Estimation of a Backward-Bending
Investment Demand Function for Agribusiness Firms

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Abstract

We investigate irreversible investment behavior under uncertainty of payoffs using U.S. firm-level panel data. 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 the investment demand curve is a backward-bending function of the interest rate; at low interest rates, an increase in the interest rate leads to increased investment by increasing the cost of postponing investment. Firm investment behavior is also consistent with real options behavior. The investment behavior of agribusiness firms is significantly different from firms in other sectors.

Keywords: investment demand, irreversible investment, real options
JEL classification: D81, D92, Q13

1. Introduction and Motivation

The neoclassical economic theory of investment states that firms invest less when interest rates are higher (Jorgensen, 1963). When investments are irreversible and payoffs are stochastic, however, the investment demand curve can be, in theory, 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, Bond and van Reenen, 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 continues the research agenda of Chetty (2007) by empirically testing the existence of a backward-bending investment function in terms of the interest rate using a large panel of firms. It contributes to the relatively small literature on the consequences of irreversible investment on the decisions under uncertainty of agribusiness firms (e.g., Isik, Coble, Hudson and House 2003; Turvey 2001) and also presents the first empirical evidence of a backward-bending investment demand curve for agribusiness firms, with comparisons made to non-agribusiness firms.

2. Theoretical Model

Neoclassical theory predicts that when interest rates rise, firms invest less because their cost of capital increases. 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.

To our knowledge, the implications of Chetty's model have not been empirically tested using agribusiness firm data. In the following we use the notation from his paper to ensure consistency. Suppose that a firm can delay investment and thereby increase expected profits at a rate of g reflecting the value of additional information. Since profits are discounted at the interest rate r then it follows that a set of necessary conditions for the firm to invest today is that the expected profit is positive and $r > g$. Specifically, three cases are possible:

- Low interest rates suggest a positive expected profit but $r < g$, therefore the firm will not invest;
- Moderate interest rates suggest a positive expected profit and $r > g$, therefore the firm will invest;
- High interest rates suggest $r > g$ but a negative expected profit so the firm will not invest.

Investment demand 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.

In his model, Chetty considers a cost of investment C for a project with uncertain revenues R_1 in the high-demand state of the world and R_0 in the low-demand state of the world with $R_1 > C > R_0$. The firm manager's subjective probability of a high-demand state of the world is

λ_0 which is revised if the manager waits one period and thus observes a noisy signal z from the true distribution, which is either low-demand state $f(z)$ or high-demand state $g(z)$. The revised probability of a high-demand state, conditional on having observed one signal z, is therefore λ_1.

Chetty derives an optimal investment rule: the firm invests in period 1 if and only if the value of investing V(i) is greater than the value of learning V(l), where:

$$V(i) = \mathrm{E}[\pi] = \lambda_0\left(\frac{R_1}{1+r} - C\right) + (1-\lambda_0)\left(\frac{R_0}{1+r} - C\right), \text{ and}$$

$$V(l) = \frac{1}{1+r}\left\{\lambda_0\beta(z^*)\left(\frac{R_1}{1+r} - C\right) + (1-\lambda_0)\alpha(z^*)\left(\frac{R_0}{1+r} - C\right)\right\}$$

where $\beta(z^*)$ corresponds to the probability of observing z less than z* in the high-demand state and $\alpha(z^*)$ corresponds to the probability of observing z less than z* in the low-demand state. Further note that $\beta(z^*)$ is the power and $\alpha(z^*)$ is the size (type 1 error rate) of a likelihood ratio test for the likelihood ratio of g(z) over f(z). The firm may find it valuable to wait in order to reduce the likelihood of investing when in fact demand is low and therefore investment is not profitable. Assuming the firm waits, then it invests in period 2 if and only if the signal z is greater than a cutoff value z*. This is because when z>z*, the probability of the high-demand state is sufficiently high such that the project is likely to be profitable.

Chetty solves for the expected growth rate *g* of profits from delaying investment, which is a function $g = g(\alpha(z^*), \beta(z^*), \lambda_0, r, R_0, R_1, C)$ and further shows that the optimal investment rule in period 1 is equivalently V(i)>0 and $r > g$.

