Shadow Costs, Credit Allocation, and Investments

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Research question. A large body of empirical studies provides evidence of the impact of financing frictions on firms' investment behavior. Frictions can affect investments either through high borrowing rates or through supply-driven quantity constraints on the amount of finance available. The latter generate heterogenous shadow prices that drive a wedge between marginal products and user costs of capital. Both interest rate premia and credit constraints lead to the same quantitative conclusion that investment is lower than it should be in the absence of frictions.

The question remains what is the relative importance of these two channels. On the one hand, investment policies of larger firms that participate in the corporate bond market appear to be highly sensitive to changes to the cost of debt (Gilchrist and Zakrajsek, 2007). On the other hand, several empirical studies focusing on small and medium firms find little, if any, sensitivity of investments to borrowing costs, providing instead robust evidence consistent with an exacerbation or relaxation of credit rationing in response to changes in credit market conditions (Petersen and Rajan, 1994).

Motivated by this contrasting empirical evidence, in this study we want to take the following questions to the data: What is the relative importance of price distortions versus quantity constraints? How does their relative importance vary across firms and over the credit cycle? The answer to these questions is of pivotal importance for many areas of economics - including monetary policy, macro/finance, corporate finance, and economic development –, with relevant implications for the design of macro-financial policies that aim at promoting sustainable economic growth. For example, the real effects of financial and regulatory frictions affecting banks' credit supply depend on whether such frictions are passed on to firms in the form of distorted market prices or tighter credit limits. Moreover, there is a growing consensus that the contribution of credit expansions/contractions to business cycle fluctuations and to long-term economic growth crucially depends on credit allocation on top of (and possibly more than) aggregate credit volumes (Gopinath et al., 2017). Yet to date, we have no robust metric to evaluate the efficiency of credit allocation across heterogeneous firms. Estimates of firm-level shadow prices would help assess whether credit flows toward those firms that need it the most (i.e. high shadow prices) and, if not, what frictions can better explain allocation failures.

Data. It is difficult, or impossible, to quantify the relative importance of prices versus quantity distortions without detailed micro-data on firm-level quantity and prices of credit and information on firms' production and financing decisions. Overcoming the data limitations of previous research, we assemble a comprehensive bank-firm-employee matched panel dataset linking the Italian census of corporations to the archives of the national credit register and to employer-employee records obtained from the social security administration. Our dataset consists of 13.3 million credit relationships, 4.7 million firm-year observations, and 7,300 thousand firms, accounting for approximately 90% of the value added produced by the Italian non-financial corporate sector between 1997 and 2014. To the best of our knowledge, ours is the first, large-scale longitudinal dataset providing information on both input, production, and financing choices, including the terms of credit agreements (borrowing costs) for the large majority of the production sector of a country.

Research design. While we can observe borrowing costs in our data, shadow costs are unobservable quantities. We propose an empirical methodology that, by combining reduced-form variation with structural estimation of production and financing parameters, allows us to shed light on the distribution of shadow prices generated by supply-driven credit constraints.

First, we estimate firm-specific gaps between marginal revenue product and user costs of capital (MRP-cost gaps). As shown by Lenzu and Manaresi (2018), MRP-cost gaps can be interpreted as Euler equations residuals, whose variation reflects, in part, heterogeneous shadow costs of funds generated by binding borrowing constraints. We measure firm-specific user costs of capital directly in the data, as the sum of firm-specific borrowing costs and depreciation rates. We adopt a structural approach to estimate firm-specific marginal revenue products of capital, accounting for the large differences in production technologies and productivity across firms.
The second step of our research design is the estimation of a dynamic structural model with real and financial frictions. In the model, financial frictions affect firms' investment choices either through interest rate premia or through borrowing limits. We allow for an upward-sloping interest rate schedule and endogenous borrowing constraints, both of which are heterogeneous – i.e. a function of firm-characteristics such as firm-size and leverage – and stochastic – i.e. move in response to credit supply shocks. We use observed investment and financing choices and information on credit contract terms (interest rates) in order to estimate the parameters of the structural model by exploiting simulated methods of moments (SMM).
Finally, we recover the distribution of shadow prices by regressing model-based estimates of borrowing limits on MRP-cost gaps, using an appropriate errors-in-variables correction model to account for the fact that borrowing limits are estimated and thus possibly mismeasured (Erickson, Jiang, and Whited, 2014).

A major challenge in the SMM procedure is to jointly identify the parameters capturing the responsiveness of firm investment policies to changes in user costs from the effect of binding quantity constraints (shadow costs). The scale and granularity of our data allows us to make progress in this dimension. Leveraging on the firm-bank matched records from the credit registry, we separately identify time-varying credit-supply shifters from firms' credit-demand shocks (Amiti and Weinstein, 2018). Using the estimated credit-supply shocks and data on borrowing costs, we estimate interest rate elasticities with respect to firm size, risk, and credit shocks, which we feed to the structural model. Moreover, we exploit within-firm variation in the credit shifters to consistently estimate the parameters of the credit shocks process. Lastly, the credit shifters allow us to estimate, in reduced form, the elasticity of investments to changes in credit supply for firms of different size and risk. These empirical moments are highly informative about the heterogeneous impact of supply-driven credit constraints on firm policies and therefore they represent an ideal moment to target in our SMM procedure.

With the structural estimates of shadow costs and the observed interest rates in hand, we can study the relative importance of price distortions versus quantity constraints in the cross-section of firms and over the credit cycle. The correlation between credit flows and shadow costs will provide us with a novel metric to evaluate the efficiency of credit allocation.

Computing language and cluster computing. We use Fortran to solve, simulate and estimate the dynamic structural model. STATA is used to estimate reduced-form elasticities and perform the structural estimation of MRP-cost gaps.

The level of heterogeneity we allow in both the reduced-form and structural analysis could not be feasible without access to the cluster computing resources available at the Bank of Italy and NYU. Cluster computing allows us efficiently manage our large-scale database, to parallelize the non-linear GMM estimation of firm-specific production function parameters, and to structurally estimate borrowing constraints' parameters that vary across industries and type of firms.

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