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SURVEY OF THE LITERATURE

THE PROGENY OF CAPM

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Do firm-specific characteristics such as size, book-to-market ratio, and momentum explain virtually all of the expected return differentials on stocks? If so, then is the Capital Asset Pricing Model (CAPM) really dead? Can conditional betas resurrect the CAPM? Do state variables such as the aggregate dividend yield, the term spread, the default spread, and the riskless rate explain the cross-section of expected returns under Merton's Intertemporal Capital Asset Pricing Model (ICAPM)? Do coskewness and cokurtosis risks matter for pricing stocks? What explains the sudden disappearance of Ross' Arbitrage Pricing Theory (APT) from the asset pricing literature? How do beta asymmetries in up and down markets affect expected return relations? The above questions point towards a diversity of issues in the asset pricing literature that a practitioner must grapple with before selecting a model for valuing stocks or making capital budgeting decisions.

A few years after William Sharpe (1964) received the Nobel Prize for inventing the CAPM in 1990, Fama and French (1992, 1993) announced the death of the CAPM in highly influential articles. By demonstrating that firm-specific characteristics such as size, earnings-to-price, debt-equity, and book-to-market ratios explain virtually all of the expected return differentials on stocks, Fama and French found no role for the CAPM beta. At first, the path-breaking article of Fama and French (1992) seemed bad news not only for the CAPM, but also for much of asset pricing since it implied the existence of riskless arbitrage opportunities through the pricing of firm-specific characteristics. However, since riskless arbitrage also contradicts market efficiency, Fama and French (1993, 1996) (FF) modified their earlier conclusion as follows. Instead of using firm-specific characteristics, they created *portfolio risk factors* that mimic the roles of size (using the difference between the returns on diversified portfolios of small and big stocks) and book-to-market ratio (using the difference between the returns on diversified portfolios of high and low book-to-market ratio stocks), in addition to the return on some proxy for the market index, to explain expected return differentials on stocks. In the last decade, the three-factor FF model has become a benchmark model against which all other models are evaluated.

Two alternative explanations have emerged for explaining the findings of the FF model. The

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behavioralists remain unimpressed by the risk-based explanations of the FF model. They claim that the irrational behavior of the investors based on greed, fear, habit, misjudgment, etc., allows firm-specific characteristics, accounting ratios, and price momentum to explain the cross-sectional variation in the expected returns. For example, the behavioralists claim that the high risk premium associated with the book-to-market factor—which is responsible for most of the improvements over the CAPM—is itself a result of investor over-reaction. Investors over-extrapolate based upon past performance, which results in stock prices that are too high for growth (i.e., low book-to-market ratio) stocks and too low for value (i.e., high book-to-market ratio) stocks. The unusually high returns for value stocks result from the subsequent correction of the overreaction by the investors. Interestingly, behavioralists reject not only the CAPM, but also the three-factor FF model, based on the anomalies related to price momentum, firm-specific characteristics, and accounting ratios.[1]

Fama and French (2004) suggest that an important area of search for a rational explanation of the CAPM failure is the investigation of multi-factor risk-based models, such as Merton's (1973) ICAPM and Ross' (1976) APT. Though the initial evidence regarding the ICAPM is favorable, it is highly unlikely that the FF model is consistent with the APT.

The story of asset pricing got a strange twist in the early to mid-1990s when a *theoretical* arbitrariness regarding Ross' APT was discovered, right after it seemed to have won the long battle against the CAPM in the 1980s. This peculiar problem did not come as an extension to the empirical critiques of Shanken (1982, 1985), which were similar in spirit to Roll's (1977) critique of the CAPM, but from the new theoretical findings of Reisman (1992) and Nawalkha (1997).

If the FF model is inconsistent with the APT (as discussed in the next section), then, could other "rational" risk-based stories explain the failure of the CAPM? Fortunately, the answer to the above question has become a "yes," especially in the past few years. Unlike the claims of Fama and French (1992, 1993, 2004), the CAPM has survived, as many conditional versions of this model explain significant portions of the pricing errors related to the various asset-pricing anomalies. Further, many extensions of the original CAPM based on state variables in the intertemporal context, and higher-order co-moments in the single period context, have appeared in the literature. Not only are these extensions not rejected by the data, they perform better than the three-factor FF model. So the progeny of the CAPM is alive and well. We review this new and exciting stream of research in Section 2, after reviewing the current status of the APT in the next section.

