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Arbitrage Pricing Theory and Utility Stock Returns

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ABSTRACT

This paper presents some new evidence that Arbitrage Pricing Theory may lead to different and better estimates of expected return than the Capital Asset Pricing Model, particularly in the case of utility stock returns. Results for monthly portfolio returns for 1971–1979 lead to the conclusion that regulators should not adopt the single-factor risk approach of the CAPM as the principal measure of risk, but give greater weight to APT, whose multiple factors provide a better indication of asset risk and a better estimate of expected return.

NOTWITHSTANDING INITIAL SKEPTICISM and recent challenges, the Capital Asset Pricing Model (CAPM) has been used to develop project screening rates, value companies, measure the impact of policy change on risk, and construct portfolios. Recently, the Federal Energy Regulatory Commission (FERC) proposed it as the principal measure of risk for the electric utilities it regulates. It would be ironic for acceptance of CAPM by policymakers to occur just as Arbitrage Pricing Theory (APT) threatens to replace it as an explanation of the relationship between return and risk. And it would be a pity if FERC were to adopt the single risk factor approach of CAPM when it could be demonstrated that the multiple factors of APT provide a better indication of asset risk and a better estimate of expected return.

This paper presents some new evidence that APT may lead to different and better estimates of expected return than CAPM and that it may be more helpful to policymakers as a result. We describe CAPM and APT, note work done by others, show how estimates of required returns for utilities developed by applying each model may differ, and finally report the evidence that convinces us that if one model is to be relied upon for policy purposes, APT would be the better choice.

I. CAPM and APT

CAPM should appeal to policymakers. The logic fits intuition, and measurement is simple if not unambiguous. The model is characterized by the descriptive

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equation

$$E(R_i) = R_F + [E(R_I) - R_F]\beta_i, \tag{1}$$

where $E(R_i)$ is expected return on asset i, R_F is the risk-free rate, $E(R_I)$ is expected return on the market portfolio, and β_i is $\text{Cov}(R_iR_I)/\text{Var}(R_i)$, the systematic risk of security i. Given the market conditions reflected in $E(R_I)$ and R_F, expected return on an asset is a linear function of only one variable, the asset's systematic risk.

That systematic risk can be estimated by applying the market model,

$$r_{it} = \alpha_i + \beta_i r_{It} + \varepsilon_{it}, \tag{2}$$

where r_{it} is the return on asset i in period t, r_{It} is the return on the market portfolio in the same period, β_i is the estimate of systematic risk, α_i is expected to be $(1 - \beta)R_F$, and ε_{it} is an error term with $E(\varepsilon_{it}) = 0$ representing residual risk.

APT's appeal to policymakers is not as obvious. Its logic is consistent with intuition, but its measurement is more involved. APT, like CAPM, describes expected return as a linear function of systematic risk but, unlike CAPM, it reflects the possibility that there may be more than one systematic risk factor. In APT's descriptive equation,

$$E(R_i) = R_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \cdots + \lambda_j b_{ij}, \tag{3}$$

where $E(R_i)$ is expected return on asset i, R_0 is the return on an asset that is risk free because all its b_{ij}s are zero, b_{ij} is the reaction coefficient describing the change in asset i's return for a unit change in factor j, and λ_j is the premium for risk associated with factor j.

The reaction coefficients that characterize an asset, like their CAPM β counterpart, are estimated from a market model,

$$r_{it} = b_{i0} + b_{i1}\delta_{1t} + b_{i2}\delta_{2t} + \cdots + b_{ij}\delta_{jt} + u_{it}, \tag{4}$$

where r_{it} is the return on asset i in period t, δ_{jt} is the value at time t of the mean zero factor j common to the returns of all assets, b_{ij} is the estimated reaction coefficient of asset i to factor j, b_{i0} is the estimated return on asset i when all δ_{jt} values are zero, and u_{it} is an error term with $E(u_{it}) = 0$ representing residual risk.

II. Prior Work

In any discipline, models are accepted because they increase understanding of what is observed, and they are discarded when newer models further increase understanding. CAPM has enhanced our understanding of expected returns on assets. APT, it is claimed, adds more to that understanding, explains why CAPM was a helpful step, and offers a systematic link between expected return and the return generating process.