2.1 Reduced-Form Model

The available dataset consists of observations of the following variables which are used in the reduced-form estimated model:

- Capital (K): operating assets consisting of debt and equity from lenders and shareholders
- Cost of capital (COC): this is the proxy used for the interest rate associated with investment, and reflects firm- and sector-specific risk
- Net operating profit after taxes (NOPAT): firm profit net of depreciation and taxes but not including interest and restricting charges
- Economic value added (EVA): economic (not accounting) profit, equal to NOPAT minus total value of capital
- Market value (MV): firm book value of outstanding debt plus market value of company common stock
- Market value added (MVA): equals market value minus total capital, or alternatively equals the net present value (NPV) of future EVA
- Future growth value: equals MVA minus capitalized current EVA
- Future growth reliance (FGR): equals FGV divided by MV
- Return on capital (ROC): equals NOPAT divided by capital

As described in the later section on empirical analysis, the reduced-form model considers the investment rate as a function of the cost of capital (proxy for interest rate) as well as firm- and sector-specific variables, including a proxy for real option value. 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:

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

where according to neoclassical theory, $f_r \leq 0, f_{rr} \geq 0$ but according to Chetty's model $f_r \geq 0, f_{rr} \leq 0$. We also test for the signs of these derivatives.

2.2 Real Options Theory

Real options theory has gained momentum in the finance literature as a means of explaining investment behavior in the presence of uncertainty, particularly when a firm's investment behavior appears to be at odds with the expected utility hypothesis and the 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 a allow the investment demand function, $ID_{it} = f(r_{it}, \mathbf{X}_{it})$, to be a function of cash flow and uncertainty.

3. Empirical Analysis

3.1 Empirical Model

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 estimate the relationship between the investment rate and the interest rate while controlling for investment opportunities, uncertainty, and other factors influencing investment. Furthermore, we investigate the relationships between investment and uncertainty and investment and profitability or cash flows to determine if firms make decisions based on expected utility theory or the real options paradigm.

The dependent variable, annual firm-level investment rate, is constructed using operating capital. Operating capital consists of working capital, plant and equipment, goodwill, and other operating assets, financed through either debt or equity. Operating capital is the amount of investment employed in operations. The difference between operating capital at time t and operating capital at time t-1 is used as a proxy for the invested capital in year t, $K_t - K_{t-1} = I_t$. The annual firm-level investment rate, defined as the change in invested operating capital divided by the initial operating capital stock, $\text{INVESTRATE}_t = (K_t - K_{t-1}) / K_{t-1} = I_t / K_{t-1}$, normalizes investment by firm size. Therefore, the annual investment rate is the percentage change in operating capital from time t-1 to time t.

Since we are primarily interested in the relationship between the investment rate and the interest rate, the firm's cost of capital, COC, is included in the model as an explanatory variable and serves as a proxy for the firm's interest rate. Cost of capital squared is also included to allow for the hypothesized backward-bending structure of the investment demand curve.

Several other explanatory variables are included in the model. The firm's investment rate lagged one period $\mathrm{INVESTRATE}_{t-1}$ is included to control for persistence in the dependent variable, since the rate of investment in time t-1 is likely to influence the rate of investment in the following period. Furthermore, to estimate the true relationship between a firm's investment rate and interest rates we control for the firm's investment opportunities. Thus, a proxy for Tobin's q is constructed using the ratio of market value (MV) to accumulated operating capital, $\mathrm{TOBINQ}_t = \mathrm{MV}_{t-1}/ \mathrm{K}_{t-1}$. Tobin's q provides a measure of how external players, specifically potential investors and creditors, view the firm's investment opportunities. Furthermore, an internal measure of investment opportunities is included in the model. This measure is the ratio of Future Growth Value (FGV) to accumulated operating capital, $\mathrm{GROWTH}_t = \mathrm{FGV}_t/ \mathrm{K}_{t-1}$, where FGV is the difference between the firm's Market Value Added (MVA) and the capitalized current level of Economic Value Added (EVA). FGV is high only when EVA can be expected to rapidly increase. The squares of the external and internal measures of investment opportunities are also included to allow for non-linear relationships. Prior studies conclude that the explanatory power of Tobin's q with respect to the investment rate is low and find that sales and cash flow are better predictors (e.g. Abel and Eberly 2002; Gomes 2001; Erickson and Whited 2000).

