Forecasting U.S. Business Fixed Investment Spending

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Abstract

In this paper, we use a number of recently developed econometric procedures to analyze the simulated out-of-sample forecasting ability of a host of variables with respect to U.S. business fixed investment spending growth over the 1980s and 1990s. The variables we consider include four "traditional" variables from the empirical literature, as well as five "new" variables recently suggested by Lettau and Ludvigson (2002) that display predictive ability with respect to excess stock returns. Overall, our empirical results indicate that traditional variables contain information useful for forecasting U.S. business fixed investment spending growth over the 1980s, while both traditional and new variables are useful for forecasting U.S. business fixed investment spending growth over the 1990s.

JEL classification codes: C22, C53, E22, E27

Key words: Business fixed investment spending; Out-of-sample forecasts; Mean square forecast error; Forecast encompassing; General-to-specific model selection

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1. Introduction

Empirical models of business fixed investment spending have a long tradition. This is not surprising, given the crucial role of investment spending in determining both long-term growth and fluctuations in aggregate activity at business-cycle horizons. The empirical literature has analyzed the predictive ability of a host of variables with respect to investment spending. Popular variables in the literature include real output, Tobin's Q (Tobin, 1969), cash flow or profits, and stock returns.[1] A partial list of empirical studies analyzing one or more or these variables includes Bischoff (1971), Clark (1979), Bernanke, Bohn, and Reiss (1985), Barro (1990), Blanchard, Rhee, and Summers (1993), Oliner, Rudebusch, and Sichel (1995), Lamont (2000), and Tevlin and Whelan (2003). In addition to these "traditional" variables, Lettau and Ludvigson (2002) recently investigate five "new" variables that demonstrate predictive ability with respect to equity risk premia (excess stock returns): the dividend yield, consumption-wealth ratio, term spread, default spread, and relative short-term interest rate. Building on the modern Q theory of investment spending [see, for example, Abel (1982) and Abel and Blanchard (1986)], Lettau and Ludvigson (2002) argue that these variables should also have forecasting ability with respect to business investment spending.

In the present paper, we use a number of recently developed econometric procedures to analyze the simulated out-of-sample forecasting ability with respect to U.S. business fixed investment spending growth of the four traditional variables listed above and the five new variables suggested by Lettau and Ludvigson (2002). Identifying variables that have out-of-sample forecasting ability with respect to investment spending is likely to be of keen interest to policymakers,[2] and out-of-sample tests of forecasting ability are widely regarded as more stringent—and thus more reliable—tests of a given variable's predictive ability. We test the out-of-sample forecasting ability of the variables over the 1980s and 1990s. It is especially interesting to test

[1] The use of real output is motivated by the accelerator (Clark, 1917; Chenery, 1952; Koyck, 1954) and neoclassical (Jorgenson, 1963; Hall and Jorgenson, 1967) models of investment spending; cash flow or profits are motivated by possible external finance constraints faced by some firms (Fazzari, Hubbard, and Petersen, 1988); stock returns are a potentially better proxy of market value than measured Q (Barro, 1990). Cash flow or profits may also contain information relevant for firms' investment opportunities (Gomes, 2001). In addition to real output, the neoclassical model suggests using the rental price of capital. However, the measured effect of the rental price of capital is typically quite small in empirical investment models. See Chirinko (1993) and Kopcke and Brauman (2001) for useful surveys of models of business fixed investment spending.

[2] See, for example, Bernanke (2003) and Poole (2003) with respect to monetary policy.

forecasting ability over the 1990s, as this recent period witnessed an investment boom that was at the center of the longest economic expansion in U.S. history.[3]

We begin by investigating the forecasting ability of each variable in turn using the framework of Stock and Watson (2003), who analyze the out-of-sample forecasting ability of a large number of individual variables with respect to inflation and real output growth in the G-7 countries. Stock and Watson (2003) generate simulated out-of-sample forecasts of inflation or real output growth using an autoregressive distributed lag (ARDL) model that includes a given variable whose potential predictive ability is of interest. These forecasts are compared to forecasts generated by an autoregressive (AR) benchmark model that excludes the potential predictor using a mean squared forecast error (MSFE) metric. Similarly, we generate simulated out-of-sample forecasts of U.S. business fixed investment spending growth using ARDL models that include each of the traditional and new variables in turn, and we compare these forecasts to forecasts generated by an AR benchmark model. We formally test whether the ARDL model forecasts are superior to the AR benchmark model forecasts using a pair of recently developed statistics. The first statistic is a variant of the popular Diebold and Mariano (1995) and West (1996) statistic due to McCracken (2004), which is used to test whether the ARDL model MSFE is significantly less than the AR benchmark model MSFE. The second statistic is a variant of the Harvey, Leybourne, and Newbold (1998) statistic due to Clark and McCracken (2001), and this statistic is used to test whether the AR benchmark model forecasts encompass the ARDL model forecasts. If the AR benchmark model forecasts do not encompass the ARDL model forecasts, this indicates that the ARDL model contains information useful for forecasting investment spending growth beyond that already contained in the AR benchmark model. Extensive Monte Carlo simulations in Clark and McCracken (2001, 2004) indicate that the McCracken (2004) and Clark and McCracken (2001) statistics can be considerably more powerful than their original counterparts in detecting forecasting ability.

In addition to analyzing the simulated out-of-sample forecasting ability of each variable in turn, we

[3] Extant studies that contain out-of-sample forecasting tests of empirical investment models include Bischoff (1971), Clark (1979), Bernanke, Bohn, and Reiss (1985), Oliner, Rudebusch, and Sichel (1995), and Tevlin and Whelan (2003).

perform an out-of-sample version of an in-sample test in Lettau and Ludvigson (2002). This test investigates whether variables that have predictive ability with respect to excess stock returns also have predictive ability with respect to investment spending growth, after controlling for traditional predictors of investment spending. We compare simulated out-of-sample forecasts of U.S. business fixed investment spending growth over the 1980s and 1990s generated by models that include excess stock return predictors to simulated out-of-sample forecasts generated by a benchmark model that includes traditional predictors of investment spending. We formally test whether the forecasts generated by the models that include excess stock return predictors are superior to forecasts generated by the benchmark model using the MSE-F and ENC-NEW statistics.

Finally, we employ a procedure recently analyzed by Clark (2004) that combines in-sample general-to-specific model selection (starting from a model that includes all potential predictors) with tests of out-of-sample forecasting ability. In Monte Carlo simulations, Clark (2004) finds this procedure to be effective in guarding against model overfitting. We use this procedure to identify which (if any) of the traditional and Lettau and Ludvigson (2002) variables are selected by general-to-specific model selection over various in-sample periods. We then test the simulated out-of-sample forecasting ability of the selected model over the 1980s and 1990s relative to an AR benchmark model, again using the MSE-F and ENC-NEW statistics.

Previewing our empirical results, when analyzed in turn using the Stock and Watson (2003) framework, the traditional variables display significant simulated out-of-sample forecasting ability with respect to U.S. business fixed investment spending growth over the 1980s and 1990s at multiple horizons, while the new variables suggested by Lettau and Ludvigson (2002) only exhibit significant forecasting ability over the 1990s. We also find that the new variables typically have simulated out-of-sample forecasting ability with respect to investment spending growth over the 1990s—but not the 1980s—after controlling for the predictive ability of traditional variables of investment spending. Finally, the Clark (2004) procedure indicates that numerous variables play important roles in forecasting investment spending growth over the 1990s, but the inclusion of new variables in models selected over the in-sample period typically leads to inferior forecasts over the 1980s. Overall, we find that traditional variables contain information useful for forecasting U.S. business fixed investment spending growth over the 1980s, while both traditional and new variables contain information useful for forecasting investment spending growth over the more recent decade of the 1990s.

The rest of the paper is organized as follows: Section 2 presents the econometric methodology, Section 3 reports the empirical results, and Section 4 concludes.

2. Econometric Methodology

2.1. Analyzing the Out-of-Sample Forecasting Ability of Individual Variables in Turn

Let $\Delta i_t = i_t - i_{t-1}$, where i_t is the log-level of real business fixed investment spending at time *t*, and let $y_{t+h} = \sum_{j=1}^{h} \Delta i_{t+j}$. Consider the following ARDL model:

$$y_{t+h} = \alpha + \sum_{j=0}^{q_1-1} \beta_j \Delta i_{t-j} + \sum_{j=0}^{q_2-1} \gamma_j x_{t-j} + \varepsilon_{t+h}, \tag{1}$$

where x_t is a variable whose predictive power we are interested in testing, *h* is the forecast horizon, and ε_{t+h} is a disturbance term. When $h > 1$, the y_{t+h} observations will be overlapping, so that the disturbance terms will be serially correlated in equation (1). Suppose that, after allowing for lags, we have *T* observations for Δi_{t-j} $(j = 0,..., q_1 - 1)$ and x_{t-j} $(j = 0,..., q_2 - 1)$ in equation (1), leaving us with $T - h$ usable observations. It is straightforward to conduct an in-sample test of the forecasting ability of x_t using all of the available observations through a Wald test of the null hypothesis that $\gamma_0 = ... = \gamma_{q_2-1} = 0$. In order the account for the serial correlation in the disturbance terms, a heteroskedasticity and autocorrelation consistent (HAC) covariance matrix, such as that suggested by Newey and West (1987), should be used in forming the Wald statistic.

