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Source: *The Journal of Finance*, Vol. 45, No. 4 (Sep., 1990), pp. 1089-1108
Published by: Blackwell Publishing for the American Finance Association
Stable URL: http://www.jstor.org/stable/2328716

THE JOURNAL OF FINANCE • VOL. XLV, NO. 4 • SEPTEMBER 1990

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ABSTRACT

Measuring the total return variation explained by shocks to expected cash flows, time-varying expected returns, and shocks to expected returns is one way to judge the rationality of stock prices. Variables that proxy for expected returns and expected-return shocks capture 30% of the variance of annual NYSE value-weighted returns. Growth rates of production, used to proxy for shocks to expected cash flows, explain 43% of the return variance. Whether the combined explanatory power of the variables—about 58% of the variance of annual returns—is good or bad news about market efficiency is left for the reader to judge.

STANDARD VALUATION MODELS POSIT three sources of variation in stock returns: (a) shocks to expected cash flows, (b) predictable return variation due to variation through time in the discount rates that price expected cash flows, and (c) shocks to discount rates. Many studies examine these three sources of return variation. Fama (1981), Geske and Roll (1983), Kaul (1987), Barro (1990), and Shah (1989) find that large fractions (often more than 50%) of annual stock-return variances can be traced to forecasts of variables such as real GNP, industrial production, and investment that are important determinants of the cash flows to firms. There is also evidence that expected returns (and thus the discount rates that price expected cash flows) vary through time (for example, Fama and Schwert (1977), Keim and Stambaugh (1986), Campbell and Shiller (1988), and Fama and French (1988, 1989)). Finally, French, Schwert, and Stambaugh (1987) find that part of the variation in stock returns can be traced to a "discount-rate effect," that is, shocks to expected returns and discount rates that generate opposite shocks to prices.

Measuring the total return variation explained by a combination of shocks to expected cash flows, time-varying expected returns, and shocks to expected returns is a logical way to judge the efficiency or rationality of stock prices. Although the three sources of return variation have been studied separately, there is little evidence on their combined explanatory power. Such evidence is a major goal of this paper.

The evidence says that variables that measure time-varying expected returns and shocks to expected returns capture about 30% of the variance of annual real returns on the value-weighted portfolio of New York Stock Exchange (NYSE) stocks. Future growth rates of industrial production, used to proxy for shocks to

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expected cash flows, explain 43% of the variance of annual returns. However, because production growth rates, expected returns, and shocks to expected returns are all related to business conditions, the combined explanatory power of the variables—about 58% of the variance of annual returns—is less than the sum of their separate explanatory powers.

Are these results good or bad news about market efficiency? One can argue that variance explained is understated because the explanatory variables do not capture all rational variation in returns. One can, on the other hand, argue that variance explained is overstated because the explanatory variables are chosen largely on the basis of goodness of fit. As always, then, the answer to the basic market-rationality question must be left to the reader.

Finally, a puzzle in the work of Fama (1981) and Kaul (1987) is that real activity explains more return variation for longer return horizons. Future production growth rates explain 6% of the variance of monthly returns on the NYSE value-weighted portfolio. The proportion rises to 43% for annual returns. A model of the reaction of stock returns to information about real activity developed here offers an explanation.

The model says that, if information about the production of a given month evolves over many previous months, the production of a given month will affect the stock returns of many previous months. A given monthly return then has information about many future production growth rates, but adjacent returns have additional information about the same production growth rates. The R^2 from regressions of monthly returns on future production growth rates will then understate the information about production in the sequence of returns. Consistent with the evidence, the model says that the proportion of the variation in returns due to information about production is captured better when longer-horizon returns are regressed on future production growth rates.

The variables used to proxy for time-varying expected returns, shocks to expected returns, and shocks to expected cash flows are discussed next. The model of the reaction of stock returns to information about real activity is presented in Section II. Sections III to V present the main empirical results and suggested theoretical interpretations.

I. The Variables

The tests attempt to explain real returns on the value-weighted portfolio of NYSE stocks. (Results for the equally weighted portfolio are similar.) Real returns are nominal returns, from the Center for Research in Security Prices, adjusted for the inflation rate of the U.S. Consumer Price Index (CPI). The tests use continuously compounded real returns, $R(t, t+T)$, for return horizons, T, of one month, one quarter, and one year.

Expected Returns

Three time-t variables, used by Fama and French (1989) to forecast returns, are used to track the expected value of $R(t, t+T)$:

(a) $D(t)/V(t)$—the dividend yield on the value-weighted NYSE portfolio, computed by summing monthly dividends on the portfolio for the year preceding t and dividing by the value of the portfolio at t.

(b) $DEF(t)$—the default spread, defined as the difference between the time-t yield on a portfolio of 100 corporate bonds, sampled to approximate a value-weighted portfolio of all corporate bonds, and the time-t yield on a portfolio of bonds with Aaa (Moody's) ratings.

(c) $TERM(t)$—the term spread, defined as the time-t difference between the yield on the Aaa corporate bond portfolio and the one-month Treasury bill rate. The corporate bond yields in $TERM(t)$ and $DEF(t)$ are from Ibbotson Associates and are made available through the sponsorship of Dimensional Fund Advisors.

The results of regressions of returns, $R(t, t + T)$, on $D(t)/V(t)$, $DEF(t)$, and $TERM(t)$ are robust to changes in the definitions of the forecasting variables. The dividend yield on Standard and Poor's 500 Index captures variation in expected returns about as well as the yield on the NYSE value-weighted portfolio. Substituting a low-grade (Baa or below Baa) bond yield for the market-portfolio yield in the default spread has little effect on the results. I use a market-portfolio bond yield because it is less subject to changes through time in the meaning of bond ratings. Substituting a long-term Government bond yield for the Aaa yield in the default and term spreads also has little effect on the results.

The hypothesis that dividend yields forecast stock returns is old (for example, Dow (1920) and Ball (1978)). The intuition of the efficient-markets version of the hypothesis is that stock prices are low relative to dividends when discount rates and expected returns are high, and vice versa, so $D(t)/V(t)$ varies with expected returns. Rozeff (1984), Shiller (1984), Campbell and Shiller (1988), and Fama and French (1988, 1989) document that dividend yields forecast stock returns.

