PhD Course: Development Economics (Micro)

Returns to capital and investment

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1 Introduction

Today we discuss the incentives and constraints for investment amongst (mostly small) firms in developing countries. It is well known that returns to capital tend to be high in developing countries. Yet investment is low. Why?

References:

de Mel, Suresh, David McKenzie and Christopher Woodruff (2008). "Returns to Capital in Microenterprises: Evidence from a Field Experiment," Quarterly Journal of Economics CXXIII(4): 1329-1372.

Schündeln, Mattias (undated), "Modeling Firm Dynamics to Identify the Cost of Financing Constraints in Ghanaian Manufacturing," mimeo, Harvard University.

Udry, Christopher, and Santosh Anagol, “The Return to Capital in Ghana,” American Economic Review, 96 (2006), 388–393.

2 Returns to Capital in Sri Lankan Microenterprises

Reference: de Mel, McKenzie and Woodruff.

2.1 Introduction

- Small and informal firms are the source of employment for half or more of the labor force in most developing countries.

- Do these firms hold the potential for income growth for their owners? If so, what's the constraint - lack of credit? Alternatively, could it be that these firms merely represent a source of subsistence income for low productivity individuals unable to find alternative work?

- The premise of **microfinance**: these firms can earn **high returns** to capital ($d\Pi/dK$) if given the opportunity.

- Evidence that some firms have high marginal returns:
  - very high interest rates paid to moneylenders,
  - large effect of credit shocks on those who apply for credit

- This paper uses a **randomized experiment** to identify the effect of incremental cash investments on the profitability of micro enterprises (fixed assets worth less than US$1,000) in Sri Lanka. The treatment involves giving **small grants** (either US$100 or US$200) to a randomly selected subset of the sampled firms.

- It also examines the **heterogeneity** of returns in order to test which theories can explain why firms may have marginal returns well above the market interest rate.

- Why important?

- An accurate measurement of returns to capital improves our understanding of the potential of microfinance. Despite the rapid spread of microfinance in recent years, there is surprisingly little evidence of its effectiveness in raising incomes of borrowers.

- Measuring returns at low levels of capital stock also provides important feedback to theory. Low returns at low levels of capital stock would suggest that individuals without access to a sufficient amount of capital would face a permanent disadvantage - a poverty trap. But if returns are high at low levels of capital stock, then entrepreneurs entering with suboptimal capital stocks would be able to grow by reinvesting profits. In this case, entrepreneurs might remain inefficiently small for some period of time, but would not be permanently disadvantaged - no poverty trap.

- If you have non-experimental data, the central challenge in estimating returns to capital is that the optimal level of capital stock is likely to depend on attributes of entrepreneurial ability, which are difficult to measure. The difficulty of obtaining an unbiased estimate of returns to capital for all microenterprises is the motivation for the field experiment underlying the present paper. Crucially, the random allocation of the grants ensures that the changes in capital stock are **uncorrelated** with entrepreneurial ability and other factors associated with the differences in the profitability of investments across firms.

- Outline of paper:
  - First, measure the effect of assignment to treatment on capital stock, profits, and hours worked by the owner.
  - Second, use the random treatments as instruments for capital stock, and estimate the real marginal return on capital using IV regressions.

– Third, set out a model that can be used to investigate the importance of imperfect credit markets and imperfect insurance markets.

– Fourth, examine the heterogeneity of treatment effects in order to see if returns to capital are higher for entrepreneurs who are more severely capital CONSTRAINED

– Fifth, use the baseline data and the untreated panel to compare returns generated by OLS, random-, and fixed-effects regressions with those generated by the experiment. Basic result: experimental returns are more than **twice as large** as the nonexperimental returns.

2.2 Description of the experiment

2.2.1 The sample

- Baseline survey of microenterprises in April 2005.

- Eight additional waves of the panel survey were then conducted at quarterly intervals, through April 2007.

- Covers three southern and southwestern districts of Sri Lanka: Kalutara, Galle, and Matara. The sample was drawn equally from areas directly affected by the 2004 tsunami; indirectly affected; and unaffected zones.

- Sample covers only firms with invested capital of 100,000 LKR (Sri Lankan rupees; about US$1,000) For such small firms, the treatments assigned as part of the experiment would be a **large shock** to business capital.

- By means of a screening survey targeting households, 659 enterprises outside of agriculture, transportation, fishing and professional services run by self-employed individuals aged between 20 and 65 were identified. Analysis excludes firms directly affected by the tsunami, leaving 408 enterprises in the main sample. Half of these are in manufacturing or services, the other half in retail sales.

2.2.2 The experiment

- Goal: provide randomly selected firms with a positive shock to their capital stock; measure the impact of the additional capital on business profits.

- The intervention: conduct a **random prize drawing**, with prizes of equipment for the business or cash. The random drawing was framed as compensation for participating in the survey. Just over half the prizes awarded after the first wave of the survey, and the remaining prizes after the third wave

- The prize consisted of one of four grants: 10,000 LKR (■US$100) of equipment or inventories for their business, 20,000 LKR in equipment/inventories, 10,000 LKR in cash, or 20,000 LKR in cash. In the case of the in-kind grants, the equipment was selected by the enterprise owner.

- Mean profit per month: LKR 3,851. Hence, the treatment amounts were large relative to the size of the firms.

- The in-kind grants were primarily spent on inventories or raw materials; on average 58% of the cash grants was invested in the business.

2.3 Data and Measurement of Main Variables

- Main outcome variable: **firm profits,** elicited by asking the following question: *What was the total income the business earned during March after paying all expenses including wages of employees, but not including any income you paid yourself. That is, what were the profits of your business during March?*

- The other key variable: **capital**, defined as the replacement cost of assets used in the enterprise.

- Lots of other variables can be constructed too - e.g. investment, inventories, work in progress, value of final goods etc.

