

THE IMPACT OF CREDIT CONSTRAINTS ON TOTAL-FACTOR ENERGY EFFICIENCY: EVIDENCE FROM MANUFACTURING FIRMS

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Overview

This paper used data on 5,154 manufacturing firms from 39 countries to evaluate how credit constraint conditions affect total-factor energy efficiency (TFEE) derived from data envelopment analysis (DEA). An endogenous switching model is applied to control for endogeneity, selection bias, and firm heterogeneity. The estimation results indicate that the average TFEE score is about 58.1 and 58.6 percentage points for credit-constrained and credit-unconstrained firms, respectively. Lifting credit constraints for constrained firms would increase their TFEE score by 7.05 percentage points. The aggregate results at the industrial sector level are consistent with those documented in previous studies. However, our results further reveal that energy efficiency and treatment effects vary across industrial sectors and firms within a sector of interest. This provides supportive evidence for policymakers to design loan guarantee programs and credit supply, among the sectoral policies and regulations, for energy efficiency improvement.

Methods

An econometric model is applied to estimate how credit constraint conditions and other potential factors determine the degree of energy efficiency of those sample firms. The regression equation is as follows:

$$TFEE_i = a_0 + a_1 \text{CreditConstrained}_i + \beta' X_i + \sum_{k=1}^n d_k \text{Country}_{k,i} + \sum_{k=1}^o e_k \text{Sector}_{k,i} + u_i \quad (1)$$

where X is a vector of explanatory variables that affect the degree of energy efficiency, in addition to credit constraint conditions. The Country and Sector dummies capture the heterogeneity across countries and manufacturing sectors. u is the error term.

The potential endogeneity issue is addressed by an endogenous switching model. The TFEE is derived from data envelopment analysis (DEA). control variables when testing the impact of credit constraints on TFEE include R&D (Research and development expenditures), Sales, Capital-Labor (The ratio of capital stock to the number of employees), Export, Foreign-Ownership, Age, and Firm-Size. All the data are calculated from the World Bank Enterprise Surveys (Enterprise Surveys, 2020).

Results

The estimation results suggest that Lease is the only significant instrumental variable. Firms with leased fixed assets are more likely to face limited access to credit, in line with the fact that firms' main obstacle when applying for bank loans is their lack of collateral. This coincides with the estimation of Capital-Labor, which is significant and negative. A high capital-to-labor ratio indicates the availability of collateral for bank loans. R&D may drain firms' liquidity reserves, resulting in credit constraints. Firms with high sales, export firms, and old firms are less likely to be constrained by access to credit. The positive coefficient of Size-Medium and Size-Large means that large firms (in terms of the number of employees) have limited access to credit. In general, large firms have a sound financial health condition. Considering the estimates of Sales, the level of sales is probably a more precise proxy of firm size than the number of employees (Zhang, 2021).

The estimation results for the two TFEE equations are substantially different, with regard to the size, sign, and significant level of the coefficients. R&D is only significant and negative in the regression for unconstrained firms. R&D may contribute to new products or new processes, which increase energy consumption more than value-added, especially in the early stage. Both Sales and Capital-Labor are significant in the two equations. The level of sales increases energy efficiency much more for unconstrained firms than for constrained firms, in line with findings in previous studies using regional data, which generally confirmed a positive relationship between economic development and energy efficiency (Yang and Wei, 2019). The Energy efficiency of unconstrained firms is less negatively affected by the capital-to-labor ratio than that of constrained firms, in line with the findings in Zhang, Li, and Ji (2020). Access to credit may facilitate investment in energy efficiency technologies and hence improves the energy efficiency of those capital-intensive firms.

Export and Age are only significant in the regression for constrained firms. Export firms and old firms have lower energy efficiency when they face credit constraints. These findings indicate that limited access to credit may distort or disconnect the relationship between energy efficiency and factors, which are expected to impact energy efficiency positively. Foreign-Ownership is only significant in the regression for unconstrained firms. For these firms, foreign ownership is negatively associated with energy efficiency, in line with the findings of Bu et al. (2019) and Yang and Wei (2019).

Size-Large is significant in the two regression equations but with opposite signs. Size-Medium is significant and negative in the regression for constrained firms. Unconstrained medium-sized and large firms in terms of the number of their employees have lower energy efficiency, indicating the lack of scale effect. Large and credit-constrained firms may effectively rely on the input of employment to enhance their energy efficiency.

Conclusions

Reducing energy consumption to mitigate its negative environmental impact has become one of the top-priority concerns for policymakers, industries, and firms around the world. This study uses data on 5,154 manufacturing firms from 39 countries to assess how total-factor energy efficiency is influenced by credit constraint conditions. Access to credit is one of the primary obstacles to operating activities and environmental practices for manufacturing firms in developing countries. At the macro level, financial development influences the level of emissions of countries around the world. Previous empirical studies evaluated energy efficiency at the level of countries, regions, and industrial sectors. Based on these evaluations, government support programs, such as financial market mechanisms and direct financial incentives, are recommended to improve energy efficiency. As our study is based on firm-level data, it complements the findings in previous sector-level studies. The revealed firm heterogeneity with regard to both energy efficiency scores and how they respond to financial constraint conditions further provides implications for sectoral policies.

From the estimated firm-level energy efficiency scores, we obtained the aggregate energy efficiency scores, which are consistent with the findings in previous studies. Thus, the measures of sector-level energy efficiency can help governments to design sectorial policies and interventions for energy efficiency improvement. However, our empirical results indicate substantial differences in firm-level energy efficiency scores for high or low energy-intensive industries. Thus, our empirical results further shed light on identifying firms with lower energy efficiency in all sectors, which helps policymakers to design government support programs at the firm level. For example, based on the documented relationship between financial development and emissions, it is recommended for policymakers to improve financial market efficiency and design loan guarantee programs in order to incentivize investment in energy efficiency technologies and equipment. Our empirical results indicate that firms with low sales, capital-intensive firms, and old firms are more likely to be constrained by access to credit. The energy efficiency of those constrained firms would be substantially improved if financial institutions would meet their demand for credit. In addition to general sectorial policies, a more efficient loan guarantee program can be implemented at the firm level, which raises banks' willingness to approve loan applications from credit-constrained firms.

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