In order to test the out-of-sample forecasting ability of x_t, we use the following recursive scheme that (apart from data availability and revisions) simulates the situation of a forecaster in real time.[4] We first divide the total sample of *T* observations into in-sample and out-of-sample portions, where the in-sample

[4] Data availability and revisions are potentially relevant for variables such as real output, but not for financial variables such as the dividend yield, term spread, default spread, and relative short rate.

observations span the first R observations and the out-of-sample observations the last P observations. We compute out-of-sample forecasts for an unrestricted model that includes the potential predictor x_t [equation (1)], as well as a restricted model that excludes x_t [equation (1) with $\gamma_0 = ... = \gamma_{q_2-1} = 0$]. The restricted model constitutes the AR benchmark model. The first out-of-sample forecast for the unrestricted model is generated in the following manner. We estimate equation (1) via OLS using data available through period *R*. Using the OLS parameter estimates and the observations for Δi_{R-j} $(j = 0, \ldots, q_1 - 1)$ and x_{R-j} $(j = 0, \ldots, q_2 - 1)$, we construct a forecast for y_{R+h} based on the unrestricted model using the fitted equation $\hat{y}_{1,R+h} = \hat{\alpha}_{1,R} + \sum_{j=0}^{q_1-1} \hat{\beta}_{1,R,j} \Delta i_{R-j} + \sum_{j=0}^{q_2-1} \hat{\gamma}_{1,R,j} x_{R-j}$, where $\hat{\alpha}_{1,R}$, $\hat{\beta}_{1,R,j}$ $(j = 0,..., q_1 - 1)$, and $\hat{\gamma}_{1,R,j}$ $(j = 0,..., q_2 - 1)$ are the OLS estimates of α, β_j $(j = 0,..., q_1 - 1)$, and γ_j $(j = 0,..., q_2 - 1)$ in equation (1) using data available through period *R*. Denote the forecast error by $\hat{u}_{1,R+h} = y_{R+h} - \hat{y}_{1,R+h}$. We generate the initial forecast error corresponding to the restricted (AR benchmark) model in a similar manner, except that the restriction $\gamma_0 = ... = \gamma_{q_2-1} = 0$ is imposed in equation (1); that is, we estimate equation (1) with $\gamma_0 = ... = \gamma_{q_2-1} = 0$ via OLS using data available through period R in order to form the forecast $\hat{y}_{0,R+h} = \hat{\alpha}_{0,R} + \sum_{j=0}^{q_1-1} \hat{\beta}_{0,R,j} \Delta i_{R-j}$, where $\hat{\alpha}_{0,R}$ and $\hat{\beta}_{0,R,j}$ $(j = 0,..., q_1 - 1)$ are the OLS estimates of α and β_j $(j = 0,..., q_1 - 1)$ in equation (1) with $\gamma_0 = ... = \gamma_{q_2-1} = 0$ using data available through period *R*. Denote the forecast error corresponding to the restricted model as $\hat{u}_{0,R+h} = y_{R+h} - \hat{y}_{0,R+h}$. In order to generate a second set of forecasts for y_{R+1+h}, we update the above procedure one period by using data available through period $R+1$. We repeat this process through the end of the available sample, leaving us with two sets of $T - R - h + 1$ recursive out-of-sample forecast errors, one each for the unrestricted and restricted models ($\{\hat{u}_{1,t+h}\}_{t=R}^{T-h}$ and $\{\hat{u}_{0,t+h}\}_{t=R}^{T-h}$).

A simple and popular metric for comparing forecasts is Theil's U, the ratio of the unrestricted model root mean squared forecast error (RMSFE) to the restricted model RMSFE.[5] Clearly, if the MSFE for the unrestricted model that includes x_t is less than the AR benchmark model MSFE, then U < 1. We formally test whether the unrestricted model MSFE is less than the restricted model MSFE using the McCracken (2004) variant of the popular Diebold and Mariano (1995) and West (1996) statistic. The statistic is based on the loss differential, $\hat{d}_{t+h} = \hat{u}^2_{0,t+h} - \hat{u}^2_{1,t+h}$. Letting $\bar{d} = (T-R-h+1)^{-1}\sum_{t=R}^{T-h}\hat{d}_{t+h} = MSFE_0 - MSFE_1$, where $MSFE_m = (T-R-h+1)^{-1}\sum_{t=R}^{T-h}u^2_{m,t+h}$ $(m = 0,1)$, the McCracken (2004) statistic can be expressed as

$$\text{MSE-F} = (T-R-h+1)\cdot\bar{d}\,/\,MSFE_1. \tag{2}$$

Under the null hypothesis of equal forecasting ability, $MSFE_0 = MSFE_1$, so that $\bar{d}$ and MSE-F are equal to zero. We test the null hypothesis against the one-sided (upper-tail) alternative hypothesis that the unrestricted model MSFE is less than the restricted model MSFE ($MSFE_0 > MSFE_1$). When comparing forecasts from nested models (as is obviously the case for our applications) and $h = 1$, McCracken (2004) shows that the MSE-F statistic has a non-standard asymptotic distribution that is a function of stochastic integrals of Brownian motion. For the case of nested models and $h > 1$, Clark and McCracken (2004) show that the MSE-F statistic has a non-standard and non-pivotal asymptotic distribution.[6] Given this last result, Clark and McCracken (2004) recommend basing inference on a bootstrap procedure along the lines of Kilian (1999). Following their recommendation, we base our inferences for the MSE-F statistic on a bootstrap procedure similar to Kilian (1999). The bootstrap procedure is described below.

As an alternative to the MSFE metric, we also use a test of forecasting ability based on the notion of forecast encompassing.[7] Consider forming an optimal composite forecast of y_{t+h} as a convex combination of

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[5] Strictly speaking, Theil's U uses a random walk model as the benchmark model. In our applications, we use an AR model as the benchmark, but still refer to the ratio of the RMSFEs from the unrestricted and restricted models as Theil's U.

[6] McCracken (2004) and Clark and McCracken (2004) also show that, for nested models, the original Diebold and Mariano (1995) and West (1996) statistic has a non-standard asymptotic distribution when $h = 1$ and a non-standard and non-pivotal asymptotic distribution when $h > 1$.

[7] See Clements and Hendry (1998) for a textbook treatment of forecast encompassing.

the forecasts from the unrestricted and restricted models:

$$\hat{y}_{c,t+h} = \lambda \hat{y}_{1,t+h} + (1-\lambda)\hat{y}_{0,t+h}, \tag{3}$$

where $0 \le \lambda \le 1$. If $\lambda = 0$, the restricted model forecasts are said to encompass the unrestricted model forecasts, as the unrestricted model does not contribute any valuable information (apart from that already contained in the restricted model) in the formation of an optimal composite forecast. If $\lambda > 0$, the restricted model forecasts do not encompass the unrestricted model forecasts, so that the unrestricted model does contain information that is useful (beyond that already contained in the restricted model) in the formation of an optimal composite forecast. Clark and McCracken (2001) propose a variant of the Harvey, Leybourne, and Newbold (1998) statistic to test the null hypothesis that $\lambda = 0$ in equation (3) against the one-sided (upper-tail) alternative hypothesis that $\lambda > 0$:

$$\text{ENC-NEW} = (T - R - h + 1) \cdot \bar{c} / MSFE_1, \tag{4}$$

where $\hat{c}_{t+h} = \hat{u}_{0,t+h}(\hat{u}_{0,t+h} - \hat{u}_{1,t+h})$ and $\bar{c} = (T - R - h + 1)^{-1} \sum_{t=R}^{T-h} \hat{c}_{t+h}$. Similar to the MSE-F statistic, Clark and McCracken (2001) show that the ENC-NEW statistic has a non-standard asymptotic distribution when $h = 1$, while Clark and McCracken (2004) show that it has a non-standard and non-pivotal asymptotic distribution when $h > 1$, when comparing forecasts from nested models.[8] Again, Clark and McCracken (2004) recommend basing inference for the ENC-NEW statistic on a bootstrap procedure, and we again base our inferences on the bootstrap procedure described below.