[Table I: Summary statistics]

TABLE I
DESCRIPTIVE STATISTICS AND VERIFICATION OF RANDOMIZATION

Baseline characteristic	Total number of observations in R1	Full sample: Mean	Full sample: SD	Means by treatment: Assigned to any treatment	Means by treatment: Assigned to control	t-test p-value
Profits March 2005	391	3,851	3,289	3,919	3,757	.63
Revenues March 2005	408	12,193	14,933	11,796	12,739	.53
Total invested capital March 2005	408	146,441	224,512	155,626	133,837	.33
Total invested capital excluding land and buildings March 2005	408	26,530	25,259	25,633	27,761	.40
Own hours worked March 2005	408	52.6	22.3	51.8	53.7	.39
Hours worked, unpaid family, March 2005	405	18.1	28.8	18.2	15.4	.31
Age of entrepreneur	408	41.8	11.4	41.8	41.9	.92
Age of firm in years	403	10.3	10.5	10.8	9.7	.34
Proportion female	387	0.491	0.5	0.459	0.533	.15
Years of schooling of entrepreneur	408	9.0	3.1	8.9	9.2	.40
Proportion whose father was an entrepreneur	408	0.385	0.49	0.373	0.401	.56
Proportion of firms that are registered	408	0.235	0.45	0.254	0.209	.32
Number of household members working in wage jobs	408	0.7	0.83	0.7	0.7	.73
Household asset index	408	0.276	1.610	0.118	0.494	.02
Number of digits recalled in Digit Span Recall Test	370	5.9	1.23	5.9	5.9	.96
Implied coefficient of relative risk aversion from lottery game	403	0.143	1.57	0.206	0.053	.33

Note: All data based on baseline survey. Profits, revenue, and capital stock data in Sri Lankan rupees. The last column reports the p-value for the t-test of the equivalence of means in the samples assigned to control on the one hand and any of the four treatments on the other. The household asset index is the first principal component of variables representing ownership of seventeen household durables, listed in the Online Appendix; Digit Span Recall is the number of digits the owner was able to repeat from memory ten seconds after viewing a card showing the numbers (ranging from 3 to 11); risk aversion is the CRRA calculated from a lottery exercise described in the text and Online Appendix.

2.4 Estimation of Basic Experimental Treatment Effects

- Outcomes of interest: capital ("first stage"); profits and hours worked by the owner. Regression models:

$$Y_{it} = \alpha + \sum_{g=1}^{4} \beta_g \text{Treatment}_{git} + \sum_{t=2}^{9} \delta_t + \lambda_i + \varepsilon_{it},$$

  estimated both in levels and in logs. Baseline specification pools all waves of the survey. Results are shown in Table II.

- Table III: Trim outliers with respect to profit change (data errors); test for the validity of pooling over time. Focus is on the profit regression.

[Tables II and III]

Basic results

TABLE II
EFFECT OF TREATMENTS ON OUTCOMES

Impact of treatment amount on:	Capital stock (1)	Log capital stock (2)	Real profits (3)	Log real profits (4)	Owner hours worked (5)
10,000 LKR in-kind	4,793*	0.40***	186	0.10	6.06**
	(2,714)	(0.077)	(387)	(0.089)	(2.86)
20,000 LKR in-kind	13,167***	0.71***	1,022*	0.21*	−0.57
	(3,773)	(0.169)	(592)	(0.115)	(3.41)
10,000 LKR cash	10,781**	0.23**	1,421***	0.15*	4.52*
	(5,139)	(0.103)	(493)	(0.080)	(2.54)
20,000 LKR cash	23,431***	0.53***	775*	0.21*	2.37
	(6,686)	(0.111)	(643)	(0.109)	(3.26)
Number of enterprises	385	385	385	385	385
Number of observations	3,155	3,155	3,248	3,248	3,378

Notes: Data from quarterly surveys conducted by the authors reflecting nine survey waves of data from March 2005 through March 2007. Capital stock and profits are measured in Sri Lankan rupees, deflated by the Sri Lankan CPI to reflect March 2005 price levels. Columns (2) and (4) use the log of capital stock and profits, respectively. Profits are measured monthly and hours worked are measured weekly. All regressions include enterprise and period (wave) fixed effects. Standard errors, clustered at the enterprise level, are shown in parentheses. Sample is trimmed for top 0.5% of changes in profits.
*** $p < .01$, ** $p < .05$, * $p < .1$.

- col 1: treatment raises K; cash grant has larger effect
- col 2: logs; same result qualitatively. Why estimate in logs?
- Compare results in (1) and (2).
- Col (3)-(4). Reduced form profit regressions. Interpret coefficients.
- Col (5). Mixed results, but on balance hours worked seem to increase

Sensitivity analysis

Treatment **amount** is the key explanatory variable here:

Now interpretable as marginal return to capital (%)

TABLE III

POOLING OF TREATMENT EFFECTS (DEPENDENT VARIABLE: REAL PROFITS)

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
Treatment amount	5.68***	5.41***				
	(2.18)	(2.09)				
Treatment amount × being 1–4 quarters posttreatment			5.47**			
			(2.08)			
Treatment amount × being 5–8 quarters posttreatment			4.88*			
			(2.85)			
In-kind treatment amount				4.17		
				(2.58)		
Cash treatment amount				6.70**		
				(2.81)		
Treated amount 10,000 LKR					7.65**	
					(3.31)	
Treated amount 20,000 LKR					8.95*	
					(4.53)	
Treatment amount × coastal zone (tsunami affected)						9.08**
						(4.36)
Treatment amount × near-coastal zone						5.10**
						(2.38)
Treatment amount × inland zone						5.34
						[illegible]
Trimming top 0.5% of changes in profits	No	Yes	Yes	Yes	Yes	Yes
F-test of equality of treatment effects *p*-value			0.76	0.45	0.80	0.44
F-test *p*-value: 2 × 10,000 treatment = 20,000 treatment					0.39	
Firm-period observations	3,274	3,248	3,248	3,248	3,248	4,913
Number of enterprises	385	385	385	385	385	585

2.5 Estimating the return to capital

- The above analysis tells us about the impact of the experiment on profits but it doesn't tell us anything about the channels through which the experiment operates.

- To estimate the marginal return on capital, the authors run regressions of the following kind:

$$\text{profits}_{i,t} = \alpha + \beta_i K_{i,t} + \sum_{t=2}^{9} \delta_t + \lambda_i + \varepsilon_{it},$$

  using the treatments as an **instrument** for capital stock $K_{i,t}$.

- Validity of instrument? We've seen that profits are correlated with treatment here. For the proposed IV strategy to work, this correlation must occur only because treatment affects the capital stock. However, treatments may affect profits through other mechanisms - e.g. hours worked by the owner (see regressions above).

- Assumption: the effect on hours worked is temporary ("initial burst in energy"). Higher quality labor input? Adjust profit variable to take this into account.