APT is still developing. Its basis is the step, from an assumed multifactor return generating process to a linear relationship between an asset's sensitivity to these factors and the asset's expected return, that Ross [22, 23] took by attributing to investors rational behavior that exhausts arbitrage opportunities. The work that has followed embellishes on and expands the basic analysis [7, 14, 15, 16], provides simplification and variations of its presentation [1, 9], and raises questions on how to test the model and whether it can be tested [3, 8, 15, 24]. None of the research challenges or changes the basic logic that the relationship between return and risk will be determined by self-interested investors who will exploit opportunities to build portfolios of short and long positions, while making zero investment but certain, positive returns.

The empirical tests of the APT model may not satisfy all the analytic objections, but they provide no reason for suspecting that the model will fail to add something more to understanding of the return/risk relationship than does CAPM. Evidence explicitly presented as a challenge to this conclusion is offered by Reinganum [19] who, with the size effect as the example, simply argues that APT may not explain everything about expected return. Reinganum provides no indication that APT does not add to CAPM, however. He only finds that it does not tell a complete story.

Dhrymes, Friend, and Gultekin [8] question work by others but present findings that are not inconsistent with the model. Chen [6] looks at APT in an empirical study that avoids some statistical difficulties of factor analysis by drawing returns for estimating the cross-sectional return/risk relationship from days not used in developing factor sensitivities. He not only finds evidence consistent with a conclusion that APT adds to understanding but also tests for a Reinganum-like residual size effect and finds no evidence of it. That is, his approach suggests that size, if it is an important determinant of returns at all, is captured by the APT factors.

Oldfield and Rogalski [17] demonstrate that factor score estimates from bond return data can add to the explanation of stock returns that is provided by a stock index. Further, they find that the intercept and risk premiums estimated for the APT return/risk equation from stock returns and factor sensitivities are not significantly different from the values the theory predicts. Roll and Ross [20] find significant risk premiums for multiple factors in more sets of stocks than chance would suggest. Other studies [4, 5, 10, 11, 12, 13, 18, 25, 26] provide nothing to suggest that the model will fail to find support in empirical work. Even more recent work by Roll and Ross [21] urges its practical usefulness and significance.

None of this evidence indicates that CAPM now can be discarded for APT. All of it is consistent with placing greater weight on APT estimates when the two models disagree. Our findings provide further reason for doing this.

III. Estimates of Expected Return

For a policymaker to be concerned with APT's challenge to CAPM, the two models must suggest different policy choices. That they can lead to different choices is illustrated by estimates of risk and required return developed with each model for two groups of utilities: noncombination electrics and natural gas distribution companies.

We estimated CAPM Equation (2) for all companies in these two groups traded continuously on the New York and American Stock Exchanges from 1971 through 1979, using monthly returns data and the CRSP value-weighted index. The unweighted average of beta for the electrics is 0.71 and for gas distribution 0.58. To get the expected or required return associated with this risk, we used as CAPM Equation (1) the annual equivalent of the average relationship of return to systematic risk for all NYSE and ASE stocks, excluding utilities, for all months 1971 through 1979. The details of these calculations and others referred to in this section are discussed in the next section of the paper. In summary, though, the results from CAPM that a policymaker would see are:

Return/Risk Relationship: $E(R_i) = 0.0555 + 0.1085\beta_i$

	Electrics	Gas Distribution
Systematic Risk (β_i)	0.71	0.58
Required Return ($E(R_i)$)	13.2%	11.8%

We made estimates with APT using the same data. All stocks continuously traded on the New York and American Stock Exchanges from 1971 through 1979, excluding utilities, were divided into industry portfolios. Portfolio returns were factor analyzed to produce monthly scores for four factors. The monthly returns for noncombination electrics and for gas distribution companies were regressed on these monthly factor scores to obtain the sensitivity coefficients, b_{ij}s, for each electric and gas distribution company that is called for in APT Equation (4). The risk premium associated with each factor in APT Equation (3) was calculated as the average value from cross-sectional regressions of portfolio monthly returns on portfolio reaction coefficients for each month 1971 through 1979. This APT analysis provides a policymaker with information that is similar in character to but different in substance from that provided by CAPM. With premiums expressed on the basis of annual returns:

