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Estimating asset pricing models with frictions

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HIGHLIGHTS

- We estimate confidences sets of risk aversion and trading costs implied by asset pricing models with frictions.
- Introducing short-selling costs for Treasury bills accounts for the low observed risk-free rate.
- The confidence sets show upper bounds on risk aversion to be at reasonable levels.
- Short-selling costs for Treasuries are not necessary under recursive preferences.

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ABSTRACT

We jointly quantify the magnitude of risk aversion and transactions costs implied by asset pricing models with trading frictions. With constant relative risk aversion and symmetric transactions costs, estimated transactions costs on Treasury bills are implausibly high, a manifestation of the risk-free rate puzzle. Introducing short-selling costs for Treasury bills offers a resolution of the puzzle. The resulting confidence sets show upper bounds on risk aversion to be at reasonable levels. Short-selling costs for Treasuries are not necessary under recursive preferences.

1. Introduction

A large body of work tests the canonical consumption-based asset-pricing model. The literature varies widely on the degree to which the data are consistent with the model. Initial tests rejected the consumption-based model (Hansen and Singleton, 1983). Various relaxations of the models have proven more consistent with the data. In this paper, we consider inference based on the introduction of frictions to the traditional asset pricing model. The frictions generate moment inequalities rather than the standard moment equalities (He and Modest, 1995; Luttmer, 1996). The contribution of this note is to utilize recently developed econometric techniques to infer the underlying preference parameters of a representative investor as well as parameters related to the frictions.

The standard consumption-based model implies that the expected discounted return equals one for all assets:

$$\mathsf{E}\left[M_{t+1}R_{i,t+1}\right] = 1, \tag{1}$$

where M is a stochastic discount factor and R_i is the return on test asset i. However, if investors incur symmetric proportionate costs to trade (denoted ρ_i) and additional short-selling costs (denoted $\rho_{i,SS}$), the first-order conditions of an investor's optimization problem create bounds on the expected discounted return:

$$\frac{1-\rho_i-\rho_{i,SS}}{1+\rho_i} \le \mathsf{E}\left[M_{t+1}R_{i,t+1}\right] \le \frac{1+\rho_i}{1-\rho_i}. \tag{2}$$

These bounds are developed and studied by He and Modest (1995) and Luttmer (1996).[1] Their work assesses whether or not the data are consistent with assumed preferences and transactions costs using Hansen and Jagannathan (1991) bounds. We take a

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[1] We show the derivation of (2) in the internet appendix (see Appendix A).

complementary approach, estimating confidence sets for preferences and trading frictions under the assumption that the model with frictions holds, namely inequality (2). Our approach thus provides estimates of risk aversion and frictions implied by the data and the model's moment inequality restrictions.

With constant relative risk aversion and symmetric transactions costs, estimated transactions costs on Treasury bills are implausibly high, a manifestation of the risk-free rate puzzle. We find that introducing short-selling costs for Treasury bills offers a resolution of the risk-free rate puzzle. The resulting confidence sets for risk aversion show upper bounds on risk aversion to be at reasonable levels (less than 3). We also relax the link between risk aversion and elasticity of intertemporal substitution using recursive preferences. Short-selling costs for Treasuries are not necessary under recursive preferences.

2. Econometric methodology

We estimate confidence sets of preference and friction parameters θ using the methodology outlined in Andrews and Barwick (2012). Consider an asset pricing model that involves p moment inequalities:

$$\mathsf{E}\left[m_j(W_i, \theta_0)\right] \geq 0 \quad \text{for } j = 1, \ldots, p$$

where $m(W_i, \theta_0)$ are moment functions of the data W_i and the parameter vector θ_0. The confidence sets are formed by inverting a test statistic for testing $H_0 : \theta = \theta_0$ for the true parameter vector θ_0. The confidence set for θ is the set of all θ values such that the associated test statistic is less than or equal to a data-dependent critical value $c(\theta)$. We use the modified method of moments (MMM) test statistic:

$$T_n^{MMM}(\theta) = \sum_{j=1}^{p} \left[n^{1/2}\bar{m}_j(\theta)/\widehat{\sigma}_j(\theta)\right]_-^2 \quad (3)$$

where $[x]_- = \min(x, 0)$, $\bar{m}_j(\theta)$ is the sample average of moment j using n observations, and $\widehat{\sigma}_j(\theta)$ is the standard deviation corresponding to the jth diagonal element of $\widehat{\Sigma}(\theta)$, the estimated covariance matrix of the sample moments.