- **Identification.** Note the i-subscript on the key parameter (β_i). This means the return to capital is potentially heterogeneous. This raises interesting questions about what exactly can be identified by means of the IV approach.

- Clearly if there is no heterogeneity in the return on capital, so that there is a common β across firms, then the IV estimator identifies the **average treatment effect**, i.e. the average (=constant) return on capital.

- However if there is heterogeneity in the return, stronger assumptions are needed in order to identify the ATE (recall the discussion in Wooldridge's textbook, Chapter 18). In particular, if the treatment induces an equal change in capital stock for all firms, then the IV estimator identifies the average return:

$$\bar{\beta} = N_{treated}^{-1} \sum_{i \in treated} \beta_i .$$

- This will also be the case if the change in the capital stock resulting from treatment is **independent** of the marginal return on capital.

- Alternatively, it could be that the IV estimator identifies a local average treatment effect (LATE), i.e. a weighted average of the marginal return, where the weights are given by how much each firm's capital stock responds to the treatment.

- Note that this is completely analogous to the case we focused on when discussing LATE in the Applied Econometrics course. The difference is that, with binary treatment, you have a nice, discrete catalogue of types, and the LATE is simply the ATE for the compliers (i.e. the compliers get a weight equal to 1, all others get a weight equal to zero). In the present case there are essentially **degrees** of compliance, hence the different weights.

- Indeed, if enterprises with higher marginal returns to capital invest more of the treatment in their business, then the LATE estimated by instrumental variables will **exceed** the average marginal return to capital.

- To shed some light on whether the effect of treatment is heterogeneous, the authors test whether the treatment effect varies with observables. They find no evidence it does, hence they cautiously interpret this as indicating that the IV estimator identifies the ATE, rather than the LATE.

- IV results are shown in Table IV.

[Results in Table A-6, taken from the Online Appendix].

[Table IV here]

Testing for heterogeneity in the treatment effect on capital

Interaction terms, surely…

Table A-6: The Lack of Heterogeneity in the Treatment Impact on Capital Stock
Dependent variable: Capital Stock, without land and buildings

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE	(7) FE
Treatment Amount	0.94***	0.93***	0.94***	0.88***	0.89***	0.99***	1.01***
	(0.17)	(0.18)	(0.18)	(0.17)	(0.18)	(0.34)	(0.23)
Household Asset Index	-0.16						
	(0.16)						
Years of Education		0.02					
		(0.05)					
Digitspan Recall			0.13				
			(0.16)				
Risk Aversion				0.03			
				(0.11)			
Uncertainty					-0.10		
					(0.52)		
Baseline Profit / sales						-0.16	
						(0.47)	
Baseline Profit / Capital							-0.32
							(0.20)
Firm-period observations	3155	3155	3062	3155	3125	2965	2983
Number of enterprises	385	385	369	385	381	362	364

Notes: Data from quarterly surveys conducted by the authors reflecting 9 waves of data from March 2005 through March 2007. Capital stock is measured in Sri Lankan rupees, deflated by the Sri Lankan CPI to reflect March 2005 price levels. The household asset index is the first principal component of variables representing ownership of 18 household durables; digitspan recall is the number of digits the owner was able to repeat from memory, ten seconds after viewing a card showing the numbers; risk averision is the CRRA calculated from a lottery exercise described in the text; and uncertainty is the coefficient of variation of expected sales three months from the date of survey. All of the interaction terms are calculated as deviations from the sample mean. All samples trimmed for the upper 0.5% of changes in capital stock; the regressions in columns 6 and 7 are trimmed for the top and bottom 1% of profit / sales and profit / capital, respectively baseline capital stock as well. All regressions include enterprise and period (wave) fixed effects. Standard errors, clustered at the enterprise level, are shown in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

TABLE IV

INSTRUMENTAL VARIABLE REGRESSIONS MEASURING RETURN TO CAPITAL FROM EXPERIMENT

	Real profits IV-FE (1)	Log real profits IV-FE (2)	Real profits 4 instruments (3)	Real profits adjusted (1) IV-FE (4)	Real profits adjusted (2) IV-FE (5)
Capital stock/log capital stock	5.85**	0.379***	5.16**	5.29**	4.59**
(excluding land & buildings)	(2.34)	(0.121)	(2.26)	(2.28)	(2.29)
First-stage					
Coefficient on treatment amount	0.91***	0.33***		0.91***	0.91***
F statistic	27.81	49.26	6.79	27.81	27.81
Observations	3,101	3,101	3,101	3,101	3,101
Number of enterprises	384	384	384	384	384

Notes. Data from quarterly surveys conducted by the authors reflecting nine waves of data from March 2005 through March 2007. Capital stock and profits are measured in Sri Lankan rupees, deflated by the Sri Lankan CPI to reflect March 2005 price levels. Profits are measured monthly. The estimated value of the owner's labor is subtracted from profits in columns (4) and (5), as described in the text. In column (4), the owner's time is valued by regression coefficients from a production function using baseline data; in column (5), we use the median hourly earnings in the baseline sample for each of six gender/education groups. A single variable measuring the rupee amount of the treatment is used as the instrument in columns (1) and (2) and (4) and (5). In column (3), we use four separate variables indicating receipt of each treatment type. Except in column (2), the coefficients show the effect of a 100-rupee increase in the capital stock. All regressions include enterprise and period (wave) fixed effects. Standard errors, clustered at the enterprise level, are shown in parentheses. The F statistic is the partial F statistic in the first-stage regression on the excluded instruments.

*** $p < .01$, ** $p < .05$, * $p < .1$.

Bottom line: The return is 5-6% **per month**, translating into a real annual return of about 60%. This is **much higher** than the going interest rate (16%-24%, nominal).

Why aren't firms taking advantage of these high returns by investing??

2.6 Heterogeneity of Treatment Effects

Why aren't firms taking advantage of the high returns documented above by investing? Survey data seem to indicate lack of credit is a key problem. For example, 78% of the owners reported that their business was smaller than the size they would like; uncertainty is also mentioned as a business problem (caveat: good reasons to interpret such answers with a great deal of caution - yes?).

- Could it be that missing markets for **credit** or for **insurance** keep investment low?

- To shed light on what types of constraints hamper investment, the authors start by writing down a simple, yet illustrative model. Let's have a look.

