EMBODIED AND DISEMBODIED CAPITAL IN ENERGY CONSERVATION: THE CASE OF CHINESE INDUSTRY

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Overview

A number of studies focused on energy conservation in Chinese industry and elsewhere employ methods, including production technologies and energy demand functions that assume the capacity of energy use in industrial economies to instantaneous adapt to policy incentives to motivate greater energy efficiency in production. Among these policy instruments are relative energy prices, taxes on energy use, and targets or caps on energy use or energy intensity. In some cases, such measures assume instantaneous adjustment or, more realistically, they may impose some arbitrary deadline for compliance.

In this paper, we explicitly acknowledge the so-called putty-clay nature of a significant portion of investment and the capital stock, that is, various forms of investment in plant and equipment are likely to embody a certain vintage of technology or factor intensities – capital-labour ratios or capital-energy ratios – that once installed afford only limited opportunity to adjust. That is, while some investment and capital may be putty-putty, so as to allow for immediate adjustment or retrofitting in the face of energy-saving policy initiatives, other forms of investment and capital are putty-clay, so that limited adjustment and energy-savings can be achieved in the short run.

Most certainly, governments and firms that are devising energy conserving strategies need to make explicit their understanding of the balance between disembodied (putty-putty) and embodied (putty-clay) technologies that infuse the investment and capital stock that determines the responsiveness and time structure of the ability of the installed capital to respond to the devised incentives.

In this paper, we estimate sets of price elasticities for different industries so as to explore the variation in the time structure with which different industries, ranging from the most to the least energy intensive respond to energy price incentives. Given the differences in the time structure of price responsiveness, we identify the embodied-disembodied profile of the underlying capital stock. Specifically, we identify and estimate the different parameters that can explain the differences in price-responsive time structures. One is simply the difference, i.e., putty-putty versus putty-clay distinction between two categorically different forms of capital. Each time structure price responsiveness can be explained by a particular mix of the two kinds of capital.

The paper is organized as follow: section 2 estimates both short-run and long-run price elasticities of energy for 38 industries, using a unique panel data recording firm-level energy consumptions from 1997 to 2004. In section 3, we develop a dynamic stochastic general equilibrium (DSGE) model, explicitly incorporating putty-clay capital and investment irreversibility. Section 4, we uncover the structural parameters in the DSGE model, which is able to re-produce the short-run and long-run price elasticities that are presented in section 2. Several policy experiments are conducted based on the estimation results in section 5. Conclusions are drawn in section 6.

Methods

Regression analysis, DSGE model, and indirect inference method.

Results

First, the DSGE model we develop in this paper is able to explain the asymmetric relationship between energy price change and output. When an economy is facing an unexpected increase in energy price, its output will drop in a greater magnitude, because the investments that were made when energy price was relatively low, are less energy efficient. This will lead to a significant decrease in output level. On the contrary, when an economy is experiencing low energy price, its output will increase in a moderate magnitude, because the investment, that were made when

energy price was relatively high, are already more energy efficient. Thus, the vintage structure in capital results in asymmetric response of output to energy price shock.

Second, our estimation results show that there is a statistically significant proportion of putty-clay capital in Chinese industries. This suggests that in comparison to disembodied technology, embodied technology plays a much important role in achieving energy efficiency in Chinese industry.

Third, from the perspective of devising energy conservation strategies, encouraging new investment in energy-saving capital tend to be an efficient policy instrument.

Conclusions

In the past thirty years, embodied technology plays an important role in achieving energy efficiency in China's industry. Encouraging firms to invest in energy-saving capital is instrumental for China's energy conservation and CO2 reduction strategies.