consumption-based asset pricing models (empirical performance)

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Abstract

Asset pricing is a branch of financial economics that is rich in puzzles and anomalies – that is, stylized empirical facts not easily explained by the canonical asset pricing models. These range from the equity premium puzzle and the risk-free rate puzzle to the fact that stock returns are highly predictable. This article discusses different consumption-based asset pricing models that have been developed to resolve these puzzles, and it evaluates their empirical performance.

Keywords

capital asset pricing model; consumption-based asset pricing models; elasticity of intertemporal substitution; equity premium puzzle; external habit; habit formation; heteroskedasticity; imperfect risk sharing; incomplete markets; precautionary savings; real business cycles; recursive preferences; representative agent; risk aversion; risk-free rate puzzle; stochastic discount factor

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Article

The aim of consumption-based asset pricing models is to explain a number of important and puzzling features of asset returns using standard economic theory. Perhaps the best-known challenge for these models is the *equity premium puzzle*. Let us start from the Euler equations for stock and bond choice, and let us assume that both of these Euler equations hold with equality. If agents have constant relative risk aversion (CRRA) preferences and if returns and consumption growth are jointly log-normal, then the Sharpe ratio (that is, the equity premium per unit of risk) can be decomposed as:

$$\frac{E(R^e)}{std(R^e)} \approx \alpha \times std(\Delta c) \times corr(\Delta c, R^e), \qquad (1)$$

where R^e is the excess return on stocks over bonds, α is the relative risk aversion (RRA) parameter, and Δc denotes log consumption growth. The equity premium is about six per cent per year in the US data with a standard deviation of 15 per cent, producing a Sharpe ratio ($E(R^e)/std(R^e)$) of 0.4. Mehra and Prescott (1985) used the construct of a representative agent who consumes the aggregate endowment stream. Constantinides (1982), Rubinstein (1974) and Wilson (1968) derived aggregation results that rely on either complete markets or the absence of idiosyncratic income risk. By appealing to these aggregation results, Mehra and Prescott could substitute *per-capita* consumption growth into (1). This series has a standard deviation of less than two per cent in the post-war US data, and a low correlation with stock returns – less than 0.25 by most estimates. Substituting these values into the expression above implies a lower bound for the relative risk aversion coefficient of 80, which is implausibly high judging by its implications for an individual's choices in other settings. In other words, we need extremely high risk aversion to rationalize the observed equity premium, and that is the puzzle. Furthermore, even if one is willing to accept such a high coefficient of risk aversion, this choice creates different puzzles itself – a point first noted by Weil (1989).

To understand Weil's 'risk-free rate puzzle', first note that the Euler equation for the risk-free asset choice can be linearized to obtain:

$$E\left[R^f\right] \approx -\ln\beta + \alpha E(\Delta c) - \frac{\alpha^2}{2} var(\Delta c). \tag{2}$$

Let us assume a positive time discount rate ($\beta < 1$), and an average consumption growth rate of 1.5 per cent per year. Let us also abstract from uncertainty for the moment. Then a risk aversion of 40 would imply an implausibly high interest rate of nearly 60 per cent per year simply because these households are extremely unwilling to substitute consumption over time. As a result, they desire a flat consumption profile and, therefore, would like to transfer resources from the future to today. But since this is not feasible in an endowment economy, the equilibrium risk-free rate needs to be very high to discourage this type of consumption smoothing and make individuals willing to consume their endowment every period.

The last term in (2) captures the precautionary savings motive, which becomes active in the presence of uncertainty. For very high levels of risk aversion, this effect dominates the intertemporal substitution effect, and an increase in the RRA coefficient *reduces* the risk-free rate. Epstein and Zin (1989) developed a class of recursive preferences that disentangles the inverse of the elasticity of intertemporal substitution from the coefficient of risk aversion. As discussed below, these preferences allow one to make progress on the equity premium puzzle without running into the risk-free rate puzzle.

Against the backdrop of Mehra and Prescott's benchmark model, subsequent papers that attempt to resolve these puzzles can be categorized according to whether they modify (i) the preferences, (ii) the endowment process, or (iii) the market and asset structure. We discuss each of these approaches in turn.

