor out-of-sample performance. Note that a striking difference of this paper from Goyal and Welch (2007) lies in that they examine the forecasting power of fixed predictors using the whole sample information, whereas I study the real-time forecasting using only historical information available up to each prediction time. Supplementing Goyal and Welch's *ex post* results, this paper further shows that those popular predictors also have poor *ex ante* forecasting power even when carefully selected over time.

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<sup>17</sup>The out-of-sample  $R^2$  statistic is computed as it is in Campbell and Thompson (2007). MSE-F reports the  $F$ -statistics defined by McCracken (2004). A rejection of the benchmark hypothesis suggests the superiority of the alternative model, rather than the benchmark in the sense that the alternative model generates smaller prediction errors.

**Table 1**  
**Real-time Out-of-Sample Performance: 1977:01 - 2005:12**

This table presents the statistical results of real-time out-of-sample performance for the monthly predictive regressions. During each out-of-sample month, investors choose a predictor from the base set which generates the smallest cumulative prediction errors in previous 24 months. There are two base sets: A: **Macro Indices** constructed from a panel of 100 economic variables using principal component analysis; and B: the ten monthly Predictors in Goyal and Welch (2007) (**GW Predictors**). The performance uses three measures: the out-of-sample R-square ( $R_{oos}^2$ ), the difference of the root-mean-squared prediction error ( $\Delta RMSE$ ) and the MSE-F statistics (McCracken [2004]) to test for the equal forecast accuracy. The benchmark is the unconditional forecast equal to the historical average. The alternative is the conditional forecast using adaptively selected predictors. One-sided critical values of MSE-F are obtained empirically from bootstrapped distributions. The boldface numbers indicate that the alternative model is superior to the benchmark with at least 90% statistical significance. The formulas for the three statistics are:

$$\begin{aligned}
 R_{oos}^2 &= 1 - \frac{\sum \hat{u}_{A,\tau}^2}{\sum \hat{u}_{B,\tau}^2} \\
 \Delta RMSE &= \sqrt{\sum \hat{u}_{B,\tau}^2} - \sqrt{\sum \hat{u}_{A,\tau}^2} \\
 MSE-F &= R \cdot \left( \frac{\sum_r \hat{u}_{A,\tau}^2 - \sum_r \hat{u}_{B,\tau}^2}{\sum_r \hat{u}_{B,\tau}^2} \right)
 \end{aligned}$$

where  $\hat{u}_{B,\tau}$  is the forecasting error from the benchmark and  $\hat{u}_{A,\tau}$  is the forecasting error from the alternative adaptive prediction model.  $R$  is the number of out-of-sample observations.

| Period           | Panel A: Macro Indices |               |             | Panel B: GW Predictors |               |        |
|------------------|------------------------|---------------|-------------|------------------------|---------------|--------|
|                  | $R_{oos}^2$            | $\Delta RMSE$ | MSE-F       | $R_{oos}^2$            | $\Delta RMSE$ | MSE-F  |
| 1977:1 - 2005:12 | 2.70                   | 0.0604        | <b>9.66</b> | -2.26                  | -0.0500       | -12.94 |
| 1980:1 - 1989:12 | 1.73                   | 0.0425        | <b>2.11</b> | -0.42                  | -0.0083       | -0.51  |
| 1990:1 - 1999:12 | 1.10                   | 0.0214        | 1.33        | -3.86                  | -0.0893       | -3.01  |
| 2000:1 - 2005:12 | 4.15                   | 0.0924        | <b>3.51</b> | -2.26                  | -0.0500       | -8.24  |

## B. The Sign of Excess Returns Forecasts

The predictive least squares criterion chooses optimal predictors according to the magnitude of their forecasting errors. Investors, however, probably consider the sign of forecasting to be equally important. Leitch and Tanner (1991) found that traditional measures like  $R^2$  fail to pick up predictors that generate equal profits from a trading strategy as a measure of the “sign” criterion. Given investors’ concerns regarding the sign of forecasting, I now examine whether the PLS criterion can choose predictors that also correctly predict the sign of excess returns.

Figure 3 presents the accuracy rate of timing the stock market under the PLS principle, which is measured by the percentage of correct signs of the excess returns predicted by macro indices. On average, the adaptive predictions get the same sign as the realized excess returns for 62 percent of all months in the trading period 1977:01 to 2006:12. Two interesting findings

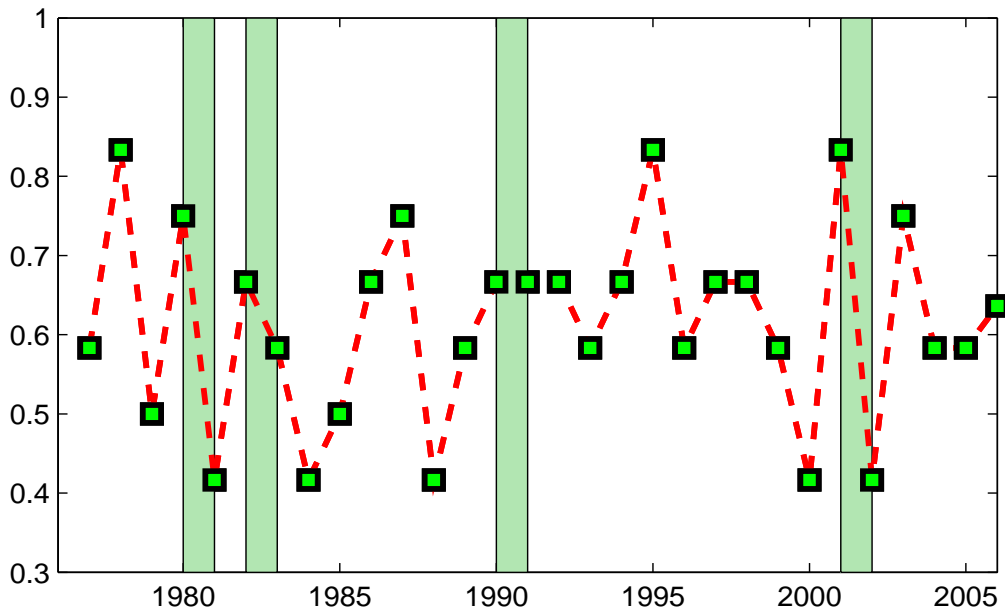


Figure 3: **Accuracy Rate of Excess Return Forecasts**, measured by the proportion of correct signs predicted by macro indices in each year of the trading period: 1977:1 - 2006:11. For example, an 83% accuracy rate means that excess return forecasts get the same sign as the realized returns for ten months within a year. Shading denotes years of recessions identified by NBER.

are worth noting. First, predictability from macro indices seems particularly high during the years of recessions and market downturns. In four recent recessions, the forecasting accuracy is locally high with respect to the years before and after recessions; the year of 2001 shows the correct predictions for 10 months with an accuracy rate of 83%, 67% for the year of 1991, 75% for 1980 and 67% for 1982. Three other spikes with the highest accurate forecasting rates occur in 1978 (83%), 1987 (75%) and 1995 (83%). Second, the degree to which the stock returns are predictable seems quite low before each recession.

The accuracy of forecasts both in magnitude and in sign exhibits a strong cyclical pattern. One possible explanation is that the predictability of stock returns may be particularly pronounced in periods of economic “regime switches” where the markets are relatively unsettled and investors are particularly uncertain of which forecasting model to use for trading (Pesaran and Timmermann [1995]). Another possible explanation of the cyclical pattern is the difficulty investors have in identifying the turning points of business cycles when macro indices carry more noise.

### 3 Economic Significance of Predictability

The ability to predict stock returns ahead of time is the backbone of investment strategies, but predictability, in itself, does not guarantee that an investor can earn profits from a trading strategy that is based on such forecasts.<sup>18</sup> In this section I study the economic significance of the adaptive prediction to see whether an investor can exploit forecasts to make a higher profit than a buy-and-hold strategy in the market portfolio will bring.

#### 3.1 Case I: 100% Stock/Bond Allocation

A simple investor considers a hundred-percent switching strategy. According to this strategy, investors should hold stocks during periods when the economic condition indicators suggest that stock returns will outperform returns from holding risk-free bonds (i.e., the predicted excess market return is positive), and otherwise hold one-month Treasury bills. I assume that investors do not allow for the short-selling of assets, nor can they use leverage when selecting their portfolios.

Figure 4 shows the month-to-month cumulative returns for the buy-and-hold market portfolio and the switching portfolios. The switching portfolios are constructed using forecasts from macro indices or from predictors in Goyal and Welch (2007), selected adaptively according to the predictive least squares criterion. This figure confirms that the switching strategy based on adaptively selected macro indices make great profits in a stable fashion. In contrast, the switching portfolio based on financial predictors earn lower returns than the market portfolio over the entire sample. The performance of the switching portfolios mirror the real-time predictability displayed in Figure 2, suggesting that macro indices have a consistent power in forecasting excess stock market returns, both statistically and economically.

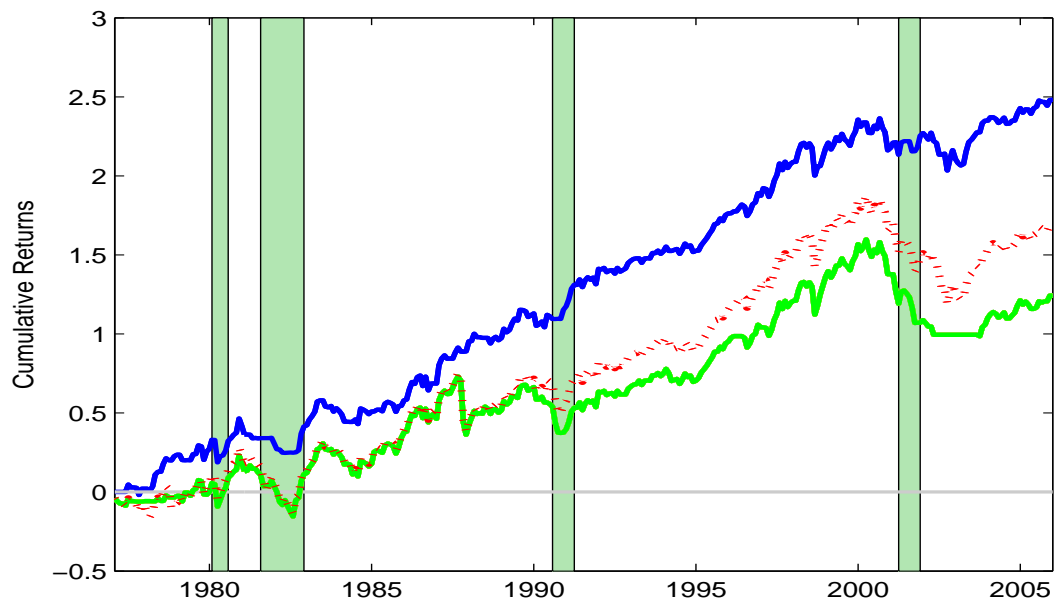
Table 2 presents the trading results. The mean annual return on the market portfolio is 7.04% over the period of 1977:1 – 2005:12, and it is smaller than the mean return on the switching portfolio based on macro indices, 9.40%. In addition, the standard deviation of the returns on the switching portfolio by macro indices (12.76%) is substantially lower than the standard deviation of returns on the market portfolio (15.38%). Taken together, the higher mean and lower standard deviation of the returns on the switching portfolio by macro indices result in high values of the Sharpe ratio, 0.75, compared to 0.47, which is the Sharpe ratio for the market portfolio. In sharp contrast, the the switching portfolio based on financial predictors generates a Sharpe ratio of 0.43, and is inferior to the performance of the market portfolio.