Chen, Roll, and Ross (1986) argue that variables like the default spread, that is, spreads of lower- over higher-grade bond yields, are measures of business conditions: the spreads are likely to be high when conditions are poor and low when they are strong. Chen (1989) confirms that $DEF(t)$ is negatively correlated with past and future output growth. $DEF(t)$ is thus a candidate to track variation in expected returns in response to business conditions. Keim and Stambaugh (1986) find that a default spread indeed forecasts returns on bonds as well as stocks. Finally, Fama and French (1989) show that $DEF(t)$ and $D(t)/V(t)$ track correlated variation in expected returns. They conclude that, like the default spread, the dividend yield captures variation in expected returns in response to business conditions.

Keim and Stambaugh (1986) show that variables like the term spread, that is, spreads of long-term over short-term bond yields, forecast stock and bond returns. Fama and French (1989) show that $TERM(t)$ has a business-cycle pattern: it is low around business peaks and high around troughs. Thus, the term spread captures cyclical variation in expected returns.

In short, the view adopted here is that the variation in returns forecast by the dividend yield, the default spread, and the term spread is rational variation in expected returns in response to business conditions. I also argue (after presenting the empirical results) that the expected-return variation tracked by $D(t)/P(t)$, $DEF(t)$, and $TERM(t)$ is consistent with the consumption-smoothing models, old and new, of Modigliani and Brumberg (1955), Friedman (1957), Lucas (1978), Brock (1982), and others.

Shocks to Expected Returns

Shocks to monthly and quarterly expected returns are measured by the residuals from first-order autoregressions (AR1's) fit to monthly and quarterly observations on the default spread and the term spread. AR1's are chosen for simplicity and because they produce residual autocorrelations (Table I) reasonably close to zero. AR1's are fit separately to monthly and quarterly observations on $DEF(t)$ and $TERM(t)$ to allow the estimates to adjust for shortcomings of the AR1 model. Shocks to annual expected returns are measured by the sums of the four relevant residuals from the AR1's fit to quarterly observations on $DEF(t)$ and $TERM(t)$.

Since shocks to $D(t)/V(t)$ are largely driven by the price $V(t)$, contemporaneous shocks to the dividend yield and stock returns are almost necessarily negatively correlated. For this reason, the tests only use expected-return shocks estimated from the expected-return variables, $DEF(t)$ and $TERM(t)$, that do not involve stock prices.

Shocks to Expected Cash Flows

As in Fama (1981), Geske and Roll (1983), and Kaul (1987), variation in stock returns due to expectations of future cash flows is estimated by regressing returns on future growth rates of real activity. Preliminary tests showed that industrial production explains as much or more return variation as other real-activity variables, but growth rates of real GNP and Gross Private Investment are close competitors. Profits or investment sometimes have marginal explanatory power in regressions that include production, but the improvements are small and often unreliable. For parsimony, and to limit the effects of data dredging, the tests use only production. Quarterly growth rates of seasonally adjusted production up to four quarters ahead are used to explain monthly, quarterly, and annual returns.

The relations between stock returns and future production surely in part reflect the information about cash flows in production, but there are at least two other possibilities (Barro (1990)): (1) Stock prices and production can respond together to other variables. For example, a fall in discount rates can cause increases in stock prices and in production of investment goods. (2) Stock returns might also cause changes in real activity. Thus, an increase in stock prices is an increase in wealth, which is likely to increase the demand for consumption and/or investment goods.

Disentangling cause and effect in the relations between stock returns and real activity is an interesting and formidable challenge, not addressed here. For present purposes, as long as the return variation that results from the relations between stock returns and real activity is rational, it is a legitimate part of the story for rational variation in returns.

Table I

Means, Standard Deviations, and Autocorrelations: 1953–1987

$R(t, t+1)$ is the continuously compounded monthly real returns (t to $t+1$) on the value-weighted portfolio of NYSE stocks. $D(t)$ is the dividend on the portfolio for the year ending at t, and $V(t)$ is the value of the portfolio at t. $DEF(t)$ is the difference between the time-t annualized yield on a proxy for the market portfolio of corporate bonds and the yield on a portfolio of Aaa bonds. $TERM(t)$ is the difference between the Aaa yield and the annualized one-month Treasury bill rate. $P(t, t+3)$ is the growth rate of seasonally adjusted industrial production for the quarter from t to $t+3$, measured as the log of production for month $t+3$ minus the log of production for month t. $DSH(t, t+T)$ and $TSH(t, t+T)$ are the shocks to the default spread and the term spread, estimated as the residuals from first-order autoregressions fit to monthly ($T = 1$) or quarterly ($T = 3$) observations on $DEF(t)$ and $TERM(t)$. The numbers in the mean and standard deviation (St Dev) columns for $DSH(t)$ and $TSH(t)$ are the AR1 slopes and their standard errors. Under the hypothesis that the true autocorrelations are zero, the standard errors of the autocorrelations for the monthly and quarterly variables are about 0.05 and 0.08.

				Autocorrelations for Monthly Lag									
Name	Obs	Mean	St Dev	1	2	3	4	5	6	12	24	36	48
Part A: Variables Used in the Regressions for Monthly Returns													
$R(t, t+1)$	420	0.005	0.043	0.09	−0.02	0.05	0.06	0.12	−0.05	0.05	−0.03	0.01	0.02
$D(t)/V(t)$	420	0.039	0.009	0.98	0.95	0.93	0.91	0.88	0.85	0.70	0.55	0.52	0.49
$DEF(t)$	420	0.006	0.003	0.88	0.83	0.76	0.71	0.67	0.63	0.48	0.15	0.02	0.12
$TERM(t)$	420	0.018	0.015	0.83	0.73	0.68	0.60	0.56	0.55	0.36	0.12	−0.10	−0.12
$P(t, t+3)$	420	0.009	0.025	0.85	0.60	0.33	0.19	0.09	0.04	−0.17	−0.22	−0.07	0.10
Part B: AR1 Models for the Default Spread, $DEF(t)$, and the Term Spread, $TERM(t)$													
Monthly													
$DSH(t, t+1)$	420	0.890	0.023	−0.18	0.09	−0.06	0.03	0.02	−0.08	−0.02	−0.09	−0.01	0.10
$TSH(t, t+1)$	420	0.837	0.028	−0.14	−0.03	0.15	−0.07	−0.03	0.12	0.19	0.13	0.01	0.04
Quarterly													
$DSH(t, t+3)$	140	0.824	0.050			−0.09			−0.02	−0.01	0.02	0.00	0.17
$TSH(t, t+3)$	140	0.580	0.073			−0.18			0.13	0.04	0.12	−0.00	0.05