Return/Risk Relationship:

$$E(R_i) = 0.0621 - 1.8550b_{i1} + 1.4448b_{i2} + 0.1244b_{i3} - 2.7240b_{i4}$$

		Electrics	Gas Distribution
Systematic Risk	(b_{i1})	−0.0318	−0.0329
	(b_{i2})	−0.0114	−0.0065
	(b_{i3})	−0.0022	−0.0138
	(b_{i4})	−0.0017	−0.0093
Required Return	($E(R_i)$)	10.9%	13.7%

Two models produce very different results from the same 1971 through 1979 data. CAPM indicates that regulators should provide electric utilities the opportunity for a return more than 1 percent above natural gas distribution companies. APT suggests that it is the gas distribution companies that have the higher required return and that the difference is close to 2 percent. We believe the APT finding is the better policy guide.

IV. Evidence: APT Versus CAPM

Two types of evidence support APT as the better choice. The first indicates that APT can explain a larger share of return variation among the securities used in the estimation process than can CAPM. The second, which we find more compelling, is that APT is better at forecasting return on securities excluded from the estimation process than is CAPM.

Our evidence is developed from monthly return data from 1971 through 1979 for 942 stocks and for four Treasury security portfolios. (For results regarding daily and weekly returns see Section VI.) Returns for the 942 stocks are from the 1981 daily CRSP tapes and the calculation of monthly return is

$$R_{it} = [(1 + r_{i1})(1 + r_{i2}) \cdots (1 + r_{in})] - 1,$$

where R_{it} is monthly return on stock i in month t, r_{ij} is return on stock i on trading day j, and n is the number of trading days in the month. The 942 stocks are all the New York and American Stock Exchange companies traded continuously 1963 through 1980 that also appeared on the COMPUSTAT tape issued in the Spring of 1981.

The 942 stocks were divided into 30 portfolios, 18 with 31 stocks and 12 with 32 stocks. Portfolios, rather than individual stocks, were used to reduce the noisiness of the data and minimize the types of problems raised in [8]. To reduce the chance of using portfolios with similar factor characteristics, we divided stocks into portfolios by COMPUSTAT industry code. (For evidence regarding what happens when portfolios are formed differently, see Section VI.) With the exception of a few very large industry groups, all companies in an industry are in one portfolio. But, because most industries have fewer than 31 companies, most portfolios contain more than one industry. The four Treasury security portfolios differ in maturity limits, one month or less, one to two years, two to three years, and over six years. The returns on these portfolios are from Gultekin and Rogalski [13].

To gather evidence of the second type, four portfolios containing 127 stocks were excluded from our initial estimates of APT and CAPM. The holdout sample, which we use to test the predictive power of each model, consists of 77 electric utilities, 23 natural gas companies, 6 telecommunications utilities, and 21 industrials.

The first type of evidence is in what APT and CAPM can explain of the returns used in their estimation. As the single market index factor for CAPM, we used the CRSP value-weighted index. To calculate APT factor scores from the monthly returns, we used the computer programs described by Oldfield and Rogalski [17] and by Gultekin and Rogalski [13]. Four factors were specified on the basis of the findings of Roll and Ross [20]. Four is not too many and is likely to be too few, a fact of the specification that does not favor APT in a comparative analysis. The four factors explain 99 percent of the return variance, however.

With the APT factor scores and the CAPM market index calculated, we estimated APT and CAPM characteristic lines, Equations (2) and (4), for each of the 26 stock and 4 bond portfolios. All portfolios had at least one APT reaction coefficient, b_{ij}, with a t ratio above two, 28 portfolios had at least two reaction coefficients with t ratios above two, 20 portfolios had three or more above two, and 3 portfolios had all four reaction coefficients with t ratios above two. With CAPM, 29 of the 30 portfolios had a β_i with a t ratio greater than two. The $\bar{R}^2$ for the APT characteristic line was higher for each of the 30 portfolios and the average value for $\bar{R}^2$ was 0.869 for the APT characteristic lines and 0.605 for the CAPM lines. These findings are consistent with a conclusion that APT provides a better description of the return generating process than does CAPM, but its support for that conclusion is limited because the APT factor scores were created from the returns they explain. (Note further evidence on stability of factor coefficients is reported in Section VI.)

