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The conditional equity premium, cross-sectional returns and stochastic volatility

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ABSTRACT

Bansal and Yaron (2004) demonstrate, by calibration, that the Consumption-based Capital Asset Pricing Model (CCAPM) can be rescued by assuming that consumption growth rate follows a stochastic volatility model. They show that the conditional equity premium is a linear function of conditional consumption and market return volatilities, which can be estimated handily by various Generalized Autoregressive Conditonal Heteroskedasticity (GARCH) and Stochastic Volatility (SV) models. We find that conditional consumption and market volatilities are capable of explaining cross-sectional return differences. The Exponential GARCH (EGARCH) volatility can explain up to 55% variation of return and the EGARCH model augmented with $\widehat{cay}$ — a cointegrating factor of consumption, labor income and asset wealth growth — greatly enhances model performance. We proceed to test another hypothesis: if Bansal and Yaron estimator is an unbiased estimator of true conditional equity premium, then the instrumental variables for estimating conditional equity premium should no longer be significant. We demonstrate that once the theoretical conditional risk premium is added to the model, it renders all instrumental variables redundant. Also, the model prediction is consistent with observed declining equity premium.

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1. Introduction

Financial derivatives can be priced in two methods — relative pricing and absolute pricing. Financial engineers, on the one hand, price a financial instrument by forming a replicating portfolio. The cash flow of a call option, for instance, can be replicated by holding stock shares and shorting bonds. The option is priced relative to the market prices of those two assets. Financial economists, on the other hand, explore the links between asset returns and macroeconomic variables which are the sources of systematic risk. One of the early attempts is the Sharpe–Lintner–Black Capital Asset Pricing Model (CAPM), in which excess return of market portfolio is the common factor that explains cross-sectional return differences. In a two period model with exogenous labor income, the equity premium is proportional to the aggregate consumption growth, in which the multiplicative factor is elasticity of intertemporal substitution of consumption. This is the famous Consumption-based Capital Asset Pricing Model (CCAPM).

In spite of the theoretical simplicity and elegance of CAPM; when faced with empirical testing, it fails miserably. For instance, Banz (1981) identifies the small firm effect — small cap stocks and value stocks have unusually high average returns, while the return of large and growth stocks are lower than what CAPM predicts. Fama and French (1993) demonstrate that CAPM virtually has no power in explaining cross-sectional return when sorted by size and book-to-market ratios. Fama and French (1993) advocate a three factor model — market return, the return of small less big stocks (SMB), and the return on a portfolio of high book-market value stocks less low book-market value stocks (HML). The Fama and French (1993) model is a resounding success; however, it is still not clear how these factors relate to underlying macroeconomic risk. In fact, the independence and economic interpretation of SMB and HML remain as a source of controversy.

An alternative to the Fama and French (1993) model is the macroeconomic factor model, in which the factors are observed macroeconomic variables that are assumed to be uncorrelated to the asset specific error. The Chen et al. (1986) multi-factor model is one of those. They construct surprise variables by using the Vector Autoregressive Model (VAR). The VAR residuals of several macroeconomic variables, for example, Consumer Price Index (CPI), industrial production growth and oil price are used as uncorrelated macroeconomic variables. While the uncorrelatedness of those macroeconomic variables is less controversial, the explanatory power is unsatisfactory especially when compared to the Fama and French (1993) model.

Jagannathan and Wang (1996) attribute the failure of CAPM to two reasons. First, CAPM holds in a conditional sense, not unconditionally. The stochastic discount factor is linear as stated in CAPM, but the coefficients are time varying. The static specification of market premium fails to take into account the effect of time-varying investment opportunities in the calculation of asset risk. For instance, the betas of firms with relatively higher leverage rise during recession; firms with different

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types of assets will be affected by the business cycle in different ways and to a different extent. Second, the return on value-weighted portfolio of all stocks is a bad proxy to wealth return. As a matter of fact, Roll (1977) argues that the market return cannot be adequately proxied by an index of common stocks. The problems are rectified by estimating a conditional version of CAPM and including human capital return, as an instrumental variable, in the model. They argue that with certain assumptions about the stochastic conditional expected excess return on zero-beta portfolio and conditional market risk premium, cross-section return can be written as a linear combination of factors with constant coefficients.[1] The Jagannathan and Wang (1996) model significantly improves predictive power of CAPM.

Lettau and Ludvigson (2001) resurrect the CCPAM. Along the line of Jagannathan and Wang (1996), they examine a conditional version of CCAPM, in which the stochastic discount factor is expressed as a conditional or scaled factor model. They model time-variation in the coefficients by interacting consumption growth with an instrument, in particular, a cointegrating factor — a cointegrating residual between consumption, asset (nonhuman) wealth, and labor income (all in log). A growing literature find that expected excess returns on aggregate stock market indices are predictable, suggesting that risk premium varies over time.[2] The parameters in the stochastic discount factor will then depend on investor's expectations of future excess return. Lettau and Ludvigson (2001) demonstrate that $\widehat{cay}$ drives time-variation in conditional expected return. While the consumption cointegrating factor alone fails to capture variation of average returns, they show that the interaction between $\widehat{cay}$ and labor income growth or consumption growth can explain the 70% variation of average return; it remains a difficult task to reconcile how this interaction term can make such a difference.