Time Period

The test period is 1953–1987. Starting in 1953 (after the Korean War) avoids the weak wartime relations between stock returns and real activity reported by Kaul (1987) and Shah (1989). The argument is that the strong real activity observed during wars is expected to be temporary. Wartime real activity is thus less informative about the expectations of long-term real activity used to set stock prices than is the real activity of normal periods. The 1953–1987 period also avoids any unusual behavior of the default spread and the term spread during the interest-rate-pegging period prior to the 1951 Treasury-Federal Reserve accord. I focus on 1953–1987, but the results for other periods examined (1948–1987, 1948–1978, 1953–1978) are similar.

II. Stock Returns and Production Growth Rates

Fama (1981), Geske and Roll (1983), Kaul (1987), Barro (1990), and Shah (1989) find that the relations between stock returns and future real activity are strong. Since their results indicate that real activity has a central rôle in any story about the variation of returns, we examine the relations between returns and real activity in detail.

A puzzling result in Fama (1981) and Kaul (1987) is that real activity explains larger fractions of return variation for longer return horizons. The analysis that follows offers an explanation. In brief, suppose that information about the production of a given period is spread over many previous periods and so affects the stock returns of many previous periods. A given short-horizon return then has information about the production growth rates of many future periods, but adjacent returns have additional information about the same production growth rates. As a result, regressions of long-horizon returns on future production growth rates (or regressions of long-horizon production growth rates on past returns) give a better picture of the cumulative information about production in returns. (If this summary suffices, the reader can skip forward to Section II.*B*.)

A. Production and Stock Returns: A Simple Model

Suppose that production growth from t to $t + 1$, $P(t, t + 1)$, has two terms:

$$P(t, t + 1) = x(t, t + 1) + y(t, t + 1). \tag{1}$$

Suppose that information about the two terms of $P(t, t + 1)$ becomes available and is incorporated in stock returns over two previous periods. Specifically, $x(t, t + 1)$ is known at t, while $y(t, t + 1)$ becomes known and is incorporated in stock returns at $t - 1$. For simplicity, suppose that

$$R(t - 1, t) = x(t, t + 1) + y(t + 1, t + 2) \tag{2a}$$

and

$$R(t - 2, t - 1) = x(t - 1, t) + y(t, t + 1); \tag{2b}$$

that is, information about production is the sole determinant of returns. More importantly, (1) and (2) say that the lagged returns, $R(t - 1, t)$ and

$R(t-2, t-1)$, contain the two components of $P(t, t+1)$, the production growth rate from t to $t+1$.

Consider the regression of $P(t, t+1)$ on the two lagged returns:

$$P(t, t+1) = a + bR(t-1, t) + cR(t-2, t-1) + e(t, t+1). \qquad (3)$$

To keep things simple, assume that x and y are uncorrelated and i.i.d., with $\sigma^2(x) = \sigma^2(y) = \sigma^2$. Then (1) and (2) imply that the production growth rate and the two returns in (3) all have the same variance, $2\sigma^2$. Since the two returns are also uncorrelated, the regression slopes in (3) are

$$b = c = \sigma^2/2\sigma^2 = 0.5. \qquad (4)$$

The breakdown of the variance of $P(t, t+1)$ given by (3) is then

$$\begin{aligned} 2\sigma^2 &= 0.5^2(2\sigma^2) + 0.5^2(2\sigma^2) + \sigma^2[e(t, t+1)] \\ &= \sigma^2 + \sigma^2[e(t, t+1)]. \qquad (5) \end{aligned}$$

Thus, the variance of the residuals in (3), $\sigma^2[e(t, t+1)]$, is equal to σ^2, and the regression R^2 is 0.5.

In short, although $R(t-2, t-1)$ and $R(t-1, t)$ contain the two terms of $P(t, t+1)$, the regression of the production growth rate on the two returns only captures 50% of the variance of $P(t, t+1)$. The problem? Although each return contains a component of $P(t, t+1)$, each also contains a component of production growth for another period. The information about the production of other periods acts like measurement error that smears the information in $R(t-2, t-1)$ and $R(t-1, t)$ about $P(t, t+1)$. Because a return forecasts production growth for two periods, it is a noisy forecast of the growth rate of either period.

The measurement-error problem and the consequent understatement of explanatory power are worse the larger the number of periods of production forecast by a given return. For example, if $P(t, t+1)$ contains ten i.i.d. terms that become known and incorporated in stock prices over ten previous periods (a case of some relevance in the tests below), the R^2 in the regression of $P(t, t+1)$ on the ten relevant lagged returns drops to 0.10.

The problem has a partial cure. Understatement of explanatory power is lower when longer-horizon production growth rates are regressed on the relevant one-period returns. Given the model of (1) and (2), let us regress the two-period growth rate, $P(t, t+2)$, on the three returns, $R(t-2, t-1)$, $R(t-1, t)$, and $R(t, t+1)$, that contain the four terms of $P(t, t+2)$:

$$\begin{aligned} P(t, t+2) = a &+ bR(t, t+1) + cR(t-1, t) \\ &+ dR(t-2, t-1) + e(t, t+2). \qquad (6) \end{aligned}$$

The regression slopes in (6) are

$$b = d = \sigma^2/2\sigma^2 = 0.5 \quad \text{and} \quad c = 2\sigma^2/2\sigma^2 = 1. \qquad (7)$$

The breakdown of the variance of $P(t, t+2)$ given by (6) is then

$$4\sigma^2 = 0.5^2(2\sigma^2) + 2\sigma^2 + 0.5^2(2\sigma^2) + \sigma^2[e(t, t+2)]. \qquad (8a)$$

$$= 3\sigma^2 + \sigma^2[e(t, t+2)]. \qquad (8b)$$

Thus, the variance of the residuals in (6), $\sigma^2[e(t, t+2)]$, is equal to σ^2, and the regression R^2 is 0.75. This increase in explanatory power (from $R^2 = 0.5$ in (3)) arises because one of the returns in (7), $R(t-1, t)$, has noise-free information about $P(t, t+2)$; that is, both terms in $R(t-1, t)$ appear in the two-period production growth rate. (See equation (2).)

