Emerging Trends: Asset Pricing

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Abstract

The modern field of asset pricing is organized around the concept of the stochastic discount factor. This essay uses this framework to discuss the literature on predictability of asset returns in the short and long run, the influence of irrational investor expectations on asset prices, and the cross-section of stock returns. Future progress will require microeconomic data on investor actions and ideally survey evidence on their risk preferences and beliefs.

INTRODUCTION

During the past 40 years, the field of asset pricing has exploited a standard conceptual framework to make a series of important empirical findings. While there remains disagreement about how to interpret these facts, the disagreement is expressed in a common language. The intellectual coherence of the field was recognized by the award of the 2013 Nobel Memorial Prize in Economics to Eugene Fama, Lars Peter Hansen, and Robert Shiller for empirical analysis of asset prices. This review, drawing on Campbell (2014), shows how emerging trends in asset pricing relate to the standard framework.

THE STOCHASTIC DISCOUNT FACTOR: THE FRAMEWORK OF CONTEMPORARY FINANCE

The SDF in Complete Markets

The modern theory of the SDF can be summarized as follows. Consider a discrete-state model with two periods, the present and the future, and complete markets. There are S states of nature $s = 1 \ \dots \ S$, all of which have strictly positive probability $\pi(s)$. Markets are complete, that is, for each state s a contingent claim is available that pays \$1 in state s and nothing in any other state. Write the price of this contingent claim as $q(s)$. All other assets can be defined by their state-contingent payoffs $X(s)$.

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The absence of arbitrage implies that all contingent claim prices are strictly positive and that the price of any asset satisfies

$$P(X) = \sum_{s=1}^{S} q(s)X(s). \tag{1}$$

If we multiply and divide Equation 1 by the objective probability of each state, $\pi(s)$, we obtain

$$P(X) = \sum_{s=1}^{S} \pi(s)\frac{q(s)}{\pi(s)}X(s) = \sum_{s=1}^{S} \pi(s)M(s)X(s) = \mathrm{E}[MX], \tag{2}$$

where $M(s) = q(s)/\pi(s)$ is the ratio of state price to probability for state s, the *stochastic discount factor* or SDF in state s. As $q(s)$ and $\pi(s)$ are strictly positive for all states s, $M(s)$ is also. The last equality in Equation 2 uses the definition of an expectation as a probability-weighted average of a random variable to write the asset price as the expected product of the asset's payoff and the SDF. This equation is sometimes given the rather grand title of the Fundamental Equation of Asset Pricing.

The SDF can be related to the decisions of an investor who chooses consumption today and in each future state to maximize time-separable utility of consumption. The investor's first-order conditions imply that

$$M(s) = \frac{q(s)}{\pi(s)} = \frac{\beta u'(C(s))}{u'(C_0)}. \tag{3}$$

In words, the SDF is the discounted ratio of marginal utility tomorrow to marginal utility today. This representation of the SDF is the starting point for the large literature on equilibrium asset pricing, which seeks to relate asset prices to the arguments of consumers' utility and particularly to their measured consumption of goods and services.

The formula given above assumes that all investors have rational expectations and thus assign the same objective probabilities to the different states of the world. If this is not the case, we must assign investor-specific subscripts to the probabilities, writing $\pi_j(s)$ for investor j's subjective probability of state s. In general, we must also allow for differences in the utility function across investors, adding a j subscript to marginal utility as well. Then, we can show that

$$M(s) = \frac{q(s)}{\pi(s)} = \left(\frac{\pi_j(s)}{\pi(s)}\right) \left(\frac{\beta u_j'\left(C_j(s)\right)}{u_j'(C_{j0})}\right) \tag{4}$$

Volatility of the SDF across states may correspond either to volatile deviations of investor j's subjective probabilities from objective probabilities or to volatile marginal utility across states. The usual assumption that investors have homogeneous beliefs rules out the first of these possibilities, but an emerging trend in asset pricing, following the behavioral finance literature, is to model belief heterogeneity.

Incomplete Markets and Volatility Bounds

The discussion so far assumes complete markets, but the SDF framework is just as useful when markets are incomplete. Cochrane (2005) offers a textbook treatment.

