



# Investment dynamics with fixed capital adjustment cost and capital market imperfections

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Received 25 November 2004; received in revised form 4 November 2005; accepted 18 April 2006

Available online 11 October 2006

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## Abstract

This paper examines the implications of financing frictions on capital stocks and on capital accumulation in the presence of non-convex costs of adjusting the capital stock. In this setup finance has an influence on both, the level of capital and the timing of investment. Finance and productivity are complements and finance influences investment the strongest when firms wish to significantly adjust capital for fundamental reasons. These theoretical considerations are confronted with UK data. While finance is mostly irrelevant for long-term capital decision, the short-run investment function shows a significant impact of finance, which is also strongest for strong fundamental investment incentives.

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*JEL classification:* E22; E44; G31; C32; C33

*Keywords:* Investment; Non-convex adjustment cost; Imperfect capital markets; Non-linear error-correction

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## 1. Introduction

Economists' knowledge of micro-level and aggregate investment is still far from being conclusive. Seemingly well established, however, is the view that the workhorse of the neoclassical theory of investment, the  $q$ -model, has a hard time explaining empirically observed patterns of investment.<sup>1</sup> Which of the assumptions of the neoclassical model actually leads to its failure remains to be answered.

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<sup>1</sup>See Caballero (2000).

Beginning with Fazzari et al. (1988) the empirical literature has emphasized the role of financial factors in firm-level investment. More recently attention has been drawn to the role of non-convexities in the investment technology. This paper aims at merging both of these strands and shows that financial factors and non-convexities are both simultaneously important, since each significantly influences the effect of the other.

This interaction has not been analyzed much, though recent contributions have drawn attention to the issue: Holt (2003) provides a theoretical real-options model of irreversible investment that shows how financial frictions and irreversibility of investment interact as complements, Caggese (2003) develops a formal test for financial constraints based on the irreversibility of fixed investment, and Whited (2006) provides evidence that firms which are identified as financially constrained exhibit investment spikes much less frequently.

Our approach differs in both methodology and focus from these studies. With nonconvex adjustment costs, firms invest infrequently and lump their investment projects. We argue that this opens two ways for finance to affect investment: first, finance can alter the target level of capital to which a company adjusts and secondly, it can influence the timing of investment, the frequency at which projects are carried out. Our focus is to disentangle the two effects both theoretically and empirically.

This makes Whited's (2006) paper most closely related, as her paper also analyzes the effect of finance on the timing of investment. However, she does not disentangle timing and level effects of finance, but only investigates if financially constrained firms adjust capital less frequently. Specifically, she estimates hazard rates for investment spikes as functions of the time elapsed since the last spike and performs this estimation for both, financially unconstrained and financially constrained firms.

By contrast, our paper employs a "gap-approach" as developed in Caballero et al. (1995). This means that we estimate a non-linear error-correction model of capital which relates capital to productivity and finance. In relation to Whited's (2006) approach, this can be understood as a step towards structural estimation; tying the theoretical model more closely to the estimation. This step allows to separate timing and level effects of finance on investment.

When we assess empirically which of the two effects is more important, the influence of finance on long-term target levels of capital or the influence of finance on the timing of investment, finance shows at best a minor influence on the long-term stocks of capital that companies hold. By contrast, finance has a significant influence on investment. In consequence, finance has only an intertemporal substitution effect—more liquidity speeds up investment.

A similar result is found in Bayer (2004a), which extends the empirical analysis here to German data. In particular, Bayer (2004a) focuses on the discussion of potential endogeneity problems of finance and shows that the results are robust to a more detailed treatment of the problem. Also for the German data, finance influences investment timing but not long-term levels of capital.

This result itself is already informative for identifying the actual form of frictions involved. Consider a convex adjustment cost model with wealth-dependent costs of capital, for example. In such model, one would expect the relative strength of both effects (level vs. frequency) to be just the reverse. Convex adjustment costs lead to partial adjustment of the current stock of capital to its target level every period and a change in finance translates into a change in the target level of capital. Consequently, our findings allow us to reject this model.

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