In the model above, increasing the horizon covered by the production growth rate and adding the relevant one-period returns as explanatory variables cause the regression R^2 to approach 1. R^2 never reaches 1 because the first and last returns in the relevant sequence always have noisy information about the cumulative production growth rate. Thus, some understatement of explanatory power remains, and, of course, if there is variation in returns unrelated to production (or vice versa), the R^2 in the regressions for cumulative production growth rates will not approach 1.

The same analysis applies when the regressions are reversed; that is, stock returns are regressed on future production growth rates. In the model of (1) and (2), the regression of $R(t, t+1)$ on $P(t+1, t+2)$ and $P(t+2, t+3)$ has slopes equal to 0.5, and R^2 is 0.5, even though the two future production growth rates contain the two terms in the return. The problem again is measurement error that arises because each production growth rate also affects the return of another period. Again, the problem is partly solved by regressing longer-horizon returns on the relevant one-period production growth rates.

B. Regressions of Production on Stock Returns

The general hypothesis underlying the analysis above is that information about the production of a given period is spread across preceding periods and so affects the stock returns of preceding periods. The hypothesis predicts that, in regressions of $P(t, t+1)$, the production growth rate for the month from t to $t+1$, on lags of monthly returns, more than one past return should have explanatory power. The estimated regression of the monthly production growth rates of 1953–1987 on 12 lags of the monthly NYSE value-weighted return is

$$\begin{aligned} P(t, t+1) = {} & \underset{(2.25)}{0.001} + \underset{(0.75)}{0.009}R(t-1, t) + \underset{(2.38)}{0.027}R(t-2, t-1) \\ & + \underset{(2.35)}{0.028}R(t-3, t-2) + \underset{(3.51)}{0.042}R(t-4, t-3) \\ & + \underset{(2.76)}{0.033}R(t-5, t-4) + \underset{(3.14)}{0.038}R(t-6, t-5) \\ & + \underset{(1.69)}{0.020}R(t-7, t-6) + \underset{(1.58)}{0.019}R(t-8, t-7) \\ & + \underset{(2.13)}{0.025}R(t-9, t-8) + \underset{(2.38)}{0.028}R(t-10, t-9) \\ & + \underset{(0.96)}{0.011}R(t-11, t-10) + \underset{(1.14)}{0.013}R(t-12, t-11) \\ & + e(t, t+1), \end{aligned} \tag{9}$$

where the numbers in parentheses are the t-statistics for the slopes and R^2 (adjusted for degrees of freedom) is 0.14. In short, up to 10 lags of the one-month return have power to forecast the one-month production growth rate. Information about production is indeed spread across many preceding periods.

Table II shows that explanatory power, as measured by R^2, is about the same when quarterly rather than monthly returns are used to forecast monthly production. The reason is that the slopes on past monthly returns in (9) decay slowly, so the implied constraints on the monthly slopes imposed in using quarterly returns have little effect on explanatory power. Henceforth, for a bit of parsimony in presenting results, quarterly returns are used to explain production growth rates, and, conversely, quarterly production growth rates are used to explain returns.

Since information about the production of a given month is spread over many past periods (10 months in (9) or four quarters in Table II), there is a presumption from the analysis of (1) to (8) that lagged returns are noisy forecasts of monthly production. The analysis suggests that the noise can be reduced, and forecast power increased, with regressions of longer-horizon production growth rates on the relevant returns. Table II confirms this prediction. The regression R^2 rises from 0.14 for monthly production growth rates to 0.30 for quarterly growth rates and 0.44 for annual growth rates.

The tests do not support one of the extreme implications of (1) to (8). In particular, regressions (not shown) of two-year production growth rates on quarterly returns produce values of R^2 like those for one-year production growth rates. The fact that R^2 increases with the forecast horizon but does not approach 1 suggests, not surprisingly, that information about production is not the sole determinant of returns, or vice versa.

C. Regressions of Returns on Production Growth Rates

The regressions of production growth rates on returns establish that information about the production of a given period is spread across several past periods. We are, however, more interested in using production to explain returns. Table III shows regressions of real returns on the NYSE value-weighted portfolio on quarterly production growth rates.

The symmetry between the return regressions and the production regressions is apparent. Table III shows that leads of quarterly production up to three or four quarters ahead help to explain monthly, quarterly, and annual stock returns. Table II shows that three or four lags of quarterly returns help to forecast monthly, quarterly, and annual production growth. The regression R^2 increases with the return horizon in Table III (from 0.06 for monthly returns to an impressive 0.43 for annual returns) in a manner similar to that observed for monthly, quarterly, and annual production growth rates in Table II.

In the model of (1) to (8), regressions of shorter-horizon returns on quarterly production growth rates understate explanatory power because information about the production of a given period is spread over preceding periods. The model, buttressed by the evidence in Tables II and III, says that the higher R^2 for annual returns in Table III is relevant for judging how much return variation is explained by information about real activity.

Table II

Regressions of Monthly, Quarterly, and Annual Production Growth Rates on Contemporaneous and One-Year of Lags of Quarterly Real Returns on the Value-Weighted NYSE Portfolio: 1953–1987

$$P(t-T,t)=a+b_1R(t-3,t)+b_2R(t-6,t-3)+b_3R(t-9,t-6)$$
$$+b_4R(t-12,t-9)+b_5R(t-15,t-12)+b_6R(t-18,t-15)$$
$$+b_7R(t-21,t-18)+b_8R(t-24,t-21)+e(t-T,t)$$

$P(t-T, t)$ is the monthly ($T=1$), quarterly ($T=3$), or annual ($T=12$) growth rate of seasonally adjusted industrial production from $t-T$ to t (the log of production for month t minus the log of production for month $t-T$). $R(t-k, t-k+3)$ is the continuously compounded value-weighted NYSE real return for the quarter from $t-k$ to $t-k+3$. Obs is the number of observations. The regressions for monthly and quarterly production growth rates use monthly or quarterly observations. The regressions for annual growth rates use overlapping quarterly observations. The residual standard errors, s(e), and the regression R^2 are adjusted for degrees of freedom. The t's for the slopes in the monthly and quarterly regressions use standard errors adjusted for heteroscedasticity. The t's for the slopes in the annual regressions use standard errors that are also adjusted for residual autocorrelation due to the overlap of quarterly observations on annual production growth rates. See White (1980), Hansen and Hodrick (1980), and Hansen (1982).