I also analyze the performance of the switching portfolios over three subperiods: 1980 to 1989, 1990 to 1999, and 2000 to 2005. For all three subperiods, the trading portfolios based

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<sup>18</sup> Some authors report significant profits using *ex ante* model calibration, see Balduzzi and Lynch (1999, 2000), and Kandel and Stambaugh (1996). Other studies of real-time investment performance, however, document that the use of predictability fails to earn excess profits over the market. Carhart (1997) and Wermers (2000) find that the failure to mutual funds; Barber and Odean (2000) find it in individual investors; Christopherson, Ferson, and Glassman (1998) confirm that for pension funds; and Pirinsky (2001) documents the failure in banks, investment advisors, and insurance companies.





the switching portfolio based on macro indices

**Table 2**  
**Real-time Performance of the Switching Portfolios**

The switching portfolios exploit forecasts of adaptive predictors from two base sets: A. macro indices and B. GW predictors. During each month of the trading period, investors choose the predictor with the smallest cumulative prediction errors in previous 24-months. If the resulting model predicts a positive excess return, investors buy one unit of CRSP stock index; if the resulting model predicts a negative excess return, investors buy one unit of risk-free one-month T-Bill. The returns on the trading portfolio are equal to the realized market returns or the one-month interest rate. The benchmark is the CRSP value-weighted portfolio with a buy-and-hold strategy. The real-time performance uses three measures.  $\mu$  refers to the average excess return of trading portfolios,  $\sigma$  is the standard deviation of realized trading portfolios, and  $SR$  means the Sharpe ratio. Mean returns and standard deviations are annualized percentage data. The model selection criterion is predictive least squares (PLS). The trading period is from January 1977 to December 2005.

| Period           | Market Portfolio |          |       | A: Macro Indices |          |             | B: GW Predictors |          |       |
|------------------|------------------|----------|-------|------------------|----------|-------------|------------------|----------|-------|
|                  | $\mu$            | $\sigma$ | SR    | $\mu$            | $\sigma$ | SR          | $\mu$            | $\sigma$ | SR    |
| 1977:1 - 2005:12 | 7.04             | 15.38    | 0.46  | 9.40             | 12.76    | <b>0.75</b> | 5.30             | 14.03    | 0.38  |
| 1980:1 - 1989:12 | 7.29             | 16.97    | 0.43  | 8.55             | 12.88    | <b>0.66</b> | 7.23             | 16.70    | 0.43  |
| 1990:1 - 1999:12 | 12.75            | 13.39    | 0.95  | 13.61            | 12.45    | <b>1.09</b> | 10.47            | 13.00    | 0.82  |
| 2000:1 - 2005:12 | -1.05            | 16.15    | -0.07 | 3.45             | 14.13    | <b>0.24</b> | -4.47            | 12.52    | -0.34 |

assets among various assets and always hold both stocks and bonds at the same time, a case I study in the next subsection.

### 3.2 Case II: Utility-based Stock/Bond Allocation

Suppose an investor has a power utility function over end-of-period wealth at the investment horizon  $T$ . The investor chooses her asset allocation policy between a risky asset (the stock market portfolio) and a risk-free asset (the one-month Treasury Bill) to maximize her expected utility. At each point in time, the investor puts a fraction  $\alpha_t$  of her wealth in the risky asset. Thus the investor's problem is to solve the dynamic portfolio allocation

$$\max_{\{\alpha\}} E_0 \left[ e^{-\rho T} \frac{W_T^{1-\gamma}}{1-\gamma} \right] \quad (5)$$

subjecting to the dynamic budget constraint:

$$\begin{aligned} dW_t/W_t &= \alpha_t dS_t/S_t + (1 - \alpha_t) dB_t/B_t, \\ dS_t/S_t &= \mu(z_t)dt + \sigma(z_t)dw_t, \\ dB_t/B_t &= r_f dt, \end{aligned}$$

where  $\rho$  is the discount rate,  $\gamma$  is the investor’s risk-aversion coefficient. The conditional mean  $\mu$  and the conditional standard deviation  $\sigma$  of stock returns rely on the predictor variable  $z_t$ . The risk-free interest rate  $r_f$  is assumed to be constant over the investment horizon, which is one month.

In solving this dynamic programming problem,<sup>19</sup> the optimal portfolio allocation in the risky asset is

$$\alpha_t = \frac{1}{\gamma} \frac{\mu_t - r_f}{\sigma_t^2} \tag{6}$$

where  $\gamma$  is the local coefficient of relative risk aversion. The proportion invested in the risky asset depends on the investor’s risk aversion  $\gamma$  and the conditional distribution of the expected stock returns  $(\mu_t, \sigma_t)$ . In practice, an investor adaptively forecasts the conditional mean and the conditional variance based on the predictive regression. The allocation to the risky asset may rise or fall over time, determined by the investor’s ability to hedge the changes in economic conditions signaled by the optimal macro index, the “market timing” ability.

Figure 5 shows the optimal allocation to risky stocks over time, based on sequentially selected macro indices which reflect the changes of economic conditions over time. A common feature for both the allocation and the predictability is a strong cyclical pattern: reduced investment in risky stocks at the beginning of recession and increased investment at the end of recession. A strong position in stocks coincides with high stock market returns. A weak position in stocks accompanies relatively low stock market returns. The optimal allocation to stocks varies mildly, from -10 to 50 percent. As an additional evidence, the tight correlation of optimal allocations and the stock market returns shows that adaptive macro indices have the ability to capture the changes in economic conditions and this hence improves the investor’s ability of market timing.

Table 3 reports the real-time performance for utility-based portfolios, which exploit the same forecast results based on macro indices as in the case of the switching portfolio. The optimal portfolios have an average annual return of 6.60% over the whole out-of-sample period, which is smaller than the market portfolio, 7.04%. However, the optimal portfolios are much less volatile, with a standard deviation of 10.66%, compared to the market portfolio’s standard deviation of 15.38%. Overall the lower mean and even lower standard deviation of the returns on the optimal portfolio result in a slightly higher value of the Sharpe ratio, 0.62, compared to that of the market portfolio, 0.46. The utility-based portfolio do not perform as well as the market portfolio in the 1990s, with a much lower value of the Sharpe ratio (0.67 vs 0.95), but it noticeably outperforms the market in the early 2000s, with a significant mean return of 4.52%, a mild volatility of 8.94% and a Sharpe ratio of 0.51, which is much higher than the Sharpe ratio of the market portfolio, -0.07.

### 3.3 The Effects of Transaction Costs

For any investment strategy, two elements are important for investors: transaction costs and taxes. Transaction costs clearly impose a drag on the performance of investment strategies.

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<sup>19</sup>Cochrane (2007c) provides details for solving this dynamic programming problem.

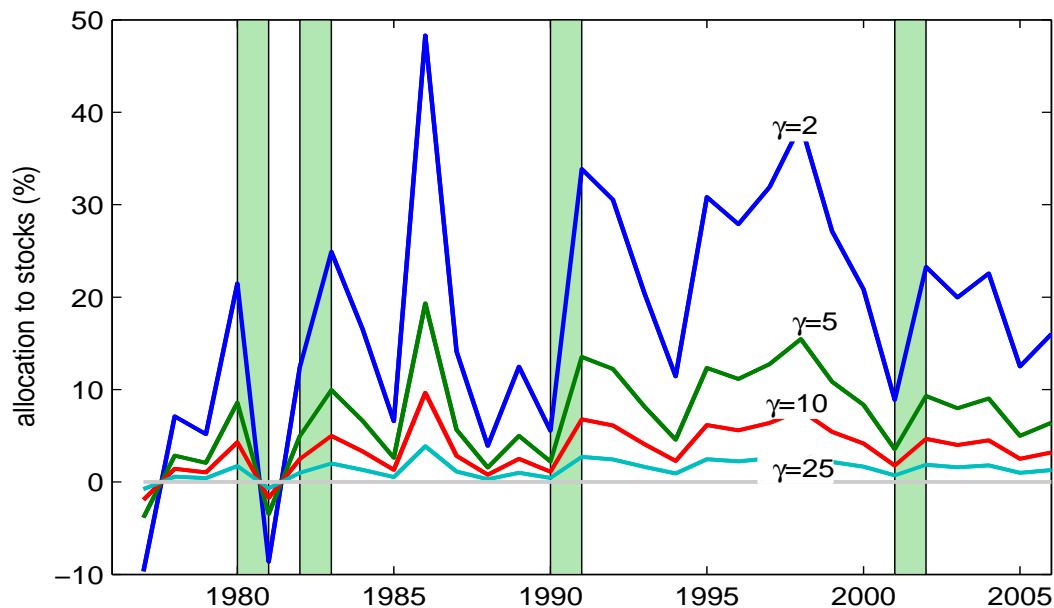


Figure 5: **Optimal Portfolio Allocation Over Time.** The allocation to risky stocks is  $\alpha_t = \frac{1}{\gamma} \frac{E_t(r^e)}{\sigma_t^2}$ . Expected excess returns come from the adaptive forecasts based on macro indices,  $r_{t+1}^e = \hat{a}_i + \hat{b}_i z_{i,t}$ . The variance of excess returns is estimated by the variance of predictive regression residuals.  $\gamma$  is the coefficient of risk aversion. This figure shows the annual allocation, which is calculated as the average of monthly allocations. The sample period is from January 1977 to November 2006. Shading denotes recessions identified by NBER.

Taxes also erode trading profits but are difficult to deal with, partly because they are investor- and investment-specific, and will therefore not be considered in this paper. For trading costs, I make a simplifying assumption that they are constant through time and symmetric with respect to whether the investor is buying or selling assets. I further assume that trading costs are simply proportional to the value of the trade, letting  $c_1$  and  $c_2$  be the percentage trading costs on stock shares and bonds, respectively.<sup>20</sup> Besides zero trading costs, I consider two additions scenarios: “Low” transaction costs with 25 basis points on trading in one unit share of stock ( $c_1 = 0.0025$ ) and 5 basis points in one unit of bond ( $c_2 = 0.0005$ ), and “High” transaction costs with 50 basis points on trading in one unit share of stock ( $c_1 = 0.005$ ) and 5 basis points in one unit of bond ( $c_2 = 0.0005$ ).

The buy-and-hold strategy is a relatively passive investment strategy and it hence incurs low transaction costs. Compared with this benchmark, an investment strategy based on adaptive predictions is likely to incur considerably higher transaction costs and may not be

<sup>20</sup>This paper doesn’t consider other types of trading costs like commission fees and bid-ask spreads.