In an effort to incorporate these findings and the elements of real option theory discussed in the prior section, we also include measures of cash flow and uncertainty in the model. Net Operating Profits After-Tax (NOPAT) is used as a proxy for cash flow and firm profitability. NOPAT is operating income, which has been cleansed of the results of financial (e.g., the financing component of operating leases) and accounting distortions. Since firm-level cash flows and sales are highly correlated and hence might lead to multicollinearity issues, we include only cash flow in our analysis.

Measuring uncertainty is a more difficult task and is not straightforward. Prior empirical studies measure firm-level uncertainty as the variability of the firm's stock returns (e.g. Bulan 2005; Baum, Caglayan, Talavera 2010). In these studies, the volatility of stock returns provide a measure of total firm uncertainty which can be decomposed into firm-specific and aggregate components using market and industry betas. The annualized measure is constructed from daily stock returns. However, if stock prices follow a random walk (Brownian motion), then the same measure of long run annualized volatility is obtained regardless of whether it is measured day by day or month by month or year by year. Furthermore, if the efficient market hypothesis holds in terms of stock prices and movements, a measure of firm-level uncertainty can be constructed using the standard deviation of NOPAT.

However, measures of uncertainty constructed using past values of NOPAT are *ex post* estimates, while managers base investment decisions on measures of uncertainty that are forward-looking. Thus, we appeal to the rational expectations assumption and use past realized values of the standard deviation of the firm's yearly NOPAT as a general proxy for uncertainty. This creates a rational expectations error that is added to the error term and is orthogonal to the information available at the beginning of each time period. Furthermore, managers may view future uncertainty differently. For example, some managers may view future risk in terms of recent variability in operating income, while others may take a longer term view. We cannot address this question specifically except to try a variety of specifications of uncertainty and make a determination as to whether the results are materially different in consequence and statistics. Hence, uncertainty is specified as the two-year, four-year and nine-year standard deviations of

NOPAT. The analysis is repeated using each measure of uncertainty. The variance of NOPAT is also included in the model to allow for a non-linear relationship between the investment rate and uncertainty.

The model also includes interaction terms between NOPAT and uncertainty (the standard deviation of NOPAT), uncertainty and Tobin's q, and uncertainty and growth. In addition, a time trend and time trend squared are included to capture changes in the investment environment and technology. Thus, the model can is summarized by the following equation:

$$\begin{aligned} &INVESTRATE_t = \beta_1 INVESTRATE_{t-1} + \beta_2 COC_t + \beta_3 COC_t^2 + \beta_4 TOBINQ_{t-1} + \beta_5 TOBINQ_{t-1}^2 + \beta_6 GROWTH_{t-1} \\ &+ \beta_7 GROWTH_{t-1}^2 + \beta_8 \frac{NOPAT_{t-1}}{K_{t-1}} + \beta_9 SIG_{t-1} + \beta_{10} SIG_{t-1}^2 + \beta_{11} SIG_{t-1} \cdot \frac{NOPAT_{t-1}}{K_{t-1}} + \beta_{12} SIG_{t-1} \cdot TOBINQ_{t-1} \\ &+ \beta_{13} SIG_{t-1} \cdot GROWTH_{t-1} + \beta_{14} t + \beta_{15} t^2 + \varepsilon_t \end{aligned} \tag{1}$$

where SIG_{t-1} is the standard deviation of NOPAT at time t-1 and all other variables are defined as above. It is assumed that investment decisions are made at the beginning of the year. Hence, TOBINQ, GROWTH, K, NOPAT, and SIG are all measured as end of the year values for t-1 and are predetermined regressors. Note that the cash flow variable (NOPAT) is scaled by operating capital (K) to normalize profitability by size.

3.2 Data

The dataset employed in the analysis consist of an unbalanced panel of firms representing 23 industries from the 2004 Stern Stewart Performance Russell 3000, which is a subset of Compustat data. The dataset contains annual information on several variables of interest including net operating profit after tax, capital, cost of capital, and market value. After deleting missing values we obtained a sample that runs from 1985 to 2003 and contains 2,685 firms.

