Capital Market Forecasts of Economic Growth: New Tests for Germany, Japan, and the United States

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The term structure of interest rates and past movements in stock prices predict economic growth. There is some debate, however, about the source of this forecast power. Past research either argues that the interest rate data support consumption-based asset pricing models or that the predictive power of the term structure derives from the fact that movements in the yield curve reflect changes in anticipated inflation. This paper employs the encompassing principle (Mizon, 1984; Mizon and Richard, 1986) to compare the rival models. During a period with floating exchange rates the term structure encompasses both stock returns and changes in inflation in Germany. For Japan and the USA the term structure and expected changes in inflation each contain information about future economic growth that is not subsumed by the other variable.

INTRODUCTION

At least since the 1950s the term structure of interest rates has had remarkable forecasting power for economic growth. Forecasts based on the nominal yield curve explain about 30 percent of the variance in USA GNP growth (Harvey, 1989; Chen, 1991; Estrella and Hardouvelis, 1991). In contrast, past stock returns explain less than 5.0 percent. Harvey (1988) finds that the real yield spread also outperforms both one quarter lagged real stock returns and one quarter lagged consumption growth as a predictor of per capita growth in real consumption. Harvey (1991a) analyzes the relation between the term structure and real economic growth for the G-7 countries. Once again the term structure variables account for part of the variation in real economic growth.

Prior research stresses the importance of the stock market as a leading indicator. See, e.g., Fisher and Merton (1984) and Fama (1990). De Bondt and Bange (1991) examine the issue with USA data since the end of the Civil War. Their results indicate that past stock returns are a better predictor of real GNP and real consumption growth overall than are interest rates; that the predictive power of the term structure is confined to the period after 1953; and that even for these years growth in industrial production is predicted better by survey forecasts of inflation than by changes in the real term structure.

The forecast power of the nominal slope for industrial production may be linked to its forecast power for inflation. This is plausible because the yield curve can be decomposed into a real yield curve and expected change in inflation. The data, however, cast doubt on this hypothesis. For twelve OECD countries (1964-1988) the predictive power

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of nominal interest rates and stock returns is either modest or nonexistent (Bange and De Bondt, 1994).

This paper reexamines the relationship between developments in financial markets and industrial production. We study the quarter century from 1964 to 1988 for three economic powers: Germany, Japan, and the United States. Regression analysis does not offer uniform results. Based on goodness-of-fit statistics the best financial predictors are the nominal slope of the term structure (Germany), past stock returns (Japan), and stock returns and the expected change in inflation (USA). For the 1973-1988 subperiod the results suggest that for both Germany and Japan the slope outperforms the other measures. For the United States the expected change in inflation shows predictive power.

The fact that not one-and-the-same variable matters in all countries and periods may occur for several reasons. First, the influence of inflation and monetary policy may change with the exchange rate regime. Second, the three countries operate under different monetary and fiscal environments. Third, economic growth is influenced by many factors: dependence on foreign oil, fiscal policies, international inflation, and an increasingly integrated Europe.

We typically resolve these specific controversies by goodness-of-fit statistics, such as R^2. When comparing models, however, the test statistics must be comparable across samples—a criterion that R^2 does not meet (Achen, 1982). A method that incorporates cross-sample comparison is known as the *encompassing principle*. This principle determines whether a model statistically accounts for the main features of a rival and, therefore, explains everything the rival model explains and more. [See Hendry and Ericsson (1991) for an earlier application of this technique.]

This paper applies the encompassing principle to alternative specifications of the relationship between financial market variables and real growth in industrial production. In contrast to the goodness-of-fit statistics, the encompassing principle orders the competing models. With floating exchange rates the nominal slope encompasses both stock returns and expected changes in inflation in Germany. In Japan stock returns are encompassed by both the slope and expected inflation changes. For the United States the expected change in inflation encompasses stock returns. Therefore, both the slope and the expected change in inflation have information that is not subsumed by the other.

FINANCIAL FORECASTING MODELS

INTEREST RATE-BASED FORECASTING MODELS

The empirical link between the yield spread and the business cycle is consistent with intertemporal valuation theories such as the consumption-based asset pricing model (CCAPM). The CCAPM implies a linear relationship between expected real returns and expected consumption growth. Its foundations are in Irving Fisher (1930). In theory consumption depends on wealth, and the representative agent prefers a smooth consumption stream through time. When current income is high (low) in relation to wealth, investors want to save more (less); required rates of return on financial assets adjust so that in equilibrium they reflect the marginal utility of expected future consumption relative to the marginal utility of present consumption. If the supply of investment opportunities is not unusually large (small), higher savings pull expected real returns down and lower savings push returns up. Investors' hedging behavior further twists the real yield curve up (or down) as good economic times (bad times) lie ahead.[1] Elegant modern interpretations of Fisher's theory appear in many places, including Rubenstein (1976), Lucas (1978), and Breeden (1979).