**Table 3**  
**Real-time Performance of the Utility-Based Optimal Portfolios**

The Utility-based optimal portfolios are constructed by allocating  $\alpha_t$  percent of the wealth to risky stocks and  $(1 - \alpha_t)$  to the one-month Treasury Bill at the beginning of each month. The allocation is calculated as  $\alpha_t = \frac{1}{\gamma} \frac{E_t(r^e)}{\sigma_t^2}$ , where expected excess returns  $E_t(r^e)$  come from the adaptive forecasts based on macro indices, and the variance of excess returns  $\sigma_t^2$  is estimated by the residual variance in predictive regressions:  $r_{t+1}^e = a_i + b_i z_{i,t} + \epsilon_{t+1}$ . The coefficient of risk aversion is set as unity in this table,  $\gamma = 1$ . The performance of trading portfolios over varying subperiods is measured by the average excess return ( $\mu$ ), the standard deviation ( $\sigma$ ) and the Sharpe ratio (SR). “Market Portfolio” refers to the CRSP value-weighted index. “Market Index” refers to utility-based optimal portfolios exploiting forecasts based on macro indices. Mean excess returns and the standard deviation are annualized data.

| Period           | Market Portfolio |          |             | Macro Index |          |             |
|------------------|------------------|----------|-------------|-------------|----------|-------------|
|                  | $\mu$            | $\sigma$ | SR          | $\mu$       | $\sigma$ | SR          |
| 1977:1 - 2005:12 | 7.04             | 15.38    | 0.46        | 6.60        | 10.66    | <b>0.62</b> |
| 1980:1 - 1989:12 | 7.29             | 16.97    | 0.43        | 6.92        | 12.46    | <b>0.56</b> |
| 1990:1 - 1999:12 | 12.75            | 13.39    | <b>0.95</b> | 7.36        | 11.01    | 0.67        |
| 2000:1 - 2005:12 | -1.05            | 16.15    | -0.07       | 4.52        | 8.94     | <b>0.51</b> |

profitable when taking into account transaction costs.<sup>21</sup> This subsection explores the performance of switching portfolios and utility-based portfolios under varying scenarios of trading costs and risk tolerance.

Table 5 presents the trading results. For each panel, I report the mean and the standard deviation of excess returns, and their Sharpe ratio. I also list the percentage of the total months when trading portfolios have negative returns and I show the final amount of wealth obtained from trading portfolios, assuming that investors start off with \$100 at the beginning of 1977 and reinvest portfolio income every month until the end of 2005. In the case of a buy-and-hold market portfolio, only the dividends are reinvested on a monthly basis. In contrast, the switching portfolios may reallocate funds between stocks and bonds, depending on whether a change in the sign of the excess return is predicted. The utility-based portfolios always have positions in both stocks and bonds but they adjust optimal allocations according to the forecasts of adaptive macro indices. A transaction cost is incurred only when investors switch or adjust positions.

First I consider the results for switching portfolios. Under all three transaction cost scenarios, the switching portfolios based on conditional forecasts by adaptively selected macro indices perform better than a buy-and-hold market portfolio: they have higher mean returns,

<sup>21</sup>As Vanguard founder Jack Bogle said, the strength of indexing (buy-and-hold strategy) stems primarily from its inherent cost advantage.

**Table 4**  
**The Effect of Transaction Costs**

The columns headed Zero, Low, and High refer to the portfolio performance under three transaction cost scenarios: “Zero”, “Low” (25 basis points on trading in one unit share of stock and 5 basis points in one unit of the one month T-bill), and “High” (50 basis points on trading in one unit share of stock and 5 basis points in one unit of the one month T-bill). The benchmark is a buy-and-hold strategy applied to the market portfolio. Panel A shows the performance of switching portfolios based on conditional forecasts of adaptive macro indices or conditional forecasts of monthly predictors used in Goyal and Welch (2007). Panel B shows the performance of utility-based portfolios with different levels of risk-aversion ( $\gamma$ ). Negative performance is the percentage of the total months when portfolios have negative returns. Investors start off with \$100 at the beginning of 1977 and reinvest the portfolio income every month until the end of 2005. The model selection criterion is the predictive least squares (PLS). The rolling window for model selection has a length of 24 months. The trading period is from January 1977 to December 2005. Mean returns and the standard deviations are in percentage form and are annualized data.

| Panel A: Switching Portfolios |                 |               |             |            |               |       |       |
|-------------------------------|-----------------|---------------|-------------|------------|---------------|-------|-------|
| Transaction Costs             | buy and<br>hold | Macro Indices |             |            | GW Predictors |       |       |
|                               |                 | Zero          | Low         | High       | Zero          | Low   | High  |
| Mean return ( $\mu$ )         | 7.04            | 9.40          | 8.92        | 8.53       | 5.30          | 5.03  | 4.81  |
| Std. Deviation ( $\sigma$ )   | 15.38           | 12.76         | 12.77       | 12.78      | 14.03         | 14.04 | 14.06 |
| Sharpe Ratio (SR)             | 0.46            | 0.74          | 0.70        | 0.67       | 0.38          | 0.36  | 0.34  |
| Negative Performance(%)       | 39.94           | 39.08         | 43.68       | 43.68      | 40.23         | 44.25 | 44.54 |
| Final Wealth (\$)             | 541             | <b>1195</b>   | <b>1042</b> | <b>929</b> | 347           | 321   | 300   |

| Panel B: Utility-Based Optimal Portfolios |                 |                                |       |       |                              |       |       |
|---|-----------------|--------------------------------|-------|-------|------------------------------|-------|-------|
| Transaction Costs                         | buy and<br>hold | Macro Indices ( $\gamma = 1$ ) |       |       | Macro Index ( $\gamma = 3$ ) |       |       |
|   |                 | Zero                           | Low   | High  | Zero                         | Low   | High  |
| Mean return ( $\mu$ )                     | 7.04            | 6.60                           | 5.13  | 3.91  | 2.17                         | 1.69  | 0.49  |
| Std. Deviation ( $\sigma$ )               | 15.38           | 10.66                          | 10.65 | 10.66 | 3.50                         | 3.50  | 3.52  |
| Sharpe Ratio (SR)                         | 0.46            | 0.62                           | 0.48  | 0.37  | 0.62                         | 0.48  | 0.14  |
| Negative Performance (%)                  | 39.94           | 38.51                          | 43.68 | 47.13 | 39.66                        | 45.11 | 54.02 |
| Final Wealth (\$)                         | 541             | <b>572</b>                     | 374   | 263   | 188                          | 163   | 114   |

higher Sharpe ratio and more final wealth. With zero cost the end-of-period funds of the switching portfolios are approximately twice as large as the end-of-period funds of the market portfolio. In sharp contrast, the switching portfolio based on forecasts by financial/accounting ratios and individual macroeconomic series performs rather poorly with lower mean returns, lower Sharpe ratios and less final wealth.

Unlike the switching strategy, the utility-based investment strategy holds more conservative positions in risky assets; hence portfolios exploiting it earn lower returns and also have lower volatility. Using the same macro indices' forecasts as in the switching strategy, the utility-based optimal portfolio has only slightly higher values of the Sharpe ratio (0.62) than the buy-and-hold market portfolio (0.46) under the zero transaction cost scenario. The slight difference is also reflected in the end-of-period wealth accrued to the investment strategies: \$572 for the optimal portfolio and \$541 for the market portfolio.

In sum, active portfolio strategies provide incremental benefits to investors, but they seem sensitive to the level of transaction costs and investors' risk tolerance. The benefits will not be substantial to style investors if the expenses are significant or if investors have a high tolerance of risk.

## 4 Forecasting: *Ex Post* vs *Ex Ante*

The approach in this paper uses time-varying combinations of a large number of variables. It is therefore not immediately clear what specific economic forces contribute to the predictability of returns over time. To overcome this obstacle, I compare several types of forecasts using different information sets. Beginning with *ex post* forecasting, I construct indices using the entire sample and examine the performance of each index with fixed weights. Then I recursively construct indices using only the historical information available for each month. In this *semi ex post* forecasting, I consistently choose the "same" index (principal components with the same order in explaining the variation of the panel data) and study the performance of each index with dynamic loadings. Finally, I revisit *ex ante* forecasting adopted in this paper, where I sequentially choose indices (principal components with different orders) rather than use the fixed index as in *ex post* forecasting. If there exists a consistent connection from *ex post* to *ex ante* forecasting, we may understand the important economic forces that contribute to equity premium predictions.

### 4.1 *Ex Post* Forecasting

I first construct fixed weight indices using the entire sample and study *ex post* forecasting performance for each fixed index. Among all indices, I entertain both in-sample and out-of-sample (oos) tests to select the best predictor.<sup>22</sup> The second principal component (F2) stands

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<sup>22</sup> Goyal and Welch (2007) believe that the out-of-sample performance is an important diagnostic tool for predictability. However, Inoue and Kilian (2004), Campbell and Thompson (2007) and Cochrane (2007) argue that out-of-sample tests provide lower power than in-sample tests. These debates are ongoing, but researchers tend to agree that in-sample tests alone cannot identify a reliable predictive model. Out-of-sample tests should

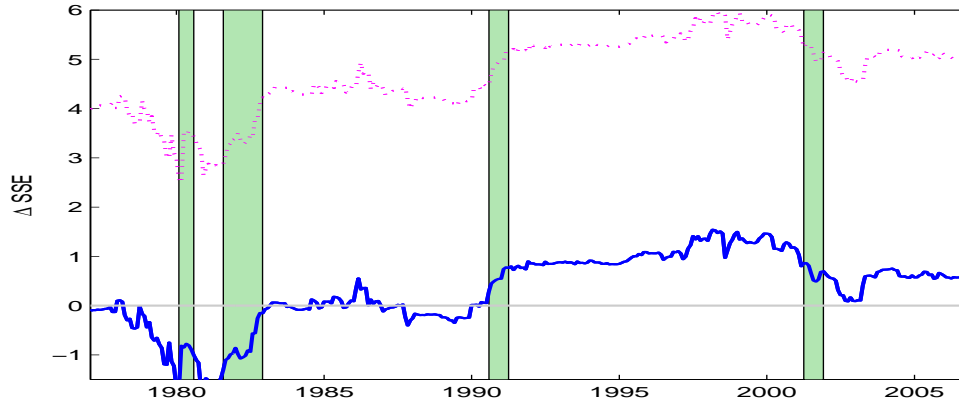


Figure 6: **Pseudo Out-of-sample Performance of F2.** The index F2 is constructed using the full sample of 1960:1-2006:11. The solid blue line (—) is the difference of cumulative prediction errors from the benchmark (the historical mean). The dotted red line (- -) is the difference of cumulative fitting errors from the benchmark. Shading denotes months of recessions designated by NBER.

out according to the criteria proposed by Goyal and Welch (2007): it has 1) both a significant in-sample and a reasonable good out-of-sample performance; 2) decreasing cumulative prediction errors compared with the benchmark (the prevailing mean); and 3) smaller cumulative prediction errors over the past several decades. Compared with the performance of adaptive macro indices in Figure 2, the fixed index F2 has weaker forecasting power, especially in the early 1980s. This evidence reinforces the importance of adaptability in real-time predictions.