- Consider a one-period model in which the enterprise owner supplies labor inelastically to the business (i.e. labor input not endogenous). The household's problem is to choose the optimal amount of capital (K) to invest in the business, subject to budget constraints and borrowing constraints:

$$\begin{aligned}
&\max_{K} EU\left(\varepsilon f\left(K,\theta\right)-rK+r\left(A-A_K\right)+\left(nw-I_K\right)\right)\\
&-\lambda\left[K-A_K-I_K-B\right]\\
&-\mu_B\left[B-\bar{B}\right]-\mu_A\left[A_K-A\right]-\mu_I\left[I_K-nw\right],
\end{aligned}$$

($E=$ expectations operator; $U=$ utility function; $f\left(.\right)=$ production function; $r=$ interest rate; A=initial household assets; A_K=assets allocated to the business; n=labor market input of household members (external wage employment); w=wage rate; $I_K=$ funds generated by wage employment allocated to the business; B=amount borrowed).

- The argument of the utility function is consumption, denoted c; i.e.

$$c = \varepsilon f(K, \theta) - rK + r(A - A_K) + (nw - I_K)$$

is the budget constraint.

- The only random variable here is ε, which is strictly positive and has mean equal to 1. The first-order condition with respect to K is

$$\begin{aligned} E\left\{\frac{\partial U(c(K;\varepsilon))}{\partial c}\frac{\partial c(K;\varepsilon)}{\partial K}\right\} - \lambda &= 0, \\ E\left\{U'(c)\left(f'_K(K,\theta) + (\varepsilon - 1) f'_K(K,\theta) - r\right)\right\} - \lambda &= 0, \end{aligned}$$

(to go from the first to the second line, use the budget constraint, add and subtract f'_K, and simplify the notation). This, in turn, can be written as

$$EU'(c) f'_K(K,\theta) + Cov\left[\varepsilon, U'(c)\right] f'_K(K,\theta) - EU'(c)\, r - \lambda = 0,$$

$$EU'(c)\, f'_K(K,\theta) + Cov\left[\varepsilon, U'(c)\right] f'_K(K,\theta) = EU'(c)\, r + \lambda,$$

and so we can easily solve for $f'_K(K,\theta)$:

$$\begin{aligned} f'_K(K,\theta) &= \frac{EU'(c)\, r + \lambda}{EU'(c) + Cov\left[\varepsilon, U'(c)\right]}, \\ f'_K(K,\theta) &= \frac{1}{1 + \frac{Cov[\varepsilon, U'(c)]}{EU'(c)}} \left(r + \frac{\lambda}{EU'(c)} \right) \end{aligned}$$

which is equation (9) in the paper (p. 1355).

- In the **special case** in which credit and insurance markets function perfectly, we will have

$$\lambda = 0,$$

and

$$Cov\left[\varepsilon, U'(c)\right] = 0.$$

Why? Hence, in this case, the f.o.c. for optimal K reduces to

$$f'_K(K, \theta) = r,$$

which is the standard condition saying that the optimal level of capital is such that the marginal return is equal to the marginal cost. Now consider two other situations:

Perfect insurance markets, missing credit markets We have

$$\lambda \geq 0,$$

where the equality will be strict if the credit constraint is binding; while perfect insurance implies

$$Cov\left[\varepsilon, U'(c)\right] = 0$$

(realizations of the shock ε don't affect consumption because of insurance; hence $U'(c)$ don't covary with ε.

In this case, the f.o.c. becomes

$$f'_K(K, \theta) = r + \frac{\lambda}{U'(c)},$$

i.e. the marginal product of capital exceeds the marginal cost if $\lambda > 0$ - i.e. if the firm is credit constrained. The wedge between MPK and MC will be particularly high if the demand for capital is high and the credit constraint tight. In such a scenario we would say that the shadow cost of capital is high.

Empirical tests:

- Marginal return to capital will be higher for firms with greater ability θ
- Marginal return to capital will be lower for firms with more workers
- Marginal return to capital will be lower for households with more liquid assets

Perfect credit markets, missing insurance market Now:

$$\lambda = 0,$$

where the equality will be strict if the credit constraint is binding; while perfect insurance implies

$$Cov\left[\varepsilon, U'(c)\right] < 0$$

(consumption will increase with ε and utility is concave; hence negative covariance). The f.o.c. becomes

$$f'_K(K,\theta) = \frac{r}{1 + \frac{Cov[\varepsilon, U'(c)]}{EU'(c)}},$$

or

$$
\begin{aligned}
f'_K(K,\theta) &= \frac{EU'(c)\,r}{EU'(c)+Cov\left[\varepsilon,U'(c)\right]}, \\
f'_K(K,\theta)\left[EU'(c)+Cov\left[\varepsilon,U'(c)\right]\right] &= EU'(c)\,r \\
f'_K(K,\theta)\,Cov\left[\varepsilon,U'(c)\right] &= \left[r-f'_K(K,\theta)\right]EU'(c)\,.
\end{aligned}
$$

Since $Cov\left[\varepsilon,U'(c)\right] < 0$, it must be that $\left[r-f'_K(K,\theta)\right] < 0$ too. That is, $f'_K(K,\theta) > r$, hence optimal capital is less than it would be under perfect insurance. The size of this gap will be increasing in the level of risk in business profits and in the level of risk aversion.

Empirical tests:

- Marginal return to capital will be higher for firms facing high uncertainty

- Marginal return to capital will be higher for firms run by more risk averse entrepreneurs.

2.7 Experimental vs. Nonexperimental Returns

- This project provides the first experimental evidence on the returns to capital in small scale enterprises. How do the results compare to those obtained for non-experimental data?

- Theoretically, the bias in the estimated returns from non-experimental (cross-sectional) data is ambiguous; for example:
  - Upward biased, if capital positively correlated with unobserved managerial ability
  - Downward biased, if selection (only the most able entrepreneurs with small K are able to survive)

– Downward biased, if measurement errors in capital.