The bootstrap procedure we employ is similar to the one in Clark and McCracken (2004), which is a version of the Kilian (1999) bootstrap procedure. Under the null hypothesis that x_t has no forecasting power with respect to investment spending growth, the data are generated by

$$\Delta i_t = a_0 + \sum_{j=1}^{p_1} a_j \Delta i_{t-j} + e_{1,t}, \tag{5}$$

[8] McCracken (2004) and Clark and McCracken (2001, 2004) also show that, for nested models, the original Harvey, Leybourne, and Newbold (1998) statistic has a non-standard asymptotic distribution when $h = 1$ and a non-standard and non-pivotal asymptotic distribution when $h > 1$.

$$x_t = b_0 + \sum_{j=1}^{p_2} b_j \Delta i_{t-j} + \sum_{j=1}^{p_3} c_j x_{t-j} + e_{2,t} \ , \tag{6}$$

where the disturbance vector $e_t = (e_{1,t}, e_{2,t})'$ is independently and identically distributed with covariance matrix Σ. We first estimate equations (5) and (6) via OLS using all of the available observations [where the lag orders (p_1, p_2, p_3) are selected using the SIC and a maximum lag order of 8] and compute the OLS residuals $\{\hat{e}_t = (\hat{e}_{1,t}, \hat{e}_{2,t})'\}_{t=1}^{T}$. In order to generate a series of disturbances for the pseudo-sample, we randomly draw (with replacement) $T+50$ times from the OLS residuals, giving us a pseudo-series of disturbance terms $\{\hat{e}_t^*\}_{t=1}^{T+50}$. Note that we draw from the OLS residuals in tandem, thereby preserving the contemporaneous correlation between the disturbances present in the original sample. Using $\{\hat{e}_t^*\}_{t=1}^{T+50}$, equations (5) and (6), the OLS parameter estimates, and setting the initial lagged observations for Δi_t and x_t equal to zero, we can build up a pseudo-sample of $T+50$ observations for Δi_t and x_t, $\{\Delta i_t^*, x_t^*\}_{t=1}^{T+50}$. We drop the first $50-p$ transient start-up observations, where $p = \max\{p_1, p_2, p_3\}$, in order to randomize the initial lagged Δi_t and x_t observations, leaving us with a pseudo-sample of $T+p$ observations, matching the size of the original sample (including the initial lagged variables). For the pseudo-sample, we calculate the MSE-F and ENC-NEW statistics, and we repeat this process 500 times, giving us an empirical distribution for each of the test statistics. For each statistic, the *p*-value is the proportion of the bootstrap statistics greater than the statistic computed using the original sample.

In extensive Monte Carlo simulations with nested models, Clark and McCracken (2001, 2004) provide evidence on the finite-sample size and power properties of the MSE-F and ENC-NEW statistics. Both statistics appear to have good size properties when inference is based on a bootstrap procedure. As we mentioned in the introduction, the simulations also indicate that the MSE-F and ENC-NEW statistics have important power advantages over the original Diebold and Mariano (1995) and West (1996) and Harvey, Leybourne, and Newbold (1998) statistics in detecting out-of-sample forecasting ability. This motivates the use of these newly developed statistics in the present paper.

2.2. An Out-of-Sample Version of the Lettau and Ludvigson (2002) Test

We next consider an out-of-sample version of the in-sample predictive regression test of Lettau and Ludvigson (2002). Consider the forecasting model,

$$y_{t+h} = \alpha + \beta_1 \Delta i_t + \sum_{k=1}^{N_1} \delta_k z_{k,t} + \sum_{k=1}^{N_2} \zeta_k x_{k,t} + \varepsilon_{t+h}, \tag{7}$$

where we treat the $z_{k,t}$ variables and Δi_t (lagged investment growth) as control variables in equation (7). Lettau and Ludvigson (2002) conduct an in-sample test of the significance of the $x_{k,t}$ variables in equation (7), where the $z_{k,t}$ variables are real output growth, average Q growth, and real profit growth. The $x_{k,t}$ variables are the consumption-wealth ratio, default spread, term spread, and relative short rate, which they analyze individually ($N_2 = 1$) and jointly ($N_2 = 4$). Lettau and Ludvigson (2002) thus test whether variables that demonstrate predictive ability with respect to excess stock returns also display predictive ability with respect to investment spending growth, after controlling for traditional predictors of investment spending. Lettau and Ludvigson (2002) obtain statistically significant estimates of the ζ_k coefficients in equation (7) at various horizons.

We conduct an out-of-sample version of this test, where we use the same recursive scheme described above in Section 2.1 to generate simulated out-of-sample forecasts for the unrestricted model given by equation (7).[9] The restricted model forecasts are generated using equation (7) with $\zeta_k = 0$ ($k = 1, \ldots, N_2$). We again compute Theil's U and use the MSE-F and ENC-NEW statistics to test whether the unrestricted model forecasts are superior to the restricted model forecasts. We base inferences on a suitably modified version of the bootstrap procedure described in Section 2.1 above, where equation (5) includes the $z_{k,t}$ variables as right-hand-side variables, and equation (6) becomes a system that includes stochastic processes

[9] Note that equation (7) assumes a more restrictive lag structure than equation (1), which has the advantage of limiting the total number of regressors appearing in equation (7). When we estimate equation (1), the SIC typically selects small values for q_1 and q_2. Furthermore, the coefficient on the first lag of x_t (Δi_t) is typically the largest in absolute value in equation (1) when $q_2 > 1$ ($q_1 > 1$). Thus, little information seems to be lost by adopting the more parsimonious lag structure in equation (7).

for both the $x_{k,t}$ and $z_{k,t}$ variables.[10]

2.3. In-Sample General-to-Specific Model Selection and Out-of-Sample Tests of Forecasting Ability

Clark (2004) analyzes a procedure that combines in-sample general-to-specific model selection with out-of-sample tests of forecasting ability. We begin with a version of equation (7) that includes all *N* of the potential predictor variables ($x_{k,t}$, $k = 1, \dots, N$):

$$y_{t+h} = \alpha + \beta_1 \Delta i_t + \sum_{k=1}^{N} \zeta_k x_{k,t} + \varepsilon_{t+h}. \tag{8}$$

In our applications in Section 3.3 below, we consider $N = 9$ potential predictors (real output growth, average Q growth, real profit growth, real stock price growth, dividend yield, consumption-wealth ratio, term spread, default spread, and relative short rate). Equation (8) is first estimated using data from the in-sample portion of the total sample. We examine each of the *t*-statistics corresponding to each of the $x_{k,t}$ variables in equation (8).[11] If the smallest *t*-statistic (in absolute value) is greater than or equal to 1.645, we select the model with all *N* of the $x_{k,t}$ variables included. If the smallest *t*-statistic is less than 1.645, we exclude the $x_{k,t}$ variable corresponding to the smallest *t*-statistic in the next model we consider. We proceed in this manner until all of the $x_{k,t}$ variables included in the model have significant *t*-statistics. Otherwise, we select the model that excludes all *N* of the $x_{k,t}$ variables.[12] Note that we always include the intercept and lagged investment growth in the model, as this serves as the AR benchmark model. If the forecasting model selected over the in-sample period includes at least one of the $x_{k,t}$ variables, then we compare simulated out-of-sample forecasts generated by the selected model to simulated out-of-sample forecasts generated by the AR benchmark model

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[10] To conserve degrees of freedom, we assume that each of the $x_{k,t}$ and $z_{k,t}$ variables follow AR processes.

[11] When $h > 1$, we use the Newey and West (1987) procedure to estimate the standard errors used in the calculation of the *t*-statistics for the in-sample regression model.

[12] This general-to-specific model selection scheme is clearly in the spirit of the LSE approach. As discussed by Clark (2004), one could use more sophisticated general-to-specific model selection schemes, such as the scheme described in Hoover and Perez (1999). Nevertheless, Clark (2004) finds that the scheme described above performs well in Monte Carlo simulations.

that excludes the $x_{k,t}$ variables in equation (8). We again form out-of-sample forecasts recursively and compare out-of-sample forecasts from the competing models using the MSE-F and ENC-NEW statistics.

As mentioned in the introduction, Clark (2004) finds this procedure to be effective in guarding against model overfitting in Monte Carlo simulations, as the out-of-sample statistics are close to being correctly sized under the null hypothesis that none of the $x_{k,t}$ variables are included in the true data-generating process. Note that it is crucial to select the forecasting model using data only from the in-sample portion of the total sample before analyzing the out-of-sample forecasts. Clark (2004) finds that considerable size distortions result if the forecasting model is selected using data from the full sample. We base inferences on a modified version of the bootstrap procedure described in Section 2.1 above, where we generate pseudo-observations for Δi_t using equation (5) and $x_{k,t}$ using equation (6), where equation (6) becomes a system that includes stochastic processes for all N of the $x_{k,t}$ variables.[13] For each pseudo-sample, we apply general-to-specific model selection to arrive at the forecasting model over the in-sample period and calculate the MSE-F and ENC-NEW statistics over the out-of-sample period. We repeat this process 500 times in order to generate an empirical distribution for each of the test statistics under the null hypothesis that none of the $x_{k,t}$ variables is a predictor of investment spending growth. For each statistic, the *p*-value is the proportion of the bootstrap statistics greater than the statistic computed using the original sample.