	Monthly $P(t-1,t)$		Quarterly $P(t-3,t)$		Annual $P(t-12,t)$	
	b	$t(b)$	b	$t(b)$	b	$t(b)$
Constant	0.00	2.27	0.00	1.94	0.02	2.29
$R(t-3,t)$	0.01	2.24	0.00	0.04	−0.09	−2.15
$R(t-6,t-3)$	0.03	4.52	0.10	3.96	0.05	1.36
$R(t-9,t-6)$	0.03	3.90	0.10	4.82	0.16	3.88
$R(t-12,t-9)$	0.02	3.92	0.06	3.11	0.26	6.52
$R(t-15,t-12)$			0.04	1.93	0.29	6.03
$R(t-18,t-15)$					0.20	6.26
$R(t-21,t-18)$					0.09	2.47
$R(t-24,t-21)$					0.02	0.50
R^2	0.14		0.30		0.44	
s(e)	0.01		0.02		0.05	
Obs	420		140		137	

We next document the relations between stock returns and the variables used to track expected returns and shocks to expected returns. We then turn to the bottom-line tests—multiple regressions that examine the total return variation explained by time-varying expected returns, shocks to expected returns, and forecasts of real activity.

III. Expected Returns and Shocks to Expected Returns

Table IV shows multiple regressions of the real stock return, $R(t, t+T)$, on the time-t term spread, $TERM(t)$, and either the dividend yield, $D(t)/V(t)$, or the default spread, $DEF(t)$. Since Fama and French (1989) find that the dividend yield and the default spread capture similar variation in expected returns, the

Table III

Regressions of Monthly, Quarterly, and Annual Continuously Compounded Real Returns on the Value-Weighted NYSE Portfolio on Contemporaneous and One-Year of Leads of Quarterly Production Growth: 1953–1987

$$R(t, t+T) = a + b_1P(t, t+3) + b_2P(t+3, t+6) + b_3P(t+6, t+9) + b_4P(t+9, t+12) + b_5P(t+12, t+15) + b_6P(t+15, t+18) + b_7P(t+18, t+21) + b_8P(t+21, t+24) + e(t, t+T)$$

$R(t, t+T)$ is the monthly ($T = 1$), quarterly ($T = 3$), or annual ($T = 12$) value-weighted NYSE real return from t to $t + T$. $P(t + k, t + k + 3)$ is the growth rate of seasonally adjusted industrial production for the quarter from $t + k$ to $t + k + 3$ (the log of production for month $t + k + 3$ minus the log of production for month $t + k$). Obs is the number of observations. The regressions for monthly and quarterly returns use monthly or quarterly observations. The regressions for annual returns use overlapping quarterly observations. The residual standard errors, s(e), and the regression R^2 are adjusted for degrees of freedom. The t's for the slopes in the monthly and quarterly regressions use standard errors adjusted for heteroscedasticity. The t's for the slopes in the annual regressions use standard errors that are also adjusted for residual autocorrelation due to the overlap of quarterly observations on annual returns. See White (1980), Hansen and Hodrick (1980), and Hansen (1982).

	Monthly $R(t, t+1)$		Quarterly $R(t, t+3)$		Annual $R(t, t+12)$	
	b	$t(b)$	b	$t(b)$	b	$t(b)$
Constant	−0.00	−0.30	−0.00	−0.18	0.00	0.08
$P(t, t+3)$	0.05	0.45	−0.46	−1.46	−0.96	−1.85
$P(t+3, t+6)$	0.29	2.78	1.10	3.09	0.35	0.92
$P(t+6, t+9)$	0.16	1.89	0.87	3.22	1.23	4.24
$P(t+9, t+12)$	0.18	2.41	0.37	1.50	2.11	7.02
$P(t+12, t+15)$			0.09	0.31	2.47	3.88
$P(t+15, t+18)$					1.18	2.14
$P(t+18, t+21)$					0.60	2.59
$P(t+21, t+24)$					0.39	0.78
R^2	0.06		0.20		0.43	
s(e)	0.04		0.08		0.13	
Obs	420		140		137	

regressions use either $D(t)/V(t)$ or $DEF(t)$. The regressions also include the estimated shocks to $DEF(t)$ and $TERM(t)$, meant to capture return variation caused by shocks to expected returns.

The dividend yield, the default spread, and the term spread forecast stock returns. The slopes for $D(t)/V(t)$ are all more than 2.4 standard errors from zero. All the slopes for $DEF(t)$ are positive, and those for quarterly and annual returns are more than 2.3 standard errors from zero. All the $TERM(t)$ slopes are positive, and five of six are more than two standard errors from zero.

The default spread and the term spread track expected returns, but the evidence that shocks to $DEF(t)$ and $TERM(t)$ produce a discount-rate effect in returns is weak. The discount-rate effect predicts that the slopes in regressions of $R(t, t+T)$ on the contemporaneous shocks to the default and term spreads,

Table IV

Multiple Regressions of Continuously Compounded NYSE Value-Weighted Returns on Variables That Track Expected Returns and Shocks to Expected Returns: 1953–1987

$$R(t, t+T) = b_0 + b_1 X(t) + b_2 TERM(t) + b_3 DSH(t, t+T) + b_4 TSH(t, t+T) + e(t, t+T)$$

