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Technological heterogeneity and corporate investment

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ABSTRACT

We propose an importance-sampling procedure to improve the computational performance of the simulated method of moments (SMM) for the estimation of structural models with fixed parameter heterogeneity. The main advantage of the procedure is that it does not require to simulate observations every time that the structural parameters change during the minimization of the SMM criterion function. We illustrate the use of our method by estimating a neoclassical model of investment for a sample of US manufacturing companies, allowing the technological parameters to vary across firms.

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1. Introduction

There is a growing body of research that estimates structural models of corporate investment and financing choices.[3] The aim of many papers in this literature is to infer from the data the value of economic variables that are not directly observable by researchers, such as the costs of external financing (Hennessy and Whited, 2007), capital adjustment costs (Cooper and Haltiwanger, 2006), and the magnitude of agency conflicts between managers and shareholders (Nikolov and Whited, 2014). The approach followed by most papers in this literature is to parameterize an intertemporal model of firm-level investment and financing decisions, and estimate the parameters by matching a set of simulated moments from the model to their empirical counterparts. However, by assuming that all firms are described by the same set of parameters, this approach cannot account for the persistent differences in firm policies that have been documented in the empirical literature.[4]

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[3] See Strebulaev and Whited (2012) for a survey of this literature.

[4] For example, Lemmon et al. (2008) show that firm fixed effects account for the majority of the explained variation in leverage regressions. Fuller et al. (2002) provide evidence of differences in acquisition policies across firms. Studies of the determinants of investment typically include firm fixed effects to account for unobserved time-invariant heterogeneity across firms (see Fazzari et al., 1988), and Campello et al. (2013) show that there is considerable variation in investment–cash-flow and investment–*Q* sensitivities across firms.

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Our paper's main contribution is to develop a tractable and robust estimation methodology, based on importance sampling, that accounts for parameter heterogeneity in the cross section of firms. We demonstrate our approach in the context of a dynamic model of investment, allowing the parameters of the profit function and the capital adjustment costs to differ across firms. We estimate the cross-sectional distribution of the model's parameters and quantify their value for each firm in a sample of US manufacturing companies.

Our methodology is based on the simulated method of moments (SMM). The standard SMM procedure solves numerically the firm's intertemporal optimization problem, simulates a sample of firms, and computes a set of simulated moments. Minimizing the distance between simulated and empirical moments requires searching over the parameter space, which, in turn, requires numerically solving the firm's problem for many different parameter combinations. In the presence of heterogeneity across firms, there is an additional computational challenge that makes the estimation of the cross-sectional distribution of parameters with the standard SMM approach intractable: at every step in the minimization, one needs to solve a separate intertemporal problem for each parameter combination that occurs in the simulated cross section of firms. To alleviate the computational burden, we propose an algorithm based on adaptive importance sampling that iteratively estimates restricted local minima by only varying the distribution function of parameters, holding the simulated sample of firms constant, until no more improvement in the estimation criterion is possible. The output of the importance sampling algorithm is then used as an initial guess for the standard SMM estimator.

To illustrate our methodology, we employ a neoclassical model of investment that has become standard in the literature (see, for example, Adda and Cooper, 2003). The model is in discrete time, and the horizon is infinite. Firms are risk neutral and maximize the present value of future cash flows. In each period, cash flows are determined by operating profits, which are affected by persistent firm-specific profit shocks, the value of investment, and capital adjustment costs. The latter are incurred whenever a firm acquires or sells capital, which depreciates over time. The specification of the adjustment cost function accounts for asymmetric costs for investment and disinvestment, in the spirit of Abel and Eberly (1994) and Zhang (2005).

The key extension over the existing structural models in the literature is that we allow the technological parameters to vary across firms. In the model, firms are heterogeneous with respect to six technological parameters: the depreciation rate of capital, the persistence and volatility of the profit shocks, a profit curvature parameter that affects the marginal returns to capital, and two parameters that measure adjustment costs for positive and negative investment, respectively. Thus, in contrast to the existing structural models, different realizations of profits and investment across firms are not necessarily due to different firm-specific shock realizations, but they can be attributed to different firm-specific technological parameters.

We parameterize and estimate the cross-sectional distribution of technologies for a sample of 906 US manufacturing companies in Compustat for the period 1972–2012. The estimation results show that a considerable amount of technological heterogeneity exists across firms. Combining the distribution of technologies with firm-specific moments of investment and profits, we are also able to obtain parameter estimates at the firm level. When we test the empirical performance of the model, we find that most simulated moments closely follow their empirical counterparts, but the discrepancies are statistically significant. This exercise shows the potential, and the limitations, of neoclassical investment models to explain persistent heterogeneity in firm profitability and corporate investment polices.

The use of importance sampling techniques for Monte-Carlo simulation has been studied extensively in the literature (see, for example, Robert and Casella, 2005). Recent application of importance sampling for simulation-based estimation are Richard and Zhang (2007), who study an efficient importance sampling procedure in the context of maximum likelihood estimation, and Ackerberg (2009), who proposes the application of importance sampling in method-of-moments estimators. Our paper contributes to this literature by formulating an importance sampling algorithm that alleviates the computational burden of SMM estimation in the context of a neoclassical model of investment.

Two recent papers estimate structural models of corporate decisions accounting for heterogeneity in firm parameters. Morellec et al. (2012) estimate a dynamic capital structure model with agency costs. In their setting, closed-form solutions for optimal policies enable estimation by simulated maximum likelihood at a feasible computational cost. To account for heterogeneity, Glover (2016) estimates firm-by-firm a trade-off model of capital structure, to quantify the cross-sectional distribution of financial-distress costs. Whereas these papers focus on financing policies, ours is the first paper, to the best of our knowledge, that estimates a neoclassical model of investment allowing for parameter heterogeneity across firms. Furthermore, our paper does not require closed-form solutions of the firm's policy functions, or to estimate the model separately for each firm in the data. The methodology employed in this paper can benefit researchers in macroeconomics, finance, or industrial organization who seek to incorporate parameter heterogeneity in the estimation of their structural models.

The paper is structured as follows. Section 2 discusses the estimation of models with fixed parameter heterogeneity using SMM. Section 3 presents the importance sampling algorithm. Section 4 applies the importance sampling algorithm to a dynamic model of firm investment. Section 5 concludes.

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