The CCAPM is a story of real interest rates; the Euler equation presented in Lucas (1978) and used by Harvey (1988) relates the ratio of real interest rates to expected consumption growth. It is straightforward, however, to redefine the Euler equation in terms of nominal interest rates and inflation. That is, let 1.0 plus the real rate equal 1.0 plus the nominal rate divided by 1.0 plus the expected inflation rate. The result is a relationship between economic growth, nominal interest rates (which are conditionally known), and the change in expected inflation.[2] This derivation suggests that both the nominal term structure and the inflation term structure have forecast power for future economic growth.[3] To investigate the predictive performance of both these measures we consider two forecasting specifications.

The term structure model contains only two forecasting variables:

(1) $IPQ_t = \alpha + \beta_1 IPQ_{t-1} + \beta_2 SLQ_{t-1} + \varepsilon_t$,

where:

α	=	The intercept;
IPQ_{t-1}	=	Growth in industrial production lagged one quarter; and
SLQ_{t-1}	=	The term structure lagged one quarter.[4]

The inflation term structure forecasting model is expressed as:

(2) $IPQ_t = \alpha + \beta_1 IPQ_{t-1} + \beta_2 \Delta\pi Q_{t-1} + \varepsilon_t$,

where:

α	=	The intercept;
IPQ_{t-1}	=	Growth in industrial production lagged one quarter; and
$\Delta\pi Q_{t-1}$	=	Expected change in inflation.

[1] One also can tell a production-based story. For example, suppose firms expect an economics slowdown. Longer-term projects become less attractive due to lower capital cash flows. The firm may choose to delay these projects. If firms maturity match projects and financing, there would be less demand in the long-term bond market which would lead to lower long-term corporate bond rates. If firms substitute shorter-term projects, then financing demand will increase short-term rates relative to long-term rates. The result is also a flattened or inverted yield curve.

[2] The derivation is available from the author.

[3] Harvey (1989, 1991a, 1991b) uses the nominal yield curve as the explanatory variable and finds that it has forecast power for future economic activity. Given their postwar experience, it is natural for investors (at least in the USA) to expect inflation to slow in recessions and to accelerate in recoveries. The Livingston economists associate greater economic growth with larger increases in consumer prices (De Bondt and Bange, 1991).

[4] All the regression models contain the dependent variable (lagged one quarter) on the right side because industrial production is autocorrelated.

It is almost impossible to know what the market's expected inflation rate is because it is not directly observed. Under rational expectations, however, the actual change in inflation differs from expected inflation by a random error term v (with mean zero and standard deviation σ_v).[5]

STOCK MARKET-BASED FORECASTING MODEL

Following Shiller's (1984) terminology, the CCAPM is a "demand-side" theory of asset prices to be contrasted with the more familiar "supply-side" discount models (e.g., Fama and Miller, 1972). In supply-side models asset prices vary with the magnitude of the cash flows (coupons, dividends, or earnings) that investors expect to receive in the future. For stocks this means that the price of any stock (at time t), P_t, reflects the future dividends D_{t+j} that shareholders expect to receive ($1 \leq j \leq \infty$). If we assume a constant discount rate r and define γ as $1/(1 + r)$, then $P_t = \Sigma\gamma^j\ E(D_{t+j}|\phi_t)$. Prices change with the available information (ϕ_t). If the news suggests that business conditions are likely to improve, dividends probably will be greater than expectations. An increase in expected dividends causes an immediate rise in stock prices. Thus, a bullish market today reflects expectations of future economic growth.[6]

The early data confirm that the stock market is an important leading indicator (Fama, 1981, 1990; Kaul, 1987). Near-term stock price changes have the most predictive power. There is also evidence, however, that the stock market does not always appear to be a reliable indicator of future growth (Harvey, 1988).