Andrews and Barwick (2012) employ a refined moment selection critical value. For each value of θ considered, the procedure compares the test statistic (3) to a data-dependent critical value, $c_n(\theta)$. The critical value is based on the $1-\phi$ quantile of an asymptotic normal distribution of an analogue of $T_n^{MMM}(\theta)$ constructed using only the moment inequalities that have sizable effects on the asymptotic null distribution of the test statistic. We refer the interested reader to Section 2 of Andrews and Barwick (2012) for details on the calculation of this critical value. We calculate confidence sets with nominal level 95% (i.e., $\phi = 0.05$). Thus, the probability that the estimated confidence set covers the true θ is 95%.

3. Confidence sets of preferences and frictions

3.1. Data

Our sample consists of monthly observations of consumption growth and asset returns from January 1959 to July 2015. We obtain the seasonally-adjusted aggregate nominal consumption expenditures on nondurable goods (PCEND) and services (PCES) through FRED at the St. Louis Fed. We use population (POP) and price deflator (PCEPI) series to construct a time-series of per capita real consumption growth. The test assets are a value-weighted equity market return together with the 90-day Treasury bill return. The equity return data are from Kenneth French's website. The Treasury bill return data are from CRSP.

3.2. Symmetric transactions costs

We consider constant relative risk aversion (CRRA) preferences with a single proportionate transaction cost for each asset. Trading costs are quite different between Treasuries and equities, so we estimate a separate symmetric cost for each asset. We initially assume no short-selling costs (i.e., $\rho_{Tbill,SS} = \rho_{Mkt,SS} = 0$). Under these assumptions, inequalities (2) correspond to $p = 4$ moment inequalities with $M_{t+1} = \beta\,(c_{t+1}/c_t)^{-\gamma}$ and parameter vector $\theta = (\beta, \gamma, \rho_{Tbill}, \rho_{Mkt})$.

Fig. 1 shows the estimated confidence sets of risk aversion and T-bill transaction costs for several equity transaction costs. We fix $\beta = 0.99$ to focus on risk aversion and trading frictions. The figure plots the value of the test statistic less the critical value. Parameter values are in the confidence set whenever the corresponding test statistic falls below the critical value, so negative values in Fig. 1 are parameter values consistent with the model's moment inequalities. These regions form the confidence set and are shaded grey in the plot.[2]

The confidence set includes low risk aversion values (below 3) and T-bill costs of at least 50 basis points and is not sensitive to the magnitude of equity transactions costs. For a risk aversion of 1, the lower edge of the Treasury bill transactions cost confidence set is approximately 70 bps. For any given level of risk aversion, higher trading frictions are required for the data to be consistent with the moment inequalities.

On the other hand, for a fixed level of transactions costs, the confidence set includes risk aversion values below some threshold, resulting in an upward slope in the confidence set in Fig. 1. To see why this is the case, one needs to understand which moment inequalities are violated. Empirically, the left-hand side moment inequality in (2) is violated most often. This inequality is associated with transferring consumption to time t from time $t+1$ through short-selling (see internet appendix (Appendix A) for the derivation). With positive net consumption growth, as is true on average in the sample, lower levels of risk aversion provide more slackness for this inequality, resulting in their inclusion in the confidence set. Economically, this moment inequality requires that the ratio of the marginal cost of less-than-optimal consumption at $t+1$ to the marginal benefit of greater-than-optimal consumption at t be greater than one. With positive net consumption growth, this ratio is declining in risk aversion, so lower levels of risk aversion are required to reconcile the data with this moment restriction for a given level of transactions cost.

How do these estimated costs compare to those assumed by He and Modest (1995) and Luttmer (1996) to construct bounds on the stochastic discount factor? Luttmer (1996) considers HJ bounds generated by transactions costs ranging from 0 to 6 bps for Treasuries and 0 to 75 bps for value-weighted market returns. He and Modest (1995) assume 1.5 bps and 75 bps for the Treasury bill and value-weighted equity returns, respectively. Our estimated Treasury bill costs are thus an order of magnitude higher than those considered in prior work, which were based on empirical estimates. Consistent with this, He and Modest (1995) and Luttmer (1996) conclude that symmetric transactions costs alone are insufficient to reconcile the aggregate consumption data with HJ bounds for low levels of risk aversion.

[2] One interesting phenomenon is that the test statistic exhibits nonmonotonic contours over some regions of the parameter space. This nonmonotonicity is a result of the fact that the numerator (a moment mean) and denominator (a moment standard deviation) for a given term j of the test statistic (3) change in magnitude at differing rates.