In incomplete markets, the existence of a strictly positive SDF is guaranteed by the absence of arbitrage—a result sometimes called the *Fundamental Theorem of Asset Pricing*—but the SDF is no longer unique as it is in complete markets. Intuitively, an SDF can be calculated from the marginal utility of any investor who can trade assets freely, but with incomplete markets, each investor can have idiosyncratic variation in his or her marginal utility and hence there are many possible SDFs.

There is however a unique SDF that can be written as a linear combination of asset payoffs and that satisfies the fundamental equation of asset pricing (Equation 2). This unique random variable is the projection of any SDF onto the space of asset payoffs, and thus any other SDF must have a higher variance. Shiller (1982), a comment by Hansen (1982a), and Hansen and Jagannathan (1991) used this insight to place lower bounds on the volatility of the SDF, based only on the properties of asset returns.

The idea of using asset return data to restrict the properties of the SDF remains a fruitful one. More recent work by Stutzer (1995), Bansal and Lehmann (1997), Alvarez and Jermann (2005), and Backus, Chernov, and Zin (2011), for example, shows how asset returns place lower bounds on the entropy of the SDF. Entropy, an alternative to variance as a measure of randomness, is playing an increasingly important role in asset pricing theory.

PREDICTING ASSET RETURNS IN THE SHORT AND LONG RUN

The Information in Asset Prices

Predictive regressions extract information in asset prices. During the 1980s, a series of papers studied fixed-income securities and found that their prices (equivalently, their yields) predicted their returns. For example, the interest differential between two currencies should predict depreciation of the high-interest-rate currency if expected rates of return are equal in the two currencies; in fact, it predicts appreciation of the high-interest-rate currency, implying large excess returns in that currency, a phenomenon that is the basis for the currency carry trade (Fama, 1984b). Similarly, the yield spread between two interest rates of different maturities should predict increases in both short-term and long-term interest rates if expected returns are equal across maturities; in fact, as shown by Shiller, Campbell, and Schoenholtz (1983) and Campbell and Shiller (1991) as well as Fama (1984a) and Fama and Bliss (1987), long-term rates tend to decline after yield spreads become unusually wide.

LeRoy and Porter (1979) and Shiller (1981) shifted attention to the stock market and argued that aggregate stock prices were too volatile to be consistent with a model in which prices equal expected future dividends, discounted at a constant rate. After a period of controversy, Campbell and Shiller (1988a) introduced a framework within which the contributions of time-varying expected dividends and discount rates could be separately quantified. By taking a Taylor approximation of the nonlinear equation relating log returns to log prices and log dividends, around the mean of the log dividend-price ratio, and solving forward the resulting loglinear difference equation, Campbell and Shiller found that

$$d_t - p_t \approx \frac{-k}{1-\rho} + \sum_{j=0}^{\infty} \rho^j [-\Delta d_{t+1+j} + r_{t+1+j}], \tag{5}$$

where lower-case letters denote logs, k and ρ are parameters of loglinearization, and the asset-specific subscript i has been dropped for notational simplicity.

This approximate equation holds ex post, as an accounting identity. It should therefore hold ex ante, not only for rational expectations but also for any expectations that satisfy identities. As the dividend-price ratio at time t is known at time t, it follows that the dividend-price ratio can be written as a discounted sum of expected future dividend growth and returns. These two components can be thought of as the “cash flow” and “discount-rate” components of the dividend-price ratio. Campbell and Shiller (1988a, 1988b) estimated these components using vector autoregressions forecasting returns (or dividend growth) with other variables including the log dividend-price ratio. As they calculated expected returns from an econometric forecasting model, they were estimating the discount rates that would be applied to cash flows by an investor with rational expectations.

In the late 1980s, a consensus developed about facts if not interpretations. The methods developed by Campbell and Shiller found a large contribution of time-varying discount rates to the volatility of the log dividend-price ratio, using VAR forecasts of long-run discounted stock returns. Fama and French (1988a) ran direct regressions of long-horizon returns onto the dividend-price ratio and found high explanatory power for these regressions. Fama and

French (1988b) and Poterba and Summers (1988), in related work, reported evidence for negative serial correlation of stock returns at annual and lower frequencies. All these results implied that time-varying discount rates—that is, rational expectations of future returns—are important for understanding the variability of the aggregate stock market.