Figure 6 shows that the index F2 has significant in-sample predictive power with an  $R^2$  value of 4.77%. The pseudo out-of-sample predictive performance is poor in the early 1980s, but it recovers after the recessions, further improves in the 1990s, and again drops during the bubble period and the 2001 recession. The out-of-sample  $R^2$  over the past three decades is 0.87%, which still outperforms the historical average at a 95% significance. To understand its economic meaning, I run a univariate regression of F2 on all the individual variables in the panel and report the marginal  $R^2$  in Figure 7. Clearly, F2 constructed from the whole sample mostly relates to sectors like interest rates and price indices. If projecting F2 onto each sector instead of the individual series, the price index sector explains 86.90 percent, whereas the interest rate sector explains 30.88 percent of the total variance in F2.



**Table 5**  
**Pseudo Out-of-Sample Performance: 1977:1 - 2005:12**

This table presents pseudo out-of-sample performance of selected predictors. The performance uses four measures: in-sample and out-of-sample R-square ( $R_{in}^2$  and  $R_{oos}^2$ ), the difference of the root-mean-squared prediction error ( $\Delta RMSE$ ) and the MSE-F statistic (McCracken, 2004) to test equal forecast accuracy. The benchmark is the unconditional forecast equal to the historical average of excess market returns. The alternative is the conditional forecast using selected predictors listed in the first column. See Table 1 for formulas of the statistics. Macro indices are recursively constructed at each month of the trading period. Other financial predictors are from Goyal and Welch (2007), including dividend-price ratios, earnings-price ratios, book-to-market ratios, net issuing activity, term spread, default spread, default return and long-term bond return.

| Predictor                                     | $R_{in}^2$ (%) | $R_{oos}^2$ (%) | $\Delta RMSE$ | MSE-F |
|---|----------------|-----------------|---------------|-------|
| Panel A: Significant Macro Indices            |                |                 |               |       |
| F2  | 4.97           | 2.58            | 0.0581        | 9.85  |
| F5  | 0.20           | 1.73            | 0.0389        | 6.54  |
| Panel B: Selected Insignificant Macro Indices |                |                 |               |       |
| F1  | 0.90           | -0.07           | -0.0015       | -0.25 |
| F3  | 0.82           | -0.29           | -0.0060       | -1.09 |
| Panel C: Other Insignificant Predictors       |                |                 |               |       |
| Dividend-Price Ratio                          | 0.26           | -0.87           | -0.0194       | -3.20 |
| Earnings-Price Ratio                          | 0.24           | -1.31           | -0.0293       | -4.82 |
| Book-to-Market Ratio                          | 0.03           | -1.36           | -0.0304       | -4.99 |
| Net Issuing Activity                          | 0.69           | 0.43            | 0.0096        | 1.60  |
| Term Spread                                   | 0.87           | -0.37           | -0.0082       | -1.36 |
| Default Spread                                | 0.72           | 0.16            | 0.0035        | 0.59  |
| Default Return                                | 0.05           | -0.37           | -0.0083       | -1.37 |
| Long-term Bond Return                         | 1.02           | -0.63           | -0.0141       | -2.33 |

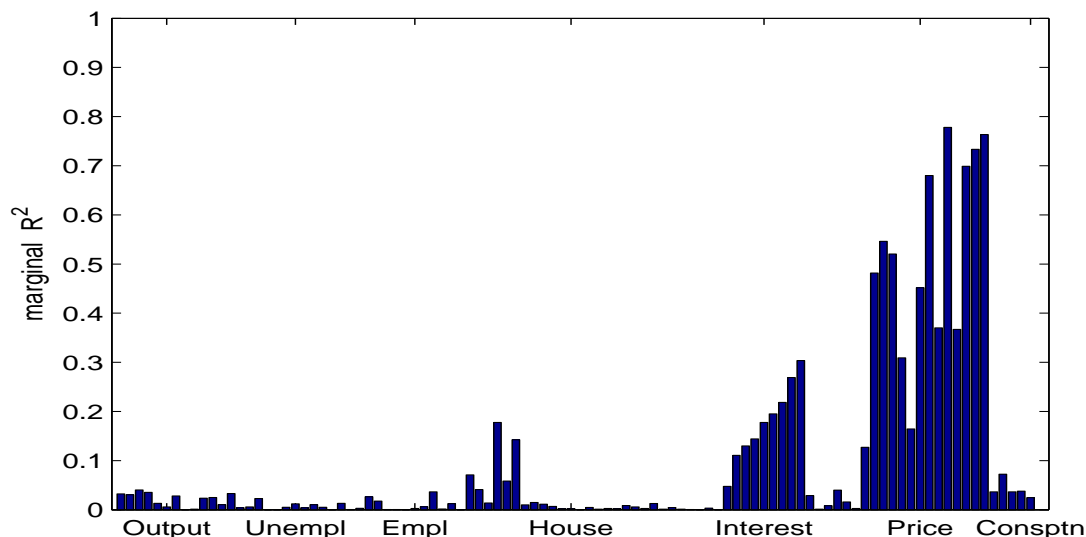


Figure 7: **Marginal  $R^2$  of F2**, calculated from the univariate regression of F2 on 100 individual variables in the panel data. The index F2 is constructed using the full sample of 1960:1-2006:11.

#### 4.2 *Semi Ex Post* Forecasting

Relaxing the fixed-weight restriction, I now reconstruct indices using only the historical information and focus on the ex post performance of indices with dynamic loadings. Using the same criteria as in the fixed weight case, F2 and F5 surpass all other indices. Figure 8 presents the in-sample and pseudo out-of-sample performance for selected indices in Panel A and for popular predictors such as financial ratios and business cycles proxies in Panel B. F2 with dynamic loadings shares a similar forecasting pattern to F2 with fixed loadings, but the former differs with regard to higher and relatively stable predictive power. F5 predicts well until the early 1980s but gradually loses power, although it still outperforms the historical average over the past three decades. In addition, the performance of F2 and F5 is superior to that of financial ratios and business cycles proxies. These results confirm the findings of poor out-of-sample performance for the well-documented predictors in Goyal and Welch (2007). Results of formal statistical tests are reported in Table 5.

Throughout the out-of-sample period, F2 and F5 by definition are the second and fifth principal components in explaining the total variance of the panel data. However, both their loadings and economic interpretations have evolved over time, in contrast to a sharp identity under the fixed weight scenario. Figure 9 illustrates the dynamic loadings of F2 and F5 for

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be a necessary supplement for in-sample performance, and a more reliable experiment should explore whether, when they are conditional on observed in-sample significance, out-of-sample diagnostics are still reasonably powerful.

Panel A: Selected Macro Indices

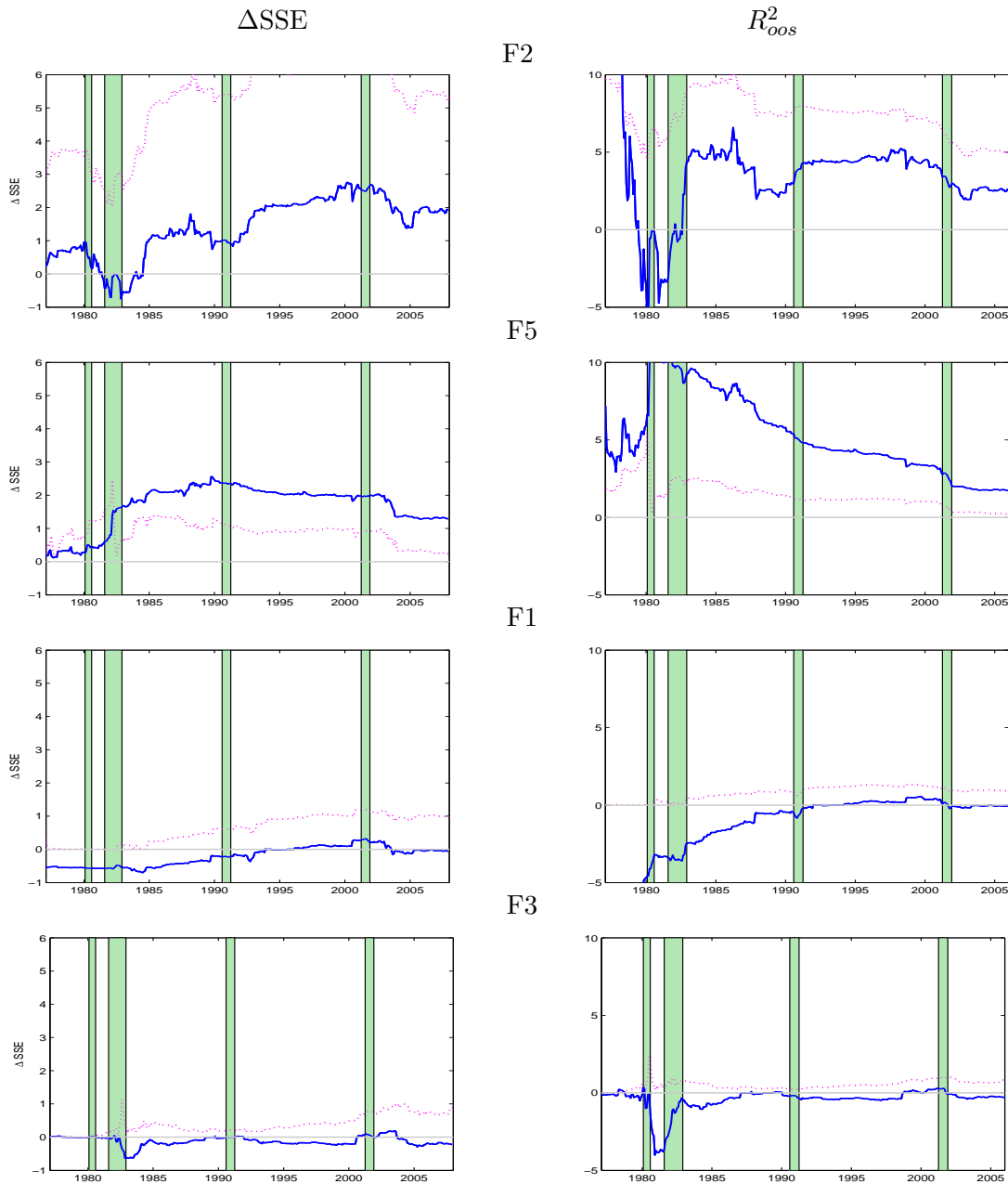


Figure 8: **In-sample** ( - - ) and **Pseudo Out-of-sample** ( — ) Performance of *Ex Post* **Forecasting**.  $\Delta$ SSE measures the difference in cumulative squared prediction errors from the benchmark (the historical average) to the conditional forecasts based on macro indices. The out-of-sample  $R^2_{00s}$  statistic is computed as it is in Campbell and Thompson (2007). Shading denotes months of recessions identified by NBER.