The dependence of the factor scores on the returns they explain may be less of an issue in qualifying the findings for the return/risk relationships in Equations (1) and (3). To fit these equations, we used the CAPM β_is and APT b_{ij}s estimated for each portfolio in the time series work just described and we ran cross-sectional regressions for each month with these risk coefficients as independent variables and return as the dependent variable. The mean values of the risk premiums for the 108 monthly CAPM and APT return/risk equations, the t values for those means (in parentheses), and the average $\bar{R}^2$ for the 108 monthly cross-sectional regressions are:

	b_0	b_1	b_2	b_3	b_4	$\bar{R}^2$
CAPM Equation (1)	0.00463	0.00904				0.274
	(4.53)	(1.72)				
APT Equation (3)	0.00517	−0.15458	0.12040	0.01037	−0.22700	0.425
		(−0.159)	(0.81)	(0.11)	(−2.52)	

The findings favor APT but the conclusion must still be qualified because of the origin of the APT factor scores in the return data.

The second type of evidence that favors APT needs no such qualification, because the returns explained played no part in the estimation of APT factor scores. The results for the 127 stocks in our holdout sample from the time series estimates of CAPM Equation (2) using the CRSP value-weighted index and from estimates of APT Equation (4) using the factor scores calculated with the 30 portfolios (excluding that sample) are shown in Table I. The $\bar{R}^2$ is higher for 102 of the 127 stocks using the APT factors. The addition, the explained variance with APT is significant at the 1 percent level for the 127-stock holdout sample and for six of seven industry groups when each industry is considered separately. This is evidence that APT does a better job of explaining the return generating process than does CAPM. And it requires no qualification on grounds that the factor scores providing the explanation were generated by the returns they are being used to explain.

An even better test of APT, as Brennan [3] observes, is with the return/risk relationship. Using the CAPM β_is and the APT b_{ij}s estimated for the 127 holdout stocks in the time-series analysis just described and return/risk Equations (1)

Table I

Comparison of APT and CAPM Characteristic Lines for the 127-Stock Holdout Sample

Industry	No. of Firms	b_{i1} or β APT	b_{i1} or β CAPM	No. of APT Sensitivity Coefficients with Average $t > 2$	$\bar{R}^2$ APT	$\bar{R}^2$ CAPM	Total Unexplained Variance for Industry APT	Total Unexplained Variance for Industry CAPM	F Ratio
4911, Electric	40	−0.0318	0.709	2	0.295	0.278	11.788	12.289	1.44
4931, Electric	37	−0.0312	0.647	2	0.319	0.254	9.341	10.550	4.05*
4922, Natural Gas	5	−0.0421	0.953	2	0.356	0.333	2.068	2.177	1.77*
4923, Natural Gas	11	−0.0327	0.736	2	0.307	0.245	4.485	4.905	3.02*
4924, Gas Distribution	7	−0.0329	0.577	2	0.350	0.194	1.828	2.358	7.94*
4811, Telephone	6	−0.0257	0.542	1	0.282	0.236	1.417	1.583	3.71*
9999, Other Industrial	21	−0.0647	1.325	1	0.353	0.302	23.682	26.023	3.18*
All	127	R^2 greater for APT than CAPM for 102					54.610	59.886	3.11*

* Significant at the 1% level.

and (3) that were estimated from data excluding portfolios containing the holdout sample, we forecast expected return for each holdout stock in each month using both CAPM and APT. The results are summarized in Table II. The amount of variance in return across the 127 holdout stocks that APT explains is greater than the amount CAPM explains, with the difference significant at the 1 percent level. Both CAPM and APT represent a considerable improvement over simply using the mean of all 127 stocks for all periods as a forecast of each return in each period. However, neither APT nor CAPM explains more of each return in each period than would a forecast able to use the average return of all 127 holdout stocks in a particular month as the prediction of the return on each stock in that month. The results support the position that APT should be given greater weight than CAPM but also suggest that the nonstationarity of risk premiums in both models presents a problem.

Even with stationarity problems, the average return/risk relationship for a period may provide a basis for estimating the expected return for the period of individual assets or groups of assets. The past average relationship also may be the best estimate of the return/risk relationship expected in the future. We tested the first of these possibilities.