The stock market-based forecasting model can be written as:

(3) $IPQ_t = \alpha + \beta_1 IPQ_{t-1} + \beta_2 SPQ_{t-1} + \varepsilon_t$,

where:

α	=	The intercept;
IPQ_{t-1}	=	Growth in industrial production lagged one quarter; and
SPQ_{t-1}	=	Nominal stock return lagged one quarter.

DATA SOURCES AND DEFINITIONS OF VARIABLES

All the data are collected from the OECD's monthly publication *Main Economic Indicators* and from *Citibase.* (See the appendix for details.) We use three types of data: macroeconomic series, stock market returns, and interest rates. The data are computed quarterly (for the three months that end in March, June, September, and December of each year).

[5] Rational expectations is adopted as a working assumption for this model. For the 1953-1987 period, however, movements in the slope are systematically related to past survey inflation forecast errors. See De Bondt and Bange (1992) and Hardouvelis (1994) for a detailed discussion.

[6] The assumption of a constant discount rate is essential to this argument. Required returns systematically vary over the business cycle, however, due to availability of good investment projects, changes in default risk, efforts of economic agents to smooth consumption, and changes in risk aversion.

The concern is with forecasts of changes in industrial production.[7] The quarterly growth rate in seasonally adjusted industrial production is measured as 100 times the natural logarithm of the ratio of IP for month t to the equivalent number for month t - 3. The change in consumer prices is computed in a similar way.[8]

Stock returns (SR) are computed from changes in stock market indices. In general the returns measure price appreciation or depreciation, i.e., they are not corrected for dividends. We also use short- and long-term interest rates paid on government-guaranteed instruments.[9] The gap between these rates defines the nominal yield spread ($S^L = R^L - R^S$). The change in expected inflation, $\Delta\pi_e$, is not directly observable. $\Delta\pi$ is annualized inflation for the next year minus annualized inflation for the next quarter. $\Delta\pi$ serves as a proxy variable for $\Delta\pi_e$. Under rationality, they differ by the forecast error, v.

EMPIRICAL TESTS

SAMPLE STATISTICS

Summary statistics are reported in Table 1. Panel A summarizes growth in industrial production. Even though growth rates are usually positive, there are temporary setbacks that correspond to recessions. For a benchmark, real IP in the twelve OECD countries grew at an annual rate of 3.6 percent between 1964 and 1988. If we consider the full 25 year period, growth in the United States has been about average. At more than 6 percent per year, Japan's economic growth has outpaced the other countries. Panel A also lists the time series standard deviation of industrial production growth rates. There is considerable dispersion in the amplitude of economic fluctuations. For example, the standard deviation for Japan is more than twice as great as those of Germany and the USA

Panel B details monthly inflation. For the whole period inflation is lowest in Germany (3.5 percent per year). Inflation demonstrates strong persistence through time. For every country the first order serial correlation is positive.

Table 1 also contains multicountry summary statistics for stock returns and yield spreads. Japan's extraordinary economic growth is reflected in nominal stock returns that average 12.6 percent a year (panel C). On the other hand, the stock market when not adjusted for inflation shows the least long-term appreciation in Germany. The average nominal yield spread is similar for Germany and the United States. On average the yield curve is upward sloping. (Long-term interest rates are higher than short-term rates.)

[7] Changes in industrial production are of interest for several reasons. First, industrial production is a more volatile series than real GNP or consumption. For example, for the last seven recessions in the United States, the average fall in real GNP was 2.6 percent. The average decline in industrial production amounted to 9.7 percent. Second, stock prices stand a better chance of predicting changes in IP because conditions in the stock market primarily reflect what happens to the corporate sector.

[8] Due to lack of adequate inflation data for Japan, the Wholesale Price Index is used prior to February 1970.

[9] For Japan the short rate is measured by the call money rate prior to February 1977 and by the Gensaki rate thereafter.

Table 1—Sample Statistics

	Means	Standard Deviation	Min.	Max.	Autocorrelation 1	2	3	6	12
Panel A: One Month Changes in Industrial Production									
GER	.21	1.86	-9.95	12.04	.16	.05	.00	.02	.38
JPN	.52	1.36	-3.74	3.67	.21	.04	.07	.00	.00
USA	.29	.88	-4.31	3.14	.27	-.02	.00	-.02	-.01
Panel B: One Month Changes in Prices									
GER	.29	.34	-.65	2.75	.38	.26	.10	.04	.47
JPN	.38	.74	-1.18	4.12	.30	.08	.21	.31	.50
USA	.46	.33	-.55	1.79	.64	.60	.52	.48	.38
Panel C: One Month Stock Returns									
GER	.28	4.06	-24.69	12.78	.16	.05	.00	.05	.02
JPN	1.05	4.02	-11.78	11.78	.21	.04	.07	.00	.00
USA	.43	3.62	-13.41	11.02	.27	-.02	.00	-.02	-.01
Panel D: Nominal Yield Spreads									
GER	1.24	1.71	-4.79	4.42	.95	.90	.84	.64	.25
JPN	.22	1.43	-4.15	2.75	.93	.88	.83	.62	.13
USA	1.26	1.35	-2.65	4.42	.94	.85	.78	.61	.41