Panel B: Selected Popular Predictors

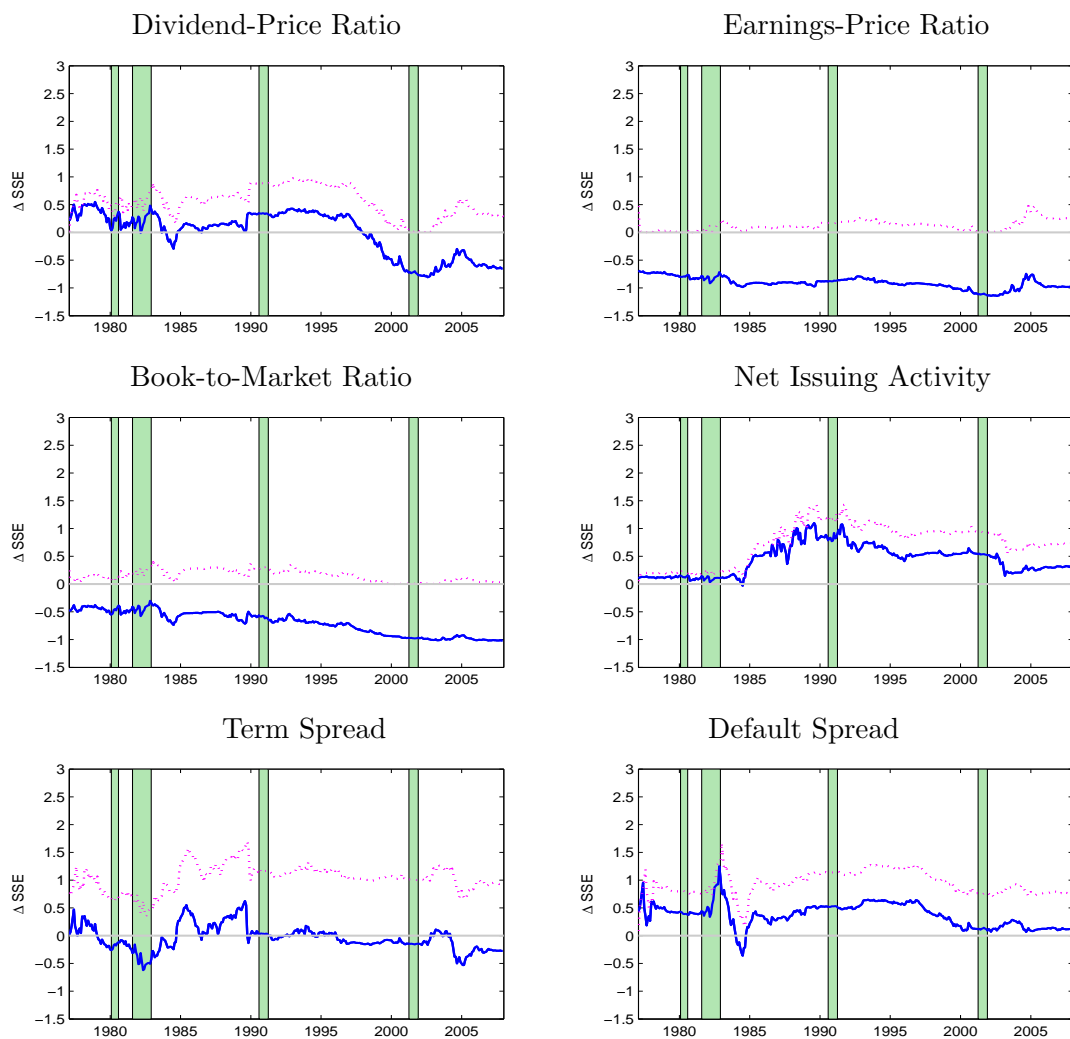


Figure 8 (Cont'd): **In-sample** (---) and **Pseudo Out-of-sample** (—) Performance of *Ex Post* Forecasting.  $\Delta SSE$  measures the difference in cumulative squared prediction errors from the benchmark (the historical average) to the conditional forecasts based on selected predictors summarized in Goyal and Welch (2007). Shading denotes months of recessions identified by NBER.

the period of 1975:1 to 2006:11.<sup>23</sup> The changing identities make the interpretation complex.

**Table 6**  
**Economic Meanings of the Best Performing Macro Indices**

Macro indices are recursively constructed during the period of 1975:1 to 2006:11. The best performing indices, F2 and F5, are selected according to their in-sample and pseudo out-of-sample performance reported in Table 5 and Figure 8. During each month I run the multiple regression of index F2 and F5 onto all variables in each economic sector. This table reports the average, the minimum and the maximum values for the adjusted  $R^2$  for twelve economic sectors that span the panel data. A detailed description of economic sectors are listed in Appendix A.1. The boldface blue numbers emphasize the sectors that are most closely correlated with indices F2 and F5.

| Economic Sector          | F2                 |                   |                   | F5                 |                   |                   |
|--------------------------|--------------------|-------------------|-------------------|--------------------|-------------------|-------------------|
|                          | $\bar{R}_{mean}^2$ | $\bar{R}_{min}^2$ | $\bar{R}_{max}^2$ | $\bar{R}_{mean}^2$ | $\bar{R}_{min}^2$ | $\bar{R}_{max}^2$ |
| Real output              | 5.85               | 1.84              | 20.63             | 13.88              | 4.96              | 32.43             |
| Unemployment             | 1.05               | -1.25             | 2.23              | 15.31              | 5.04              | 35.39             |
| Employment               | <b>28.33</b>       | 21.38             | 53.13             | <b>40.88</b>       | 4.97              | 75.17             |
| Wages                    | 15.82              | 5.78              | 19.68             | 4.60               | 0.62              | 27.11             |
| Housing                  | 19.50              | 8.41              | 43.89             | <b>32.87</b>       | 3.47              | 47.51             |
| Exchange Rates           | 5.65               | 0.99              | 11.30             | 4.69               | -0.54             | 9.60              |
| Money & Credit Aggregate | 2.95               | -2.06             | 6.24              | 6.76               | -0.67             | 71.48             |
| Interest Rates           | <b>42.93</b>       | 11.78             | 56.93             | 5.78               | 0.42              | 43.41             |
| Inventory and Orders     | 12.49              | 6.75              | 47.52             | <b>22.44</b>       | 3.06              | 31.53             |
| Price Indices            | <b>72.35</b>       | 60.02             | 86.91             | 9.66               | 1.07              | 18.51             |
| Consumer Confidence      | 1.76               | 0.32              | 10.42             | 1.80               | 0.00              | 4.33              |
| Consumption              | 8.37               | 6.88              | 12.47             | 4.80               | 0.83              | 16.43             |

Yet behind the good performance of F2 and F5, do some economic intuitions exist? To gain insight into this question, I project the key indices onto each economic sector at each month to see which sectors relate the most to F2 and F5 over time. Table 6 reports the average, the minimum and the maximum values for the adjusted  $R^2$  across economic sectors. In spite of the varying meanings of each single index, the essential economic sectors that F2 and F5 remix still include interest rates and price indices, plus housing and employment.

<sup>23</sup>The loadings are in the absolute form, which makes it easy to compare the relative importance of each component. The sign of the loadings may also be of interest, but the scale is sufficient here since the purpose is to illustrate the absolute correlation between components and the index.

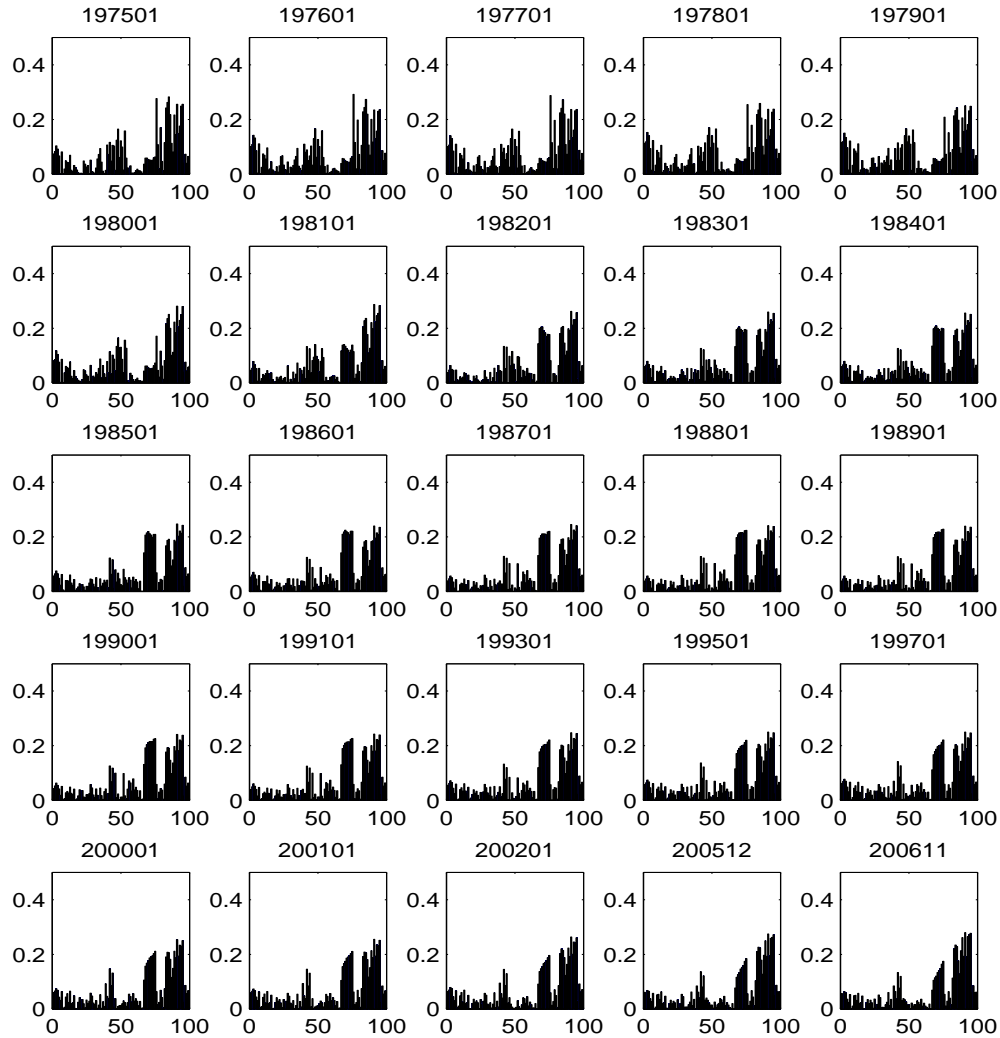


Figure 9: **Dynamic Loadings for Macro Index F2.** Index F2, as the second principal component of the panel data, is recursively constructed at each month using historical information. The vertical axis reports the absolute loadings of index F2 on each individual series. Along the horizontal axis, economic variables are located as Real Output (1-14), Unemployment (15-25), Employment (26-41), **Wages** (42-44), Housing (45-54), Exchange Rates (55-59), Money & Credit Aggregates (60-66), **Interest Rates** (67-75), Inventory & Orders (76-81), **Price Indices** (82-95), Confidence Index (96), and Consumption (97-100).