Twenty-three industries are represented in the sample: energy, materials, capital goods, commercial services and suppliers, transportation, autos and components, consumer durables and apparel, hotels, restaurants and leisure, media, retailing, food and staples retailing, food, beverage and tobacco, household and personal products, health and equipment and services, pharmaceuticals and biotechnology, banks, diversified financials, insurance, software and services, technology, hardware and equipment, semiconductors and semiconductor equipment, telecommunication services, and utilities. Since we are primarily interested in the investment behavior of agribusiness firms, we aggregate the 23 industries into two broadly defined industries using Standardizes Industrial Classification (SIC) codes. The two industries of interest are agribusiness and non-agribusiness sectors.

3.3 Estimation Methodology

Equation (1) is estimated allowing for firm-level fixed effects with a robust variance-covariance estimator. Given our use of realized values of volatility as a proxy for future uncertainty, an instrumental variables approach might be more appropriate to deal with the associated endogeneity issues and the rational expectations error term created by the use of this uncertainty measure. Hence, the model is also estimated using a two-stage least squares estimation and the results are compared. Fixed effects in the two-stage least squares estimation are eliminated using the approach in outlined in Arellano and Bover (1995). Lagged values of all right-hand side variables are used as the instruments.

To determine whether uncertainty is endogenous, we compute a Hausman test (see e.g. Cameron and Triverdi, 2005, p. 272-273). The null and alternative hypotheses are:

$$H_0 : p\lim(\hat{\theta} - \tilde{\theta}) = 0$$

$$H_a : p\lim(\hat{\theta} - \tilde{\theta}) \neq 0$$

where $\hat{\theta}$ is the OLS estimator and $\tilde{\theta}$ is the 2SLS estimator. The test statistic is:

$$H = \frac{(\hat{\theta} - \tilde{\theta})^2}{\hat{s}^2 - \tilde{s}^2}$$

which is distributed $\chi^2(1)$ and where $\hat{s}$ and $\tilde{s}$ the OLS and 2SLS reported standard errors of the parameter estimate, respectively.

Furthermore, we are interested in how investment behavior differs across industries due to differences in irreversibility and asset-fixity. Specifically, a Chow (1960) test is used to determine if agribusiness firms behave significantly different than firms in other industries. Since the dataset includes non-agribusiness firms such as banks, bio-technology firms and information technology firms, we estimate the model for both agribusiness and non-agribusiness firms. Then, we compare the investment demand curves of agribusiness firms to other firms in other sectors using a Chow test.

3.4 Estimation Results

Using the data described above, we estimate the investment demand function in terms of the interest rate, adjusting for uncertainty, cash flow, investment opportunities and real option values. We proceed first by discussing the descriptive statistic and the correlations between the variables and then the estimation of regression equations.

Examination of the descriptive statistics in Table 1 shows that the mean of annual firm-level investment is $264,310 for the sample of firms. The standard deviation of annual firm-level investment is $2,725,880, indicating that the firms in the sample are not homogenous and that annual firm-level investment varies widely across years and firms. Similarly, the investment rate has a mean of 0.22 and a standard deviation of 2.60. Furthermore, all of the independent variables have relatively large standard deviations expect for cost of capital, which has a standard deviation of 2.1 percent. On average, firms in the sample had a cost of capital of 9 percent.

Correlations reveal weak relationships between the annual firm-level investment rate and the explanatory variables, as shown in Table 2. Specifically, a higher cost of capital tends to be weakly positively correlated with investments rate with a Pearson correlation coefficient of 0.0336. Higher levels of profitability also tend to be weakly negatively correlated with the annual investments rate. Furthermore, we find a positive, but weak, association between the investment rate and standard deviation of profitability. Collectively, however, the correlations do not suggest as strong a behavioral response as might be expected from mean-variance analysis or expected utility hypothesis.

Regression results for Equation (1) estimated using a firm-level fixed effects model with a robust variance-covariance estimator are reported in Table 3. The effects of all of the variables included in the model are significant except for the effects of cost of capital squared and the time trend squared. There is a significant negative relationship between the annual investment rate and the annual investment rate lagged one period, indicating that periods of high levels of investment tend to be followed by periods of lower levels of investment.