1 A reexamination of APT

Nawalkha (2004) explains the disenchantment with the APT, and the resurgence of the ICAPM as follows. Ross (1976) and Huberman (1982) showed that if the asset returns follow a finite-dimensional factor structure with error terms uncorrelated across assets, then the absence of arbitrage guarantees that the sum of squared deviations from an APT pricing relation remains finite, even as the number of assets becomes infinite. Ross interpreted this to mean that *most* assets are priced with infinitesimally small error, even though a *few* assets may be mispriced significantly.[2]

The theoretical arbitrariness of the APT was revealed by the multibeta representation theorems of Reisman (1992)[3] and Nawalkha (1997), which proved that, under the assumptions of the APT, the sum of squared deviations from the APT pricing relation remains finite even if the original factors are replaced by arbitrary reference variables correlated with the factors (e.g., price of tea in China and IBM stock return can replace the two factors in a two-factor APT model!). Further, according to the multibeta theorem of Nawalkha (1997, Theorem 1), the original K factors can be replaced by virtually any K asset returns *without any loss in pricing accuracy*, both in finite and infinite economies with uncorrelated residuals, for both the APT and the equilibrium APT models.

Also, any weakly correlated residuals economy can be converted into an uncorrelated residuals economy, in which most of the repackaged assets remain "quite similar" to the original assets (see Grinblatt and Titman, 1985). Since the repackaged assets have uncorrelated residuals, any K repackaged asset returns—which may contain significant idiosyncratic risks—can price all the remaining assets without any loss in pricing accuracy, even if the original economy has weakly correlated residuals as in the APT models of Chamberlain and Rothschild (1983) and Ingersoll (1984), and the equilibrium APT of Connor (1984).

Hence, if the FF model is consistent with the APT, then there must be nothing special about the three specific well-diversified risk factors based on book-to-market, size, etc., since any three arbitrarily chosen stock returns (or three repackaged asset returns), or portfolio returns can replace the three diversified factors for pricing all other stocks![4] This is obviously bizarre, and inconsistent with the most basic intuition of asset pricing in the equity markets. However, note that the APT applies well in the markets where the arbitrariness of the pricing factors is not an issue, such as the term structure models or the derivative pricing models. Since the arbitrariness of the APT pricing relation is *theoretically* implied, it may prove to be a serious challenge to its very survival, unlike the *empirical* arbitrariness of the factors pointed out by Shanken (1982).[5]

2 CAPM, and its progeny

Fama and French (1992, 1993) could not have hoped for a better response from their critics on the failure of the CAPM reported by them. The mispricing of stocks related to value and size created an immediate furor, even though these anomalies had been published repeatedly by many, and had been well known for more than a decade. Partly, this was because, unlike others, Fama and French boldly announced that the CAPM emperor was naked and dead! Immediately, many explanations based on data mining (or snooping), survivorship bias, and beta estimation were leveled against their findings.[6] However, over time, other researchers with different data sets and corrections to survivorship bias found additional support for the main criticisms of the CAPM (for a recent survey see: Fama and French, 2004).

In defense of the CAPM, the results of Roll and Ross (1994) and Kandel and Stambaugh (1995) show that a slight deviation from the mean–variance efficiency frontier can produce a complete absence of relationship between expected returns and betas, so the findings of Fama and French should not be surprising. Despite the above results, Kothari *et al.* (1995) (KSS) find that the compensation for market beta risk measured using *annual* intervals is about 6–9%, which is both economically and statistically significant. Though KSS find some evidence of a size effect, they question the role of survivorship bias for explaining the weak book-to-market effect. Ang and Chen (2003) demonstrate that over the long run from 1926 to 2001, the CAPM can account for portfolios sorted by book-to-market ratios. Cohen *et al.* (2002), using stock prices instead of returns, and cash flow betas instead of return betas, find that mispricing is not an important factor in determining the prices of value and growth stocks using the CAPM. They also find that premium on the cash-flow-based market beta remains high even after including size-sorted portfolios. Mello-e-Souza (2002) argues that even though CAPM is theoretically consistent with bankruptcy and limited liability, the measures of expected returns and systematic risks have never been estimated with an appropriate adjustment for these features. Mello-e-Souza finds that ignoring these features, especially when using the portfolio tests, can lead to significant biases that can translate into some of the asset pricing anomalies.