Finance Theory and Return Predictability

The literature on return predictability has remained active over the past 25 years. Variance decompositions can be calculated not only for the log dividend-price ratio but also for other valuation ratios such as the log ratio of prices to smoothed earnings (Campbell & Shiller, 1988b) and the log ratio of enterprise value to total payout (Larrain & Yogo 2008), or even for the log ratio of consumption to total wealth (Lettau & Ludvigson, 2001a). Each of these ratios may have a different decomposition, as transitory variation in a payout measure implies variability in expected future payout growth, which in turn contributes to the volatility of the corresponding valuation ratio. As an alternative approach, Campbell (1991) suggested calculating variance decompositions for returns rather than for valuation ratios. Variance decompositions can also be calculated for individual stocks and style portfolios, although this requires confronting nonstationarities in firm-level payout policy that are less important at the aggregate level (Vuolteenaho, 2002, Cohen, Polk, & Vuolteenaho, 2009).

There has been considerable concern about the small-sample properties of regressions predicting stock returns from valuation ratios. Stambaugh (1999) pointed out that when the explanatory variables in return-predicting regressions are persistent and have innovations that are correlated with returns (as is certainly the case for valuation ratios), the coefficients are biased upward. A similar problem afflicts t-statistics as shown by Cavanagh, Elliott, and Stock (1995).

During the 2000s, a number of papers proposed to use theoretical restrictions to improve the power of tests of return predictability. Lewellen (2004) showed that when theory tells us that the log dividend-price ratio cannot be explosive, it is possible to compute a test statistic under the worst-case assumption that this ratio has a unit root. In samples where the valuation ratio appears to have a root very close to unity, Lewellen's test can reject more strongly than the standard test—and this is exactly what happens in an application to US data. Campbell and Yogo (2006) propose a related procedure.

Cochrane (2008) emphasizes the inability of the log dividend-price ratio to predict dividend growth. Using the Campbell–Shiller approximation, he notes that if the dividend-price ratio fails to predict stock returns positively, it will be explosive unless it predicts dividend growth negatively. Appealing like Lewellen (2004) to a theoretical presumption that the dividend-price ratio cannot be explosive, Cochrane argues that the absence of predictable dividend growth strengthens the evidence for predictable returns.

Several other recent papers also use restrictions from finance theory to improve forecasts of stock returns. Goyal and Welch (2008) direct attention to the poor out-of-sample performance of return predictions based on regressions that include both a constant and time-varying explanatory variables such as the dividend-price ratio. The difficulty with these regressions is partly that they must estimate the unconditional mean of stock returns using noisy historical data. In response, Campbell and Thompson (2008) show that out-of-sample performance is improved by imposing theoretically motivated sign restrictions on the regression coefficient and the fitted value and improved further using a version of a Gordon growth model to avoid directly estimating the unconditional mean of stock returns. Similarly, Fama and French (2002) argue that the unconditional mean stock return can be better estimated by correcting historical average returns for the historical change in valuation ratios because finance theory implies that such changes cannot be expected to continue. Avdis and Wachter (2013) make a similar correction in a formal maximum likelihood framework.

During the same quarter-century, finance theorists have built increasingly sophisticated equilibrium models that are consistent with the econometric evidence for return predictability. The focus has been on mechanisms that generate time-variation in risk premia, often related to the business cycle given the evidence for cyclical variation in risk premia presented in Fama and French (1989), and sometimes capturing acyclical variation that has been highlighted in more recent research.

One class of models, following Merton (1980), has time-varying volatility of aggregate stock returns and an equity premium that moves in proportion to either the standard deviation of returns (implying a constant Sharpe ratio) or the variance of returns (implying a constant allocation to stocks in a static portfolio choice model). A vast empirical literature shows that stock market volatility moves over time. However, while there is some evidence that the equity premium is positively related to equity volatility, it does not seem to move in proportion with either the standard deviation or variance of aggregate stock returns (Campbell, 1987; French, Schwert, & Stambaugh, 1987; Ghysels, Santa-Clara, & Valkanov, 2005; Harvey, 1989). Hence, the literature has sought to model time-variation in the reward that investors require for bearing equity risk or equivalently time-variation in the volatility of the SDF. This can be achieved, while maintaining the assumption that investors have rational expectations, through time-variation in the volatility of aggregate consumption growth (as in the long-run risk literature following Kandel

& Stambaugh, 1991; Bansal & Yaron, 2004; and Hansen, Heaton, & Li, 2008; or in the model of Martin, 2013), tail risk in the consumption distribution (as in Gabaix, 2012 and Wachter, 2013), curvature of the utility function (as in the habit formation model of Campbell & Cochrane, 1999), or uninsurable idiosyncratic risk (as in Constantinides & Duffie, 1996; Mankiw, 1986; and Storesletten, Telmer, & Yaron, 2008).