In this paper, we undertake the investigation of the CAPM by using a conditional market premium derived from an optimization-based model. Declining consumption volatility has been a plausible explanation for the declining equity premium. Bansal and Yaron (2004, hereafter referred to as the BY model) justify the equity premium by assuming that consumption growth rate follows a stochastic volatility model. They show that the conditional equity premium is a linear function of conditional consumption and market return volatilities. Therefore, we proceed to estimate two stochastic volatility models to test the validity of the BY model. Meanwhile, estimation methods of conditional volatility abound in the econometrics literature; for instance, the large class of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. We will apply the Fama–MacBeth approach to test the validity of the BY model using 25 Fama–French portfolios (U.S.A.) sorted by size and book-to-market value. A couple of questions will be addressed in the following sections. Once the ex-post market risk premium is replaced by conditional consumption and market return volatilities, does it improve the predictive power of CAPM? Is this study robust that different GARCH models give similar results? Furthermore, the following null hypothesis will be tested: if the theoretical BY equity premium is adequate, it would render the instrumental variables redundant.

The first procedure is the estimation of conditional consumption and market volatilities by GARCH, Exponential GARCH (EGARCH), Threshold GARCH (TGARCH) and two stochastic volatility models. The predicted volatilities will then be used as factors for the second-step Fama–MacBeth procedure. Since we will compare the model performance to the conventional CAPM, Fama and French (1993) and Lettau and Ludvigson (2001) models, the U.S. 25 Fama–French portfolio returns sorted by size and book-to-equity value will be used.

We find that the Bansal and Yaron theoretical premium significantly outperforms traditional CAPM using observed market premium. Using GARCH consumption and market volatility alone can explain the 55% variation of cross-section return difference. Not only does it improve the Fama and French model, by replacing the ex-post market risk premium with the Bansal and Yaron (2004) premium, the Lettau and Ludvigson (2001) model also outperforms the former. Moreover, various χ^2 tests reject the joint significance of Lettau and Ludvigson instrumental variables.

There are two contributions of this research. 1. We found supportive evidence to a general equilibrium model with the potential to resolve the equity premium puzzle. 2. Our statistical method is more straightforward than the existing literature — which is mostly calibration instead of statistical estimation — on the Bansal and Yaron (2004) model.

This paper is structured as follows. Section 3 outlines the Bansal and Yaron model. We briefly describe the derivation of the theoretical market premium. Section 4 is devoted to modelling conditional volatilities. Two Stochastic Volatilities and three typical GARCH type volatilities are estimated: Generalized Autoregressive Conditional Heteroskedasticity (GARCH), Exponential GARCH and Threshold GARCH. The idea is that if the Bansal and Yaron premium can truly explain cross-sectional return differences, the result should be applied to various conditional volatility specifications. Section 5 delineates the estimation equations. Section 5 reports the results and Section 6 is a discussion of the findings.

2. Outline of Bansal and Yaron (2004) model

We now consider the Bansal and Yaron (2004) model. It shows that, if consumption and dividend growth rate contain a small long-run predictable component, consumption volatility is stochastic, and, if the representative household has Epstein and Zin preference, the asset and return premium will be a linear function of conditional consumption and market volatility. The Euler condition is given by

$$E_t\left[\delta^{\theta} G_{t+1}^{-\frac{\theta}{\psi}} R_{a,t+1}^{-(1-\theta)} R_{i,t+1}\right] = 1 \quad (1)$$

where δ is the discount factor, G_{t+1} is the gross return of consumption, $R_{a,t+1}$ is the gross return on an asset that delivers aggregate consumption as its dividend each period, and $R_{a,t+1}$ is the individual asset return. As well-documented in the literature, this class of preference disentangles the relation between intertemporal elasticity of substitution (IES) and risk aversion. The parameter $\theta = \frac{1-\gamma}{1-\frac{1}{\psi}}$, with $\gamma \geq 0$ as the degree of risk aversion, Ψ denotes IES. Campbell and Shiller (1988) show that the log-linearized asset return ($r_{a,t+1}$) can be expressed as

$$r_{a,t+1} = \kappa_0 + \kappa_1 z_{t+1} - z_t + g_{t+1} \quad (2)$$

where κ_0 and κ_1 are the constants; $z_t = \log = \left(\frac{P_t}{C_t}\right)$ is the log price–consumption ratio, and g_{t+1} is the log return of consumption. The log-linearized first order Euler condition is

$$m_{t+1} = \theta log\delta - \frac{\theta}{\psi} g_{t+1} + (\theta - 1) r_{a,t+1} \quad (3)$$

where m_{t+1} is the stochastic discount factor. When $\theta = 1$, then $\gamma = \frac{1}{\psi}$, and the above equation is pinned down to the case of Constant Elasticity of Substitution (CES) utility function. Moreover, if $\theta = 1$ and $\gamma = 1$, we get the standard case of log utility. In the spirit of neo-classical

[1] The proof can be found at the Appendix of Jagannathan and Wang (1996).

[2] See the study of Campbell (1991) and Lamont (1998).

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