What has become clear through this debate is that the reports of the CAPM's death may be greatly exaggerated since the evidence is quite mixed. However, the perceived failure of the CAPM by many has opened up a fresh challenge in asset pricing research: to derive and test new asset pricing models that can explain the anomalies noted by Fama and French. Many have responded to this challenge and three major classes of extensions to the original CAPM have appeared in the literature:

1. Conditional CAPMs
2. Intertemporal CAPMs
3. Higher-order co-moment-based CAPMs

2.1 Conditional CAPMs

Conditional CAPMs allow the asset betas and the market risk premium to be non-stationary over time, and assume that the single-beta CAPM holds period by period. Jagannathan and Wang (1996) (JW) and Petkova and Zhang (2003) find that the betas of small size and high book-to-market stocks vary over the business cycle in a manner that results in positive alphas as found in the tests of the unconditional CAPM by Fama and French. JW show that the single-beta conditional CAPM leads to a two-beta unconditional CAPM, which together with a proxy for human capital can explain much of the value premium and size premium discovered by Fama and French.

Petkova and Zhang (2003), using the changes in *expected* market risk premiums instead of *ex-post* market risk premiums, find a novel result. They show that conditional market betas of value stocks covary positively with the expected market risk premium, while conditional market betas of growth stocks covary negatively with expected market risk premium. They show that the above beta asymmetry between value and growth stocks was not found earlier because most researchers used *ex-post* changes in the market risk premium instead of *ex-ante* or expected changes. Their results are consistent with the conditional CAPM of JW, and explain away much of the value and size premiums.

Zhang (2003) demonstrates that value stocks are a lot riskier than growth stocks, especially in economic downturns when the market price of risk is high. High betas for value stocks during bad economic times when market price of risk is high, largely explains the high positive alphas associated with these stocks, using the *unconditional* version of CAPM. Zhang uses *costly reversibility* of investments as the main endogenous reason for explaining the increase in the risks of value stocks in bad economic times. Similar results favoring the conditional CAPM are also reported by Adrian and Franzoni (2002), Franzoni (2004), and Lustig and Nieuwerburgh (2003).

Though the conditional CAPM is theoretically motivated by Sharpe's constant beta CAPM, it is empirically implemented with changing betas and risk premiums. This creates a slight problem since this model can be neither considered a special case of the multi-beta ICAPM, nor is it consistent with the single-beta CAPM. In general, for the conditional single-beta CAPM to be consistent with the unconditional single-beta CAPM, the covariance between changes in the beta and the changes in the market risk premium (or market volatility) must be zero. Otherwise hedging demands are created in an intertemporal context (see Chen, 2002).

Ang and Chen (2003) consider a simpler version of the conditional CAPM by allowing persistent time-varying betas, while assuming a *constant* market price of risk. Thus, they derive a conditional CAPM that does not create hedging demands as the other conditional CAPMs discussed above do. Ang and Chen find that over the long run, from 1926 to 2001, the CAPM can account for the spread in the returns of value sorted portfolios. Unlike Fama and French and others who find a strong book-to-market effect using asymptotic standard errors in the post-1963 period, Ang and Chen (2003) using the correct small sample inference, find the post-1963 book-to-market effect is statistically insignificant. Ang and Liu (2004) also show the importance of capturing the effects of beta variation using the conditional CAPM for discounting cash flows.

Given the importance of beta variation, many papers have focused on the sources and patterns of this variation itself, abstracting from the issue of explaining the anomalies related to the CAPM. The work of Jostova and Philipov (2004) proposes a general theoretical framework for the time-varying beta model, which allows significant improvement in the estimation of the latent betas. The model by these authors nests most other beta models as special cases and allows testing of their restrictions. Using a simulation study, they demonstrate their approach to be superior to many competing methods such as GARCH or rolling regression models.

Santos and Veronesi (2004) study the sources of time variation in the conditional betas. They find that the conditional betas depend upon the level of market risk premium, the firm's expected dividend growth, and the firm's fundamental risk measured by its cash flow covariation with the economic conditions. They also find support for the theoretical predictions of their model when the firm's fundamental risk is high.

Finally, Andersen *et al.* (2003) assess the dynamics and predictability of the realized betas, relative to those of the underlying market variance and covariances. They find that although the realized variances and covariances fluctuate wildly and are highly predictable and persistent, the realized betas display less persistence and predictability.

Just when most researchers in the asset pricing field became convinced that the conditional CAPMs do explain the failure of the unconditional CAPM, Lewellen and Nagel (2004) called into question one of the main results underlying the success of the many conditional CAPM models. Lewellen and Nagel demonstrate that the covariations between the betas and the market risk premium (and/or the market return volatility) are just too low for explaining the large pricing errors reported by Fama and French and others, due to the book-to-market and momentum effects. They show that using the more realistic parameter values, the conditional CAPM should explain a small fraction of the pricing errors of the unconditional CAPM.