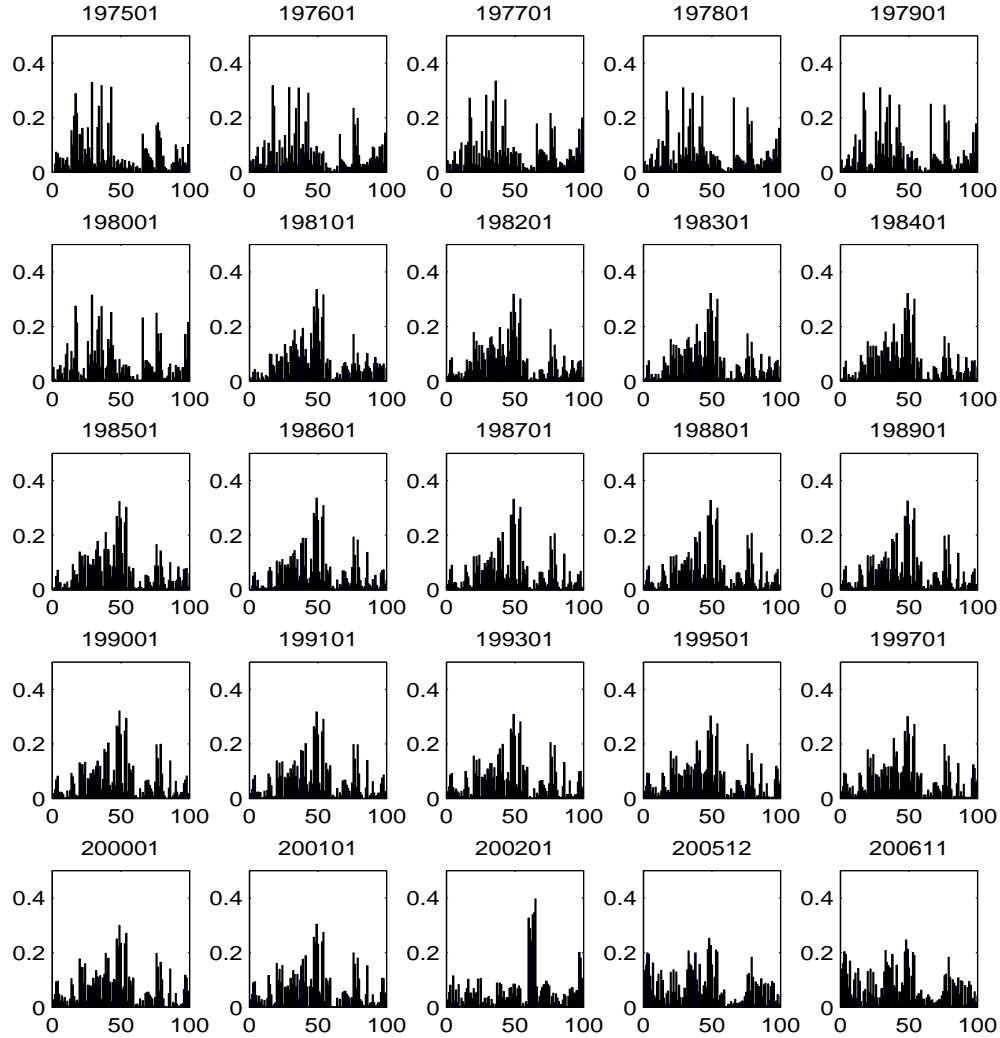


Figure 9 (Cont'd): **Dynamic Loadings for Macro Index F5**. Index F5, as the fifth principal component of the panel data, is recursively constructed at each month using historical information. The vertical axis reports the absolute loadings of index F5 on each individual series. Along the horizontal axis, economic variables are located as Real Output (1-14), Unemployment (15-25), **Employment** (26-41), Wages (42-44), **Housing** (45-54), Exchange Rates (55-59), Money & Credit Aggregates (60-66), Interest Rates (67-75), Inventory & Orders (76-81), Price Indices (82-95), Confidence Index (96), and Consumption (97-100).

### 4.3 Ex Ante Forecasting

The ex ante performance coincides with the ex post forecasting in the sense that F2 and F5 are also the most frequently selected predictors in the adaptive forecasting process. Figure 10 shows the top five macro indices most frequently selected over time and through different rolling windows. The value of the  $y$ -axis indicates whether a variable was included ( $y = 1$ ) or excluded ( $y = 0$ ) at each time point for the “one month ahead” prediction of excess returns. Inclusion percentages are reported in parentheses. It is possible that a predictor occasionally gets included by chance but not because its predictive power. In such cases, however, it is unlikely that the predictor under consideration would be included in the adaptive process for long in subsequent periods. In contrast, when a forecasting variable is selected in a large proportion of the time periods and on a continuous basis, then it is reasonable to expect this predictor to be an important factor in generating the observed predictability of stock returns.

Under a 24-month selection window, F2 becomes an optimal predictor for one-third of the time in the past three years. If choosing an optimal predictor based on its previous 120-month performance, the included frequency of F2 increases to 50.57% which means F2 does well for half of the time over the course of three decades. After the second principal component, the index F5 is the second most frequently selected predictor. The included frequency for F5 is 6.96% using a 24-month rolling window; it increases to 23.19% with a ten year selection window. Since indices here are also recursively reconstructed in the same way as they were in ex post forecasting based on indices with dynamic loadings, it is natural to conclude that the real-time predictability also benefits from joint economic forces such as interest rates, price indices, housing and employment.

### 4.4 Summary

The increasing predictive power of indices comes at the cost of diminishing clarity in economic identity. Real-time prediction using adaptively selected macro indices has strong and robust performance, but obscure economic interpretations. The *ex post* prediction using fixed weight indices has a relatively poor performance but a sharp economic identity. Between them lies the *ex post* prediction using indices with dynamic loadings. The more adaptable the procedure is, the more predictive power it has. By decomposing indices, I find that the economic fundamentals link to the financial market combining the effect of interest rates, price indices, housing and employment.

## 5 Robustness Check

### 5.1 Other Model Selection Criteria

A special feature of this adaptive prediction procedure is the use of an out-of-sample criterion for model selection: predictive least squares (PLS). In this subsection, I compare the real-time forecasting performance using the out-of-sample PLS and other model selection criteria: the in-sample R-square ( $R_{in}^2$ ), Bayesian Information Criterion (BIC) and the in-sample



A.  $m=24$

PLS. The difference between the in-sample and the out-of-sample PLS lies in the information set used to construct macro indices. The in-sample PLS is calculated as the cumulative square *fitting* errors where macro indices are estimated using both historical information and information of the model selection period. The out-of-sample PLS is the cumulative square *prediction* errors where macro indices are estimated using only historical information.

Figure 11 presents the out-of-sample forecasting performance according to these three model selection criteria. The BIC fail to pick up predictors that have significant out-of-sample forecasting power because 1) the benchmark and the prediction model based on BIC have almost the same magnitude of squared prediction errors, and 2) the prediction model based on BIC generate greater prediction errors. The forecasts based on predictors selected by the in-sample PLS generally have smaller prediction errors than the benchmark. However, this in-sample PLS is still inferior to its out-of-sample counterpart since forecasts based on the out-of-sample PLS principle have even smaller prediction errors. The predictors selected by  $R_{in}^2$  seem to have strong out-of-sample forecasting power. However, compared to the performance based on the out-of-sample PLS principle, the prediction errors according to  $R_{in}^2$  are more unstable due to its higher volatility. In addition,  $R_{in}^2$  fails to select good predictors in the beginning of 1980s.

## 5.2 Predictability of Real Stock Returns

Real stock returns are, in themselves, an equally interesting research target. I investigate the predictability of real stock returns using the same adaptive prediction procedure. The primary finding is that adaptively selected macro indices have an even higher predictive power on real returns. The predictability of real stock returns illustrated in Figure 12 shares similar a cyclical pattern to that of excess returns but differs in the early 1980s. The prediction errors based on macro indices dropped dramatically in the anti-inflation period of 1979-1980. The sharp increasing predictive power may benefit from the fact that macro indices adequately capture the changing information of monetary policy. The possibility is further confirmed in the predictability of the risk-free rate in Panel B. The power of macro indices was relatively high in predicting the interest rate in the early 1980s, but it remained flat throughout the 1980s and 1990s, and increased again after the recession of 2001. As documented in Sargent (1999), U.S. monetary policy in the period of 1979-1980 shifted from an overly accommodative policy to one that was sufficiently responsive to inflation. Since the conquest of inflation, the monetary policy has been relatively steady until the early 2000s.

Table 7 provides quantitative results. Calculated from the forecasting errors, the out-of-sample  $R^2$  for the real return predictions is 3.36% over the full sample of 1977:1 to 2005:12, and higher than that for the excess return predictions, 2.70%. Except for the subperiod of the 1990s, real stock returns are more predictable by indices than excess returns with substantially higher  $R_{oos}^2$  values. In addition, the predictability of the one-month Treasury bill rate is even more striking if using the prevailing mean as the benchmark for forecasting.<sup>24</sup>

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<sup>24</sup>The predictability of the interest rate is not the focus of this paper. Interests rate may have another base

a. Bayesian Information Criterion

Panel A: Raw Stock Return

**Table 7**  
**Predictability of Raw Stock Returns**

This table presents the statistical results of real-time out-of-sample performance for the monthly predictive regressions. The predicted asset is the CRSP value-weighted index and the one-month Treasury Bill rate. The forecasting variables are adaptively selected macro indices, constructed from a panel of 100 economic variables. During each out-of-sample month, investors choose a predictor from the base set which generates the smallest cumulative prediction errors in previous 24 months. The performance uses three measures: the out-of-sample R-square ( $R_{oos}^2$ ), the difference of the root-mean-squared prediction error ( $\Delta RMSE$ ) and the MSE-F statistics (McCracken [2004]) to test for the equal forecast accuracy. The benchmark is the unconditional forecast equal to the historical average. The alternative is the conditional forecast using adaptively selected predictors. One-sided critical values of MSE-F are obtained empirically from bootstrapped distributions. The boldface numbers indicate that the alternative model is superior to the benchmark with at least 90% statistical significance. The formulas for the three statistics are:

$$\begin{aligned}
 R_{oos}^2 &= 1 - \frac{\sum \hat{u}_{A,\tau}^2}{\sum \hat{u}_{B,\tau}^2} \\
 \Delta RMSE &= \sqrt{\sum \hat{u}_{B,\tau}^2} - \sqrt{\sum \hat{u}_{A,\tau}^2} \\
 MSE-F &= R \cdot \left( \frac{\sum_r \hat{u}_{A,\tau}^2 - \sum_r \hat{u}_{B,\tau}^2}{\sum_r \hat{u}_{B,\tau}^2} \right)
 \end{aligned}$$

where  $\hat{u}_{B,\tau}$  is the forecasting error from the benchmark and  $\hat{u}_{A,\tau}$  is the forecasting error from the alternative adaptive prediction model.  $R$  is the number of out-of-sample observations.

|                  | Raw Stock Return |               |              | Risk-free Interest Rate |               |               |
|------------------|------------------|---------------|--------------|-------------------------|---------------|---------------|
| Period           | $R_{oos}^2$      | $\Delta RMSE$ | MSE-F        | $R_{oos}^2$             | $\Delta RMSE$ | MSE-F         |
| 1977:1 - 2005:12 | 3.36             | 0.0741        | <b>12.46</b> | 27.69                   | 0.0396        | <b>137.50</b> |
| 1980:1 - 1989:12 | 3.75             | 0.0923        | <b>4.68</b>  | 18.51                   | 0.0329        | <b>27.26</b>  |
| 1990:1 - 1999:12 | 0.24             | 0.0046        | 0.29         | 25.67                   | 0.0202        | <b>41.43</b>  |
| 2000:1 - 2005:12 | 4.33             | 0.0966        | <b>3.67</b>  | 30.57                   | 0.0449        | <b>35.67</b>  |

### 5.3 Real-time Availability of Macro Data

The availability of economic data in real time is an important concern. The data obtained by economists may not be historically available to investors. For example, the Consumer Price Index for All Urban Consumers (CPI-U) is subject to revision for up to five years after its original release. Each year, the previous five years of data are seasonally adjusted using annually-computed seasonal factors; data from January 2002 through December 2006 were replaced in January 2007. As another example, all unadjusted Producer Price Indices (PPI) are routinely subject to a single revision, four months after the original publication,<sup>25</sup> to reflect

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set of sensible predictors suitable as the benchmark, but to maintain consistency within this paper I use the historical average as the benchmark.