[Table VII: Comparison of nonexperimental and experimental results]

TABLE VII

COMPARING EXPERIMENTAL TO NONEXPERIMENTAL ESTIMATES (DEPENDENT VARIABLE: REAL PROFITS ADJUSTED FOR VALUE OF OWNER'S HOURS WORKED)

Instrumental Variables

	Nonexperimental results			Experimental results
	(1) OLS	(2) Random effects	(3) Firm FE	(4) Firm FE
Invested capital (excluding land and buildings)	2.58***	1.71*	0.07	5.29**
	(0.70)	(1.02)	(1.07)	(2.28)
Age of owner	−45.7***	−38.3*		
	(15.5)	(20.3)		
Education of owner	−215.3***	−105.8		
	(59.7)	(72.9)		
Owner is female	−1,359***	−2,430***		
	(339)	(491)		
Constant	6,485***	5,800***	2,299***	1,487***
	(985)	(1,163)	(300)	(498)
Observations	349	698	698	3,101
Number of enterprises	349	151	151	384

Higher.
- Why?
- Significantly different?

Notes: The sample for the regression in column (1) includes all firms but uses only the baseline (pretreatment) data. The second and third columns use only untreated firms and the first five waves of data. The final column repeats the regression shown in Table IV, column (4). The coefficients show the effect of a 100-LKR increase in the capital stock. The second through fourth regressions include period (wave) fixed effects, and the third and fourth include period and enterprise fixed effects. Standard errors, clustered at the enterprise level, are shown in parentheses.
*** $p < .01$, ** $p < .05$, * $p < .1$.

2.8 Conclusions

- random cash or in-kind grants increase profits of microenterprises by over 5% per month, or at least 60% per year.

- Marginal returns are highest for entrepreneurs with more **ability** and with **fewer other workers** in the household. This is consistent with the idea that **credit constraints** hamper investment.

- In contrast, returns do not differ with risk aversion of the entrepreneur, or with the perceived uncertainty about future profits. Hence, lack of insurance does not appear to affect investment.

- High variance in returns (based on models allowing for heterogeneous effects; Table V). Although the average is high, many have returns that are lower than the market interest rate (e.g. most women). Might explain why so few entrepreneurs in the sample borrow from formal lenders.

- Using an IV approach, the authors report estimates of the return to capital of around 5% per month, or 60% per year. In other words, average returns are very **high** for this sample of **small firms**. Hence, poverty traps are unlikely (high returns mean you can reinvest profits and eventually grow; not possible with low returns (trap)).

3 The Return to Capital in Ghana

Reference: Udry and Anagol.

- Output per worker is much higher in rich than in poor countries. This suggests that the return to capital is much higher in poor than in rich countries (high cost of capital $\rightarrow$ low capital-labour ratio $\rightarrow$ low output per worker; think CRS Cobb-Douglas technology)

- Robert E. Lucas Jr: "Why doesn't capital flow from rich to poor countries?"

- Several studies that estimate the rate of return on capital in developing countries report that these returns are very high - often in excess of 100%.

- A corollary of high returns is high costs (equilibrium condition).

- Udry and Anagol estimate the return to capital in Ghana.

3.1 The simplest approach

- Calculate the internal rate of return, defined as the discount rate r that equalizes the initial cost of investment to the NPV of future profit streams; e.g. solve for r here:

$$-\text{Investment} + \sum_{s=0}^{T} \left(\frac{1}{1+r}\right)^s \text{profits}_s = 0.$$

- Data: Inputs and outputs at the plot level for 1,659 plots cultivated by 435 farmers in four village clusters over a 2-year period in southern Ghana.

- Output and inputs are valued at village-survey round specific prices.

[Returns shown in Fig. 1-2]

New technology (exports of pineapples began in the 1990s)

(100%)

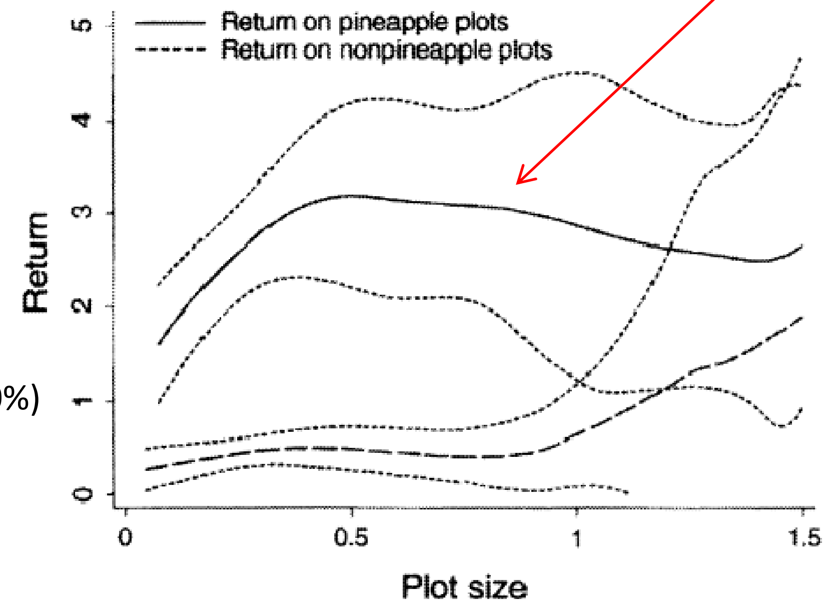


FIGURE 1. RATES OF RETURN BY PLOT SIZE WITH 2 S.E. POINTWISE CONFIDENCE INTERVAL

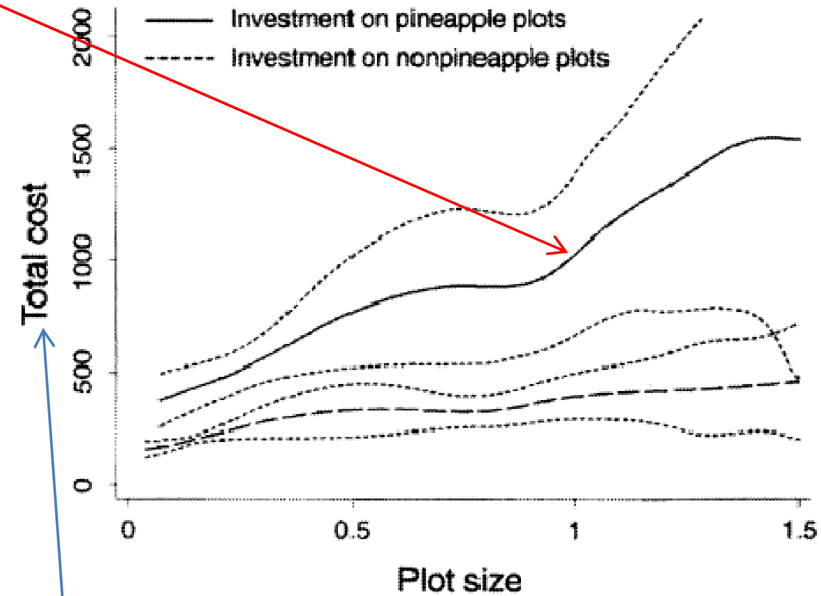


FIGURE 2. INVESTMENT BY PLOT SIZE WITH 2 S.E. POINTWISE CONFIDENCE INTERVAL

Magnitude of the investment (500 = 250 US$).