3. Empirical Results

Most of the quarterly data we use are from Lettau and Ludvigson (2002) and are described in detail in Lettau and Ludvigson (2002, Appendix A). The rest of the data are from FRED II (Federal Reserve Economic Data).[14] Real business fixed investment spending is fixed private nonresidential investment, seasonally adjusted in chain-weighted 1996 dollars. We calculate real investment spending growth as the first differences of the log-levels of real business fixed investment. The four traditional variables we use to

[13] To conserve degrees of freedom, we again assume that the $x_{k,t}$ variables follow AR processes.

[14] FRED II is available at http://research.stlouisfed.org/fred2/.

forecast investment spending growth are:

- *Real output growth*, defined as the first differences of the log-levels of GDP, where GDP is seasonally adjusted and measured in chain-weighted 1996 dollars.
- *Average Q growth*, defined as the first differences of the log-levels of Q, where Q is computed using the tax-adjusted formula in Bernanke, Bohn, and Reiss (1985, Appendix A).
- *Real profit growth*, defined as the first differences of the log-levels of real profits, where real profits are after-tax corporate profits with inventory valuation and capital consumption adjustments, seasonally adjusted in current dollars deflated by the GDP deflator.
- *Real stock price growth*, defined as the first differences of the log-levels of real stock prices, where real stock prices are the S&P 500 Composite Index deflated by the GDP deflator.

These variables are measured in growth rates to ensure they are stationary.[15] The five variables suggested by Lettau and Ludvigson (2002) are:

- *Dividend yield* (in log-levels), where the dividend yield is for the S&P 500 Composite Index, with four-quarter trailing dividends.
- *Consumption-wealth ratio*, defined as $c_t^* - 0.31a_t^* - 0.59y_t^* - 0.60$, where c_t^* is the log-level of real consumption, a_t^* is the log-level of real asset wealth (household net worth), and y_t^* is the log-level of real after-tax labor income; see Lettau and Ludvigson (2001) for details on the construction of the consumption-wealth ratio, including the procedure used to estimate the cointegrating vector.[16]
- *Term spread*, defined as the difference between the 10-year Treasury bond yield and the 3-month Treasury bill rate.
- *Default spread*, defined as the difference between the BAA corporate bond rate and the AAA

[15] We also tested for a cointegrating relationship between the log-level of real investment spending and, in turn, the log-levels of real GDP, average Q, real profits, and real stock prices. If a cointegrating relationship exists between the log-level of real investment spending and a given variable, equation (1) should include an error-correction term. We find no evidence of cointegrating relationships. The cointegration test results are available upon request from the authors.

[16] Note that the cointegrating vector used in forming the consumption-wealth ratio is estimated using data from the entire sample period, so that, strictly speaking, the estimated cointegrating vector is not available to agents in forming forecasts in real time.

corporate bond rate.

- *Relative short rate*, defined as 3-month Treasury bill rate minus its four-quarter moving average.

Our full sample covers the period 1960:2-2000:3, and we consider three out-of-sample periods: (i) 1980:1-2000:3; (ii) 1980:1-1989:4; (iii) 1990:1-2000:3. The longest out-of-sample period corresponds to approximately half of the full sample. We divide the longer 1980:1-2000:3 out-of-sample period into two shorter out-of-sample periods in order to investigate whether there are important differences in forecasting ability over the decades of the 1980s and 1990s. As noted in the introduction, testing forecasting ability over the 1990s is especially interesting, given the investment boom that occurred during this decade.

3.1. Analyzing the Out-of-Sample Forecasting Ability of Individual Variables in Turn

We begin by analyzing the variables in turn using the procedure described above in Section 2.1, and the results are reported in Table 1. We consider horizons (*h*) of 1, 2, 4, 8, and 16 quarters. We select the lag orders for the ARDL model in equation (1) using the SIC and data through the end of the in-sample period. We consider q_1 values from 0-8, and, to ensure that the potential predictor appears in the unrestricted model, we consider q_2 values from 1-8.

Concentrating first on the results for the traditional variables in Table 1, we see that the forecasting ability of real GDP growth is strongest at shorter horizons of 1, 2, and 4 quarters for all of the out-of-sample periods, as both the MSE-F and ENC-NEW statistics are significant at these horizons for real GDP growth. Both statistics are also significant at the 8-quarter horizon for the 1980:1-2000:3 and 1980:1-1989:4 out-of-sample periods. The U values are below unity for all of the out-of-sample periods at shorter horizons for real GDP growth, with the largest reduction in RMSFE occurring at the 2-quarter horizon for the 1980:1-1989:4 out-of-sample period, where the RMSFE for the ARDL model that includes real output growth is 22% lower than the AR benchmark model RMSFE. Average Q growth also displays significant forecasting ability at shorter horizons for all of the out-of-sample periods, with both out-of-sample statistics significant at horizons of 1, 2, and 4 quarters. In addition, there is evidence of significant forecasting ability for average Q growth at the 8-quarter (12-quarter) horizon according to one or both statistics over all three (1980:1-2000:3 and 1990:1-2000:3) of the out-of-sample periods. Most of the U values are below unity for average Q growth. Turning to real profit growth, the ENC-NEW statistic is significant at all reported horizons for all of the out-of-sample periods, while the MSE-F statistic is significant at all reported horizons for the 1980:1-2000:3 out-of-sample period; many of the MSE-F statistics are also significant for the 1980:1-1989:4 and 1990:1-2000:3 out-of-sample periods. Almost all of the U values are below unity for the different out-of-sample periods for real profit growth. The ENC-NEW statistic is significant at horizons of 1, 2, 4, 8, and 12 quarters for real stock price growth for the 1980:1-2000:3 and 1990:1-2000:3 out-of-sample periods; it is significant at horizons of 1, 2, and 4 quarters for the 1980:1-1989:4 out-of-sample period. The MSE-F statistic is significant at a horizon of 4 (4, 8, and 12) quarters for the 1980:1-2000:3 and 1980:1-1989:4 (1990:1-2000:3) out-of-sample periods. The U values are below unity at horizons of 4, 8, 12, and 16 quarters for the 1990:1-2000:3 out-of-sample period, but the U value is below unity only at the 4-quarter horizon for the 1980:1-2000:3 and 1980:1-1989:4 out-of-sample periods. Overall, the traditional variables display significant evidence of simulated out-of-sample forecasting ability with respect to U.S. business fixed investment spending growth at multiple horizons over the 1980:1-2000:3 period. Observe that the forecasting results for three of the traditional variables—real GDP growth, average Q growth, and real profit growth—are very similar for the 1980:1-1989:4 and 1990:1-2000:3 out-of-sample periods.

We next consider the results for the Lettau and Ludvigson (2002) variables in Table 1. Significant evidence of forecasting ability for the dividend yield is primarily limited to the 1990:1-2000:3 out-of-sample period, where the MSE-F and/or ENC-NEW statistics are significant at horizons of 1, 2, 4, 8, and 12 quarters. Note the strong contrast between the U values at longer horizons for the 1980:1-1989:4 and 1990:1-2000:3 out-of-sample periods: the U values are well above unity (1.35, 1.64, 1.39) at horizons of 8, 12, and 16 quarters for the former period but well below unity (0.78, 0.88, 0.91) for the latter period. Significant evidence of forecasting ability for the consumption-wealth ratio is only evident at horizons of 12 and 16 quarters for the 1990:1-2000:3 out-of-sample period, where both statistics are significant. For these horizons, there is again a strong contrast in the U values over the 1980s and 1990s, as the U values are well above unity (1.48 and 1.30) for the 1980:1-1989:4 out-of-sample period and well below unity (0.83 at both horizons) for the 1990:1-2000:3 out-of-sample period. We also see a marked contrast between the forecasting results for the 1980:1-1989:4 and 1990:1-2000:3 out-of-sample periods for the term spread. The forecasting ability of the term spread is only significant at horizons of 1 and 8 quarters over the 1980:1-1989:4 out-of-sample period according to the ENC-NEW statistic, while the ENC-NEW (MSE-F) statistic is significant at horizons of 2, 4, 8, and 12 (4, 8, and 12) for the 1990:1-2000:3 out-of-sample period. Furthermore, the U values are always well above unity over the 1980:1-1989:4 out-of-sample period, but are often well below unity for the 1990:1-2000:3 out-of-sample period. The default spread evinces significant forecasting ability at the 1-quarter horizon according to the ENC-NEW statistic over all of the out-of-sample periods, while the MSE-F statistic is only significant at horizons of 1 and 2 quarters for the 1990:1-2000:3 out-of-sample period. We again see a marked contrast in forecasting ability over the 1980s and 1990s according to the U values, with all of the U values well above unity for the 1980:1-1989:4 out-of-sample period, but below unity for the 1990:1-2000:3 out-of-sample period. For the relative short rate, the ENC-NEW statistic is significant at some horizons over all of the out-of-sample periods, but none of the MSE-F statistics is significant. In addition, all of the U values are greater than or equal to unity for all of the out-of-sample periods.

