Journal of Monetary Economics 82 (2016) 52–69

Contents lists available at ScienceDirect

Journal of Monetary Economics

journal homepage: www.elsevier.com/locate/jme

Risks for the long run: Estimation with time aggregation ☆

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ARTICLE INFO

Article history:
Received 18 August 2015
Received in revised form
29 June 2016
Accepted 4 July 2016
Available online 16 July 2016

Keywords:
Long-run risks
Time-aggregation
Asset prices

ABSTRACT

The discrepancy between the decision and data-sampling intervals, known as time aggregation, confounds the identification of long-, short-run growth, and volatility risks in asset prices. This paper develops a method to simultaneously estimate the model parameters and the decision interval of the agent by exploiting identifying restrictions of the Long Run Risk (LRR) model that account for time aggregation. The LRR model finds considerable empirical support in the data; the estimated decision interval of the agents is 33 days. Our estimation results establish that long-run growth and volatility risks are important for asset prices.

1. Introduction

The long-run risks (LRR) model developed by Bansal and Yaron (2004) has motivated a significant amount of research in macro and financial economics. The model captures the intuition that low-frequency fluctuations in consumption growth and its volatility are important for understanding asset prices. The implications of the LRR model are typically evaluated via calibrations because the estimation of the model is known to present a number of challenges. First, the return of the aggregate consumption claim that governs the dynamics of marginal utility in the LRR model is not observable. Second, time aggregation of consumption and dividend data may hinder the identification of the model risk components and parameters. This paper develops a method that addresses these challenges and estimates the model using consumption and financial market data. It shows that the LRR model is able to simultaneously account for the joint dynamics of aggregate consumption, asset cash flows and prices – the model's asset pricing restrictions find support both in a long sample of annual data and a shorter sample of post-war quarterly data. It further shows that the failure to account for time aggregation leads to a significant mismeasurement of risks, distorted parameter estimates, and false model rejections. Our paper, thus, underscores the importance of time aggregation for estimating the dynamics of the LRR model.

☆ We thank Andy Abel, George Constantinides, Lars Hansen, John Heaton, Ricardo Reiss (editor) Tom Sargent, Martin Schneider, Annette Vissing-Jorgensen, anonymous referee, seminar participants at Boston University, Copenhagen School of Business, Carnegie-Mellon University, Duke University, Harvard University, LBS, LSE, Norwegian School of Management, NYU, Stockholm School of Economics, Tel-Aviv University, University of California-Berkeley, University of Chicago, University of Texas-Austin, University of Washington-St. Louis, University of Wisconsin, Wharton, Yale, and conference participants at the Summer Econometric Society Meetings, the NBER Asset-Pricing meeting, Nemmers Prize Conference, Frontiers of Monetary policy – St. Louis FRB, and CIRANO Financial Econometrics Conference in Montreal for useful comments. Yaron thanks support from the Rodney White Center at the Wharton School. This paper builds on our earlier working paper, *Risks for the Long Run: Estimation and Inference*.

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http://dx.doi.org/10.1016/j.jmoneco.2016.07.003
0304-3932/

Time aggregation arises from a mismatch between the decision interval of agents and the sampling frequency of the data. This impedes identification of the model parameters as discussed in Hansen and Sargent (1983). To appropriately identify various risks and structural parameters, we derive consumption, dividend and asset price dynamics of the time-aggregated LRR model by factoring in the unknown decision interval of the agent. By exploiting the derived moment restrictions we are able to extract the latent risk factors and estimate the decision frequency along with all other model parameters in a GMM framework of Hansen (1982). We show that the decision interval, a parameter that we estimate, has a significant effect on the models dynamics and, therefore, on the identification of the underlying risks.