BEYOND RATIONAL EXPECTATIONS: BEHAVIORAL FINANCE AND AMBIGUITY AVERSION

Beyond Rational Expectations

Since the high tide of rational expectations macroeconomics in the early 1980s, economists have explored alternatives to the assumption that economic agents' subjective expectations always equal objective expectations. Asset pricing is a natural context in which to consider irrational expectations because the theory of the stochastic discount factor tells us exactly how to find subjective expectations that can rationalize asset prices without any risk aversion on the part of investors. These so-called risk-neutral expectations can be found as follows. Starting from the relation between asset prices and state prices, $P(X) = \sum q(s)\, X(s)$, multiply and divide by the sum of the state prices, $\sum q(s) = P_f = 1\,/\,(1 + R_f)$, to obtain

$$P(X) = \frac{1}{1+R_f} \sum_{s=1}^{S} \pi^*(s) X(s) = \frac{1}{1+R_f} \mathrm{E}^*[X], \tag{6}$$

where $\pi^*(s) = q(s) / \sum q(s)$ is a "pseudo-probability" of state s. It has the necessary properties to be a probability, namely that it is positive and sums to one across all possible states. However, it is derived only from state prices and need not correspond to the objective probability of state s. Equation 6 says that the asset price equals the pseudo-probability-weighted average payoff, or equivalently the pseudo-expectation of the payoff, discounted at the riskless interest rate. For this reason, $\pi^*(s)$ is also known as a *risk-neutral probability*.

If all investors have subjective probabilities $\pi^*(s)$, then observed asset prices can be reconciled with risk-neutral preferences. Put another way, any asset pricing model that relies on utility curvature and rational expectations can be matched by a model with linear utility and particular irrational expectations. A similar procedure can be used to reconcile asset prices with an arbitrary risk-averse utility function. Thus, asset price data alone cannot tell us whether investors have rational expectations; we need some external evidence on either preferences or expectations to resolve the issue.

BEHAVIORAL FINANCE

Shiller (1984) motivates an irrational expectations asset pricing model by arguing that the true model of the economy is unknowable to economists and investors alike. In this context, subjective views about future economic prospects and asset payoffs spread among investors in a manner analogous to the spread of infections in epidemiological models. Shiller writes down a simple model of equilibrium in a stock market with both rational and irrational investors. The equity demand function of risk-averse rational investors is linear in the expected return. Irrational investors demand an exogenous value of shares; equivalently, their equity demand function has unit price elasticity. In this model, stock prices can be written as a discounted present value of future dividends and exogenous irrational investor demands. Irrational investors have a larger effect on stock prices when they are more persistent and when the risk-bearing capacity of rational investors is smaller.

The subsequent literature on behavioral finance addresses a number of important questions about equilibrium with both rational and irrational investors. First, what determines the asset demands of irrational investors? Shiller (1984) modeled these demands as an exogenous stochastic process, but it is appealing to derive them from assumptions about irrational investors' expectations and perhaps also their preferences. For example, Barberis, Shleifer, and Vishny (1998) model expectations as switching between two false models in a way that generates both short-run momentum and long-run mean reversion. Other behavioral research has emphasized overconfidence in private information (Daniel, Hirshleifer, & Subrahmanyam, 1998, 2001), direct utility from optimistic anticipation of the future (Bénabou, 2013; Brunnermeier & Parker, 2005), and time-varying risk aversion driven by nonstandard prospect theory preferences (Barberis, Huang, & Santos, 2001; Benartzi & Thaler, 1995; Kahneman & Tversky, 1979; Thaler & Johnson, 1990). Shiller (1988) and Shiller and Pound (1989) used surveys around the time of the 1987 stock market crash to understand investor belief formation, and survey data have also been used by Barberis, Greenwood, Jin, and Shleifer (2013), Froot and Frankel (1989), Froot (1989), and Greenwood and Shleifer (2013) among others.