Summarizing the results in Table 1, traditional variables such as real output growth, average Q growth, and real profit growth demonstrate considerable out-of-sample forecasting ability with respect to U.S. business fixed investment spending growth over the 1980s and 1990s. The new variables suggested by Lettau and Ludvigson (2002) fail to exhibit ample out-of-sample forecasting ability over the 1980s, but do evince ample forecasting ability over the 1990s.

3.2. An Out-of-Sample Version of the Lettau and Ludvigson (2002) Test

Results for the out-of-sample version of the Lettau and Ludvigson (2002) in-sample test based on equation (5) are reported in Table 2. We test the simulated out-of-sample forecasting ability of the consumption-wealth ratio, relative short rate, term spread, and default spread (individually and jointly) with respect to investment spending growth, after controlling for lagged investment growth, real profit growth, average Q growth, and real GDP growth.

Looking first at the simulated out-of-sample forecasting tests for the individual variables, the consumption-wealth ratio displays significant out-of-sample forecasting ability at longer horizons of 12 and 16 quarters for the 1990:1-2000:3 period, where both the MSE-F and ENC-NEW statistics are significant. Furthermore, the U values are well below unity at these horizons (0.85 and 0.84). Neither statistic is significant at the same horizons for the 1980:1-1989:4 out-of-sample period (the MSE-F statistic is significant at the 16-quarter horizon for the 1980:1-2000:3 out-of-sample period), and the U values are well above unity (1.27 and 1.22). The ENC-NEW statistic is significant at the 8-quarter horizon for the relative short rate for all three of the out-of-sample periods, and the MSE-F statistic is significant at this horizon over the 1990:1-2000:3 out-of-sample period. The ENC-NEW statistic is also significant at the 12-quarter horizon for the 1980:1-2000:3 and 1980:1-1989:4 out-of-sample periods. The U values are always above unity for the 1980:1-1989:4 out-of-sample period, while they are typically below unity for the 1990:1-2000:3 out-of-sample period. For the term spread and the 1980:1-1989:4 (1980:1-2000:3) out-of-sample period, only the ENC-NEW statistic is significant at the 8-quarter (4-quarter and 8-quarter) horizon, and the U values are all well above unity. For the 1990:1-2000:3 out-of-sample period, the term spread evinces significant out-of-sample forecasting ability at horizons of 2, 4, 8, and 12 quarters, with both out-of-sample statistics significant and all U values below unity at these horizons. For the default spread, both statistics are significant at horizons of 1 and 2 quarters for the 1980:1-2000:3 out-of-sample period. For the 1990:1-2000:3 out-of-sample period, the ENC-NEW (MSE-F) statistic is significant at horizons of 1, 2, and 4 (1 and 2) quarters, and the U values are below unity at all reported horizons. For the 1980:1-1989:4 out-of-sample period, only the ENC-NEW statistic is significant at the 1-quarter horizon, and the U values are always greater than or equal to their values for the 1990:1-2000:3 out-of-sample period.

We test the simulated out-of-sample forecasting ability of the consumption-wealth ratio, relative short rate, term spread, and default spread jointly in the bottom part of Table 2. The ENC-NEW statistic is significant at horizons of 1, 2, and 8 quarters for the 1980:1-2000:3 out-of-sample period. For the 1980:1-

1989:4 out-of-sample period, only the ENC-NEW statistic is significant at the 1-quarter horizon, and all of the U values are well above unity, ranging from 1.13 to 1.51. The results for are quite different for the 1990:1-2000:3 out-of-sample period, where we obtain significant evidence of out-of-sample forecasting ability at all reported horizons. The MSE-F statistic is significant at all reported horizons, and the ENC-NEW statistic is significant at horizons of 1, 2, 4, 8, and 12 quarters. The marginal forecasting information contained in these variables appears to be especially important at longer horizons of 12 and 16 quarters, where the U values are 0.75 and 0.80.

Overall, there is little out-of-sample support over the 1980s in Table 2 for the Lettau and Ludvigson (2002) proposition that variables with forecasting ability with respect to excess stock returns also have forecasting ability with respect to investment spending growth, after controlling for traditional predictors of investment spending growth. However, there is considerable out-of-sample support for the Lettau and Ludvigson (2002) proposition over the 1990s.

3.3. In-Sample General-to-Specific Model Selection and Out-of-Sample Tests of Forecasting Ability

We next use the procedure analyzed by Clark (2004) that combines in-sample general-to-specific model selection with tests of out-of-sample forecasting ability, and the results are reported in Table 3. For the 1980:1-2000:3 out-of-sample period, multiple variables are typically included in the model selected over the in-sample period, and the ENC-NEW (MSE-F) statistic is significant at horizons of 1, 2, 4, 8, and 12 (12 and 16) quarters. As in Tables 1 and 2, there is a marked contrast in the results for the 1980:1-1989:4 and 1990:1-2000:3 out-of-sample periods. For the former out-of-sample period, while multiple variables are typically included in the model selected over the in-sample period, the ENC-NEW statistic is only significant at horizons of 1, 2, and 8 quarters, none of the MSE-F statistics is significant, and the U values are all well above unity. For the 1990:1-2000:3 out-of-sample period, multiple variables, both traditional and new, are included in the model selected over the in-sample period at all reported horizons. The ENC-NEW statistic is significant at all reported horizons, and the MSE-F statistic is significant at horizons of 2, 8, 12, and 16 quarters, so there is ample evidence that the model selected over the in-sample period produces simulated out-of-sample forecasts that are superior to the AR benchmark model forecasts. The U values are below unity at horizons of 2, 8, 12, and 16 quarters. The reduction in RMSFE is especially noteworthy at longer horizons of 12 and 16 quarters, where the model selected over the in-sample period has an RMSFE that is 33% and 43% smaller than the benchmark AR model RMSFE. For the 1980:1-1989:4 out-of-sample period, it is interesting to note that the model selected over the in-sample period always includes at least one of the new variables suggested by Lettau and Ludvigson (2002). Focusing on the U values, we see that inclusion of these variables does not help to improve the accuracy of forecasting models of investment spending growth over the 1980s, but does help to improve forecast accuracy over the 1990s, especially at longer horizons.[17]

4. Conclusion

In the present paper, we analyze the simulated out-of-sample forecasting ability of four traditional variables, as well as five new variables recently suggested by Lettau and Ludvigson (2002), with respect to U.S. business fixed investment spending growth over the decades of the 1980s and 1990s. When we analyze the simulated out-of-sample forecasting ability of each variable in turn using the Stock and Watson (2003) framework, we find that traditional variables typically exhibit significant forecasting ability at multiple horizons over both the 1980s and 1990s, while the new variables are only reliable forecasters over the 1990s. We fail to obtain out-of-sample support over the 1980s for the Lettau and Ludvigson (2002) in-sample finding that variables demonstrating significant predictive ability with respect to excess stock returns also demonstrate significant predictive ability with respect to investment spending growth, after controlling for traditional predictors of investment spending. However, we do obtain out-of-sample support for the Lettau and Ludvigson (2002) in-sample finding over the 1990s. Finally, the procedure analyzed by Clark (2004) that combines in-sample general-to-specific model selection with tests of out-of-sample forecasting ability also indicates that the new variables suggested by Lettau and Ludvigson (2002) contain information useful for

[17] We obtain similar results when we use information criteria such as the AIC or SIC to select the forecasting model over the in-sample period. We also generated recursive out-of-sample forecasts using Bayesian model averaging (see, for example, Wright, 2003a,b in the context of exchange rate and inflation forecasting), and we obtain results similar to those in Table 3, in that out-of-sample forecasts have U values above (below) unity for the 1980s (1990s). The complete Bayesian model averaging results are available upon request from the authors.

forecasting investment spending growth over the 1990s, but not the 1980s. Overall, our results suggest a pair of stylized forecasting facts: (i) traditional variables contain information useful for forecasting U.S. business fixed investment spending growth over the 1980s and 1990s; (ii) variables demonstrating predictive ability with respect to excess stock returns also exhibit forecasting ability with respect to U.S. business fixed investment spending growth over the 1990s, but not the 1980s.

