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Investment options and the business cycle

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Abstract

This paper extends [R. Mehra, E.C. Prescott, Recursive competitive equilibrium: The case of homogeneous households, Econometrica 48 (1980) 1365–1380] to a production economy with two capital goods. It is an RBC model in which each unit of investment requires a new idea, an 'option.' When options are scarce, new capital is harder to put in place and the value of old capital rises. Thus the stock market and Tobin's Q are *negative* indexes of intangibles. During a boom, Q rises *gradually*, as options are used up. Because investment represents an exercise of options, it has an intertemporal substitution tradeoff that is absent from the adjustment-cost model. Equilibrium may be efficient even without markets for knowledge; the stock market may suffice.

JEL classification: E3

Keywords: Tobin's Q; Adjustment costs; Intertemporal substitution

1. Introduction

This paper extends [14] to a production economy with two capital goods. One is a traditional capital stock, the other is unimplemented knowledge that I refer to as 'investment options.' I shall refer to traditional capital as 'trees' and to the unexercised options as 'seeds.' The paper is a specialization of Lucas's model in the sense that the shocks to the trees' productivities are common.

An investment option is a profit opportunity that requires an investment to implement. It is postponable if it is a patentable invention, or if it is specific to a firm so that others cannot reduce

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its value by copying it. In some cases a firm can protect the option by secrecy alone. Thus, a firm may use it up immediately, or store it for future use.

I set up a competitive GE model in which to plant a tree one needs a seed. seeds are produced by trees that are already planted. The number of trees grows over time and, in the absence of the seed constraint on investment, the model would be a standard one-sector Ak model with shocks to technology.

The model also embeds in GE and endogenizes what Abel and Eberly[1] refer to as 'growth options.' The model has no shocks to the investment technology, but it behaves a bit like models that do have such shocks, such as [5] and [7] because an abundance of seeds works in a way similar to a low price of capital goods. Investment options are also a focus of new Keynesian models [19], and strategic delay models [2,16]. The paper also relates to models of inventories, e.g. [4]. The paper's main results are as follows:

(i) *Intangibles reduce Q.*—Because seeds (i.e., 'intangibles') are scarce, the value of planted trees (i.e., firms) and thus Tobin's Q, is always above unity. When there are many seeds, their price falls, and if the decline is sharp enough, so then does the price of claims to the output of planted trees.[2] Contrast that to [9], where Q is a positive indicator of the stock of intangibles because his intangibles are not embodied in capital but, rather, enter the final-goods production function as a separate input. A natural experiment is a prolonged war during which defense-oriented research leads to a pile-up of unimplemented inventions. My model says that after such a war Q should be low, whereas Hall's model says that it should be high. It turns out that after both world wars, Q in the U.S. was unusually low. Also, measures of intangibles based on aggregate patent applications and trademarks co-move negatively with Tobin's Q, thus supporting my model.

(ii) *Q rising during a boom.*—The main difference between the seeds model and the adjustment-cost model is that in a boom during which seeds become ever more scarce, Tobin's Q gradually rises. This may explain the late '20s and the '90s. For this implication, the ability to store seeds is crucial; the stockpile dwindles as the boom continues. Conversely, a rising supply of seeds during a recession means that Q gradually falls and investment gradually rises. Related to this are models of liquidity constraints that prevent firms from eliminating the gap between Q and unity. [6] reports a liquidity factor in asset prices that, however, behaves procyclically: 'Liquidity' seems to pose a greater constraint in the boom, which is consistent with the seeds model but regarded as inconsistent with the financial frictions model that they propose.

(iii) *More volatile investment.*—The seeds model introduces an intertemporal substitution in investment that raises its volatility for given average levels of Q.[3] By contrast, convex adjustment costs make investment smoother. The concept of investment in this model is 'extensive' investment in new things, and such investment responds more elastically to variations in Q; witness, e.g., how closely and elastically venture-backed investment follows the Nasdaq index.

(iv) *Decentralization.*—I provide two decentralizations of the planner's optimum. The first has a market for seeds and trees, the second has only a market for shares of firms. The latter has an equilibrium that coincides with the planner's optimum, but it may have other, inefficient equilibria.

[1] A. Abel, J. Eberly, Investment, valuation, and growth options, Wharton School, October 2005.

[2] This GE arises when *all* firms have more seeds. For a firm that *alone* receives an additional seed, Q would rise.

[3] By the same token, the ability to postpone investment reduces the model's ability to explain the volatility in Q. Intertemporal substitutability raises supply elasticities generally; e.g., of labor supply in [13], or of sales in [4] and [12], and lowers the volatility of equilibrium wages and prices.