$R(t, t+T)$ is the monthly ($T = 1$), quarterly ($T = 3$), or annual ($T = 12$) real return on the value-weighted NYSE portfolio from t to $t + T$. $D(t)$ is the dividend on the portfolio for the year ending at t, and $V(t)$ is the value of the portfolio at t. $DEF(t)$ is the difference between the time-t annualized yield on a proxy for the market portfolio of corporate bonds and the yield on a portfolio of Aaa bonds. $TERM(t)$ is the difference between the Aaa yield and the annualized one-month bill rate. Monthly and quarterly $DSH(t, t+T)$ are shocks to the default spread and the term spread, estimated as the residuals from first-order autoregressions fit to monthly and quarterly observations on $DEF(t)$ and $TERM(t)$. Annual $DSH(t, t+T)$ and $TSH(t, t+T)$ are overlapping sums of four quarterly shocks. Obs is the number of observations. The regressions for monthly and quarterly returns use monthly or quarterly observations. The regressions for annual returns use overlapping quarterly observations. The standard error of the residuals, s(e), and the regression R^2 are adjusted for degrees of freedom. The t's for the slopes in the monthly and quarterly regressions use standard errors adjusted for heteroscedasticity. The t's for the slopes in the annual regressions use standard errors that are also adjusted for residual autocorrelation due to the overlap of quarterly observations on annual returns. See White (1980), Hansen and Hodrick (1980), and Hansen (1982).

	$X(t) = D(t)/V(t)$						$X(t) = DEF(t)$					
	Monthly $R(t, t+1)$		Quarterly $R(t, t+3)$		Annual $R(t, t+12)$		Monthly $R(t, t+1)$		Quarterly $R(t, t+3)$		Annual $R(t, t+12)$	
	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$
Constant	−0.03	−2.81	−0.10	−3.27	−0.35	−3.15	−0.01	−2.02	−0.03	−2.08	−0.13	−2.11
$X(t)$	0.62	2.41	2.39	3.34	9.55	3.93	1.10	1.58	5.11	2.36	26.52	3.34
$TERM(t)$	0.52	3.50	1.28	2.48	2.81	1.84	0.51	3.44	1.24	2.32	3.42	2.20
$DSH(t, t+T)$	−1.76	−1.10	−12.24	−2.38	−12.69	−1.74	−1.31	−0.84	−10.71	−2.14	−8.54	−1.38
$TSH(t, t+T)$	−0.10	−0.25	−0.18	−0.22	0.51	0.72	−0.12	−0.29	−0.29	−0.32	−0.14	−0.21
R^2	0.04		0.13		0.33		0.03		0.10		0.28	
s(e)	0.04		0.08		0.14		0.04		0.08		0.15	
Obs	420		140		137		420		140		137	

$DSH(t, t+T)$ and $TSH(t, t+T)$, are negative. The slopes for $DSH(t, t+T)$ in Table IV are negative, but only two of six are more than two standard errors from zero. All the slopes for $TSH(t, t+T)$ are less than one standard error from zero. Given these results, $TSH(t, t+T)$ is not included among the explanatory variables when we next add production growth rates to the regressions.

IV. Expected Returns, Shocks to Expected Returns, and Production

Table V shows multiple regressions that explain the return, $R(t, t+T)$, with contemporaneous and one-year of future quarterly production growth rates, the shock to the default spread, $DSH(t, t+T)$, and the expected-return variables, $TERM(t)$ and either $D(t)/V(t)$ or $DEF(t)$. These regressions are the central evidence on the proportions of the variances of 1953–1987 returns explained by the combination of time-varying expected returns, shocks to expected returns, and forecasts of real activity.

As in Table IV, the dividend yield and the default spread show reliable forecast power in Table V. The slopes for $DEF(t)$ are all more than 2.1 standard errors from zero; the $D(t)/V(t)$ slopes are more than 3.8 standard errors from zero. If anything, the evidence that $D(t)/V(t)$ and $DEF(t)$ track expected returns is more reliable when production growth rates are also used to explain returns. This happens in part because the slopes for the two variables increase (monthly and quarterly returns) and in part because including production substantially reduces residual variance.

The strong relations between production and returns in Table III also remain when the variables chosen to track expected returns and shocks to expected returns are included in the regressions. As in Table III, three or four leads of quarterly production growth help to explain monthly, quarterly, and annual returns in Table V. Annual returns are also in part explained by contemporaneous production growth for the last three quarters of the year.

The losers in Table V are the term spread and shocks to the default spread. With production growth rates in the regressions, all $TERM(t)$ slopes are less than two standard errors from zero; four of six are within one standard error of zero. Including production also kills any explanatory power of shocks to the default spread. Only one $DSH(t, t+T)$ slope is more than two standard errors from zero, and it is positive—the wrong sign for the hypothesis that shocks to expected returns generate opposite shocks to prices and returns.

V. The Relations between Expected Returns and Real Activity

A. Evidence

The decline in the explanatory power of the term spread and shocks to the default spread that occurs when production growth rates are included in the return regressions suggests collinearity. The correlation matrix for the regression variables in Table VI shows some relevant evidence.

Table V

Multiple Regressions of Continuously Compounded NYSE Value-Weighted Returns on Expected-Return Variables, Shocks to the Default Spread, and Contemporaneous and One-Year of Leads of Quarterly Production Growth: 1953–1987

$$R(t, t+T) = b_0 + b_1 X(t) + b_2 TERM(t) + b_3 DSH(t, t+T) + b_4 P(t, t+3)$$
$$+ b_5 P(t+3, t+6) + b_6 P(t+6, t+9) + b_7 P(t+9, t+12)$$
$$+ b_8 P(t+12, t+15) + b_9 P(t+15, t+18)$$
$$+ b_{10} P(t+18, t+21) + b_{11} P(t+21, t+24) + e(t, t+T)$$

$R(t, t+T)$ is the monthly ($T = 1$), quarterly ($T = 3$), or annual ($T = 12$) real return on the value-weighted NYSE portfolio from t to $t + T$. $D(t)$ is the dividend on the portfolio for the year ending at t, and $V(t)$ is the value of the portfolio at t. $DEF(t)$ is the difference between the time-t annualized yield on a proxy for the market portfolio of corporate bonds and the yield on a portfolio of Aaa bonds. $TERM(t)$ is the difference between the Aaa yield and the annualized one-month bill rate. Monthly and quarterly $DSH(t, t+T)$ are shocks to the default spread, estimated as the residuals from AR1's fit to monthly and quarterly observations on $DEF(t)$. Annual $DSH(t, t+T)$ are overlapping sums of four quarterly shocks. $P(t+k, t+k+3)$ is the growth rate of seasonally adjusted production for the quarter from month $t + k$ to month $t + k + 3$. Obs is the number of observations. The regressions for monthly and quarterly returns use monthly or quarterly observations. The regressions for annual returns use overlapping quarterly observations. The standard error of the residuals, s(e), and R^2 are adjusted for degrees of freedom. The t's for the slopes in the monthly and quarterly regressions use standard errors adjusted for heteroscedasticity. The t's for the slopes in the annual regressions use standard errors that are also adjusted for residual autocorrelation due to the overlap of quarterly observations on annual returns. See White (1980), Hansen and Hodrick (1980), and Hansen (1982).