- Very **high** returns: Pineapples, mean >250% per annum! Trad. high too.
- Initial investment for pineapples high – consistent with the notion that **lack of capital** is the main barrier to the adoption of pineapple (cf. Theoretical model by de Mel et al, high lambda if credit constraints are high).

- Quite possibly these numbers **overestimate** the true marginal return on capital. For example, it's not possible with the simple method above to distinguish between the returns to entrepreneurship (skills) and the returns to capital, since the former is unobserved.

3.2 Lower bound on returns: Analysis of durable goods

- In equilibrium, the initial cost of an investment is equal to the net present value of future cash flow streams associated with the investment, i.e.

$$-\text{Investment} + \sum_{s=0}^{T} \left(\frac{1}{1+r}\right)^{s} \text{profits}_s = 0.$$

- Now consider two durable goods that are identical in every respect except they have different expected lives - i.e. T differs between the goods. Can we learn anything about the opportunity cost of capital by from the prices of these two products? Yes we can, according to the following argument.

- Because the two products are (assumed) identical in every respect except expected life, and the latter difference will be reflected in the prices of these goods, firms choosing between the products should be indifferent between them Note that, during the 'life' of these products they generate the same profits, denoted π.

- The discounted value of future profits associated with durable i is equal to

$$\sum_{s=0}^{T_i} \left(\frac{1}{1+r}\right)^s \pi \;=\; \left[\frac{1-\left(\frac{1}{1+r}\right)^{T_i+1}}{1-\left(\left(\frac{1}{1+r}\right)\right)}\right]\pi$$

$$\sum_{s=0}^{T_i} \left(\frac{1}{1+r}\right)^s \pi \;=\; \left[\frac{1-\left(\frac{1}{1+r}\right)^{T_i}\left(\frac{1}{1+r}\right)}{\left(\frac{r}{1+r}\right)}\right]\pi$$

$$\sum_{s=0}^{T_i} \left(\frac{1}{1+r}\right)^s \pi \;=\; \left[\frac{1-\left(\frac{1}{1+r}\right)^{T_i}}{r}\right]\pi$$

(this makes use of the summation formula for a finite geometric series).

- Obviously, then, the discounted value of future profits associated with durable j is equal to

$$\sum_{s=0}^{T_j} \left(\frac{1}{1+r}\right)^s \pi = \left[\frac{1 - \left(\frac{1}{1+r}\right)^{T_j}}{r}\right] \pi,$$

and so it follows that

$$p_i = \left[\frac{1 - \left(\frac{1}{1+r}\right)^{T_i}}{r}\right] \pi,$$

and

$$p_j = \left[\frac{1 - \left(\frac{1}{1+r}\right)^{T_j}}{r}\right] \pi,$$

where p_i and p_j denote the initial price of durables i and j, respectively.

- Our goal is to back out the discount rate r. As we don't observe π we can't do this directly using the equations above. But we can, however, infer it from relative differences in the prices and expected lives of the two products, since π disappears:

$$\pi = \frac{p_i}{\left[\frac{1-\left(\frac{1}{1+r}\right)^{T_i}}{r}\right]} = \frac{p_j}{\left[\frac{1-\left(\frac{1}{1+r}\right)^{T_j}}{r}\right]},$$

hence

$$\frac{p_i}{1-\left(\frac{1}{1+r}\right)^{T_i}} = \frac{p_j}{1-\left(\frac{1}{1+r}\right)^{T_j}}.$$

That is, given data on $\left(p_i, p_j, T_i, T_j\right)$, we can solve for r.

- Udry and Anagol collected information on the prices and expected lives of groups of parts from used auto parts dealers in Accra. They have usable data on 56 such pairs of parts. Hence, for each pair k, they can calculate the implied discount rate r_k:

$$\frac{p_{ik}}{1-\left(\frac{1}{1+r}\right)^{T_{ik}}}=\frac{p_{jk}}{1-\left(\frac{1}{1+r}\right)^{T_{jk}}},$$

- This is nice and simple. It's a lower bound on the discount rate, because costs associated with breakdowns of the durable goods are not taken into account.

- The median r_k is 32% and the mean is 66%.

- They also report the ML estimate of a common r is 0.60 - check the paper if you are interested.

- Basic conclusion for the high return to capital: **financial market imperfections**.

4 A structural approach for identifying the cost of financing

Reference: Schundeln (not dated).

- The two papers discussed above agree that financing constraints are an important reason as to why the returns to capital tend to be very high in developing countries.

- What is the "cost" of such financing constraints, in terms of foregone output and lost welfare? This we don't know very much about.

- The main goal in the paper by Schundeln is to document the cost of financing constraints to manufacturing firms in Ghana (1991-99), and analyze the aggregate implications. That is, the paper seeks to quantify the effect of removing all financial constraints in the sector.

- The following observation presents the starting point: On average, returns to capital in Ghanaian manufacturing are high, yet investment is low. Also, the correlation between investment and the returns to capital is weak. Could financing constraints explain this?

- Basic approach: estimate a structural dynamic model of the firm, in which the firm chooses investment optimally (forward-looking) subject to financing constraints. The degree of financing constraints will be captured in the model by a specific parameter; once this is estimated, one can do counterfactual analysis of what would happen to the firms and the sector if the financing imperfection were removed (so that the cost of external financing coincides with the cost of internal financing).

- The parameters are estimated by means of a simulations based approach (Method of Simulated Moments; MSM).

- The approach adopted in this paper is thus very different from that used by de Mel et al. (Sri Lanka). In the current paper, theory plays a much more prominent role - indeed, the approach requires that you write down a fully specified model of how the firm works.