Our empirical evidence provides considerable support for the LRR model and suggests that: (i) investors have a preference for early resolution of uncertainty, (ii) shocks to the expected growth component of consumption have a long-run effect that extends beyond typical business cycle frequencies, (iii) variation in consumption volatility, while relatively small, is very persistent, (iv) agents decision interval is roughly one month and, hence, is quite close to the value typically assumed in the calibrated versions of the LRR model. To be specific, based on annual data from 1930 to 2015, the estimates of the coefficient of risk aversion and the intertemporal elasticity of substitution (IES) are 9.7 and 2.2, respectively. Both have relatively tight standard errors – 1.4 for risk aversion and 0.2 for the IES. The long-run growth and volatility components of consumption are highly persistent, with implied annual autocorrelations of 0.75 and 0.98, respectively. The long-lasting nature of expected growth and volatility shocks manifests into high risk premia and high volatility of equity prices. The estimated model implies a market risk premium of 6.7% and a 17.3% volatility of stock market returns, and generates a low risk-free rate of about 1%. The number of decision periods within a year is estimated at 11, which corresponds to a decision interval of approximately 33 days. Importantly, this estimated model, referred to as the benchmark LRR model, is not rejected with a p-value associated with the J-test for overidentifying restrictions of 11%.[1]

The inference and the economic implications change significantly if in estimation the effect of time aggregation is ignored. To demonstrate this, we estimate an "annual" version of the LRR model that assumes that the decision interval of agents is equal to the annual sampling frequency of the data. First, the annual specification is strongly rejected. Second, while the estimates of the annual specification also imply relatively high persistence of the expected consumption growth, the contribution of long-run risks to the overall volatility of consumption growth in the annual specification is much smaller than in the benchmark model. This difference is driven by time aggregation. In the annual specification, most of the annual consumption shock is incorrectly identified as short-run risk. As the implied contribution of long-run risk in the annual specification is incorrectly estimated to be quite small, the model requires high risk aversion to match the equity premium, despite this it fails to account for the dynamics of asset prices and, therefore, is rejected.

Using simulations the paper documents that when time aggregation is ignored, the model is overly rejected, the risk aversion estimate is upward biased, and the contribution of long-run growth risks is severely understated, all of which is consistent with our empirical findings. When the restrictions of time aggregation are not imposed, a sizable portion of the low-frequency growth shock tends to be attributed to the short-run shock, which diminishes the role of long-run risks and thereby lowers the ability of the model to match volatility of asset returns and prices. Overall, our evidence suggests that accounting for temporal aggregation in estimating the model and measuring the contribution of different sources of risks is extremely important.

In addition to the time-series implications of the benchmark LRR model the paper also evaluates its implications for the cross-section of size and book-to-market sorted portfolios. We find that assets with large mean returns, such as value and small market capitalization portfolios, are more sensitive to long-run risks. Similarly to the implications for the market portfolio, low-frequency growth and volatility risks are the key source of risk premia in the cross section. The LRR model is able to replicate the failure of the CAPM; in particular, it generates low market betas and high CAPM alphas of the value-minus-growth and small-minus-large strategies, of the same magnitudes as in the data.

Earlier work by Epstein and Zin (1989) rely on the GMM technique of Hansen and Singleton (1982) to estimate a model based on recursive preferences by replacing the unobservable return on the consumption asset with the market equity return. Different from them, we infer the dynamics of the wealth return from the observed consumption data by exploiting the model's pricing restrictions. The ability of long-run growth risks to account for various features of asset market data has been explored in a series of papers. Bansal et al. (2005), and Hansen et al. (2008) show that long-run risks in cash flows are important for understanding the cross-sectional variation in risk premia. Recent contributions to the long-run risk literature also include Parker and Julliard (2005), Kiku (2006), Bansal et al. (2007), Bekaert et al. (2009), Malloy et al. (2009), Lettau and Ludvigson (2009), Constantinides and Gosh (2011), Colacito and Croce (2011), Ferson et al. (2013), Calvet and Czellar (2015), Colin-Dufresne et al. (2016), and Jagannathan and Liu (2016). Distinct from these papers, we estimate and evaluate the LRR model in a GMM framework while imposing the models restrictions on the joint dynamics of consumption, dividends, and prices that appropriately account for temporal aggregation and highlight the importance of time aggregation in identifying the underlying risks.

The paper continues as follows. Section 2 presents the model and its testable restrictions. Section 3 provides details of our estimation methodology. Section 4 describes the data. Section 5 presents and discusses results of our empirical analysis. Section 6 provides concluding remarks.

[1] As discussed below, the estimates and the implications of the model estimated using post-war quarterly data are quite similar.