Our test used the average return/risk relationships estimated from monthly returns, without the holdout portfolios, for 1971–1979 for CAPM Equation (1) and APT Equation (3). We put the CAPM β_is and the APT b_{ij}s for each of the 127 stocks in the holdout sample into these return/risk equations to forecast expected or required return during the 1971–1979 period for each of the 127 stocks. A summary of the return/risk equations, mean sensitivity coefficients, and forecast return and actual return for each industry represented in the 127-stock holdout sample is presented in Table III.

The quality of the forecast was assessed by using an approach suggested by Theil [28]. The Theil measure, U^2, uses the sum of squared differences of each stock's average return for the 1971–1979 period, $\bar{R}_i$, from its CAPM or APT

Table II

Explained Variance of Returns Across the 127-Stock Holdout Sample for 108 Months Using APT and CAPM

Model	Observations	Unexplained Variance*	Degrees of Freedom Used
Mean return for 127 stocks over 108 months	13716	82.3804	1
Mean return for each month for 127 stocks	13716	54.4337	108
CAPM	13716	59.6152	216
APT	13716	54.1892	540

* F ratio for APT vs. CAPM is 3.79 (significant at 1% level). F ratio for APT vs. Monthly Mean is 0.14.

Table III

Required Return for Industries Represented in the Holdout Sample Using APT and CAPM Return/Risk Relationships Estimated from Monthly Data Without Utility Portfolios for 1971–1979

APT: $\hat{R}_i = 0.005173 - 0.154584b_{i1}\ 0.120404b_{i2} + 0.010366b_{i3} - 0.227002b_{i4}$

CAPM: $\hat{R}_i = 0.004629 + 0.009038\beta_i$

	APT Sensitivity Coefficients				CAPM	Forecast Return		Actual Return
Industry	b_{i1}	b_{i2}	b_{i3}	b_{i4}	β_i	R_{APT}	R_{CAPM}	R
4911	−0.03181	−0.01141	−0.00219	−0.00168	0.70873	0.00870	0.01103	0.00457
4931	−0.03121	−0.01051	−0.00737	−0.00260	0.64692	0.00925	0.01048	0.00492
4922	−0.04212	−0.00601	+0.01387	−0.01214	0.95347	0.01386	0.01325	0.01140
4923	−0.03271	−0.01008	+0.00944	−0.01465	0.73650	0.01244	0.01129	0.01270
4924	−0.03290	−0.00649	−0.01382	−0.00932	0.57709	0.01150	0.00984	0.00807
4811	−0.02573	−0.00830	+0.00506	−0.00409	0.54211	0.00825	0.00953	0.00402
9999	−0.06471	−0.00814	+0.00372	+0.00433	1.32504	0.01413	0.01660	0.01595

forecast of return, $\hat{R}_i$, and the sum of the squared differences of average return for each stock from the average return for all stocks, $\bar{R}$. The ratio of these squared differences, U^2, for all stocks is used to evaluate the contribution of the model as a forecasting device. The smaller the ratio, the better is the model forecast relative to the naive forecast. The U^2s for CAPM and APT are:

	APT	CAPM
$U^2 = \dfrac{\sum_{i=1}^{127} (\bar{R}_i - \hat{R}_i)^2}{\sum_{i=1}^{127} (\bar{R}_i - \hat{R})^2}$	0.822	1.115

CAPM does not do as well as the naive model. APT does better than the naive model, although it still leaves 82 percent of the naive variance of the holdout sample unexplained.

As a forecasting model of required or expected return, APT does better than CAPM. It also does better than CAPM in explaining period-by-period changes in returns of individual stocks and better in explaining differences in return among stocks in a particular period. It demonstrates this superiority even though the market index used for CAPM forecasting includes the utility stocks held out in the calculation of APT factors. Leaving out the utility stocks actually biases the findings against APT by opening up the possibility that the factors most important for the utilities held out may not be represented.

V. Evidence: Utilities Included

What happens when the four portfolios containing utility stocks are included in developing APT factors and calculating the APT and CAPM return/risk relationships? Just what would be expected. APT does a substantially better job of explaining or forecasting the returns of stocks in those four portfolios. Summary figures, which match the ones in Tables I and II and should be compared to those figures, are presented in Tables IV and V.