<sup>25</sup>The Bureau of Labor Statistics does not use the term “preliminary” to describe the originally released numbers, because preliminary usually describes data that are based on a small information sample, typically

late reports and corrections by respondents. Despite various rules, revisions of macroeconomic data usually have two common features: 1) indices are considered final once revised; and 2) revisions are usually minor, especially for highly aggregated data.

**Table 8**  
**Example of Data Revision: CPI-U**

The Consumer Price Index for All Urban Consumers (CPI-U) is one variable in the panel data listed in Appendix A.1. Both the unadjusted and the adjusted data come from the archives of economic news release in the Bureau of Labor Statistics. The adjusted data are also the same ones used in this paper from the Global Insight Basic Economic Database. The difference is the adjusted number minus the unadjusted one. The noise ( $0.1 \cdot \sigma_{i,s} \cdot e$ ) is generated according to the formula (7).

| Time     | Unadjusted<br>(Original Release) | Adjusted<br>(Final Release) | difference | Noise |
|----------|----------------------------------|-----------------------------|------------|-------|
| Nov 2006 | 201.5                            | 201.7                       | -0.2       | -0.34 |
| Oct 2006 | 201.8                            | 201.7                       | 0.1        | 0.22  |
| Sep 2006 | 202.9                            | 202.7                       | 0.2        | 0.23  |
| Aug 2006 | 203.9                            | 203.7                       | 0.2        | -0.06 |

To check the robustness of the predictability results, I add noise to the data used throughout this paper and conduct the same experiment. Specifically, the new data come from the final released observations plus one-tenth of the standard deviation in each year multiplied by a random number generated from the standard normal distribution,

$$x_{i,t}^{new} = x_{i,t} + \text{noise} = x_{i,t} + 0.1 \cdot \sigma_{i,s} \cdot e, \quad e \sim N(0, 1) \tag{7}$$

where  $\sigma_{i,s}$  is the standard deviation of the variable  $x_i$  in the year  $s$ . The seemingly arbitrary number “0.1” actually effectively captures the magnitude of revision. I collect the historical releases of the Consumer Price Index (CPI-U) for the period of August to November 2006. Table 9 lists the originally released numbers, the adjusted numbers (identical to those used in the paper), their difference and the noise generated using formula (7). The noise might not have the same sign as the difference, but they at least have the same magnitude. Hence the noise-added data capture the revision in the real world to some extent.

Figure 13 presents the performance for the noise-added data. The performance is based on Monte Carlo Simulations with 100 iterations based on the revision formula (7). They

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subject to large revisions. When Consumer Price Indices and Producer Price Indices are first released, they are typically based on a substantial portion of the total number of returns that eventually will be received from respondents. Hence, subsequent revisions are normally minor, especially at the more highly aggregated grouping levels. “First published” and “originally released” are more appropriate terms than “preliminary”. Changes in previously published data caused by a processing error are so indicated in a subsequent news release or detailed report; such occurrences are rare.

## 6 Concluding Remarks

The simple adaptive prediction model based on  
By recursively choosing the optimal index under the pre

A: Cumulative Prediction Errors

ditional forecasts outperform both the unconditional forecasts (historical average) and forecasts conditional on prominent variables from the literature. It is robust — the ex ante forecasting performs well over the past three decades. More importantly, investment strategies exploiting real-time forecasts are able to earn excess profits over the market portfolio with moderate transaction costs.

There are several promising directions for future research. Macro indices explored in this paper provide a fresh opportunity to investigate the determinants of asset risk. The findings on the time-series behavior of excess returns can be linked to the large body of literature on cross-sectional asset pricing. According to the ICAPM of Merton (1973), innovations in state variables – only those state variables that are capable of predicting the expected returns over time – are likely to describe stochastic investment opportunities and hence command risk premia. Macro indices F2 and F5 are the most frequently selected optimal predictors in real-time forecasting; thus, innovations to them could be potential risk factors that explain the cross-sectional pattern of expected returns. No matter what these macro indices turn out to be, whether priced factors or merely good conditioning variables, the cross-sectional investigation takes us one step closer to understanding the main challenge of financial markets: what are the fundamental macroeconomic forces that drive risk premia in the stock market?

An alternative direction involves exploring the connection between structural breaks in financial ratios and time-varying macroeconomic conditions. Lettau and Nieuwerburgh (2007) suggest that the inconsistent results for in-sample and out-of-sample regressions based on financial ratios can be reconciled once we adjust for shifts in the conditional mean. Since detecting a structural break is impossible for investors in real-time forecasting, it is more meaningful to ask why there are structural breaks in the conditional mean (or volatility) of financial ratios, and to seek what is the source of such instability. As quantitative descriptions of economic conditions, macro indices may play a key role in uncovering the real mechanism of financial ratios' nonstationarity.

## Appendix

### A. Data Description

#### A.1 Macroeconomic Series

Following Stock and Watson (2002, 2005), I choose series to capture broad U.S. economic conditions. This panel data comprises 100 economic series, a subset of Stock and Watson's 132 dataset excluding stock market data and various author-calculated spreads of interest rates. I also extend the panel to include the most recent available observations, a sample period from 1960:01 to 2006:11. The format is: series number, short name of each series, its mnemonic (the series label used in the source database), the transformation applied to the series, and a brief data description. All series come from the Global Insights Basic Economics Database.

In the transformation column,  $\ln$  denotes logarithm,  $\Delta \ln$  and  $\Delta^2 \ln$  denote the first and second differences of the logarithm,  $lv$  denotes the level of the series, and  $\Delta lv$ , the difference of the level.



|                     | Short Name        | Mnemonic | Tran | Description   |
|---------------------|-------------------|----------|------|---|
| <b>Real Output</b>  |                   |          |      |   |
| 1                   | IP: total         | ips10    | Δln  | Industrial Production Index- Total Index                                    |
| 2                   | IP: products      | ips11    | Δln  | Industrial Production Index - Products, Total                               |
| 3                   | IP: final prod    | ips299   | Δln  | Industrial Production Index - Final Products                                |
| 4                   | IP: cons gds      | ips12    | Δln  | Industrial Production Index - Consumer Goods                                |
| 5                   | IP: cons dble     | ips13    | Δln  | Industrial Production Index - Durable Consumer Goods                        |
| 6                   | IP: cons nondble  | ips18    | Δln  | Industrial Production Index - Nondurable Consumer Goods                     |
| 7                   | IP: bus eqpt      | ips25    | Δln  | Industrial Production Index - Business Equipment                            |
| 8                   | IP: matls         | ips32    | Δln  | Industrial Production Index - Materials                                     |
| 9                   | IP: dble matls    | ips34    | Δln  | Industrial Production Index - Durable Goods Materials                       |
| 10                  | IP: nondble matls | ips38    | Δln  | Industrial Production Index - Nondurable Goods Materials                    |
| 11                  | IP: mfg           | ips43    | Δln  | Industrial Production Index - Manufacturing (Sic)                           |
| 12                  | IP: res util      | ips307   | Δln  | Industrial Production Index - Residential Utilities                         |
| 13                  | IP: fuels         | ips306   | Δln  | Industrial Production Index - Fuels   |
| 14                  | NAPM prodn        | pmp      | lv   | Napm Production Index (Percent)   |
| <b>Unemployment</b> |                   |          |      |   |
| 15                  | Help wanted indx  | lhel     | Δlv  | Index Of Help-Wanted Advertising In Newspapers (1967=100;Sa)                |
| 16                  | Help wanted/emp   | lhelx    | Δlv  | Employment: Ratio; Help-Wanted Ads:No. Unemployed Clf                       |
| 17                  | Emp CPS total     | lhem     | Δln  | Civilian Labor Force: Employed, Total (Thous.,Sa)                           |
| 18                  | Emp CPS nonag     | lhmag    | Δln  | Civilian Labor Force: Employed, Nonagric.Industries (Thous.,Sa)             |
| 19                  | U: all            | lhur     | Δlv  | Unemployment Rate: All Workers, 16 Years Over (%;Sa)                        |
| 20                  | U: mean duration  | lhu680   | Δlv  | Unemploy.By Duration: Average(Mean)Duration In Weeks (Sa)                   |
| 21                  | U ; 5 wks         | lhu5     | Δln  | Unemploy.By Duration: Persons Unempl.Less Than 5 Wks (Thous.,Sa)            |
| 22                  | U 5-14 wks        | lhu14    | Δln  | Unemploy.By Duration: Persons Unempl.5 To 14 Wks (Thous.,Sa)                |
| 23                  | U 15+ wks         | lhu15    | Δln  | Unemploy.By Duration: Persons Unempl.15 Wks + (Thous.,Sa)                   |
| 24                  | U 15-26 wks       | lhu26    | Δln  | Unemploy.By Duration: Persons Unempl.15 To 26 Wks (Thous.,Sa)               |
| 25                  | U 27+ wks         | lhu27    | Δln  | Unemploy.By Duration: Persons Unempl.27 Wks + (Thous.,Sa)                   |
| <b>Employment</b>   |                   |          |      |   |
| 26                  | Emp: total        | ces002   | Δln  | Employees On Nonfarm Payrolls: Total Private                                |
| 27                  | Emp: gds prod     | ces003   | Δln  | Employees On Nonfarm Payrolls - Goods-Producing                             |
| 28                  | Emp: mining       | ces006   | Δln  | Employees On Nonfarm Payrolls - Mining                                      |
| 29                  | Emp: const        | ces011   | Δln  | Employees On Nonfarm Payrolls - Construction                                |
| 30                  | Emp: mfg          | ces015   | Δln  | Employees On Nonfarm Payrolls - Manufacturing                               |
| 31                  | Emp: dble gds     | ces017   | Δln  | Employees On Nonfarm Payrolls - Durable Goods                               |
| 32                  | Emp: nondbles     | ces033   | Δln  | Employees On Nonfarm Payrolls - Nondurable Goods                            |
| 33                  | Emp: services     | ces046   | Δln  | Employees On Nonfarm Payrolls - Service-Providing                           |
| 34                  | Emp: TTU          | ces048   | Δln  | Employees On Nonfarm Payrolls - Trade, Transportation, And Utilities        |
| 35                  | Emp: wholesale    | ces049   | Δln  | Employees On Nonfarm Payrolls - Wholesale Trade                             |
| 36                  | Emp: retail       | ces053   | Δln  | Employees On Nonfarm Payrolls - Retail Trade                                |
| 37                  | Emp: FIRE         | ces088   | Δln  | Employees On Nonfarm Payrolls - Financial Activities                        |
| 38                  | Emp: Govt         | ces140   | Δln  | Employees On Nonfarm Payrolls - Government                                  |
| 39                  | Avg hrs           | ces151   | lv   | Avg Weekly Hrs of Workers On Private Nonfarm Payrolls - Goods-Producing     |
| 40                  | Overtime: mfg     | ces155   | lv   | Avg Weekly Hrs of Workers On Private Nonfarm Payrolls-Mfg Overtime          |
| 41                  | NAPM empl         | pmemp    | lv   | Napm Employment Index (Percent)   |
| <b>Wages</b>        |                   |          |      |   |
| 42                  | AHE: goods        | ces275   | Δln  | Avg Hourly Earnings of Workers On Private Nonfarm Payrolls-Goods-Producing  |
| 43                  | AHE: const        | ces277   | Δln  | Avg Hourly Earnings of Workers On Private Nonfarm Payrolls-Construction     |
| 44                  | AHE: mfg          | ces278   | Δln  | Avg Hourly Earnings of Workers On Private Nonfarm Payrolls-Manufacturing    |
| <b>Housing</b>      |                   |          |      |   |
| 45                  | Starts: nonfarm   | hsfr     | ln   | Housing Starts: Nonfarm(1947-58);Total Farm and Nonfarm(1959-)(Thous.,Saar) |
| 46                  | Starts: NE        | hsne     | ln   | Housing Starts:Northeast (Thous.U.)S.A.                                     |
| 47                  | Starts: MW        | hsmw     | ln   | Housing Starts:Midwest(Thous.U.)S.A.  |
| 48                  | Starts: South     | hssou    | ln   | Housing Starts:South (Thous.U.)S.A.   |
| 49                  | Starts: West      | hswst    | ln   | Housing Starts:West (Thous.U.)S.A.  |
| 50                  | BP: total         | hsbr     | ln   | Housing Authorized: Total New Priv Housing Units (Thous.,Saar)              |
| 51                  | BP: NE            | hsbne    | ln   | Houses Authorized By Build. Permits:Northeast(Thou.U.)S.A.                  |