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Table 1: U.S. business fixed investment spending growth, simulated out-of-sample forecasting results

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
<u>Real GDP growth</u>						
1980:1-2000:3 out-of-sample period						
U	0.95	0.80	0.87	0.97	0.99	1.00
MSE-F	**8.61** (0.03)	**47.39** (0.00)	**26.74** (0.00)	**4.39** (0.10)	0.77 (0.25)	-0.13 (0.39)
ENC-NEW	**5.94** (0.05)	**42.87** (0.00)	**24.57** (0.00)	**4.14** (0.09)	0.81 (0.33)	0.02 (0.50)
1980:1-1989:4 out-of-sample period						
U	0.95	0.78	0.86	0.96	0.99	0.99
MSE-F	**4.78** (0.02)	**24.98** (0.00)	**13.38** (0.10)	**2.48** (0.09)	0.81 (0.20)	0.46 (0.25)
ENC-NEW	**3.10** (0.04)	**22.59** (0.00)	**12.77** (0.01)	**2.62** (0.06)	0.82 (0.21)	0.38 (0.27)
1990:1-2000:3 out-of-sample period						
U	0.86	0.83	0.88	0.98	1.00	1.00
MSE-F	**14.92** (0.00)	**19.13** (0.00)	**11.42** (0.01)	1.65 (0.15)	0.21 (0.35)	-0.15 (0.54)
ENC-NEW	**13.82** (0.00)	**17.54** (0.00)	**9.79** (0.01)	1.28 (0.18)	0.17 (0.41)	-0.06 (0.62)
<u>Average Q growth</u>						
1980:1-2000:3 out-of-sample period						
U	0.97	0.93	0.96	0.98	0.99	1.00
MSE-F	**5.59** (0.00)	**12.42** (0.00)	**7.25** (0.00)	**2.54** (0.01)	**0.81** (0.06)	0.43 (0.12)
ENC-NEW	**6.19** (0.00)	**11.48** (0.00)	**6.21** (0.00)	**2.66** (0.01)	0.57 (0.12)	0.29 (0.21)
1980:1-1989:4 out-of-sample period						
U	0.98	0.94	0.96	1.00	1.00	1.00
MSE-F	**1.84** (0.03)	**5.59** (0.00)	**3.41** (0.00)	0.36 (0.18)	0.22 (0.26)	-0.19 (0.50)
ENC-NEW	**2.72** (0.01)	**5.48** (0.00)	**3.15** (0.01)	**1.17** (0.06)	0.25 (0.26)	-0.03 (0.52)
1990:1-2000:3 out-of-sample period						
U	0.95	0.91	0.94	0.98	0.99	0.99
MSE-F	**4.98** (0.00)	**9.06** (0.00)	**5.61** (0.00)	**1.23** (0.03)	**0.81** (0.06)	0.37 (0.14)
ENC-NEW	**3.83** (0.00)	**6.97** (0.00)	**3.55** (0.00)	**0.67** (0.06)	**0.42** (0.10)	0.19 (0.17)
<u>Real profit growth</u>						
1980:1-2000:3 out-of-sample period						
U	0.95	0.98	0.99	0.97	0.96	0.99
MSE-F	**8.21** (0.00)	**3.75** (0.01)	**1.55** (0.07)	**4.42** (0.02)	**5.41** (0.00)	**1.21** (0.10)
ENC-NEW	**10.99** (0.00)	**9.80** (0.00)	**14.24** (0.00)	**9.84** (0.01)	**7.21** (0.00)	**2.65** (0.06)
1980:1-1989:4 out-of-sample period						
U	0.91	0.97	1.01	0.98	0.91	1.00
MSE-F	**8.55** (0.00)	**2.53** (0.03)	-0.58 (0.55)	1.19 (0.12)	**6.09** (0.02)	0.16 (0.32)
ENC-NEW	**6.86** (0.00)	**4.61** (0.01)	**6.84** (0.01)	**4.89** (0.02)	**5.84** (0.02)	**2.01** (0.06)
1990:1-2000:3 out-of-sample period						
U	1.05	0.99	1.08	0.97	0.96	0.98
MSE-F	-3.66 (0.99)	**0.97** (0.07)	-6.01 (0.98)	**2.01** (0.04)	**2.44** (0.03)	**1.30** (0.04)
ENC-NEW	**3.01** (0.01)	**5.81** (0.00)	**1.83** (0.01)	**3.56** (0.02)	**2.24** (0.03)	**1.19** (0.03)

Notes: U is the ratio of the unrestricted model out-of-sample RMSFE to the restricted model out-of-sample RMSFE, where the unrestricted (restricted) model includes (excludes) the indicated variable. The MSE-F statistic is used to test the null hypothesis that the unrestricted model out-of-sample MSFE is equal to the restricted model out-of-sample MSFE against the one-sided (upper-tail) hypothesis that the unrestricted model out-of-sample MSFE is lower than the restricted model out-of-sample MSFE. The ENC-NEW statistic is used to test the null hypothesis that the restricted model out-of-sample forecasts encompass the unrestricted model out-of-sample forecasts against the one-sided (upper-tail) hypothesis that the restricted model out-of-sample forecasts do not encompass the unrestricted model out-of-sample forecasts. Bootstrapped *p*-values are given in parentheses; 0.00 signifies < 0.005. Bold entries indicate significance at the 10% level according to the bootstrapped *p*-value.

Table 1 (continued)

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
Real stock price growth						
1980:1-2000:3 out-of-sample period						
U	1.04	1.01	0.98	1.03	1.00	1.00
MSE-F	-6.48 (0.39)	-1.87 (0.80)	**2.77** (0.02)	-3.68 (0.89)	-0.41 (0.47)	-0.67 (0.60
ENC-NEW	**5.83** (0.00)	**14.26** (0.00)	**12.85** (0.00)	**4.81** (0.03)	**1.05** (0.07)	0.02 (0.44)
1980:1-1989:4 out-of-sample period						
U	1.04	1.00	0.99	1.11	1.03	1.02
MSE-F	-2.83 (0.93)	-0.37 (0.52)	**1.04** (0.09)	-6.13 (0.96)	-1.74 (0.81)	-1.05 (0.76)
ENC-NEW	**3.13** (0.01)	**6.89** (0.00)	**5.90** (0.01)	0.73 (0.14)	-0.12 (0.60)	-0.14 (0.66)
1990:1-2000:3 out-of-sample period						
U	1.05	1.00	0.90	0.90	0.96	0.99
MSE-F	-4.01 (0.99)	-0.37 (0.54)	**9.14** (0.00)	**7.96** (0.00)	**2.56** (0.01)	0.65 (0.12)
ENC-NEW	**2.32** (0.01)	**7.29** (0.00)	**10.94** (0.00)	**5.22** (0.01)	**1.44** (0.04)	0.34 (0.16)
Dividend yield						
1980:1-2000:3 out-of-sample period						
U	1.01	1.00	1.13	1.14	1.20	1.04
MSE-F	-2.08 (0.15)	**0.03** (0.06)	-16.56 (0.40)	-17.28 (0.13)	-22.05 (0.11)	**-4.71** (0.05)
ENC-NEW	**7.55** (0.09)	**13.88** (0.05)	7.76 (0.18)	1.09 (0.39)	-4.30 (0.56)	0.16 (0.40)
1980:1-1989:4 out-of-sample period						
U	1.01	0.99	1.21	1.35	1.64	1.39
MSE-F	-0.92 (0.62)	0.64 (0.18)	-11.86 (0.92)	-15.01 (0.88)	-18.23 (0.94)	-12.07 (0.83)
ENC-NEW	**2.87** (0.03)	**5.21** (0.02)	0.19 (0.41)	-3.10 (0.82)	-5.34 (0.96)	-3.24 (0.87)
1990:1-2000:3 out-of-sample period						
U	1.02	0.98	0.85	0.78	0.88	0.91
MSE-F	-1.26 (0.24)	**1.32** (0.08)	**15.75** (0.02)	**23.20** (0.04)	**8.91** (0.09)	6.09 (0.12)
ENC-NEW	**5.64** (0.04)	**13.24** (0.02)	**22.86** (0.02)	**18.27** (0.09)	5.13 (0.25)	3.27 (0.33)
Consumption-wealth ratio						
1980:1-2000:3 out-of-sample period						
U	1.06	1.03	1.14	1.22	1.07	0.96
MSE-F	-9.09 (0.99)	-5.13 (0.88)	-18.59 (0.96)	-24.61 (0.92)	-9.36 (0.70)	6.52 (0.11)
ENC-NEW	-1.66 (0.98)	-0.03 (0.41)	-2.16 (0.84)	-3.00 (0.77)	1.26 (0.33)	5.72 (0.16)
1980:1-1989:4 out-of-sample period						
U	1.05	1.02	1.23	1.49	1.48	1.30
MSE-F	-4.05 (0.96)	-1.40 (0.65)	-12.63 (0.97)	-18.21 (0.99)	-15.69 (0.95)	-10.25 (0.90)
ENC-NEW	-0.76 (0.90)	0.05 (0.35)	-4.01 (0.98)	-5.22 (0.99)	-5.98 (0.99)	-3.95 (0.96)
1990:1-2000:3 out-of-sample period						
U	1.01	1.06	1.07	0.99	0.83	0.83
MSE-F	-0.68 (0.68)	-4.41 (0.94)	-4.79 (0.87)	0.77 (0.27)	**14.80** (0.03)	**13.14** (0.03)
ENC-NEW	-0.32 (0.78)	0.20 (0.33)	1.87 (0.11)	2.96 (0.16)	**9.52** (0.06)	**7.63** (0.08)