Table IV

Comparison of APT and CAPM Characteristic Lines for the 127-Stock Holdout Sample When the Stocks Are Not Held Out

Industry	No. of Firms	$\bar{R}^2$		Total Unexplained Variance for Industry		F Ratio
		APT	CAPM	APT	CAPM	
4911, Electric	40	0.595	0.278	6.730	12.289	17.71*
4931, Electric	37	0.614	0.254	5.221	10.550	17.85*
4922, Natural Gas	5	0.425	0.333	1.833	2.177	5.58*
4923, Natural Gas	11	0.377	0.245	4.117	4.905	5.68*
4924, Gas Distribution	7	0.493	0.194	1.414	2.358	14.15*
4811, Telephone	6	0.328	0.236	1.348	1.583	5.24*
9999, Other Industrial	21	0.350	0.302	23.506	26.023	3.42*
All	127			44.169	59.886	9.27*

* Significant at the 1% level.

Table V

Explained Variance of Returns Across the 127-Stock Holdout Sample for 108 Months Using APT and CAPM When the Stocks Are Not Held Out

Model	Observations	Unexplained Variance*	Degrees of Freedom Used
Mean return for 127 stocks over 108 months	13716	82.3804	1
Mean return for each month for 127 stocks	13716	54.4337	108
CAPM	13716	56.5811	216
APT	13716	45.5825	540

* F ratio for APT vs. CAPM is 8.09 (significant at 1% level). F ratio for APT vs. Monthly Mean is 5.12 (significant at 1% level).

Table IV presents the time-series results for CAPM Equation (2) and APT Equation (4). The $\bar{R}^2$s and unexplained variances for CAPM are unchanged from Table I. This is because the CRSP value-weighted index, which includes the 127 stocks, was used in both cases. The $\bar{R}^2$s rise and the unexplained variances fall for the APT estimates. Factor scores developed with the set of 34 portfolios that includes the 127 companies originally held out, rather than the 30 portfolios that did not include them, provide APT Equation (4) estimates for these 127 stocks that fit the monthly returns much more closely. The improvement in the APT fit and the increased superiority of APT over CAPM is largest for the two groups of electrics and smallest for the industrials. The forecast improvement and the distribution of that improvement across industry groups are consistent with a conclusion that entirely omitting a class of companies, such as utilities, from the factor estimation process will provide scores that fail to reflect factors to which utilities may be particularly responsive. This is a bias against APT in our holdout tests that makes the holdout findings presented in the previous section even more impressive.

Table V shows the cross-sectional results from estimating return/risk Equations (1) and (3) monthly with portfolios that include the 127 stocks formerly held out, then using those equations with the risk coefficients of each stock to forecast its return in the month. APT's advantage over CAPM is increased from that shown in Table II, and APT now explains significantly more return variance than is explained by using the average return of the 127 stocks in each month as the predictor. The same improvement is reflected in Theil's U^2 for APT. The U^2 results using the average monthly return/risk equations for CAPM and APT and the risk coefficients for each of the 127 stocks to predict the stock's average return for the 108 months are now:

	APT	CAPM
$U^2 = \frac{\sum_{i=1}^{127} (\bar{R}_i - \hat{R}_i)^2}{\sum_{i=1}^{127} (\bar{R}_i - \hat{R})^2}$	0.505	1.018

CAPM still does no better than the naive alternative but APT explains about half the variance of actual return from the return forecast by the naive model.

It is difficult to develop APT factors that reflect the influences that strongly affect a particular group of companies when that group of companies is not included in the statistical estimation process used to develop the factors. But it is tempting to conclude, when that group of companies is included, that any APT advantage in explaining their return behavior simply is the result of a statistical method that catches their period-specific idiosyncracies. We have tried it both ways and found that together the two ways provide a stronger case for preferring APT to CAPM as an explanation of the return/risk relationship than either holding out or including would provide if considered alone.

VI. More Evidence for APT

The comparative analysis of CAPM and APT in explaining and forecasting returns on the basis of risk characteristics and market relationships is not the only work we have done on APT. Other findings, presented in [1, 2], which we will only note here, also influence our conclusion that policymakers would be wrong to ignore APT results and/or fail to weight APT more heavily than CAPM.