The utility function

Recursive preferences

In the case of CRRA utility, the stochastic discount factor (SDF) has the following form: $M_{t,t+1} = \beta(C_{t+1}/C_t)^{-\alpha}$, where C denotes the level of consumption. A drawback of this specification is that it restricts the elasticity of intertemporal substitution (EIS) to be the reciprocal of the RRA parameter when in fact these two parameters capture conceptually distinct aspects of individuals' preferences. Building on work by Kreps and Porteus (1978), Epstein and Zin (1989) and Weil (1989) introduced 'recursive preferences' (also called 'non-expected utility'):

$$U_t = \left[(1-\beta)C_t^\rho + \beta E_t(U_{t+1}^{1-\alpha})^{\rho/1-\alpha}\right]^{1/\rho}, \tag{3}$$

where α is still the RRA parameter, but now the EIS is captured by a separate parameter: $1/(1-\rho)$. In this case, the SDF is given by:

$$M_{t,t+1} = \left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\rho-1}\right]^\gamma \left(\frac{1}{R_t^M}\right)^{1-\gamma},$$

where $\gamma = \alpha/\rho$, and R_t^M is the total return on the investors' wealth portfolio (including human capital which must be tradable for this representation to be derived; see Epstein and Zin, 1989, and Weil, 1989). An appealing feature of this SDF is that it combines two components that are each central to separate asset pricing theories: in particular, the SDF is a geometric average of consumption growth and the market return, where the latter is the relevant SDF in the standard capital asset pricing model (CAPM). Moreover, when $\alpha = 0$ (logarithmic risk preferences), then the CAPM emerges as a special case whereas $\alpha = \rho$ reduces it to the standard case of expected utility (see Epstein and Zin, 1989; Campbell, 2000).

In addition, this preference specification is flexible enough to allow a choice of a coefficient of relative risk aversion that is high enough to match the equity premium without being forced to accept a very low EIS. The low EIS is responsible for the risk-free rate puzzle, as explained above. Bansal and Yaron (2004) exploit this agent's concern for long-run consumption risk by introducing a small predictable component in consumption growth.

Habit formation and catching-up with the Joneses

Another approach, pioneered by Sundaresan (1989), Abel (1990) and Constantinides (1990), starts from the following specification of the investor's preferences over consumption streams C_t:

$$U_t = \frac{(C_t - X_t)^{1-\alpha}}{1-\alpha}$$

where X_t is some function of either (i) the individual's own past consumption or (ii) the past consumption of a reference group, such as an individual's peers, neighbours, or the population as a whole. Abel's specification features the ratio of C_t to X_t instead of the level difference. The first approach allows an individual's marginal utility to depend on her own past consumption history. This is commonly referred to as habit formation, endogenous habit, or internal habit. The second interpretation allows an individual's utility to depend on her status *relative* to her peers, neighbours or the population as a whole. This is referred to as catching-up with the Joneses or as external habit. These preference specifications amplify the effect of consumption growth shocks on the marginal utility growth of investors, in turn generating a high equity premium.

A particularly successful version of the catching-up-with-the-Joneses specification was developed by Campbell and Cochrane (1999) (henceforth CC) who choose the sensitivity of X to consumption growth shocks to match the conditional and unconditional moments of returns. In the baseline CC model, aggregate consumption and dividend growth are i.i.d. over time. Menzly, Santos and Veronesi (2004) introduce additional cash flow dynamics to explain the time series and cross-section of stock returns, while Santos and Veronesi (2005) emphasize the importance of labour income share variation to understand time variation in risk premia. Wachter (2002) applies a version of the CC model to the term structure, while Verdelhan (2004) uses the same model to explain the forward premium puzzle.

Looks like habit

Several recent papers have proposed models with standard preferences (such as CRRA) but consider economic environments that give rise to SDFs similar to those resulting from external habit preferences (such as the one used in CC). Examples include work by Piazzesi, Schneider and Tuzel (2007) who introduce housing services consumption into this framework, and by Yogo (2006) who considers durable consumption broadly defined, building on earlier work by Dunn and Singleton (1986) and Eichenbaum and Hansen (1990). Finally, Guvenen (2005) studies a model with limited stock market participation and shows that while the asset pricing implications of his model are similar to those in CC, the implications for macroeconomic questions (such as policy analysis, and so on) are quite different.

Additional arguments in the utility function

The models discussed so far assume that investors only derive utility from non-durable consumption. In exchange economy models (in which the consumption process is exogenous) this is equivalent to assuming that non-durable consumption enters the utility function in a separable manner. Some recent papers explicitly model the utility flow from housing consumption (in a non-separable manner), and find that such an extension improves the asset pricing performance (see Grossman and Laroque, 1990; Piazzesi, Schneider and Tuzel, 2007; Flavin and Yamashita, 2002). Similarly, a labour–leisure choice was introduced by Boldrin, Christiano and Fisher (2001) and Danthine and Donaldson (2002), in a representative agent framework, and by Uhlig (2006) in an incomplete markets framework. However, these authors find that this extension negatively affects the performance of asset pricing models, because it allows households to smooth their marginal utility by adjusting on the labour–leisure margin. As a result, one needs to introduce additional – typically labour market – frictions to counteract this new smoothing opportunity.