Though the results of Lewellen and Nagel may make one skeptical about the conditional CAPMs of Jagannathan and Wang (1996), Petkova and Zhang (2003), and others, recall that the conditional CAPM of Ang and Chen (2003) still remains valid as it does not depend upon the covariation between betas and market risk premiums. More research is required to assess whether the conditional CAPMs can continue to explain the failure of the unconditional CAPM, in the light of the important findings by Lewellen and Nagel (2004) and Ang and Chen (2003).[7]

2.2 Intertemporal CAPMs

The ICAPM framework allows the pricing of state variables correlated with the market portfolio return, because in an intertemporal framework investors not only care about the current return on the market portfolio, but also about the relationship between future returns on the market and the state variables describing the economic opportunities (e.g., investors may value those stocks more, which do well when their labor income is low, or when inflation is high). However, it is hard to make a case that the empirically motivated firm-characteristics-based risk factors in the FF model represent the state variables in the ICAPM framework. In fact, Chen (2002) demonstrates that risk premiums associated with empirically constructed factors such as book-to-market are *too high* to be justified as the changes in the state variables within the ICAPM framework.

Some researchers have investigated if the FF factors are related to the state variables representing macroeconomic variables. The relationship between the size and book-to-market factors and macroeconomic growth rates has been shown by Liew and Vassalou (2000), Lettau and Ludvigson (2001), and Vassalou (2003). However, Campbell (1996) suggests that the empirical implementations of the ICAPM model should be more directly related to the innovations in state variables that represent future investment opportunities instead of changes in the macrovariables.

In an important study, Petkova (2004) follows Campbell's suggestion and selects the state variables, which most likely represent future investment opportunities, such as the one-month Treasury-bill rate, the term spread, the default spread, and the dividend yield. Petkova finds that the ICAPM based on the above state variables has more explanatory power than the three-factor FF model. In addition, Petkova finds that when the loadings on the chosen state variables are present in the model, the loadings on the size and the book-to-market factors lose their explanatory power for the cross-section of returns. The superiority of Petkova's model comes from its ability in explaining common time-varying patterns in returns. It captures cross-sectional differences in sensitivities with respect to conditioning information. As shown by Ferson and Harvey (1999), the FF model is unsuccessful in capturing the effect of conditioning information.

In another interesting paper, Brennan *et al.* (2003) (BWX) assume the real interest rate and the Sharpe ratio as the two state variables under the ICAPM. BWX further assume that both these state variables follow correlated Ornstein–Uhlenbeck processes, so that their current values are sufficient statistics for the future investment opportunities. Using both a two-stage cross-sectional regression procedure and a GMM test procedure, BWX demonstrate their two-state-variable ICAPM model is not rejected, while both the CAPM and the three-factor FF model are rejected.

Campbell and Vuolteenaho (2004) explain the size and value anomalies using a two-beta model consistent with the ICAPM. The static single-period market beta is broken into two betas in an intertemporal setting, one reflecting market's cash flows, and the other reflecting market's discount rate. The ICAPM suggests that the former beta should have a higher market price of risk. Campbell and Vuolteenaho find that the value stocks and small stocks have considerably higher cash flow betas than growth stocks and large stocks, which explains their higher expected returns.

The results of BWX, Petkova, and Campbell and Vuolteenaho are fascinating and are sure to attract more interest in the investigations of the ICAPM. In hindsight, these results make one wonder why more serious investigations of ICAPM with intuitively appealing state variables were not done until recently, especially in the light of the crisis in asset pricing unleashed by Fama and French. Perhaps, as BWX explain, this was due to "the tendency to lump the ICAPM and APT as simply different examples of factor pricing models," and not recognize the important role of state variables as the predictors of future returns.