Table 1 (continued)

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
Term spread						
1980:1-2000:3 out-of-sample period						
U	1.03	1.06	1.12	1.11	1.11	1.15
MSE-F	-4.54 (0.95)	-9.20 (0.92)	-16.61 (0.93)	-14.12 (0.82)	-14.00 (0.74)	-16.27 (0.78)
ENC-NEW	**2.83** (0.06)	**4.98** (0.05)	**9.19** (0.04)	**16.00** (0.04)	6.59 (0.15)	2.69 (0.68)
1980:1-1989:4 out-of-sample period						
U	1.05	1.10	1.21	1.30	1.40	1.64
MSE-F	-3.61 (0.94)	-6.89 (0.95)	-11.82 (0.95)	-13.58 (0.94)	-14.16 (0.93)	-15.98 (0.96)
ENC-NEW	**1.14** (0.08)	1.69 (0.11)	2.79 (0.13)	**5.81** (0.09)	1.79 (0.24)	-2.66 (0.86)
1990:1-2000:3 out-of-sample period						
U	1.00	0.99	0.96	0.89	0.84	0.92
MSE-F	0.25 (0.25)	1.29 (0.14)	**3.41** (0.09)	**9.95** (0.03)	**12.82** (0.04)	4.81 (0.17)
ENC-NEW	0.84 (0.13)	**2.68** (0.07)	**7.55** (0.02)	**10.96** (0.03)	**8.35** (0.06)	2.59 (0.25)
Default spread						
1980:1-2000:3 out-of-sample period						
U	1.03	1.05	1.08	1.09	1.06	1.04
MSE-F	-4.60 (0.91)	-7.78 (0.92)	-11.77 (0.87)	-11.92 (0.72)	-8.42 (0.54)	-4.56 (0.39)
ENC-NEW	**7.08** (0.03)	4.16 (0.11)	-0.75 (0.60)	-0.39 (0.47)	-1.96 (0.57)	-0.95 (0.49)
1980:1-1989:4 out-of-sample period						
U	1.08	1.09	1.13	1.20	1.20	1.30
MSE-F	-5.75 (0.99)	-5.97 (0.93)	-7.96 (0.91)	-10.04 (0.86)	-8.97 (0.75)	-10.16 (0.79)
ENC-NEW	**2.57** (0.03)	1.66 (0.13)	-1.11 (0.73)	-0.99 (0.66)	-2.32 (0.76)	-3.18 (0.85)
1990:1-2000:3 out-of-sample period						
U	0.93	0.98	0.98	0.97	0.99	0.97
MSE-F	**6.72** (0.01)	**1.96** (0.09)	1.59 (0.18)	2.56 (0.18)	0.94 (0.28)	1.86 (0.27)
ENC-NEW	**6.71** (0.01)	**2.84** (0.05)	1.95 (0.17)	1.59 (0.24)	0.48 (0.39)	0.95 (0.38)
Relative short rate						
1980:1-2000:3 out-of-sample period						
U	1.01	1.03	1.05	1.01	1.08	1.07
MSE-F	-2.35 (0.88)	-5.49 (0.92)	-7.16 (0.93)	-0.97 (0.51)	-9.85 (0.87)	-8.51 (0.86)
ENC-NEW	-0.50 (0.81)	-0.73 (0.85)	**25.38** (0.00)	**26.33** (0.00)	**11.56** (0.01)	0.09 (0.43)
1980:1-1989:4 out-of-sample period						
U	1.02	1.05	1.05	1.07	1.25	1.38
MSE-F	-1.78 (0.86)	-3.68 (0.92)	-3.25 (0.88)	-4.07 (0.87)	-10.52 (0.95)	-11.84 (0.97)
ENC-NEW	-0.42 (0.82)	-0.47 (0.77)	**14.99** (0.00)	**15.74** (0.00)	**8.11** (0.0.2)	-0.29 (0.67)
1990:1-2000:3 out-of-sample period						
U	1.00	1.06	1.08	1.01	1.02	1.00
MSE-F	0.15 (0.32)	-4.43 (0.97)	-5.40 (0.95)	-0.75 (0.62)	-1.36 (0.72)	0.14 (0.37)
ENC-NEW	0.12 (0.41)	**2.19** (0.07)	**2.97** (0.06)	**4.17** (0.03)	0.67 (0.27)	0.16 (0.43)

Table 2: U.S. business fixed investment spending growth, simulated out-of-sample forecasting results for Lettau and Ludvigson (2002) variables after controlling for lagged investment growth, real profit growth, average Q growth, and real GDP growth

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
Consumption-wealth ratio						
1980:1-2000:3 out-of-sample period						
U	1.01	1.01	1.02	1.03	1.01	0.94
MSE-F	-1.30 (0.68)	-0.90 (0.36)	-2.96 (0.60)	-4.39 (0.56)	-1.22 (0.35)	**8.50** (0.09)
ENC-NEW	-0.48 (0.76)	-0.43 (0.54)	-0.13 (0.38)	1.06 (0.28)	2.75 (0.24)	6.69 (0.13)
1980:1-1989:4 out-of-sample period						
U	1.01	1.00	1.01	1.06	1.27	1.22
MSE-F	-0.50 (0.54)	-0.32 (0.37)	-0.80 (0.50)	-3.37 (0.74)	-10.92 (0.95)	-8.31 (0.92)
ENC-NEW	-0.19 (0.60)	-0.15 (0.49)	-0.13 (0.48)	-0.52 (0.61)	-3.79 (0.97)	-2.42 (0.92)
1990:1-2000:3 out-of-sample period						
U	1.01	1.01	1.03	0.99	0.85	0.84
MSE-F	-0.90 (0.76)	-0.74 (0.60)	-2.32 (0.75)	1.01 (0.23)	**12.77** (0.03)	**11.33** (0.03)
ENC-NEW	-0.31 (0.76)	-0.35 (0.69)	0.21 (0.37)	2.62 (0.14)	**7.89** (0.04)	**6.44** (0.05)
Relative short rate						
1980:1-2000:3 out-of-sample period						
U	1.01	1.03	1.01	1.03	1.04	1.02
MSE-F	-2.06 (0.85)	-4.46 (0.94)	-2.25 (0.63)	-4.30 (0.76)	-4.90 (0.77)	-2.95 (0.66)
ENC-NEW	-0.54 (0.83)	-1.30 (0.94)	0.93 (0.22)	**10.91** (0.01)	**8.15** (0.02)	0.50 (0.33)
1980:1-1989:4 out-of-sample period						
U	1.02	1.04	1.03	1.11	1.24	1.21
MSE-F	-1.38 (0.83)	-2.97 (0.94)	-1.89 (0.75)	-6.38 (0.94)	-10.05 (0.98)	-7.80 (0.95)
ENC-NEW	-0.40 (0.78)	-0.88 (0.91)	0.47 (0.26)	**6.68** (0.01)	**5.53** (0.04)	-0.83 (0.76)
1990:1-2000:3 out-of-sample period						
U	1.00	1.01	0.99	0.95	0.96	0.98
MSE-F	-0.38 (0.55)	-0.49 (0.56)	0.81 (0.18)	**3.47** (0.06)	2.62 (0.11)	0.86 (0.25)
ENC-NEW	-0.04 (0.42)	-0.15 (0.56)	0.49 (0.23)	**2.64** (0.07)	1.66 (0.13)	0.48 (0.33)
Term spread						
1980:1-2000:3 out-of-sample period						
U	1.02	1.05	1.08	1.10	1.11	1.12
MSE-F	-3.51 (0.92)	-8.23 (0.97)	-11.97 (0.95)	-13.27 (0.90)	-13.38 (0.83)	-14.21 (0.81)
ENC-NEW	0.00 (0.37)	0.75 (0.22)	**5.98** (0.05)	**13.19** (0.04)	4.03 (0.21)	-3.44 (0.74)
1980:1-1989:4 out-of-sample period						
U	1.04	1.09	1.17	1.30	1.44	1.51
MSE-F	-2.86 (0.93)	-6.12 (0.97)	-9.84 (0.98)	-13.53 (0.98)	-14.93 (0.97)	-14.04 (0.96)
ENC-NEW	-0.16 (0.57)	-0.05 (0.41)	1.66 (0.14)	**4.64** (0.10)	0.93 (0.37)	-2.87 (0.90)
1990:1-2000:3 out-of-sample period						
U	1.00	0.98	0.93	0.88	0.88	0.97
MSE-F	0.39 (0.16)	**1.71** (0.10)	**6.37** (0.02)	**10.97** (0.03)	**9.34** (0.05)	1.99 (0.21)
ENC-NEW	0.31 (0.19)	**1.42** (0.09)	**6.08** (0.01)	**9.73** (0.03)	**5.61** (0.08)	1.03 (0.28)