There is a positive significant relationship between annual firm-level investment and the cost of capital. Furthermore, there is a negative, but not significant, relationship between the dependent variable and the square of cost of capital. Together these two results indicate that the investment demand curve might be backward bending. The turning point is 2.04 percent at which point the function is no longer monotonic and begins to bend backward. Therefore, at very low interest rates the investment demand curve exhibits a positive relationship between the annual investment rate and the interest rate, but once the interest rate exceeds approximately 2 percent the relationship between the annual investment rate and the interest rate becomes negative. While conventional neoclassical economic theory suggests that firms invest less when interest rates are higher, the results indicate that this is only true for some range of interest rates.

To better understand how the cost of capital, our proxy for interest rates, affects the firm-level annual investment rate, the marginal effect is calculated using Equation (2).

$$(2)\quad f_r = \frac{\partial INVESTRATE_t}{\partial COC_t} = \beta_2 + 2\beta_3 COC_t$$

The marginal effect of the cost of capital on the annual firm-level investment rate evaluated at the mean is 17.92, which suggests that a 1 percent increase in the interest rate increase the investment rate by 17.92 percent.

The second derivative of investment demand function with respect to the interest rate (cost of capital) is negative (-9.1892). Therefore, we find that $f_r \geq 0, f_{rr} \leq 0$, which supports Chetty's theoretical findings.

Moreover, we seek to determine if firms make investment decisions based on the expected utility hypothesis or if there is any evidence that firms employ the real options paradigm when making investment decisions. Thus, it is also necessary to calculate the marginal effects of profitability and uncertainty. More specifically, the expected utility hypothesis predicts that $\frac{\partial INVESTRATE_t}{\partial SIG_{t-1}} < 0$ and $\frac{\partial INVESTRATE_t}{\partial PROFIT_{t-1}} > 0$. The total variation of $INVESTRATE_t$ with respect to SIG_{t-1}, in the model is equal to:

$$(3)\quad \frac{\partial INVESTRATE_t}{\partial SIG_{t-1}} = \beta_9 + 2\beta_{10} SIG_{t-1} + \beta_{11}\frac{NOPAT_{t-1}}{K_{t-1}} + \beta_{12} TOBINQ_{t-1} + \beta_{13} GROWTH_{t-1}$$

and the total variation of $INVESTRATE_t$ with respect to $\frac{NOPAT_{t-1}}{K_{t-1}}$, in the model is equal to:

$$\frac{\partial INVESTRATE_t}{\partial\left(\frac{NOPAT_{t-1}}{K_{t-1}}\right)} = \beta_8 + \beta_{11} SIG_{t-1} \tag{4}$$

.

Evaluated at the mean, both marginal effects are significant and negative as shown in Table 4. This provides evidence of real options with firms exercising their option to wait.

For completeness, the marginal effects of both measures of investment opportunities (internal and external views) are also calculated and reported in Table 4. Both marginal effects are significantly positive, which indicates that firms with more investment opportunities have a higher rate of annual investment.

Since realized values of volatility are used as a proxy for future uncertainty thus creating an additional rational expectations error term and possible endogeneity issues due to the persistence of the volatility, we also estimate the model using a two stage least squares approach and compared the results to the fixed effects model. The results of the two-stage least squares estimation (2SLS) are also reported in Table 3. Using the results from Table 3, the Hausman statistic for the uncertainty variable is 32.077, which is greater than the critical value of 6.635 at the 1% level of significance.

Only four coefficients are significant at a 10 percent significance level in the 2SLS estimation. The relationships between the annual investment rate and profitability and the annual investment rate and Tobin’s Q are both significant and take the same signs as in the fixed effects model. On the other hand, the relationships between growth squared and the interaction between uncertainty and growth are both significant and have opposite signs as those found by fixed effects estimation. Additionally, the 2SLS estimation suggests that the turning point at which the investment demand curve is no longer monotonically increasing is much lower at 0.22 percent.

However, the marginal effects evaluated at the means are all significantly different from zero and have the same signs as those found by the fixed effects estimation.

Given the similarity in the results and the higher adjusted R squared for the fixed effects model, we use the fixed effects estimation to compare agribusiness to non-agribusiness firms. Furthermore, the Durbin-Watson test statistics indicate that serial autocorrelation is minimal and hence an instrumental variables approach might not be necessary.