Second, what prevents rational investors at a point in time from arbitraging away the effects of irrational investors on asset prices? The most obvious answer, and the one discussed by Shiller (1984), is that rational investors are risk-averse. As rational investors trade with irrational investors, they take on more or less stock market exposure and the covariance of their marginal utility with stock returns varies accordingly, justifying a time-varying expected stock return. This logic implies that even within a behavioral model, the risk assessments of rational investors remain relevant.

The behavioral literature explores other answers to this question. For example, there may be short-sales constraints so that pessimistic rational investors cannot offset the demands of optimistic irrational investors (Harrison & Kreps, 1978; Miller 1977; Scheinkman & Xiong, 2003). In addition, rational investors may be financial intermediaries whose clients pull their capital after losses have been incurred (Brunnermeier & Pedersen, 2009; Shleifer & Vishny, 1997).

Third, why don't rational investors become richer than irrational investors over the long run, ultimately minimizing the price impacts of irrational investors as conjectured by Friedman (1953) and Shiller (1984) answers this objection by pointing out that wealthy rational investors eventually die and leave their money to less rational descendants. DeLong, Shleifer, Summers, and Waldmann (1990a, 1990b) argue that rational investors may be more risk-averse than irrational investors, whose willingness to earn a risk premium may outweigh their poor market timing and allow them to accumulate wealth. Kogan, Ross, Wang, and Westerfield (2006) show that irrational investors can have a significant impact on asset prices even when their wealth is small relative to that of rational investors.

Ambiguity Aversion

The view that investors do not know the true model of the economy, which motivated Shiller's (1984) development of behavioral finance, is also the starting point for a theoretical literature on ambiguity aversion. Building on the insights of Knight (1921) and the experimental evidence of Ellsberg (1961), this literature argues that investors handle uncertainty about models differently from uncertainty about outcomes within a model. Within a model, outcomes can be described by a probability distribution, but investors do not behave as if they have a subjective probability distribution over alternative models and therefore cannot be described as Bayesians in their response to model uncertainty or "ambiguity." Instead, authors such as Gilboa and Schmeidler (1989), Epstein and Wang (1994), Klibanoff, Marinacci, and Mukerji (2005), and Hansen and Sargent (2008) have argued that investors behave conservatively with respect to ambiguity, acting as if a worst-reasonable-case model is true. Hansen and Sargent use an entropy penalty to determine the worst reasonable model investors consider. Epstein and Schneider (2010) offer a recent review.

The literature on ambiguity aversion blurs the distinctions between positive and normative economics and between rational and irrational decision-making. Conservative pessimism can be treated as a positive prediction about investor behavior, but it can also be defended as a normatively justifiable (robust) response to model uncertainty. This contrasts with the behavioral finance literature, in which some investors are regarded as having beliefs or behaviors that do objective damage to their interests.

Both the literature on ambiguity and the behavioral finance literature model asset prices using assumed deviations from rational expectations. However, the literature on ambiguity assumes that investors are always more pessimistic than a rational agent would be (although the degree of pessimism may vary over time). Some behavioral finance models, such as the model by Benartzi and Thaler (1995) of myopic loss aversion, are similar in spirit, but others, such as the model by Brunnermeier and Parker (2005) of anticipation utility, or Shiller's (2000) discussion of "irrational exuberance," emphasize optimistic belief distortions.

THE CROSS-SECTION OF STOCK RETURNS

Since the early 1990s, the asset pricing literature has moved decisively beyond the Capital Asset Pricing Model (CAPM), which explains the cross-section of stock returns using the return on an aggregate stock index, a proxy for the market portfolio of aggregate wealth. The modern literature starts from the famous Fama–French three-factor model (Fama & French, 1993), which adds two new factors to the market factor, long-short portfolios that go long value stocks with high book-market ratios and short growth stocks with low book-market ratios (HML) and go long small stocks and short large or "big" stocks (SMB). The Fama–French approach of adding factors related to average stock returns has been an effective way to simplify and unify the vast literature on the cross-section of stock returns (Cochrane, 2011).