Notes: U is the ratio of the unrestricted model out-of-sample RMSFE to the restricted model out-of-sample RMSFE, where the unrestricted model includes the indicated variable or variables, and both the unrestricted and restricted models include lagged investment growth, real profit growth, average Q growth, and real GDP growth. The MSE-F statistic is used to test the null hypothesis that the unrestricted model out-of-sample MSFE is equal to the restricted model out-of-sample MSFE against the one-sided (upper-tail) hypothesis that the unrestricted model out-of-sample MSFE is lower than the restricted model out-of-sample MSFE. The ENC-NEW statistic is used to test the null hypothesis that the restricted model out-of-sample forecasts encompass the unrestricted model out-of-sample forecasts against the one-sided (upper-tail) hypothesis that the restricted model out-of-sample forecasts do not encompass the unrestricted model out-of-sample forecasts. Bootstrapped *p*-values are given in parentheses; 0.00 signifies < 0.005. Bold entries indicate significance at the 10% level.

Table 2 (continued)

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
<u>Default spread</u>						
1980:1-2000:3 out-of-sample period						
U	0.98	0.98	1.01	1.01	0.99	0.95
MSE-F	**3.64** (0.00)	**2.78** (0.06)	-1.93 (0.38)	-0.77 (0.28)	0.87 (0.23)	7.43 (0.13)
ENC-NEW	**5.31** (0.00)	**3.32** (0.07)	-0.15 (0..38)	0.24 (0.37)	1.23 (0.37)	4.11 (0.25)
1980:1-1989:4 out-of-sample period						
U	0.99	1.01	1.04	1.04	1.05	0.94
MSE-F	0.47 (0.17)	-0.39 (0.38)	-2.94 (0.68)	-2.69 (0.59)	-2.87 (0.58)	3.41 (0.17)
ENC-NEW	**2.42** (0.02)	0.82 (0.20)	-1.03 (0.73)	-0.93 (0.66)	-0.57 (0.57)	1.99 (0.25)
1990:1-2000:3 out-of-sample period						
U	0.95	0.93	0.95	0.96	0.96	0.94
MSE-F	**4.33** (0.01)	**6.41** (0.01)	**4.90** (0.07)	2.77 (0.17)	2.72 (0.21)	3.93 (0.18)
ENC-NEW	**3.02** (0.01)	**3.97** (0.02)	2.33 (0.10)	1.55 (0.25)	1.47 (0.29)	2.14 (0.24)
<u>Consumption-wealth ratio, Relative short rate, Term spread, Default spread</u>						
1980:1-2000:3 out-of-sample period						
U	1.08	1.13	1.23	1.22	1.03	0.99
MSE-F	-11.30 (0.98)	-18.08 (0.96)	-27.72 (0.98)	-24.83 (0.81)	-4.25 (0.24)	1.81 (0.17)
ENC-NEW	**6.44** (0.01)	**6.92** (0.06)	6.82 (0.12)	**21.00** (0.04)	11.00 (0.18)	6.49 (0.27)
1980:1-1989:4 out-of-sample period						
U	1.13	1.22	1.38	1.51	1.41	1.34
MSE-F	-8.87 (0.93)	-12.73 (0.99)	-17.47 (0.96)	-18.48 (0.95)	-14.39 (0.83)	-11.06 (0.70)
ENC-NEW	**2.20** (0.09)	1.50 (0.24)	1.15 (0.37)	8.47 (0.12)	0.81 (0.43)	-0.96 (0.58)
1990:1-2000:3 out-of-sample period						
U	0.98	0.95	0.96	0.86	0.75	0.80
MSE-F	**2.21** (0.05)	**4.94** (0.03)	**3.57** (0.11)	**12.32** (0.06)	**24.68** (0.02)	**15.97** (0.06)
ENC-NEW	**5.46** (0.01)	**9.50** (0.01)	**11.00** (0.02)	**15.30** (0.05)	**16.76** (0.05)	9.76 (0.13)

Table 3: U.S. business fixed investment spending growth, general-to-specific in-sample model selection and simulated out-of-sample forecasting results

Horizon:	1 quarter	2 quarters	4 quarters	8 quarters	12 quarters	16 quarters
1980:1-2000:3 out-of-sample period						
Included variables	Real profit growth, Term spread, Default spread, Relative short rate	Real stock price growth, Consumption-wealth ratio, Term spread, Default spread, Relative short rate	Real profit growth, Real stock price growth, Term spread, Default spread, Relative short rate	Real profit growth, Real stock price growth, Dividend yield, Term spread, Default spread	Real profit growth, Dividend yield, Consumption-wealth ratio, Term spread, Default spread	Consumption-wealth ratio
U	1.02	1.10	1.18	1.97	1.01	0.94
MSE-F	-3.69 (0.31)	-14.35 (0.69)	-22.42 (0.63)	-22.93 (0.41)	**-1.76** (0.09)	**8.69** (0.06)
ENC-NEW	**15.21** (0.00)	**14.27** (0.01)	**17.54** (0.03)	**25.75** (0.06)	**16.77** (0.10)	7.09 (0.26)
1980:1-1989:4 out-of-sample period						
Included variables	Real profit growth, Term spread, Default spread, Relative short rate	Real stock price growth, Consumption-wealth ratio, Term spread, Default spread Relative short rate	Real profit growth, Real stock price growth, Term spread, Default spread, Relative short rate	Real profit growth, Real stock price growth, Dividend yield, Term spread, Default spread	Real profit growth, Dividend yield, Consumption-wealth ratio, Term spread, Default spread	Consumption-wealth ratio
U	1.02	1.16	1.26	1.41	1.23	1.26
MSE-F	-1.87 (0.35)	-10.04 (0.85)	-13.61 (0.82)	-16.42 (0.81)	-9.79 (0.56)	-9.27 (0.58)
ENC-NEW	**7.64** (0.00)	**5.12** (0.07)	6.23 (0.11)	**11.81** (0.08)	2.69 (0.32)	-3.10 (0.79)
1990:1-2000:3 out-of-sample period						
Included variables	Real profit growth, Term spread, Default spread, Relative short rate	Real profit growth, Real stock price growth, Term spread, Default spread, Relative short rate	Real profit growth, Real stock price growth, Term spread, Default spread, Relative short rate	Real profit growth, Dividend yield, Consumption-wealth ratio	Real profit growth, Real stock price growth, Dividend yield, Consumption-wealth ratio, Relative short rate	Real profit growth, Real stock price growth, Dividend yield, Consumption-wealth ratio
U	1.02	0.98	1.01	0.83	0.67	0.57
MSE-F	-1.73 (0.37)	**1.62** (0.10)	-0.85 (0.23)	**16.21** (0.03)	**40.14** (0.02)	**57.83** (0.01)
ENC-NEW	**7.26** (0.00)	**15.25** (0.01)	**15.70** (0.03)	**26.35** (0.03)	**39.47** (0.03)	**47.93** (0.02)

Notes: Included variables are the variables in the model selected over the in-sample period. U is the ratio of the unrestricted model out-of-sample RMSFE to the restricted model out-of-sample RMSFE, where the restricted model is an AR benchmark model that includes lagged investment growth and the unrestricted model includes the indicated variables. The MSE-F statistic is used to test the null hypothesis that the unrestricted model out-of-sample MSFE is equal to the restricted model out-of-sample MSFE against the one-sided (upper-tail) hypothesis that the unrestricted model out-of-sample MSFE is lower than the restricted model out-of-sample MSFE. The ENC-NEW statistic is used to test the null hypothesis that the restricted model out-of-sample forecasts encompass the unrestricted model out-of-sample forecasts against the one-sided (upper-tail) hypothesis that the restricted model out-of-sample forecasts do not encompass the unrestricted model out-of-sample forecasts. Bootstrapped *p*-values are given in parentheses; 0.00 signifies < 0.005. Bold entries indicate significance at the 10% level according to the bootstrapped *p*-values.