Table V—*Continued*

	$X(t) = D(t)/V(t)$						$X(t) = DEF(t)$					
	Monthly $R(t, t+1)$		Quarterly $R(t, t+3)$		Annual $R(t, t+12)$		Monthly $R(t, t+1)$		Quarterly $R(t, t+3)$		Annual $R(t, t+12)$	
	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$	b	$t(b)$
Constant	−0.04	−4.17	−0.12	−4.12	−0.31	−4.19	−0.01	−2.40	−0.04	−2.17	−0.13	−3.11
$X(t)$	0.95	3.83	2.88	4.30	7.62	4.42	1.67	2.16	5.35	2.19	19.71	3.73
$TERM(t)$	0.19	1.09	0.26	0.60	0.32	0.24	0.20	1.22	0.33	0.75	0.63	0.46
$DSH(t, t+T)$	−0.88	−0.54	−4.83	−1.13	6.34	1.21	−0.31	−0.20	−3.27	−0.78	9.79	2.25
$P(t, t+3)$	0.12	1.29	−0.12	−0.38	0.01	0.01	0.09	0.87	−0.29	−0.81	−0.16	−0.28
$P(t+3, t+6)$	0.30	2.79	1.10	3.13	0.77	2.68	0.27	2.56	1.06	3.00	0.71	1.82
$P(t+6, t+9)$	0.16	1.85	0.78	2.71	1.46	3.99	0.14	1.70	0.74	2.83	1.37	3.62
$P(t+9, t+12)$	0.14	1.89	0.33	1.43	2.13	8.26	0.14	1.84	0.33	1.42	2.16	7.91
$P(t+12, t+15)$			0.02	0.07	2.57	4.29			0.02	0.07	2.72	4.17
$P(t+15, t+18)$					1.28	3.06					1.28	2.62
$P(t+18, t+21)$					0.44	1.61					0.44	1.43
$P(t+21, t+24)$					0.44	1.72					0.28	1.05
R^2	0.09		0.27		0.59		0.07		0.23		0.56	
s(e)	0.04		0.07		0.11		0.04		0.07		0.12	
Obs	420		140		137		420		140		137	

Table VI
Correlation Matrix for the Variables in the Regressions for Quarterly Returns in Table V: 1953–1987

Each correlation is based on 140 quarterly observations. $R(t, t+3)$, labeled R, is the continuously compounded quarterly real return (from t to $t+3$) on the value-weighted portfolio of NYSE stocks. $D(t)$ is the dividend on the portfolio for the year ending at t, and $V(t)$ is the value of the portfolio at t. $DEF(t)$ is the difference between the time-t annualized yield on a proxy for the market portfolio of corporate bonds and the yield on a portfolio of Aaa bonds. $TERM(t)$ is the difference between the Aaa yield and the annualized one-month Treasury bill rate. $P(t+k, t+k+3)$ is the growth rate (change in the log) of seasonally adjusted industrial production for the quarter from month $t+k$ to month $t+k+3$. $DSH(t, t+3)$ and $TSH(t, t+3)$ are the shocks to the default spread and the term spread, estimated as the residuals from first-order autoregressions fit to quarterly observations on $DEF(t)$ and $TERM(t)$. $P(3)$ is short for $P(t, t+3)$, $P(6)$ is short for $P(t+3, t+6)$, etc.

Variable	R	D/P	DEF	$TERM$	DSH	TSH	$P(3)$	$P(6)$	$P(9)$	$P(12)$
$D(t)/V(t)$	0.21									
$DEF(t)$	0.18	0.46								
$TERM(t)$	0.23	0.02	0.07							
$DSH(t, t+3)$	−0.24	0.12	−0.05	−0.06						
$TSH(t, t+3)$	0.05	0.12	0.27	−0.00	−0.19					
$P(t, t+3)$	0.01	−0.38	−0.32	0.20	−0.05	−0.17				
$P(t+3, t+6)$	0.36	−0.23	−0.15	0.25	−0.33	0.06	0.38			
$P(t+6, t+9)$	0.39	−0.07	0.02	0.33	−0.28	0.08	0.09	0.38		
$P(t+9, t+12)$	0.23	0.02	0.06	0.33	−0.04	0.16	0.02	0.09	0.38	
$P(t+12, t+15)$	0.11	0.10	0.11	0.23	−0.03	0.24	−0.17	0.02	0.09	0.38

Table VI confirms that $TERM(t)$ is positively correlated with quarterly growth rates of production for at least five quarters ahead. Fama and French (1989) show that the term spread has a business-cycle pattern. $TERM(t)$ is low around business peaks when future recession growth rates of production will be low, and it is high around troughs, preceding the strong growth rates of production observed during the early phases of business expansions.

Intuition says that a positive shock to the default spread (an increase in the spread of lower- over higher-grade bond yields) signals a market forecast that business conditions will be weaker than previously anticipated. Table VI confirms that shocks to the default spread are negatively correlated with production growth one (−0.33) and two (−0.28) quarters ahead. The correlations can explain the decline in the $DSH(t, t + T)$ slopes that occurs when production growth rates are included in the return regressions.

The dividend yield and the default spread are also negatively correlated with production growth one and perhaps two quarters ahead. High values of the variables signal lower than average near-term production growth, and vice versa. Chen (1989) finds that $D(t)/V(t)$ and $DEF(t)$ show more persistent negative correlation with past output; they are high when times have been persistently poor and low when conditions have been strong. Fama and French (1989) make the same point with time-series plots of $D(t)/V(t)$ and $DEF(t)$.