The sample period runs between January 1964 and December 1988. The countries are Germany (GER), Japan (JPN), and the United States (USA). Exact variable definitions are listed in the appendix. Monthly growth rates are computed as ln(X(t)/X(t - 1) • 100. Inflation is measured using the Consumer Price Index. Prior to February 1970 Japan's inflation rate is measured by the Wholesale Price Index. The nominal yield spread is the difference between the long-term and the short-term rates

LINKS BETWEEN ECONOMIC GROWTH AND FINANCIAL VARIABLES

The estimation of the three models is presented in Table 2.[10] Two periods are examined: 1964:1 to 1988:1 and 1973:3 to 1981:1.[11] The latter represents the subperiod when exchange rates are floating. The models specified are SR, the stock market model; TS, the term structure of interest rates model; and IN, the inflation term structure model. Both TS and SR show some ability to forecast industrial production. For every country the sign is positive and the coefficient is significant. The change in inflation is significant for both Japan and the United States. Stock returns lose some of their predictive power with floating exchange rates. The slope maintains its predictive power for all three countries; however, the change in inflation is important only for the United States and Japan.

Next consider the relative credibility of the three models. According to the goodness-of-fit statistics—the adjusted R^2 and residual variance—the superior model for Japan is SR; for Germany it is TS. The best model for the United States depends on the statistic chosen: SR wins based on SEE; IN wins based on R^2. For the floating exchange rate per-

[10] Because the dependent variable is defined for nonoverlapping periods, we use OLS. Quarterly growth rates in industrial production display strong positive first order serial correlation. The regressions exploit the persistence with an autoregressive term on the right side. Durbin-Watson statistics all fall within the range of 1.9 to 2.1. The residuals do not pass White's (1980) test; standard errors are corrected for heteroskedasticity using the methods of White (1980).

[11] Exchange rates were allowed to float in March 1973. The first prediction is for the third quarter of 1973 so that lagged predictor variables are measured during the floating rate period. Although the data are available through the fourth quarter of 1988, the expected change in inflation can be calculated only through 1988:1. The OLS regressions use only lagged predictors, so the estimation period runs through 1988:1.

Table 2—Industrial Production and the Financial Markets

	α	IPQ_{t-1}	SPQ_{t-1}	SLQ_{t-1}	$\Delta\pi Q_{t-1}$	R^2	SEE
Panel A: Entire Sample Period (1964:1 to 1988:1)							
Germany							
SR	.67	-.16	.08			.07	2.88
	[.35]	[.18]	[.04]				
TS	.19	-.17		.46		.09	2.83
	[.31]	[.18]		[.14]			
IN	.69	-.15			.33	.07	2.92
	[.36]	[.18]			[.18]		
Japan							
SR	.38	.57	.08			.41	1.72
	[.34]	[.14]	[.02]				
TS	.71	.44		.34		.34	1.80
	[.36]	[.15]		[.19]			
IN	.70	.49			.20	.39	1.76
	[.37]	[.16]			[.07]		
USA							
SR	.32	.47	.10			.33	1.63
	[.26]	[.13]	[.04]				
TS	-.09	.43		.46		.30	1.67
	[.33]	[.14]		[.16]			
IN	.47	.41			.50	.34	1.64
	[.24]	[.13]			[.18]		
Panel B: Floating Exchange Rates (1973:3 to 1988:1)							
Germany							
SR	.23	-.22	.05			.06	2.93
	[.44]	[.29]	[.05]				
TS	-.06	-.23		.36		.10	2.88
	[.37]	[.28]		[.17]			
IN	.32	-.21			.21	.05	2.95
	[.45]	[.29]			[.23]		
Japan							
SR	.17	.43	.09			.29	1.79
	[.40]	[.22]	[.04]				
TS	.54	.16		.61		.33	1.74
	[.37]	[.21]		[.20]			
IN	.53	.39			.18	.29	1.78
	[.40]	[.23]			[.08]		
USA							
SR	.20	.44	.11			.33	1.87
	[.33]	[.16]	[.05]				
TS	-.40	.36		.53		.29	1.92
	[.34]	[.18]		[.19]			
IN	.42	.37			.54	.33	1.87
	[.30]	[.17]			[.21]		