A Chow test indicates that the investment behavior of firms in the agribusiness sector is significantly different than the investment behavior of firms in other sectors (with an F-statistic of 10.04). The effects of profitability, uncertainty, and Tobin's appear to be industry dependent; not only do the magnitudes of these effects change across sectors but they also change sign. Table 5 presents the fixed effects estimation results for agribusiness and non-agribusiness firm separately. Furthermore, the marginal effects also vary by industry. There is evidence that both sectors consider real option values when making investment decisions. However, the investment behavior of agribusiness firms is indicative of growth options (the marginal effect of profitability is positive but not significant), while the investment behavior of agribusiness firms is indicative of options to wait. Moreover, the point at which the investment demand curve bends backward is lower for agribusiness firms (0.08) than for non-agribusiness firms (2.01). Differences in the marginal effects and the turning point are likely due to differences in irreversibility of investments and asset-fixity.

Lastly, we estimate the models specifying uncertainty in various ways to determine if the relationship between uncertainty and investment is robust to such changes in specifications. When uncertainty is specified as the two-year, four-year and nine-year standard deviation of NOPAT, we find no noteworthy differences in the estimation results. Hence, all results presented in this paper are obtained using the four-year standard deviation of NOPAT as a measure of uncertainty.

4. Conclusions and implications

Firms are expected to invest less when interest rates are higher, because the cost of capital increases. Since firms, however, need to service their outstanding debt, a higher interest rate also motivates them to invest sooner, with the goal of obtaining higher profits earlier and paying off their debt more quickly. Chetty (2007) presents a theoretical model that analyzes these two opposing forces and shows that the investment demand curve should be a backward-bending function of the interest rate (or cost of capital) when investments are irreversible and payoffs are stochastic . Thus, investment should be increasing in the interest rate r until r reaches the point r^*, but decreasing for r greater than r^*.

To our knowledge Chetty's model and its implications have not been studied empirically. More specifically, the question of whether investment demand could be backward-bending has not been studied for agribusiness firms. This paper studies the determinants of investment demand including the rate of interest (using the cost of capital as proxy) and finds that the interest rate level at which investment demand is maximized, r^* , equals 2.04 percent for all firms (using the preferred fixed effects estimate) but only 0.08 percent for agribusiness firms. That is, Chetty's hypothesis is confirmed for non-agribusiness firms but not for agribusiness firms. To explain this finding, further research could examine differences in capital structure, asset-fixity and debt levels between agribusiness and other firms.

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Table 1: Descriptive statistics.

	Mean	Std Dev	Minimum	Maximum
I (in thousands)	$ 264.31	$ 2,725.88	$ (79,022.92)	$ 198,475.53
INVESTRATE	0.2208	2.5963	-324.2044	128.1046
COC	0.0909	0.0210	0.0435	0.1725
PROFIT	0.0819	0.7357	-81.9484	28.9223
SIGMA	0.0872	1.1633	6.8608E-07	87.1687
TOBINQ	2.5625	14.8792	-868.7163	1,144.9297
GROWTH	0.0148	1.0089	-12.5613	150.6419
SIGMA*PROFIT	-0.2475	46.4438	-6,603.9971	1,684.5526
SIGMA*TOBIN	2.2940	473.5041	-16,296.6045	66,685.3906
SIGMA*GROWTH	0.6429	86.4785	-308.6479	13,131.2539
Number of Firms	2,685			
Number of Observations	24,315			

Table 2: Sample correlations.

	INVESTRATE	COC	PROFIT	SIG	TOBINQ	GROWTH	SIGPROFIT	SIGTOBIN
INVESTRATE	1.0000							
COC	0.0336	1.0000						
PROFIT	-0.0382	0.0034	1.0000					
SIG	0.0229	0.0239	-0.2210	1.0000				
TOBINQ	0.0989	0.0720	0.4154	0.1470	1.0000			
GROWTH	0.0563	0.0053	-0.0579	0.5392	0.0257	1.0000		
SIGPROFIT	-0.0130	0.0015	0.8583	-0.3141	0.2861	-0.0681	1.0000	
SIGTOBIN	-0.0276	0.0024	0.5375	0.1705	0.6937	-0.0296	0.5001	1.0000
SIGGROWTH	0.0162	-0.0020	-0.0475	0.5546	-0.0119	0.9898	-0.0554	-0.0442

Table 3: Fixed Effects and 2SLS Regression Results.