4.1 Background: Ghanaian manufacturing, Financing & Data

- Ghana: Population = 18 million; 1991-99 not a very good period for the economy; small manufacturing sector (10% of total value-added); under-developed financial sector (despite reforms; particularly hard for small firms to get loans).

- Data: 9 years of panel data on manufacturing firms; extension of the Ghana RPED data (see the paper on learning by exporting by Bigsten et al); each round covers around 200 firms; within manufacturing, fairly wide coverage of sub-sectors; small as well as large firms included; four urban centres covered.

- In this paper, firms with more than 30 employees are excluded; firms with state ownership or foreign ownership are also excluded. The basic reason is to arrive at a reasonably homogeneous sample of small and medium sized firms. Final sample has 507 firm-year observations.

- There's data on debt but - awkwardly - no data on positive financial assets. If (as seems likely) firms save in order to deal with financial imperfections, this type of mechanism cannot be captured in the data.

[Table 1: Summary statistics]

Summary statistics					
	mean	std.dev.	min	max	N
employment	13.87	11.38	1	88	507
capital	25.23	75.37	0.013	638.1	507
output	24.32	52.35	0.098	827.8	507
value added	9.07	23.26	0.003	371.2	507
investment	0.72	4.45	0	57.3	507
age	14.0	10.6	1	66	507
debt	3.08	18.26	0	210.0	507
debt (conditional on debt>0)	9.82	31.64	0.001	210.0	159

Notes: all monetary values are in million Ghanaian Cedis, deflated to 1991 values; 1 million Cedis (1991) approximately equals 2500 USD

Table 1: Summary statistics

Note how small these firms are: for example, average value-added is 9.1 million / 2500 = 3,640 USD.

4.2 A dynamic model of firm investment in the presence of financing constraints and uncertainty

- A fully parameterized dynamic model of the firm is developed in Section 4 in the paper. I will only highlight its main features here.

- The entrepreneur is assumed to maximize the value of the firm, defined by the Bellman equation

$$V(x) = \max_{\text{exit,stay}} \left\{ \text{outside option(x)}, \sup_{c \in C(x)} E\left\{ u(x,c) + \beta V\left(x' | x, c\right)\right\}\right\},$$

where exit,stay are dummy variables indicating whether the firm chooses to close down or stay in the market in the current period; the outside option is the value of closing down (e.g. you sell off all equipment); $u(x,c)$ is the utility associated with optimal decisions c regarding investment in the current period (control variables) conditional on initial conditions x (state variables), β is the discount factor, and x' is the state in the next period which depends on the decisions today.

- The choice variables of the firm: Debt; Capital; Exit; Labour; and Dividends.

- The per unit cost of credit is modeled as a function of the risk free interest rate, $\underline{r}$, and firm characteristics:

  $\ln\left(r_{t,i} - \underline{r}\right) = \beta_0 + \beta_1 K_{t,i} + \beta_2 \left(debt_{t+1,i}/K_{t,i}\right) + \beta_3 debt_{t+1}, i + \eta_i.$

  This is pretty much ad hoc. Justification for this particular specification:

- The availability of collateral (K) reduces the cost of credit.
- Higher debt is associate with higher risk of default, which is compensated by higher interest rate
- There are potentially important unobservables, captured here by a firm fixed effect η_i.

• The $\beta-$parameters are key parameters of interest. There are many other parameters in the model too, motivated by various technological constraints (e.g. adjustment costs). Check the paper for details.