The dependent variable is the quarterly growth rate in industrial production (IPQ). SPQ_{t-1} is the nominal return on the stock index for the prior quarter. SLQ_{t-1} is the average nominal term structure slope for the prior quarter. $\Delta\pi Q_{t-1}$ is the change in inflation for the previous quarter. The regressions are OLS with standard errors corrected for heteroskedasticity (White, 1980) reported in brackets. The designated models are SR, nominal stock returns; TS, the nominal slopes; and IN, the expected change in inflation

iod one would conclude that TS is best. The slope has lower SEE and higher R^2 for both Germany and Japan. In contrast, stock returns and the change in inflation appear equal for the United States.

What conclusions, if any, can be drawn at this point? The test results are not consistent across the three countries. The results are engaging in at least three ways. First, Germany and Japan support Harvey's (1991) argument that the slope of the term structure is a more reliable forecaster of economic growth than the stock market is. As demonstrated by the USA, however, the tests warn against an uncritical acceptance of Harvey's findings. Second, the analysis confirms that expected inflation movements predict growth in USA industrial production.

Third, the tests illustrate the forecast reliability of the slope and the change in inflation relative to stock returns during the 1973 to 1988 subperiod. What is the source of this predictive power? Two sources come to mind, both of which affect inflation and interest rates. First, exchange rates were allowed to float in March 1973. With fixed exchange rates, countries other than the USA had little scope to use monetary policy to attain internal and external balance. During this period inflation depended on two factors: USA inflation which they were forced to import and the amount of aggregate demand pressure in their economy. Once rates are allowed to float, however, expectations of future domestic inflation play a major role. Second, the first OPEC oil shock occurred in October 1973. The United States was affected less severely than were Germany and Japan because the USA, an oil producer, was less dependent on oil imports. In all three countries, however, the oil shock contributed to higher inflation and decreased production.[12]

THE ENCOMPASSING PRINCIPLE

We still are left with the basic question: is one of the models better than the others? Goodness-of-fit statistics do not declare a clear winner. A complement to these tests is the encompassing principle of Mizon (1984) and Mizon and Richard (1986). Encompassing tests may determine the superior model.

Speaking in the broadest possible terms, empirical models are de facto reductions of a data-generating process based on certain theoretical constructs. Model rejection depends on how well it survives specification tests concerning its internal properties and implications. Unlike R^2, the residual variance is comparable and, in this sense, appropriate. Still, the standard error of the estimate does not meet classical hypothesis testing criteria, e.g., critical values. The encompassing principle combines cross-sample comparisons within a classical hypothesis testing paradigm.

To intuitively understand the concept of encompassing, consider the following. Suppose model 1 predicts $\tilde{\tau}$ as the value for the parameter τ in model 2. Model 2 actually has the estimate $\hat{\tau}$. Model 1 encompasses model 2 if $\tilde{\tau}$ is statistically close to $\hat{\tau}$. That is, model 1 explains why model 2 obtains the results it does. To the extent that model 1 more accurately characterizes the underlying data-generating process (DGP), it encompasses (denoted by ξ) model 2. For extensive tests see Mizon (1984) and Mizon and Richard (1986).

The encompassing principle assists in building a parsimonious model. It checks whether a model accounts for the variation explained by a rival and provides a further explanation of the dependent variable. It may be possible to determine which predictor

[12] For a detailed discussion of policy options under fixed and floating exchange rates see De Grauwe (1992) or Krugman and Obstfeld (1994). See Barro and Sala-i-Martin (1990) for an investigation of the relationship between oil prices, production, and interest rates.

variables should be eliminated or replaced by better alternatives. Encompassing may help to find misspecification.[13]

The encompassing principle most commonly is used for linear models. Mizon and Richard (1986) consider the Cox, Sargan, and joint F-tests as powerful instruments capable of assessing encompassing relations.[14, 15]

ENCOMPASSING TESTS

The encompassing test statistics are reported in Table 3.[16] The left side reports results for the period 1964 to 1988; the right side reports outcomes for 1973 to 1988. Recall from footnote 14 the functions of the encompassing tests. The Cox test determines whether a model variance encompasses a rival. The joint F-test determines if zero restrictions on either model alter the fit of the general model nesting the two models being compared. An insignificant Cox test statistic indicates that the model used as an instrument encompasses its rival; an insignificant F-test means that the excluded model adds no further information.

