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# An equilibrium model of irreversible investment <sup>☆</sup>

Leonid Kogan\*

*Finance Department, The Wharton School, University of Pennsylvania, Philadelphia,  
PA 19104-6367, USA*

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## Abstract

This paper presents a general equilibrium model of a two-sector production economy with irreversible real investment. Irreversibility of investment is the most prominent feature of the productive sector. It restricts capital accumulation, affecting firms' investment decisions, which in turn determine properties of asset prices. Thus, this model provides a framework for connecting stock returns to firm characteristics that proxy for real economic activity. The primary focus of this paper is on the analysis of the equilibrium and the effects of irreversibility of investment. © 2001 Elsevier Science S.A. All rights reserved.

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\*Corresponding author. Tel.: +1-215-898-7617; fax: +1-215-898-6200.

*E-mail address:* lkogan@wharton.upenn.edu (L. Kogan).

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## 1. Introduction

Most asset pricing models focus on the demand side of the economy, making extremely simple assumptions about the supply side. For example, consider two of the most influential papers in this literature, Lucas (1978), and Cox et al. (1985). Lucas assumes that the supply of risky assets in the economy is completely exogenous. Thus, the elasticity of supply is equal to zero and demand shocks are absorbed entirely by changes in asset prices. On the other hand, Cox, Ingersoll, and Ross assume the opposite extreme. In their model the supply of basic risky assets is perfectly elastic. As a result, demand shocks have no effect on the prices of these assets. In both cases the elasticity of supply is fixed, either at infinity or at zero.

The focus on the demand side of the economy proves to be fruitful by delivering tractable models. The obvious drawback is that such models do not lead to a realistic description of supply dynamics, limiting one's understanding of the interaction between real economic activity and prices of financial assets. To learn more about such interaction, the traditional paradigm must be augmented by incorporating economic activity of firms, such as their production and investment decisions.

In this paper, I develop a two-sector continuous-time general-equilibrium model of a production economy with irreversible investment. Irreversibility of investment is the most prominent feature of the productive sector. It restricts the process of capital accumulation, affecting firms' investment decisions, which in turn determine properties of asset prices. Thus, this model leads to a structural relation between stock returns and firm characteristics that proxy for real economic activity.

The main objective of this paper is to introduce and analyze a tractable equilibrium model with irreversibility, with a focus on the investment behavior. I study the impact of irreversible investment on the behavior of stock returns in Kogan (2000).

Extensive literature analyzes effects of irreversibility and adjustment costs on investment activity. Earlier contributions to this field investigate implications of capital immobility under certainty. Examples of this line of research include Arrow (1968), Johansen (1967), Dasgupta (1969), Ryder (1969), Bose (1970), Floyd and Hynes (1979), Smith and Starnes (1979), LeRoy (1983), and others.

More recent literature has focused on the interaction between irreversibility and uncertainty. One avenue of the literature is concerned with optimal timing of irreversible investment projects, emphasizing the value of the option to delay investment that arises due to irreversibility.<sup>1</sup> Another strand of the literature

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<sup>1</sup>This direction is explored by Henry (1974), Baldwin and Meyer (1979), Baldwin (1982), Brennan and Schwartz (1985), McDonald and Siegel (1986), Ingersoll and Ross (1987), Dixit (1989a, b, 1992) and others. Some of the models incorporate the process of firms' learning about the

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