Consumption dynamics

In consumption-based asset pricing models, it is common to assume that aggregate consumption growth is i.i.d. over time, because the evidence for consumption growth predictability in the data is weak. In the i.i.d. case, the conditional market price of risk, which can be approximated by the conditional standard deviation of the log SDF, $\sigma_t(logM_{t,t+1}) = \alpha \times \sigma_t(\Delta c)$, is constant. Therefore, these models cannot generate any time variation in risk premia on equity or any other asset.

In the context of a standard representative agent model, Kandel and Stambaugh (1990) generate time-variation in risk premia by introducing heteroskedasticity in aggregate consumption growth. Bansal and Yaron (2004) deviate from the i.i.d. assumption by introducing a small predictable component in consumption growth that is statistically hard to detect. This long-run component increases the market price of consumption risk. In addition, they add some time variation in the size of the long-run risk component. Colacito and Croce (2005) show these long-run risk models can reconcile the low volatility of exchange rate changes with the large market price of risk. Finally, Longstaff and Piazzesi (2002) argue that corporate earnings are much more risky than aggregate consumption growth, and that this can account for a large share of the equity premium puzzle.

Production economy models

These asset pricing puzzles have also attracted a lot attention from macroeconomists because the same basic framework used in Mehra and Prescott (1985) also forms the backbone of the Kydland and Prescott (1982) model and the subsequent real business cycle literature. Therefore, understanding why individuals dislike risk in financial markets could help shed light on individuals' perceptions of macro risk and consumption fluctuations, which are key issues for macroeconomic policy. However, macroeconomists are also interested in the determination of quantities, such as output, investment and consumption, making the exchange economy framework unsuitable for their purposes. Therefore, macroeconomists replace the exogenous endowment stream with the endogenous equilibrium consumption process generated by a standard neoclassical production economy that faces technology shocks. One of the first findings of this approach, summarized in Rouwenhorst (1995), is that resolving the equity premium puzzle in a production economy is far more challenging than in an exchange economy, because this endogenous consumption process becomes too smooth if one increases risk aversion. As a result, one needs to resort to real frictions such as large adjustment costs in Jermann's (1998) model. Furthermore, and as noted above, allowing for an endogenous labour supply choice, as is common in macroeconomic analysis, gives consumers another margin to smooth marginal utility and further reduces the equity premium. Boldrin, Christiano and Fisher (2001) and Uhlig (2006) have successfully introduced labour market frictions to effectively shut down this channel.

Market and asset structure

The aggregation results we appeal to in order to use a representative agent in asset pricing depend on market completeness. A natural question is to ask what happens if some of these markets are shut down.

Incomplete markets

In an attempt to resolve the equity premium puzzle, *uninsurable* idiosyncratic income risk has been introduced into consumption-based asset pricing models by Aiyagari and Gertler (1991), Telmer (1993), Lucas (1994), Heaton and Lucas (1996), Krusell and Smith (1997) and Marcet and Singleton (1999), among others. Their main results, obtained numerically for a range of parameter values, suggest that the impact of uninsurable labour income risk on the equity premium is small, because agents manage to smooth consumption quite well by trading a risk-free bond. In fact, Levine and Zame (2002) show that under general conditions the equilibrium allocations and prices in incomplete market economies converge to the complete market counterparts as households become more patient, rendering the incompleteness moot.

So when does imperfect risk sharing matter? Mankiw (1986) derives a sufficient condition for imperfect risk sharing to increase the equity risk premium: the cross-sectional variance of consumption growth needs to increase when returns are low (that is, in recessions). Constantinides and Duffie (1996) embed this counter-cyclical cross-sectional variance mechanism in a general equilibrium model. Grossman and Shiller (1982) show that the Mankiw-Constantinides-Duffie (MCD) mechanism breaks down in continuous-time diffusion models, because the cross-sectional variance of consumption growth is deterministic.

Discussion of other models

Rietz (1988) was the first to argue that countries like the United States may simply have been very lucky. Hence, the observed history of the US economy may understate the actual probability of economic disasters, such as the Great Depression (at least as perceived by investors). In this case, the volatility of the SDF may be significantly higher than the one estimated from historical time series. As a result, investors will shun stocks and demand a much higher equity premium to hold them. One difficulty with this explanation is that many economic disasters also result in governments reneging on their debt obligations. Barro (2006) extends Rietz's framework by distinguishing between two types of disasters – those that only affect the stock market and those that affect all asset markets – and explores the empirical implications of this mechanism in recent work.

See Also

- capital asset pricing model
- consumption-based asset pricing models (theory)
- elasticity of intertemporal substitution
- incomplete markets
- recursive preferences

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