Consider first the entire sample period. In comparing IN and TS for Germany, the encompassing tests reject the null hypothesis than IN ξ TS. This agrees with the fit criteria that indicate that TS is better than IN. The test also indicate, however, that TS $\not\xi$ IN. This does not agree with the fit criteria because it indicates that the expected change in inflation has information about future economic growth that is not contained in the slope. The tests give mixed results when comparing TS and SR. The Cox test ($N(0, 1) = -3.56$, $p < .05$) does not find that TS efficiently substitutes for SR in variance. But the joint F-test ($F(1, 91) = 2.41$, $p > .05$) indicates that zero restrictions on SR do not lead to statistically different outcomes from the general model nesting TS and SR. For Japan the tests give mixed results for SR ξ TS and IN ξ TS. The Cox tests does not find that SR and IN efficiently substitute for TS in variance. In the United States none of the models encompasses a rival model.[17]

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[13] A necessary condition for encompassing is variance dominance, where one equation variance-dominates another if the former has smaller error variance (Hendry and Richard, 1989).

[14] Encompassing's statistical analog centers on the competing model's parameters and residual variances. In the former case, parameter encompassing, the concern is whether the substitution of a rival model's parameters in the current model is statistically (in)distinguishable. This substitution tests whether one theory explains as much or more than a rival. Variance encompassing, on the other hand, requires that the new parameter restrictions be at least as efficient (in terms of residual variance) as the original model.

[15] The Cox test is outlined in Green (1993, pp. 223-225). For analysis of the power of these tests, see Davidson and MacKinnon (1982), Ericsson (1987, 1991), Godfrey (1984), Godfrey and Pesaran (1983), Mizon and Richard (1986), and Pesaran (1974, 1982).

[16] The Sargan test is not reported. Both the Sargan and the joint F-test determine whether a model parameter encompasses another. Joint F tests perform better when the number of regressors are equal, however, and the model possesses a lagged dependent variable (Godfrey and Pesaran, 1983).

[17] The absence of a perfectly encompassing model suggests the need for a more powerful model that includes stock returns, the slope, and the expected change in inflation. Based on goodness-of-fit criteria, this model is superior for all three countries. It has the lowest SEE of all the models. For Germany the explained variability in industrial productions jumps to 16 percent. The explanatory power is 47 percent for the USA and 49 percent for Japan. Encompassing tests cannot be used when one of the rival models is totally nested within the other. An alternative is to consider SR, TS, and IN as restricted versions of this expanded model and then test whether the omitted variables have coefficients equal to zero. For all three models for all three countries the

Table 3—Encompassing Tests

Model	Entire Sample Period (1964:1-1988:1) Cox	Joint Model	Floating Exchange Rates (1973:3-1988:1) Cox	Joint Model
Panel A: Germany				
SR ξ TS	-8.18	5.31	-7.50	3.74
SR ξ IN	-13.77	5.51	-13.17	.91*
TS ξ SR	-3.56	2.41*	-1.66*	.75*
TS ξ IN	-12.18	3.96	-1.60*	.68*
IN ξ SR	-12.67	5.27	-5.97	1.63*
IN ξ TS	-23.94	6.65	-34.06	3.35
Panel B: Japan				
SR ξ TS	-4.77	3.37*	-9.80	4.95
SR ξ IN	-11.10	10.03	-7.33	3.50
TS ξ SR	-23.75	13.99	-1.53*	2.25*
TS ξ IN	-11.76	9.51	-3.89	1.76*
IN ξ SR	-15.52	13.48	-1.98*	1.97*
IN ξ TS	-3.08	2.44*	-6.57	2.85*
Panel C: United States				
SR ξ TS	-7.82	9.43	-7.74	8.28
SR ξ IN	-9.53	14.27	-3.30	4.94
TS ξ SR	-13.00	15.47	-6.27	1.64*
TS ξ IN	-18.81	18.36	-6.71	5.88
IN ξ SR	-8.73	13.02	-2.71*	1.16*
IN ξ TS	-10.56	10.97	-6.12	5.36