We paralleled our holdout analysis of monthly returns with an analysis using weekly returns. The weekly work differed only in that the portfolios used in the initial estimation procedures numbered 28 and included two rather than four Treasury security portfolios. The results were similar. $\bar{R}^2$s for the portfolios were higher for APT Equations (3) and (4) than for CAPM Equations (1) and (2). APT explained significantly more of the return variance for the 127 holdout stocks in each industry group in the time-series tests using Equations (2) and (4) and significantly more of the variance for all 127 stocks in the cross-sectional tests of Equations (1) and (3). The U^2s for APT and CAPM that parallel the monthly U^2s were 0.498 and 0.938, respectively.

We also worked with daily returns for the years 1971 through 1980. Our concern in this work was with the characteristics of APT estimates and whether APT factors and sensitivity coefficients were more likely to be a reflection of real, continuing relationships than a product of statistical manipulation. We used no holdout sample and the work was with 30 stock portfolios.

Initially we formed portfolios by three different methods. The first set was alphabetic, essentially random; the second set was by CAPM β, with the first portfolio made up of the lowest beta stocks and the thirtieth portfolio made up of the highest β stocks; and the last set was by industry group. We generated factor scores for four factors with each set of portfolios and found that the scores for the first factor, presumably the "market" factor, had almost identical movement. The other factors differed depending on the portfolio set used to generate them. We concluded that each portfolio set's four factors, when combined with the associated factor sensitivity coefficients, might provide a meaningful description of how return varied with risk, but that the factors estimated had to be considered constructs or combinations of the real factors operating rather than representations of the individual real factors themselves. We found that, no matter which portfolio set we used, APT Equation (3) explained more of the variance in portfolio returns as a function of risk sensitivity than did CAPM Equation (1). We also found that in the industry set more of the APT factor risk premiums were significant, confirming our idea that the industry breakdown would contribute more to portfolio diversity required to distinguish risk factors. That is, interportfolio dissimilarity seems important in estimating common factors designed to maximize explanation of returns.

Working with the industry portfolios, we split the 1971 through 1980 daily returns into two sets of five years each. We developed scores for four APT factors for each period as well as for the full period. We estimated factor sensitivities for each portfolio for each five-year period using the factor scores developed from the period's returns. Scores for each factor from each subperiod had essentially the same movement as scores for the subperiod developed from returns for the full ten years. For 1976–1980, for example, factor four scores generated from 1976–1980 returns had a 0.95 correlation with corresponding scores for 1976–1980 generated using 1971–1980 returns. For factor one, two, and three scores, the correlations were even higher. Sensitivity coefficients for portfolios from each subperiod were also closely related. Cross-sectional regressions of b_{ij} for 1976–1980 on b_{ij} for 1971–1975 with the 30 portfolio observations produced R^2s of 0.74 for b_{i1}, $-$ 0.79 for b_{i2}, 0.46 for b_{i3}, and 0.64 for b_{i4}. This consistency in the estimate of factor scores and factor sensitivities with different sets of returns convinced us that the APT model's success in using risk to explain and forecast returns was more likely the result of the model's reflection of real relationships than of the "hunting license" the APT model may provide for sophisticated statistical search.

VII. Conclusion

The case for APT is certainly not decisive, neither as others have developed it, nor as we have expanded upon it. In our tests, however, APT does do better than CAPM in explaining and conditionally forecasting return variations through time and across assets. Others might make different choices of form and estimation methods for CAPM and APT, and their results might show APT in a less favorable light. Until conflicting results emerge, though, we believe policymakers should not adopt CAPM as a sole standard. Instead they would be wise to give APT greater weight in decisions.

REFERENCES

1. Dorothy H. Bower, Richard S. Bower, and Dennis E. Logue. "APT Project, July 20, 1982." Mimeo, Amos Tuck School of Business Administration, Dartmouth College, 1982.
2. ———. "Equity Screening Rates Using APT." Mimeo, Amos Tuck School of Business Administration, Dartmouth College, 1982.
3. M. J. Brennan. "Discussion of Treasury Bill Factors and Common Stock Returns." *Journal of Finance* 36 (May 1981), 352–53.
4. P. Brennan. "A Test of the Arbitrage Pricing Model." Working paper, University of British Columbia, 1981.
5. S. J. Brown and M. I. Weinstein. "A New Test of the Arbitrage Pricing Model." Bell Laboratories, 7 August, 1981.