Variable	Fixed Effects	2SLS
INVESTRATE$_{t-1}$	-0.1205 ***	-4.27×10-4
	(0.0098)	(0.0270)
COC	18.7541 **	6.0275
	(8.6265)	(7.5444)
COCSQ	-4.5981	-3.7460
	(41.4173)	(36.2196)
PROFIT	-2.4308 ***	-1.3422 ***
	(0.0726)	(0.2948)
SIG	-0.6063 ***	-0.5085 *
	(0.0545)	(0.2914)
SIGSQ	0.0393 ***	-0.0007
	(0.0015)	(0.0063)
TOBINQ	0.0955 ***	0.0221 *
	(0.0020)	(0.0121)
TOBINQSQ	1.47×10^{-4} ***	-1.00×10-5
	(2.83×10^{-6})	(2.05×10^{-4})
GROWTH	5.9555 ***	0.0060
	(0.1270)	(0.0060)
GROWTHSQ	-0.1027 ***	0.0018 ***
	(0.0034)	(4.69×10^{-4})
SIGPROFIT	0.1303 ***	-0.0204
	(0.0032)	(0.0268)
SIGTOBIN	-0.0083 ***	0.0017
	(1.51×10^{-4})	(0.0013)
SIGGROWTH	0.0824 ***	-0.4287 **
	(0.0061)	(0.1786)
T	0.0613 ***	-0.0136
	(0.0201)	(0.0302)
TSQ	-0.0013	0.0021
	(8.16×10^{-4})	(0.0014)
Intercept		-0.2065
		(0.4102)
Number of firms	2,579	2,579
Number of Observations	24,315	21,685
Durbin-Waston	1.6793	1.3798
Adjusted R-squared	0.2115	0.0069

Table 4: Turning Point and Marginal Effects.

	Fixed Effects		2SLS		Agribusiness		Non-Agribusines	
Turning point	2.04		0.22		0.08		2.01	
	Marginal Effect	F-Statistic	Marginal Effect	F-Statistic	Marginal Effect	F-Statistic	Marginal Effect	F-Statistic
COC	17.918	32.02	5.347	4201.54	2.063	2.27	18.363	31.13
PROFIT	-2.537	1972.44	-1.431	3807.29	1.896	21.82	-2.548	1908.56
SIG	-0.609	2515.65	-0.505	1061.49	3.254	24.40	-0.610	2444.71
TOBINQ	0.096	2703.12	0.022	1493.69	-0.002	24.13	0.096	2610.83
GROWTH	5.960	3743.40	0.013	2421.12	2.244	2.61	5.960	3615.57

Table 5: Fixed Effects Regression Results for Agribusiness and Non-Agribusiness Firms.

Variable	Agribusiness		Non-Agribusiness	
INVESTRATE$_{t-1}$	-0.1203	***	-0.1204	***
	(0.0310)		(0.0100)	
COC	18.8601	*	19.2405	**
	(11.7464)		(9.1408)	
COCSQ	-113.6000		-4.7837	
	(72.6414)		(43.5765)	
PROFIT	1.7240	***	-2.4385	***
	(0.3664)		(0.0745)	
SIG	3.9862	***	-0.6078	***
	(0.6035)		(0.0559)	
SIGSQ	-1.9451		0.0393	***
	(1.3646)		(0.0016)	
TOBINQ	-0.0195		0.0955	***
	(0.0172)		(0.0020)	
TOBINQSQ	0.0026	**	1.47×10^{-4}	***
	(0.0011)		-2.91×10-6	
GROWTH	2.5505		5.9562	***
	(2.8398)		(0.1302)	
GROWTHSQ	5.2531		-0.1030	***
	(11.3174)		(0.0035)	
SIGPROFIT	-12.5192	***	0.1306	***
	(3.6992)		(0.0033)	
SIGTOBIN	0.3380	*	-0.0083	***
	(0.1742)		(1.55×10^{-4})	
SIGGROWTH	-15.0341	*	0.0827	***
	(9.3318)		(0.0062)	
T	-0.0021		0.0646	***
	(0.0143)		(0.0211)	
TSQ	0.0003		-0.0014	*
	(0.0006)		(8.59×10^{-4})	
Number of firms	96		2,483	
Number of Observations	1,159		23,156	
Durbin-Watson Statistic	1.9876		1.6794	
Adjusted R-squared	0.1505		0.2790	