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Fixed costs and long-lived investments

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ABSTRACT

Fixed costs models are difficult to analyze because they feature non-degenerate, time-varying distributions of capital across firms. If investments are sufficiently long-lived however then the cross-sectional distribution of capital holdings has virtually no bearing on the equilibrium and the aggregate behavior of fixed-cost models is essentially identical to neoclassical models. The findings are due to a near infinite elasticity of investment timing for long-lived investments – a feature shared by fixed-cost models and neoclassical models. "Irrelevance results" found in numerical studies of fixed-cost models are not parametric special cases but instead are fundamental properties of models with long-lived investment goods.

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1. Introduction

Conventional neoclassical investment models typically assume that capital adjustment costs rise smoothly with investment and thus predict that firms should make frequent, small adjustments to their capital stocks. Microeconomic evidence, however, shows that firms make infrequent, large adjustments to their capital stocks (see, e.g., Doms and Dunne, 1998). Motivated by the micro-evidence, researchers have developed models emphasizing *fixed* adjustment costs. To avoid paying the fixed cost too often, firms wait to adjust their capital, and when they do adjust, they make large adjustments. While these models generate the observed firm-level investment behavior, it is not clear that the aggregate equilibrium behavior of fixed cost models differs significantly from the equilibrium behavior generated by neoclassical investment models. Prominent numerical studies of calibrated DSGE models with fixed adjustment costs suggest that there are only minor differences between the two (e.g., Thomas, 2002; Veracierto, 2002; Khan and Thomas, 2008). The cause of these "irrelevance results" is often attributed to consumption smoothing forces present in general equilibrium. The irrelevance results have been contested by other researchers on the grounds that they hold only for some parameter values and are not a general feature of equilibrium models with fixed costs.

The aggregate behavior of models with fixed adjustment costs is important for several reasons. Much of our existing understanding of investment is based on neoclassical models that abstract from fixed adjustment costs. Because the earlier models contrast sharply with the microeconomic evidence, researchers are justifiably concerned that predictions or policy conclusions based on these models may be misleading. On the other hand, if the aggregate behavior of the two modeling frameworks is similar, then the apparent failure of neoclassical models at the micro level does not mean that we need to

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abandon the neoclassical framework entirely to analyze aggregate investment. Indeed, there may be reasons to prefer the neoclassical model. Unlike neoclassical investment models, fixed-cost models are analytically very cumbersome. Models with fixed costs typically have non-degenerate distributions of capital across firms. These distributions are time-varying objects which enter the models as additional state variables, making the models extremely difficult to analyze, particularly in equilibrium settings.

This paper analyzes the approximate equilibrium behavior of an investment model where fixed costs matter at the microeconomic level. The analysis shows that optimal investment behavior is characterized by an extremely high intertemporal elasticity of substitution for investment purchases. For sufficiently long-lived capital goods (capital goods with low rates of economic depreciation), the elasticity is nearly infinite. This property has a number of implications.

First, for long-lived investment goods, the underlying distribution of capital holdings across firms has little bearing on the equilibrium. Because they are willing to drastically change the timing of their investments, firms that are bunched up or spread out relative to the steady state distribution simply delay or accelerate the timing of their investments to avoid high prices or take advantage of low prices. The high intertemporal elasticity of investment demand effectively eliminates any role for the cross-sectional distribution to influence aggregate investment.

Second, the near infinite elasticity of investment timing is a property that fixed-cost models share with neoclassical investment models. Investment demand in both models can be approximated by a demand curve which is essentially flat. As a result, if investment supply were the same, the equilibrium paths in the two models would be almost identical. Put differently, the analysis suggests that the "irrelevance results" are fundamental properties of fixed-cost models – not artifacts of particular calibrations. Thus, at the aggregate level, investment and investment prices, particularly for long-lived capital goods, can often be accurately analyzed with traditional, neoclassical investment models. While neoclassical models cannot match the behavior of the firms at the microeconomic level, they provide an easy, reliable guide to aggregate behavior, policy analysis and empirical predictions.

The similarity between neoclassical models and fixed-cost models does not rely exclusively on consumption smoothing. Because neoclassical models and fixed-cost models both have high intertemporal elasticities for investment timing, anything that causes the effective price of new capital goods to increase with total investment will make the models difficult to distinguish with aggregate data. An increasing quadratic adjustment cost in a neoclassical framework and an upward-sloping supply curve in the fixed-cost model will result in the same equilibrium paths provided that the elasticity of the marginal cost of investment is the same in each case. In one-good DSGE models, consumption smoothing motives naturally imply increasing marginal costs of investment and result in the striking similarities between dynamic models with and without fixed costs.

Before proceeding, I should make clear that the key property of the model which generates the irrelevance results – the infinite elasticity of investment demand – is a feature of the *models* and may not be a feature of *reality*. In the model, firms are extremely willing to change the timing of their investments in response to small price changes. In reality, firms might not pay much attention to small price changes and may be unwilling to change the timing of their investment plans.

2. Background and related literature

In micro data, plant level investment is characterized by long periods of relative inaction punctuated by episodes of high investment. Doms and Dunne (1998) show that most U.S. manufacturing plants experience at least one year in which their capital stock rises by at least 50 percent and for many establishments, half of all plant-level investment spending over a 17-year horizon is concentrated in the three years surrounding the year with the plant's greatest investment. Cooper et al. (1999) show that each year, roughly 1 out of every 5 manufacturing plants experiences an "investment spike," defined as an increase in plant-level capital of at least 20 percent. Moreover, aggregate variation in investment spikes accounts for the bulk of the variation in U.S. manufacturing investment. Gourio and Kashyap (2007) show that aggregate variation in investment spikes is primarily driven by changes in the number of firms experiencing spikes rather than changes in the average size of spikes.[1] As a whole, the evidence from the micro-data is in stark contrast to the predictions of standard neoclassical investment models with convex adjustment costs (e.g., Abel, 1982; Hayashi, 1982 and Summers, 1981).

Investment models with fixed costs can rationalize the lumpy investment seen in the data. Firms invest infrequently to avoid paying the fixed cost. Unlike earlier convex models however, models with fixed costs are difficult to solve even in partial equilibrium and are often completely intractable in general equilibrium. The difficulty in solving these models arises because not all firms have the same level of capital at any point in time. Some firms have old, outdated capital and are likely to adjust in the near term. Other firms have recently adjusted and will not purchase new capital for quite some time. The distribution of capital across firms changes whenever shocks or policies disturb the market. To solve the model, one must keep track of an endogenous, time-varying distribution of capital.

Because the position and dynamics of the distribution of capital can potentially influence the equilibrium, the distribution often plays a prominent role in the questions posed by the literature on fixed costs. For example, if there were an unusually large number of firms with relatively old capital, one might expect to observe unusually high investment

[1] Doms and Dunne (1998) and Cooper et al. (1999) base their findings on data from the Longitudinal Research Database (LRD), which includes most U.S. manufacturing plants. Gourio and Kashyap (2007) use both LRD and Chilean data on manufacturing plants. See also Cooper and Haltiwanger (2006).

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