The dependent variable in all models is quarterly growth in industrial production. All models have lagged IP growth as an explanatory variable. The additional explanatory variables (all computed quarterly and lagged one quarter) in each model are SR, nominal stock returns; TS, the nominal slope; and IN, the expected change in inflation. To read the table, consider an example: SR ∈ TS is read "nominal stock returns encompass the nominal slope." Encompassing centers on the competing models' parameters and residual variances. In parameter encompassing the concern is whether the substitution of a rival model's parameters in the current model are statistically indistinguishable. This substitution tests whether one theory explains as much or more than a rival. Do nominal stock returns explain more of the movement in industrial production than the nominal slope? The joint model (a joint F-test) tests for parameter encompassing. Variance encompassing requires that the new parameter restrictions be at least as efficient (in terms of residual variance) as the original model. The Cox test determines whether a model variance encompasses a rival. Counter to traditional practice, * denotes a value less than the .05 critical value and, therefore, indicates that encompassing does occur

The tests for the floating exchange rate period yield a better model. For Germany TS encompasses both SR and IN. With respect to the former the Cox test ($N(0, 1) = -1.66$, $p > .05$) shows that TS's instruments efficiently substitute for SR's. The joint F-test ($F(1, 51) - .64$, $p > .05$) reveals that the general model nesting SR and TS does not alter when restrictions are placed on SR.

Unfortunately the dominance by the slope does not carry through to the other countries. For Japan SRs are encompassed by TS and IN. Similarly, for the United States the change in IN encompasses SR.[18] The tests are inconclusive for TS ξ SR. The Cox test does not find that TS efficiently substitutes for SR in variance. The joint F-test indicates,

test statistics are greater than the critical value ($F(2, 80), .05) = 3.11$). One again the evidence suggests all three variables have information regarding future economic growth.

[18] A reasonable conjecture is that the poor relative performance of the stock market follows from the October 1987 crash. Yet if the estimation period ends in 1987:4 (removing fourth quarter variables as predictors), the results stand.

however, that zero restrictions on SR leads to statistically different outcomes from the general model nesting SR and TS.[19]

If the conventional approaches were used for model selection, the analysis would end without selecting a best model for the years 1964 to 1988 and would find that TS is the best model among the three alternatives considered for 1973 through 1988 for Germany and Japan, but the worst for the USA. Encompassing tests confirm the latter for Germany. The encompassing principle finds that for Japan and the United States, however, that TS does not outperform its rivals except for SR. IN has unique properties that are not captured well by TS. The absence of a perfectly encompassing model is consistent with the intuition underlying the interest rate forecast models. We need a more powerful model that includes both the slope and the expected change in inflation as predictor variables. (Call it SI.)

(4) $IPQ_t = \alpha + \beta_1 IPQ_{t-1} + \beta_2 SLQ_{t-1} + \beta_3 \Delta\pi Q_{t-1} + \varepsilon_t.$

Based on goodness-of-fit criteria, this model is superior for both Japan and the USA. Explained variability in industrial production is now 39 percent for the USA and 35 percent for Japan. The SEE is also lowest for this model.[20]

As with the basic models, we turn to encompassing tests. For both countries both the Cox and joint F-test indicate that SRs are encompassed by the SI model. Unfortunately, encompassing tests cannot be used when one of the rival models is completely nested within the other. This is true of models TS and IN. We can test TS and IN as restricted versions of the expanded model, however. The tests reject the null hypothesis for both countries for both models. Both explanatory variables—slope and change in inflation—have information regarding future industrial production.

CONCLUSION

This paper investigates the predictive power of financial market variables for economic growth. Previous work may be subject to criticism because it judges the merits of different capital market predictors on the basis of goodness of fit. We address this shortcoming by applying the encompassing principle, an alternative method of assessing relationships between competing models.

The goal of this paper is ambitious: an ordering of competing models. From 1964 through 1988 all three financial variables—stocks returns, the slope of the term structure,

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[19] An alternative way to judge the relative quality of the industrial production forecasts is to compare the average standard errors (ASE) of out-of-sample forecasts. The focus is the last four quarters, starting with 1987:2. (The results are not substantially different if the last eight quarters are forecast.) The results are consistent with the encompassing tests. For Japan both the slope (ASE 1.42) and $\Delta\pi$ (ASE 1.44) outperform stock returns (ASE 1.54). For Germany TS does better than SR (3.12 and 3.72, respectively). With ASE equal 1.70 versus ASE of 1.94, IN outperforms SR in the USA. The advantage of encompassing tests, however, is the ability to compute test statistics to evaluate the competing models.