The fact that the dividend yield and the default spread are mostly backward-looking with respect to output, but the term spread is strongly forward-looking, can explain, in mechanical terms, why future production growth absorbs the forecast power of $TERM(t)$, but not of $D(t)/V(t)$ and $DEF(t)$. Theory also is not lacking. I argue next that the relations between stock returns, expected returns, and real activity are consistent with asset-pricing models, new and old, in which consumption smoothing plays an important role.

B. Theory

Building on the consumption-smoothing models of Lucas (1978), Brock (1982), Cox, Ingersoll, and Ross (1985), and Abel (1988), Chen (1989) presents a model in which expected returns are high when output growth has been poor (so wealth is low), and vice versa. He argues that his analysis can explain the expected-return variation tracked by the dividend yield and the default spread. Chen's story that $D(t)/V(t)$ and $DEF(t)$ track variation in expected returns due to the effects of past economic conditions on wealth can in principle explain why the forecast power of the two variables remains strong in return regressions that also include future production growth rates.

Breeden (1986) develops a variant of the consumption-smoothing model in which expected returns are positively correlated with expected output growth. Since the term spread is positively correlated with output growth up to at least five quarters ahead (Table VI), his model can in principle explain the expected-return variation captured by $TERM(t)$. Balvers, Cosimano, and McDonald (1990) and Cochrane (1989) also develop models in which expected returns depend on expected output growth but, in addition, unexpected returns depend on unexpected output growth. Thus, their models can in principle explain (a) why future production captures variation in returns left unexplained by expected returns and (b) why future production growth absorbs the expected-return variation captured by the term spread.

Finally, the general message about expected returns that comes out of the regressions is that they vary opposite to business conditions; expected returns are high when times have been poor ($D(t)/V(t)$ and $DEF(t)$) and when times are poor but improvement is anticipated ($TERM(t)$). If aggregate income (output) has a temporary component, this behavior of expected returns is also consistent with the original consumption-smoothing stories, the permanent-income models of Modigliani and Brumberg (1955) and Friedman (1957).

Thus, suppose that income has a temporary component so that income varies more with business conditions than wealth. Like its modern formal variants, the original permanent-income model says that, when income is temporarily high, investors try to save more to smooth consumption into the future. If the marginal return on capital declines with the level of investment, the desire to save more when income is high lowers the expected returns on securities. Conversely, the attempts of investors to save less (move consumption from the future to the present) when income is temporarily low raise the expected returns on securities.

C. Collinearity and Explanatory Power

The fact that the expected-return variables are related to business conditions, and in ways consistent with asset-pricing theory, is a plus for the view that the expected-return variation they capture is rational. However, one consequence of the relations between expected returns and business conditions that now faces us as we approach the central market-efficiency question is that the combined explanatory power of the expected-return variables and production growth rates is far from the sum of their separate explanatory powers.

Thus, in Table III, contemporaneous and one-year of leads of quarterly production growth explain a substantial 43% of the variance of annual returns on the NYSE value-weighted portfolio. In Table IV, the dividend yield, the term spread, and shocks to the default spread together explain 33% of the variance of the annual return. When $D(t)/P(t)$, $TERM(t)$, and $DSH(t, t + T)$ are combined with the production growth rates in Table V, however, the proportion of variance explained, 0.59, is large, but rather far from 0.76—and from 1.

VI. The Bottom Line

Section II says that regressions of short-horizon returns on production growth rates understate explanatory power because of measurement-error problems that arise when the returns of several past periods forecast the production growth of a given period. Thus, in judging how well production explains returns, we concentrate on annual returns. Since regressions that explain returns with expected-return variables (Table IV) also produce higher values of R^2 for longer-return horizons, nothing seems to be lost in focusing on annual returns.

The R^2 (adjusted for degrees of freedom) of the annual-return regressions in

Table V could be improved by dropping variables that do not have explanatory power, specifically the term spread, the shock to the default spread, and the first quarterly production growth rate. Using hindsight to delete variables, however, would raise the possibility that explanatory power is exaggerated because of data dredging.

The R^2 in the annual-return regressions could also be increased (to values as large as 0.85 for value-weighted returns) by using only end-of-year annual returns. There is, however, no reason to prefer the stronger results for end-of-year annual returns over the weaker results for annual returns that end in other quarters. Thus, Table V shows results for overlapping quarterly observations on annual returns. (The results for monthly observations on annual returns are similar.)

We come, then, to the central question. Is explaining 59% of the variance of annual returns on the value-weighted portfolio of NYSE stocks good news or bad news about the rationality of stock prices? I consider the issues but leave the answer to the reader.

One can argue that the tests understate the return variation that has a rational explanation. It seems unlikely that combining the term spread with the dividend yield or the default spread captures all variation in expected returns. It follows that shocks to the term spread and the default spread probably miss some of the adjustment of prices to shocks to expected returns.

It seems most unlikely that a single macro-variable, production, captures all variation in returns due to information about future cash flows. Conversely, it seems likely that there is variation in future production that is irrelevant for current returns. For example, some of the production growth of future periods is unpredictable and so irrelevant for current returns. A simple extension of the analysis in Section II then implies that, in the return regressions, irrelevant production variation acts like measurement error to smear the relevant information in production about returns.

One also can argue, however, that the regressions overstate explanatory power. The variables used to explain returns are chosen largely on the basis of goodness-of-fit rather than the directives of a well developed theory. Moreover, explained variation is not necessarily rational variation in returns. For example, it is plausible that return variation in response to forecasts of output is rational. However, it is also possible that the market misuses its forecast power; that is, information about output does not translate into information about cash flows or the discount rates relevant for pricing them. Also, irrational variation in stock prices might, through a standard wealth effect, induce variation in production.

In short, the tests suggest that a large fraction of the variation of stock returns can be explained, primarily by time-varying expected returns and forecasts of real activity. It is possible that, with fresh data, the explanatory power of the variables used here would be lower than that measured for 1953–1987. It is also possible that some explained return variation is not rational. On the other hand, it is possible that, if the variables and functional forms that drive the rational variation in stock prices were somehow revealed, we would find that the in-sample R^2 values obtained here understate the rational proportion of the variation in returns.

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