Manufacturing investment of heterogeneous firms facing non convex adjustment costs

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Overview

In this research work, I introduce technological choice embodied in capital to a general equilibrium model with heterogeneous agents where firms face convex and non convex adjustment costs to investment. They may choose between a "clean" and a "dirty" capital stock, each using a specific energy input with a specifici productivity. This generates an inertia and a lumpiness in investment at firm level faced by heavy industry firms characterized by capital intensiveness and long investment cycles, as identified by Doms & Dune (1995).

We consider an initial steady state where the dirty technology dominates, due to higher productivity and lower energy price. We test public policies composed of a carbon price and a subsidy to investment, as well as the effect of a shock to energy prices and analyse the resulting steady state and transition dynamics.

We thus explore a case in point of "carbon lock-in" (Unruh 2002) whereby carbon using technology benefits from its historical adoption in posterior adoption choices, a situation notably explored by Acemoglu, Aghion, Bursztyn and Hemous (2012) with directed technical change We focus here on the role of capital investment with frictions.

Methods

We build a general equilibrium model with heterogeneous firms. Invetment is subjected to a quadratic cost, as well as a discrete cost when investment exceed a maintenance threshold. Investment is furthermore irreversible, and can by directed either toward a clean and a dirty technology, embodied in capital.

Heterogeneity stems from an idiosyncratic productivity shock faced by firms, as well as the distribution over each period of the discrete cost. Households have a standard concave utility function with a habit formation behaviour, which, following Winberry (2021), limits the volatility of interest rates which may nullify the effects of non convex adjustment costs, as in Khan and Thomas (2008).

We leverage the endogeneous gridpoint method as a recursive method (Carroll 2006), which we apply to the non-convex case (Ishkakov 2017, Druedahl and Jorgensen 2017, Druedahl 2021). We then use the Sequence Space Jacobian framework developed by Auclert & al. (2021) that allows to efficiently compute agents response to a future shock at the steady state while accounting for heterogeneity.

We test the evolution of productivity using a bounded learning by doing framework as used by Kahlkuhl (2012), where productivity stems from accumulated production with an asymptotic maximal productivity.

Results

We show the presence of a low responsiveness area of public policies, due to firms existing stock of dirty capital associated with an inertia generated by discrete adjustment costs. The maintenance investment allows firms to maintain their dirty capital stock close to their optimal capital stock while building a clean invesmtment stock requires that firms initiate a large investment, resulting in a limited extensive margin (the mass of firms that invest in the clean technology).

Conclusions

We analysed how a heavy industry sector, facing long investment cycles and capital intensive technological choices, may switch its investments toward clean production technologies, thus phase down its use of fossil fuels. We do it through convex and non convex adjustment costs that may limits firms reaction to policies or price shock when they are too small. We accordingly show how large policy or price push may allow the clean technology to take-off and thus decarbonize the manufacturing sector.

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