2.3 Higher-order co-moment-based CAPMs

Skewness preference is a stylized feature of economic decision-making, as almost everyone buys insurance of some kind and many of us also gamble and/or buy lotteries. How is skewness reflected in asset pricing? Though attempts to answer this question have been made since the late 1970s, when stock returns were first discovered to be skewed and leptokurtic, it has assumed new relevance over the last decade as anomalies due to size, value, and momentum have been reported. It is somewhat intuitive to expect the return distributions of stocks sorted on size, growth, and momentum to have differences in coskewness (and perhaps, cokurtosis) with the benchmark portfolios. If so, then is it possible that failure of the unconditional CAPM has resulted simply because it is misspecified, and the asset pricing anomalies are just capturing the omitted effects, such as coskewness and cokurtosis risk?[8]

Smith (2003) estimates a *conditional* three-moment CAPM using a GMM estimation of the time-varying coskewness. Smith's approach avoids modeling asset specific parameters, does not *explicitly* model the co-moments, and is robust to distributional assumptions about asset returns. Smith finds that both a conditional two-moment CAPM and a conditional version of the three-factor FF model are rejected, but a model that includes coskewness is not rejected. Further, Smith finds that the investors are highly concerned about coskewness risk when the market is positively skewed, sacrificing, on average, 7.81% annually when holding positive gamma stocks. However, when the market in negatively skewed, investors seem relatively unconcerned about coskewness risk. Smith also finds certain statistical estimation advantages of using his method over the SDF approach used by Dittmar (2002) and the explicit moment-based conditional coskewness CAPM of Harvey and Siddique (2000). Interestingly, unlike Dittmar who found that cokurtosis is the important unexplained risk, Smith finds that conditional coskewness with his general methodology can explain more of the variation in expected returns.

On the theoretical front, Jurczenko and Maillet (2002) derive a four-moment Kernel Asset Pricing Model (KAPM). From the pricing kernel the authors extract a linear relation for expected returns using four benchmark portfolios: the market portfolio, the riskless asset, a skewness spanning portfolio, and a kurtosis spanning portfolio. In another theoretical development, Nawalkha (1997, 2004) argues that a more intuitive interpretation of the "factors" in a K-factor MFST (see Ross, 1978) or equilibrium APT model is that these factors represent higher-order co-moment risks, leading to higher-order co-moment CAPMs.

3 Summary and conclusions

Fama and French (1992, 1993) changed the course of research on asset pricing theory by challenging the empirical validity of the CAPM, the main text-book model for asset pricing in finance. Interestingly, we find that their results may not be fatal for the CAPM as the conditional versions of the CAPM can explain many of the asset pricing anomalies. Paradoxically, Nawalkha (1997, 2004) demonstrates that the APT is inconsistent with the pricing of the three specific factors discovered by Fama and French (1993) due to the arbitrariness of its pricing implications.

The progeny of the CAPM is alive and well, as a variety of extensions based on state variables in the intertemporal context, and higher-order co-moments in the single-period context, can explain the asset pricing anomalies noted by Fama and French. Further, many of these multifactor extensions have higher explanatory power than the three-factor FF model and are not rejected in the empirical tests, even when the data reject the FF model. Another class of CAPMs that the readers may wish to explore is that of semi-variance CAPMs, which are based on the downside beta. Post and Vliet (2004) and Estrada (2003) find evidence that the relationship of expected returns is much stronger with the downside betas than it is with the standard CAPM betas.

Notes

1 A huge behavioral literature on this topic is outside the scope of this article which is primarily concerned with rational risk-based explanations of the CAPM failure.

2 Shanken's (1982) critique was based on the meaning of the italicized words, "most" and "few" in the previous sentence, since in the real world we do not have an infinite number of assets, and so the sum of squared pricing deviations *must always remain finite* (i.e., the APT result is a tautology with no empirical content). However, the APT survived Shanken's critique as the interest in the theory grew throughout the 1980s, as new equilibrium versions of the theory were derived that seemed to address Shanken's critique.

3 See Shanken (1992) for a non-technical summary of Reisman's (1992) critique of the APT, and some other important insights.

4 See the previous footnote and the results in Nawalkha (1997) on a large variety of *well-diversified variables*, including arbitrary non-linear functions of the factors, all of which can substitute for the original factors without any loss in pricing accuracy.

5 The empirical unobservability of the market portfolio for the CAPM pointed out by Roll (1977) does not invalidate the CAPM, *theoretically*.

6 See Black (1993), Kothari *et al.* (1995), MacKinlay (1995), and Conrad *et al.* (2003), among others.

7 Since this article focuses on the recent working papers, we have not cited many of the conditional CAPM models from the late 1980s and early 1990s.

8 The tests of the pricing of *unconditional* coskewness risk in the 1970s were not highly successful. This was expected as coskewness is highly non-stationary, especially for stocks that exhibit momentum and reversals, represent rapidly growing or shrinking companies, or companies whose assets are dominated with options sensitive to economic conditions. Also, the whole market exhibits periods of positive and negative skewness. Unlike covariance risk, which remains positive for most stocks, coskewness may vary from positive to negative for individual stocks.

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