|                                    |                   |        |               |  |
|------------------------------------|-------------------|--------|---------------|--|
| 52                                 | BP: MW            | hsbmw  | ln            | Houses Authorized By Build. Permits:Midwest(Thou.U.)S.A.                     |
| 53                                 | BP: South         | hsbsou | ln            | Houses Authorized By Build. Permits:South(Thou.U.)S.A.                       |
| 54                                 | BP: West          | hsbwst | ln            | Houses Authorized By Build. Permits:West(Thou.U.)S.A.                        |
| <b>Exchange Rates</b>              |                   |        |               |  |
| 55                                 | Ex rate: avg      | exrus  | $\Delta$ ln   | United States;Effective Exchange Rate(Merm)(Index No.)                       |
| 56                                 | Ex rate: Switz    | exrsw  | $\Delta$ ln   | Foreign Exchange Rate: Switzerland (Swiss Franc Per U.S.\$ )                 |
| 57                                 | Ex rate: Japan    | exrjan | $\Delta$ ln   | Foreign Exchange Rate: Japan (Yen Per U.S.\$ )                               |
| 58                                 | Ex rate: UK       | exruk  | $\Delta$ ln   | Foreign Exchange Rate: United Kingdom (Cents Per Pound)                      |
| 59                                 | EX rate: Canada   | exrcan | $\Delta$ ln   | Foreign Exchange Rate: Canada (Canadian \$ Per U.S.\$ )                      |
| <b>Money and Credit Aggregates</b> |                   |        |               |  |
| 60                                 | M1                | fm1    | $\Delta^2$ ln | Money Stock: M1(Curr,Trav.Cks,Dem Dep,Other Ck'able Dep)(Bil\$,Sa)           |
| 61                                 | M2                | fm2    | $\Delta^2$ ln | Money Stock:M2(M1+O'nite Rps,Euro\$,G/P&B/D Mmmfs&Sav&Sm Time Dep)(Bil\$,Sa) |
| 62                                 | M3                | fm3    | $\Delta^2$ ln | Money Stock: M3(M2+Lg Time Dep,Term Rp's&Inst Only Mmmfs)(Bil\$,Sa)          |
| 63                                 | MB                | fmfba  | $\Delta^2$ ln | Monetary Base, Adj For Reserve Requirement Changes(Mil\$,Sa)                 |
| 64                                 | Reserves tot      | fmrra  | $\Delta^2$ ln | Depository Inst Reserves:Total, Adj For Reserve Req Chgs(Mil\$,Sa)           |
| 65                                 | REServes nonbor   | fmrnba | $\Delta^2$ ln | Depository Inst Reserves:Nonborrowed,Adj Res Req Chgs(Mil\$,Sa)              |
| 66                                 | Cons credit       | ccinrv | $\Delta^2$ ln | Consumer Credit Outstanding -Nonrevolving(G19)                               |
| <b>Interest Rate</b>               |                   |        |               |  |
| 67                                 | Fed Funds         | fyff   | $\Delta$ lv   | Interest Rate: Federal Funds (Effective) (% Per Annum,Nsa)                   |
| 68                                 | 3 mo T-bill       | fygm3  | $\Delta$ lv   | Interest Rate: U.S.Treasury Bills,Sec Mkt,3-Mo.(% Per Ann,Nsa)               |
| 69                                 | 6 mo T-bill       | fygm6  | $\Delta$ lv   | Interest Rate: U.S.Treasury Bills,Sec Mkt,6-Mo.(% Per Ann,Nsa)               |
| 70                                 | 1 yr T-bond       | fygt1  | $\Delta$ lv   | Interest Rate: U.S.Treasury Const Maturities,1-Yr.(% Per Ann,Nsa)            |
| 71                                 | 3 yr T-bond       | fygt3  | $\Delta$ lv   | Interest Rate: U.S.Treasury Const Maturities,3-Yr.(% Per Ann,Nsa)            |
| 72                                 | 5 yr T-bond       | fygt5  | $\Delta$ lv   | Interest Rate: U.S.Treasury Const Maturities,5-Yr.(% Per Ann,Nsa)            |
| 73                                 | 10 yr T-bond      | fygt10 | $\Delta$ lv   | Interest Rate: U.S.Treasury Const Maturities,10-Yr.(% Per Ann,Nsa)           |
| 74                                 | Aaa bond          | fyaaac | $\Delta$ lv   | Bond Yield: Moody's Aaa Corporate (% Per Annum)                              |
| 75                                 | Baa bond          | fybaac | $\Delta$ lv   | Bond Yield: Moody's Baa Corporate (% Per Annum)                              |
| <b>Inventories and Orders</b>      |                   |        |               |  |
| 76                                 | PMI               | pmi    | lv            | Purchasing Managers' Index (Sa)  |
| 77                                 | NAPM new ordrs    | pmno   | lv            | Napm New Orders Index (Percent)  |
| 78                                 | NAPM vendor del   | pmdel  | lv            | Napm Vendor Deliveries Index (Percent)                                       |
| 79                                 | NAPM Invent       | pmnv   | lv            | Napm Inventories Index (Percent)   |
| 80                                 | Orders:coms gds   | mocmq  | $\Delta$ ln   | New orders -consumer goods & materials, 1996 dollars (BCI)                   |
| 81                                 | Orders:cap gds    | msondq | $\Delta$ ln   | New orders, nondefense capital goods,in 1996 dollars(BCI)                    |
| <b>Price indices</b>               |                   |        |               |  |
| 82                                 | PPI: fin gds      | pwfsa  | $\Delta$ ln   | Producer Price Index: Finished Goods (82=100,Sa)                             |
| 83                                 | PPI: cons gds     | pwfcsa | $\Delta$ ln   | Producer Price Index: Finished Consumer Goods (82=100,Sa)                    |
| 84                                 | PPI: int mat'ls   | pwimsa | $\Delta$ ln   | Producer Price Index:Intermed Mat.Supplies & Components(82=100,Sa)           |
| 85                                 | PPI: crude mat'ls | pwcmsa | $\Delta$ ln   | Producer Price Index: Crude Materials (82=100,Sa)                            |
| 86                                 | NAPM com price    | pmcp   | lv            | Napm Commodity Prices Index (Percent)  |
| 87                                 | CPI-U: all        | punew  | $\Delta$ ln   | Cpi-U: All Items (82-84=100,Sa)  |
| 88                                 | CPI-U: apparel    | pu83   | $\Delta$ ln   | Cpi-U: Apparel & Upkeep (82-84=100,Sa)                                       |
| 89                                 | CPI-U: transp     | pu84   | $\Delta$ ln   | Cpi-U: Transportation (82-84=100,Sa)   |
| 90                                 | CPI-U: comm.      | puc    | $\Delta$ ln   | Cpi-U: Commodities (82-84=100,Sa)  |
| 91                                 | CPI-U: dbles      | pucd   | $\Delta$ ln   | Cpi-U: Durables (82-84=100,Sa)   |
| 92                                 | CPI-U: services   | pus    | $\Delta$ ln   | Cpi-U: Services (82-84=100,Sa)   |
| 93                                 | CPI-U: ex food    | puxf   | $\Delta$ ln   | Cpi-U: All Items Less Food (82-84=100,Sa)                                    |
| 94                                 | CPI-U: ex shelter | puxhs  | $\Delta$ ln   | Cpi-U: All Items Less Shelter (82-84=100,Sa)                                 |
| 95                                 | CPI-U: ex med     | puxm   | $\Delta$ ln   | Cpi-U: All Items Less Midical Care (82-84=100,Sa)                            |
| <b>Misellaneous</b>                |                   |        |               |  |
| 96                                 | Consumer expect   | hhsntn | $\Delta$ lv   | U. Of Mich. Index Of Consumer Expectations(Bcd-83)                           |
| <b>Consumption</b>                 |                   |        |               |  |
| 97                                 | PCE defl          | gmdc   | $\Delta$ ln   | Pce, Impl Pr Defl:Pce (1987=100)   |
| 98                                 | PCE defl: dlbes   | gmdcd  | $\Delta$ ln   | Pce, Impl Pr Defl:Pce; Durables (1987=100)                                   |
| 99                                 | PCE defl: nondble | gmdcn  | $\Delta$ ln   | Pce, Impl Pr Defl:Pce; Nondurables (1996=100)                                |

## A.2 Predictors in Goyal and Welch (2007)

In the monthly prediction, Goyal and Welch (2007) uses the following predictors: the dividend price ratio, the earnings price ratio, the dividend-earnings ratio, the book-to-market ratio, the long-term government bond return, net equity expansion, inflation measured by the first difference of the logarithm in Consumer Price Index (All Urban Consumers), the term spread, the default yield spread, and the default return spread. For a detailed description and data sources, please see the original paper. In this paper, I use these data for a sample period of January 1960 to December 2005.

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