6. Nai-fu Chen. "Some Empirical Tests of the Theory of Arbitrage Pricing." *Journal of Finance* 38 (December 1983), 1393–1414.
7. Gregory Connor. "Asset Prices in a Well Diversified Economy," Working paper, Yale University, 1980.
8. Phoebus J. Dhrymes, Irwin Friend, and N. Bulent Gultekin. "Contribution of Arbitrage Pricing Theory to Capital Asset Pricing." Preliminary draft of paper presented to European Finance Association, Jerusalem, September 1982.
9. H. Russell Fogler. "Common Sense on CAPM, APT, and Correlated Residuals." *Journal of Portfolio Management* 8 (Summer 1982), 20–28.
10. ———, John Kose, and James Tipton. "Three Factors, Interest Rate Differentials and Stock Groups," *Journal of Finance* 36 (May 1981), 323–35.
11. Adam Gehr, Jr. "Some Tests of the Arbitrage Pricing Theory." *Journal of the Midwest Finance Association* (1976), 91–105.
12. Michael Gibbons. "Empirical Examination of the Return Generating Process of the Arbitrage Pricing Theory." Working paper, Graduate School of Business, Stanford University, 1981.
13. N. Bulent Gultekin and Richard J. Rogalski. "Government Bond Returns, Measurement of Interest Rate Risk, and the Arbitrage Pricing Theory." Working paper, Amos Tuck School of Business Administration, Dartmouth College, 1982.
14. Gur Huberman. "Arbitrage Pricing Theory: A Simple Approach." Working paper, Yale University, 1979.
15. Jonathan E. Ingersoll, Jr. "Some Results in the Theory of Arbitrage Pricing." Working paper No. 67, Graduate School of Business, University of Chicago, Revised April 1982.
16. Robert Jarrow and Andrew Rudd. "Real Assets, Technology and the Arbitrage Pricing Theory." Working paper, Graduate School of Business and Public Administration, Cornell University, May 1980.
17. George S. Oldfield and Richard J. Rogalski. "Treasury Bill Factors and Common Stock Returns." *Journal of Finance* 36 (May 1981), 337–50.
18. Robert A. Pari and Son-Nan Chen. "An Empirical Test of the Arbitrage Pricing Theory." *The Financial Review* 17 (July 1982), 64.
19. Marc Reinganum. "The Arbitrage Pricing Theory: Some Empirical Results." *Journal of Finance* 36 (May 1981), 313–21.
20. Richard Roll and Stephen A. Ross. "An Empirical Investigation of the Arbitrage Pricing Theory." *Journal of Finance* 35 (December 1980), 1073–1103.
21. ———. "Regulation, the Capital Asset Pricing Model, and the Arbitrage Pricing Theory." *Public Utilities Fortnightly* 111 (May 26, 1983), 22–28.
22. Stephen A. Ross. "The Arbitrage Theory of Capital Asset Pricing." *Journal of Economic Theory* 13 (1976), 341–60.
23. ———. "Return, Risk, and Arbitrage." In *Risk and Return in Finance*. I. Friend and J. Bicksler (eds.), Volume 1, Cambridge, MA: Ballinger, 1977, 189–218.
24. Jay Shanken. "The Arbitrage Pricing Theory: Is It Testable?" *Journal of Finance* 37 (December 1982), 1129–40.
25. William F. Sharpe. "Factors in New York Stock Exchange Returns, 1931–1979." *Journal of Portfolio Management* 8 (Summer 1982), 5–19.
26. Richard J. Sweeney and Arthur Warga. "Affects on Estimating Beta of Changes in Expected Inflation: The Case of Electric Utilities." 4th Draft, Claremont McKenna College, April 1981.
27. ———. "Indeterminants in the Arbitrage Pricing Theory with Observable Factors." Draft, Claremont McKenna College, April 1981.
28. Henry Theil. *Applied Economic Forecasting*. Amsterdam: North-Holland Publishing Co., 1966.