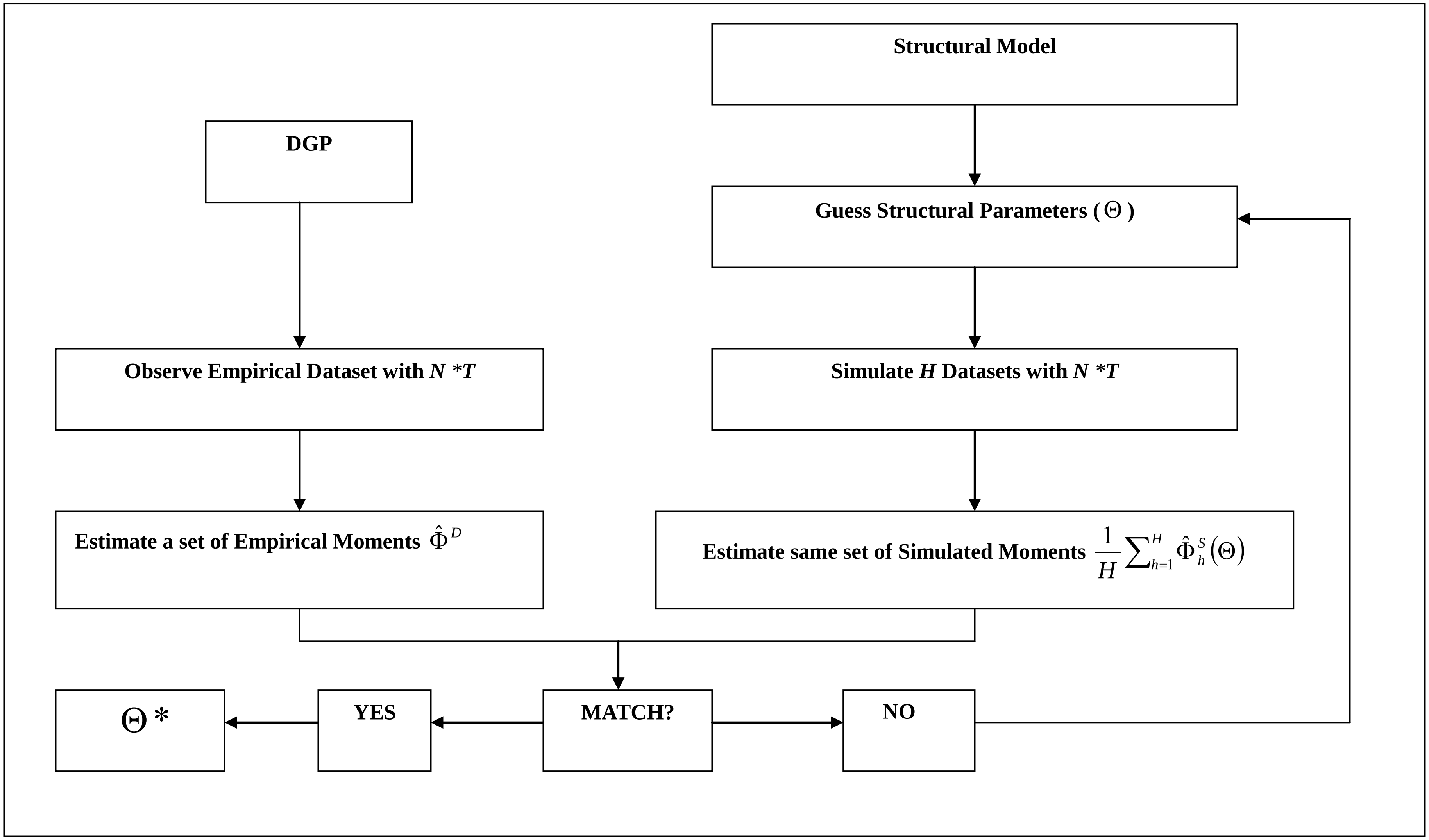
4.3 Estimation

- Summary of the procedure:
  - An outer algorithm calculates the **criterion function** (see equation 11 in the paper, page 21) and searches for its minimum
  - The inner algorithm solves the **dynamic problem** of the firm for the currently given parameter vector, starting from an initial guess for the vector of parameters, which is updated in the outer algorithm
- The criterion function is a quadratic function of the deviations of simulated from real moments. Basically, you search over all the structural parameters until the model can generate simulated moments that are as close as possible to real moments.

[Illustration of procedure; not from present paper]

[Table 3]

Figure 4.2: Illustration of Method of Simulated Moments



	estimates from the dynamic model	
	assuming w=0.15	assuming w=0.25
Production function estimates		
α_L	0.388	0.568
	(0.030)	(0.003)
α_K	0.391	0.300
	(0.019)	(0.016)
constant $\mu_{food/bakery}$	1.159	0.893
	(0.080)	(0.049)
constant $\mu_{garment/textiles}$	0.838	0.673
	(0.054)	(0.039)
constant $\mu_{furniture/wood}$	0.707	0.728
	(0.100)	(0.031)
constant $\mu_{metal/machines}$	1.038	0.857
	(0.031)	(0.048)
σ_ω	0.167	0.156
	(0.093)	(0.010)
ρ	0.621	0.659
	(0.094)	(0.327)
$\sigma_{initial\ \omega}$ (initial productivity)	0.747	0.435
	(0.013)	(0.614)
cost-of-credit function parameters: $r_{t,i} = \underline{r} + exp(\beta_0 + \beta_1 K_{t,i} + \beta_2 (debt_{t+1,i}/K_{t,i}) + \beta_3 debt_{t+1,i} + \eta_i)$		
β_0	-0.480	0.556
	(0.985)	(1.202)
β_1	-0.343	-0.422
	(0.245)	(0.970)
β_2	0.916	0.716
	(0.639)	(1.786)
β_3	0.237	0.274
	(0.158)	(0.132)
σ_η (fixed credit effect)	2.042	2.813
	(0.394)	(1.171)
υ (adjustment cost parameter)	0.917	0.552
	(0.160)	(0.060)

Notes: (1) Standard errors are in parentheses; (2) $debt = -A > 0$

Table 3: Estimation results

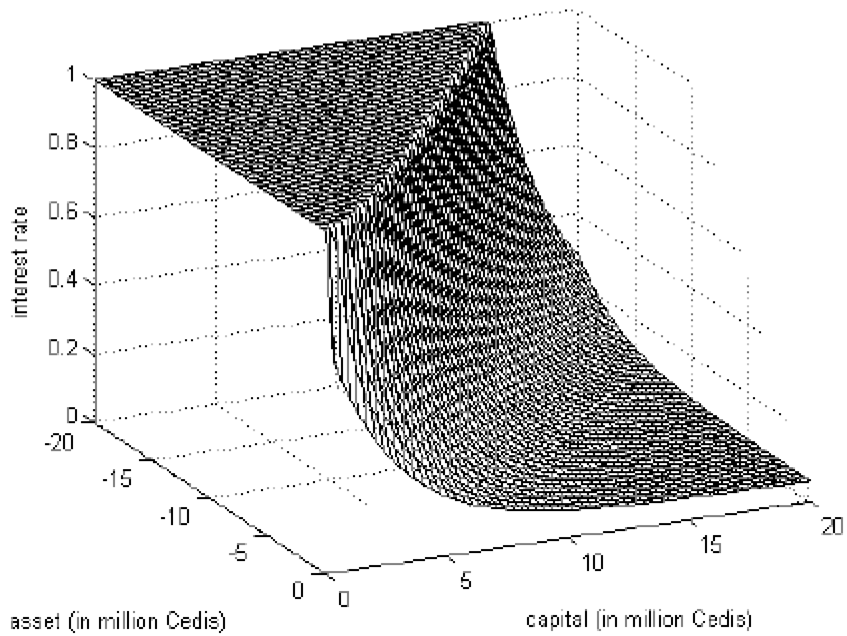


Figure 3: The interest rate schedule (truncated above at 1) for estimates with w=0.15

Counterfactual simulations:
What happens if you remove the constraints?

	simulation results		
	with constraints	without constraints	$\frac{\text{without constraints}}{\text{with constraints}}$
mean capital	22.508	23.189	1.030
mean investment	3.518	3.474	0.988
mean value added	12.996	13.372	1.029
debt (conditional on debt>0)	5.953	6.521	1.095
firms with debt	53.4%	84.0%	1.573
mean dividend (consumption)	3.864	4.051	1.048

Notes: results from simulation of 5070 obs.; simulated age distribution and initial capital/asset distribution are the empirical distributions from the data; all monetary units in this table are in 1 million Cedis, approx. 2500 USD (1991)

Table 6: The effect of removing the constraints, w=0.15

4.4 Conclusion

Three major results.

- New evidence for the existence of financing constraints, obtained from a dynamic model

- Second, the estimates of the parameters of the cost-of-credit function imply that the per-unit cost of credit is increasing with the amount of debt a firm incurs and decreasing with the capital stock already used by a firm. This is consistent with conventional models of imperfect credit markets.

- Third, the estimated cost of financing constraints are economically significant. Counterfactual analyses indicate that removing the constraints would imply firm growth with economically significant increases in firm sizes. Consumption would increase accordingly: by 5-8% on average in the full sample used, and by 50-178% if only the smallest firms are considered.

- Discuss.