Heterogeneous Agent Calibration via Sparse Bayesian Structural Estimation: A Constrained Optimization Framework for Macroeconomic Equilibrium Decomposition

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Abstract. This paper develops a constrained sparse Bayesian structural estimation framework for calibrating heterogeneous agent models (HAMs) under aggregate demand uncertainty and endogenous credit market frictions. Existing methodological approaches frequently suffer from parameter identification failure and computational intractability when applied to high-dimensional income distribution panels. We address these limitations by integrating L1-regularized posterior inference with Krusell–Smith algorithm extensions, enabling tractable equilibrium decomposition across asymmetric household portfolios. Employing longitudinal microdata from fourteen OECD economies (2005–2023), our framework achieves a 34% reduction in simulated method-of-moments estimation error relative to conventional DSGE benchmarks. The results demonstrate that precautionary savings heterogeneity accounts for approximately 41% of unexplained cross-country output gap variance, providing actionable implications for macroprudential policy calibration and distributional fiscal consolidation strategies.

Keywords: heterogeneous agent models, sparse Bayesian estimation, structural macroeconomic calibration, Krusell-Smith equilibrium, macroprudential policy, income distribution dynamics, simulated method of moments, DSGE model identification, precautionary savings heterogeneity

Introduction

The calibration of heterogeneous agent macroeconomic models represents one of the most persistent and consequential methodological challenges confronting contemporary economic science. As global economies grapple with post-pandemic fiscal fragmentation, rising household income inequality, and structurally elevated sovereign debt burdens—conditions that have intensified considerably between 2024 and 2026—the demand for

tractable yet empirically grounded equilibrium frameworks has never been more acute. Standard representative-agent dynamic stochastic general equilibrium (DSGE) models, long considered the workhorse of central bank forecasting and academic macroeconomic analysis, fundamentally misrepresent distributional dynamics by abstracting away from portfolio heterogeneity, idiosyncratic income risk, and non-linear precautionary savings behavior. These limitations translate directly into policy errors: miscalibrated multiplier estimates, inaccurate assessments of fiscal consolidation spillovers, and systematically biased projections of aggregate consumption under credit constraint regimes. The heterogeneous agent framework pioneered by Aiyagari (1994) and subsequently operationalized in the Krusell–Smith (1998) paradigm offered a partial resolution to these deficiencies by introducing idiosyncratic endowment shocks and incomplete insurance markets. However, the structural estimation of such models remains computationally prohibitive at scale. The high-dimensional joint distribution of household assets, income states, and borrowing constraints yields a parameter space whose posterior geometry is riddled with local optima, weak identification regions, and multicollinear moment conditions. These barriers have historically confined rigorous HAM estimation to narrow applications involving simplified income processes or severely restricted agent heterogeneity. Recent advances in sparse regularization, Markov Chain Monte Carlo sampling efficiency, and large-scale panel microdata availability now create a viable pathway toward resolving these long-standing estimation bottlenecks. Sparse Bayesian methods, originally developed within the machine learning literature for high-dimensional variable selection, offer principled shrinkage mechanisms that simultaneously enforce parameter parsimony and preserve posterior uncertainty quantification—properties of direct relevance to structural economic identification. When integrated with moment-condition targeting from longitudinal household finance surveys across OECD member states, such methods yield a novel class of constrained estimators capable of recovering equilibrium distributions with substantially reduced simulation variance. This paper contributes to this emerging literature along three principal dimensions. First, we formally derive an L1-penalized Bayesian posterior objective function adapted for Krusell–Smith value function iteration, establishing conditions under which sparse identification is both consistent and asymptotically efficient. Second, we implement the framework on a harmonized fourteen-country OECD microdata panel spanning 2005–2023, benchmarking performance against standard simulated method-of-moments DSGE estimators. Third, we apply the calibrated model to quantify the contribution of precautionary savings heterogeneity to cross-country output gap dispersion, yielding direct implications for macroprudential capital buffer design and optimal progressive fiscal adjustment paths. The remainder of this paper is organized as follows. Section 2 reviews the structural estimation literature on heterogeneous agent models and positions our contribution within current methodological debates. Section 3 presents the theoretical framework, including the sparse Bayesian posterior derivation and its integration with the extended Krusell–Smith algorithm. Section 4 describes the data construction, harmonization procedure, and moment selection strategy. Section 5 reports

estimation results and decomposition analyses. Section 6 discusses macroprudential and fiscal policy implications, and Section 7 concludes with directions for future research.

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