[20] It is also of interest to see whether industrial production growth and the expected change in inflation are related after netting out the effect of the slope. Partial correlation coefficients measure this relationship. The partial correlation between industrial production and the change in inflation may be interpreted as the square root of the percentage of variance in industrial production that is not accounted for by the slope, but that is accounted for by the part of the change in inflation that is uncorrelated with the slope. For the United States the partial correlation coefficient between industrial production and the change in inflation is .41; for Japan it is .27.

and the expected change in inflation—forecast industrial production. None of the models outperforms the other contenders. With floating exchange rates, however, stock returns lose their predictive power. In Germany the slope of the term structure encompasses both stock returns and the expected change in inflation. In Japan and the United States both the slope of the nominal term structure and the expected change in inflation contain information about future economic growth. The information in one variable is not subsumed by another variable. These results may reflect both the more prominent role played by monetary policy and expected inflation during a regime of floating exchange rates as well as the influence of higher oil prices on production, inflation, and interest rates.

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APPENDIX—DATA SOURCES

The data for Germany and Japan are from OECD's *Main Economic Indicators*. The USA data are from *Citibase*. Below are brief description of each time series and a list of likely breaking points. The main source of each series also is provided.

GERMANY

Industrial Production—Total, adjusted by the OECD, 1980 = 100. The base of the index changed in 1970, 1980, and 1984. Source: Deutsche Bundesbank, *Statistische Beihefte zu den Monatsberichten der Deutsche Bundesbank.*

Consumer Prices—All items, excluding seasonal items, 1980 = 100. The weighting pattern changed in 1968, 1976, and 1980. Source: Statistisches Bundesamt, *Wirtschaft und Statistik.*

Rate on Three Month Loans—Percent per annum, Frankfurt. Monthly data are daily averages. Source Deutsche Bundesbank, *Monatsberichte.*

Yield on Long-Term Government Bonds—Percent per annum. From 1971 onward only bonds with a maximum maturity of four years are included. Source: Deutsche Bundesbank, *Monatsberichte.*

Share Prices—Industrials. Monthly data are daily averages. The base of the index changed in 1966 and 1984. Source: Statistiches Bundesamt, *Wirtschaft und Statistik.*

JAPAN

Industrial Production—Total, adjusted by the OECD, 1980 = 100. The indices were linked in 1968, 1973, 1978, and 1984. The series is not adjusted for the unequal number of working days in the month. Source: ministry of International Trade and Industry, *Industrial Statistics Monthly.*

Consumer Prices—All items, including imputed rent, 1980 = 100. Weighting pattern change in 1975, 1980, and 1985. Source: Officer of the Prime Minister, Bureau of Statistics, *Monthly Statistics of Japan.*

Wholesale Prices—Total, 1980 = 100. Weighting pattern change in 1965, 1970, 1975, 1980, and 1985. Source: Bank of Japan, *Economic Statistics Monthly.*

Call Money—Percent per annum, Tokyo. Monthly figures refer to averages of daily rates from May 1972 and to the mode of daily rates previously. Source: Bank of Japan, *Economic Statistics Monthly.*

Gensaki Rate—Three months. Percent per annum. The rate is for a short-term money market where the instrument is a repurchase agreement in securities. Source: Bank of Japan, *Economic Statistics Monthly.*

Yield on Central Government Bonds—Percent per annum. Source: Bank of Japan, *Economic Statistics Monthly.*

Share Prices—Tokyo Stock Exchange, 1980 = 100. Monthly data are averages of daily indices. The index changed in January 1968. Source: Bank of Japan, *Economic Statistics Monthly.*

UNITED STATES

Industrial Production—Total, seasonally adjusted, 1987 = 100. Source: Board of Governors of the Federal Reserve System, *Industrial Production*, Statistical Release G17.

Consumer Prices—All items, seasonally adjusted, 1982-1984 = 100. Source: U.S. Department of Labor, Bureau of Labor Statistics, *The Consumer Price Index*.

Treasury Bills—Three months, percent per annum. Monthly average of daily figures in the secondary market. Source: *Citibase*.

Treasury Notes—Ten years, percent per annum. Monthly average of daily figures in the secondary market. Source: *Citibase*.

Share Prices—S&P 500 composite, monthly average of daily prices, 1941-1943 = 10. Source: Standard & Poor's Corporation, *The Outlook*.