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Asset fixity and backward-bending investment demand functions

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ABSTRACT

We investigate irreversible investment behavior under uncertainty of payoffs using U.S. firm-level panel data. Specifically, we estimate the relationship between the firm's investment to capital ratio and the interest rate, while controlling for investment opportunities, real option values, uncertainty, and profitability. The results indicate that the investment demand curve is a backward-bending function of the interest rate. That is, at low interest rates an increase in the interest rate leads to additional investment by increasing the cost of postponing investment. Interestingly, the backward-bending shape of investment demand does not hold for the sub-sample of agribusiness firms in our dataset, which are characterized by greater asset fixity. Lastly, firm investment behavior is consistent with the existence of real option values.

1. Introduction and motivation

The neoclassical economic theory of investment states that firms invest less when interest rates are higher (Jorgensen, 1963; Caballero et al., 1995). When investments are irreversible and payoffs are stochastic, however, the investment demand curve can be backward-bending (Chetty, 2007). In Chetty's model, firms can delay investment to learn more about its potential profitability. This result is closely related to the literature on real options in investment projects (Dixit and Pindyck, 1994). Indeed, when uncertainty is high, real option values associated with irreversible investments increase substantially (Bloom et al., 2007). As a result, in uncertain times firms are likely to either exercise growth options and invest immediately to establish market share, or postpone investing in positive net present value projects until some of the uncertainty is resolved, thus corresponding to an option to wait.

This paper builds on Chetty (2007) by empirically testing for the existence of a backward-bending investment function in terms of the interest rate, using a large panel of U.S. firms. Although the empirical literature on this specific topic is small, a notable and closely related study by Jovanovic and Rousseau (2004) found that in the context of Initial Public Offerings (IPOs), interest rates and investment are non-monotonically related. Their evidence suggests that IPOs are delayed when interest

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rates are low. On the other hand, the authors also found that the investment demand function of established (incumbent) firms decreases monotonically in the interest rate.

Our main analysis relies on a large panel of U.S. firms. However, another key issue affecting the investment demand function is asset fixity. To investigate the impact of asset fixity, we consider additionally a subsample of firms in the agribusiness sector. Indeed, firms in this sector have been found to be characterized by greater asset fixity (e.g., Chambers and Vasavada, 1983). If the degree of asset fixity is higher for the agribusiness sector, then we would expect such firms to exhibit investment behavior that differs from other sectors. Therefore, agribusiness firms are likely to exhibit investment behavior which differs from other sectors.

The remainder of this paper is as follows. Section 2 introduces the theoretical model based on Chetty (2007) and real options theory. The empirical model, data, econometric specifications, estimation methodology and estimation results are presented in Section 3. Section 4 concludes.

2. Theoretical model

Neoclassical theory predicts that when interest rates rise, firms invest less because their cost of capital increases (Jorgensen 1963). In a recent paper, however, Chetty (2007) shows that the investment demand function is a backward-bending function of the interest rate. His analysis uses arguments similar to those from the real options literature. In his motivating example, a firm that is considering making a new investment has two choices: invest now, or wait and obtain more information. When interest rates rise, so does the cost of capital, therefore investment is less desirable. However, higher interest rates also imply higher costs of the firm's outstanding debt. This effect encourages the firm to invest in order to obtain profits sooner and thus pay off their debt more quickly.

The result of the opposing effects is a backward-bending investment demand curve as a function of the interest rate. Ceteris paribus, investment demand *ID* is therefore increasing in r for $r \in (0, r^*)$ and decreasing in r for $r > r^*$ where r^* is the interest rate at which investment demand is maximized.

More generally, the investment demand function ID for firm i at time t is a function of the interest rate faced by firm i at time t as well as other variables:

$$ID_{it} = f(r_{it}, \mathbf{X}_{it})$$

Note that according to neoclassical theory, $f_r \leq 0, f_{rr} \geq 0$, but in Chetty's model $f_r \geq 0, f_{rr} \leq 0$. To evaluate Chetty's claims, we test for the sign of these derivatives.

To our knowledge, the implications of Chetty's model have not been empirically tested using firm data.

2.1. Real options theory

Real options theory helps explain investment behavior in the presence of uncertainty, particularly when a firm's investment behavior appears to be at odds with practice of investing if the net present value of the project is positive. The real options paradigm suggests that in uncertain times firms are likely to either exercise growth options and invest immediately to establish market share, or postpone investing in positive net present value projects until some of the uncertainty is resolved, thus corresponding to an option to wait.

Taken together, the two real options propositions and the expected utility hypothesis collectively lead to three testable hypotheses:

(1) If the level of capital investment exhibits a negative relationship with uncertainty and positive relationship with cash flow, then this is consistent with the expected utility hypothesis;
(2) If the level of capital investment exhibits a negative relationship with uncertainty regardless of the relationship between the level of capital investment and cash flow, then this would be consistent with an option to wait;
(3) If the level of capital investment exhibits a positive relationship with uncertainty regardless of the relationship between the level of capital investment and cash flow, then this would be consistent with firms taking advantage of growth options.

The only conflict occurs with (1) and (2) when cash flows are positive. If there is a negative relationship between uncertainty and investment and a positive relationship between cash flows and investment, then an ambiguity would arise that would not permit a distinction between a reduction in investment due the real options framework, specifically the option to wait, or risk aversion under the expected utility hypothesis. Hence, to test the three hypotheses we allow the investment demand function,$ID_{it} = f(r_{it}, \mathbf{X}_{it})$, for firm i at time t to be a function of cash flow and uncertainty.

3. Empirical analysis

We test the hypothesis that the investment demand curve is a backward-bending function of the interest rate when investments are irreversible and payoffs are stochastic. To test this relationship we use a firm-level fixed effects model to