Academics following Fama and French have suggested additional factors, such as the momentum factor of Carhart (1997), and have asked why risk factors such as HML and SMB should have nonzero prices. Why should investors care about exposure to the common movements of value stocks or small stocks? The rational asset pricing literature offers several answers. First, the empirical proxy for the market portfolio used in standard tests of the CAPM may omit components of wealth, most importantly human capital (Fama & French, 1996). Second, a single-factor model conditional on the information of investors may imply a multifactor unconditional model, a point first made by Hansen and Richard (1987). Campbell and Cochrane (1999) and Lettau and Ludvigson (2001b) propose conditional consumption-based models, whereas Lewellen and Nagel (2006) and Roussanov (2014) argue that neither the conditional CAPM nor a conditional consumption CAPM can explain the cross-section of stock returns. Third, the intertemporal model of Merton (1973) implies that investors care not only about shocks to wealth but also about shocks to the rates of return that can be earned when wealth is reinvested. Campbell and Vuolteenaho (2004) and Lettau and Wachter (2007) have argued that growth stocks are good hedges against declines in expected stock returns, and Campbell, Giglio, Polk, and Turley (2013) have argued that they also hedge against increases in stock return volatility. Fourth, researchers working with consumption-based asset pricing models have argued that value stocks may covary with future consumption growth in a way that is relevant for investors with Epstein–Zin (Epstein & Zin, 1989) preferences (Hansen, Heaton, & Li, 2008; Parker & Julliard, 2005), and with the stock of durable goods in a way that is relevant for investors with nonseparable preferences over durables and nondurables (Yogo, 2006).

In parallel with the rational asset pricing literature, the behavioral finance literature has also explored asset pricing patterns within the cross-section of asset returns. There is a particularly active debate over the rationality or otherwise of the value premium, the anomalously high returns to value stocks, and the related phenomenon of long-run mean-reversion in individual stock returns highlighted by De Bondt and Thaler (1985). Momentum, the tendency of high returns over the past year (excluding the past 1–3 months) to predict high future returns, is also a favorite target for behavioral modeling and is much more difficult for rational models to explain. Selected papers from this literature include Baker and Wurgler (2006), Chan, Jegadeesh, and Lakonishok (1996), Hong, Lim, and Stein (2000), Hong and Stein (1999), and LaPorta, Lakonishok, Shleifer, and Vishny (1997).

FUTURE DIRECTIONS

Empirical economists working in asset pricing, including the 2013 Nobel laureates and their students, have documented a rich variety of facts about asset prices. For example, news events typically move asset prices in a manner that scales appropriately with the fundamental impacts of the events, allowing asset prices to be used to indirectly measure such fundamental impacts. Asset prices sometimes drift in the aftermath of events, most famously corporate earnings announcements, but these drifts typically weaken over time as arbitrageurs exploit them. Aggregate fluctuations in asset prices appear to reflect variation in discount rates, and specifically risk premia, so that valuation ratios can be used to predict returns. Time-varying risk premia do not move in proportion with return volatility, and they tend to be countercyclical, rising when the economy deteriorates. In the cross-section of stock returns, extremely modest predictability in the returns of individual stocks can be amplified by sorting stocks with similar characteristics into portfolios. Portfolios of value stocks and momentum stocks, to take the two most famous examples, have high average returns. High returns to these characteristics are found in other asset classes as well, and rewards for asset-class risk exposures are typically higher when the risk is taken by leveraging an index than when it is taken by buying individual assets with high betas to the index. These facts are reviewed and summarized in papers such as Asness, Moskowitz, and Pedersen (2013) and Cochrane (2011), academic books such as Campbell, Lo, and MacKinlay (1997) and Cochrane (2005), and trade books such as Ilmanen (2011). Taken together, they make asset pricing one of the most successful empirical fields in economics.

Emerging trends in the field involve modeling the interaction of heterogeneous investors who may have different preferences, beliefs, and constraints on their financial positions. Economists need to understand the markets from the perspectives of these different investors, including rational investors who likely have time-varying risk exposures. Direct measurement of investors' financial holdings, ideally linked to survey data about their risk preferences and beliefs, will be important to make further progress.

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