

# Modeling Firm Dynamics to Identify the Cost of Financing Constraints in Ghanaian Manufacturing\*

Matthias Schündeln

Yale University

This version: November 7, 2003

## Abstract

Economic development requires the growth of productive firms. However, financing constraints may limit firms' investment abilities. This paper studies the questions: what is the cost of financing constraints, for example in terms of idle investment opportunities, to firms and what are the aggregate implications?

In the first part of the paper I use firm level panel data to demonstrate that, on average, the returns to capital in Ghanaian manufacturing are large, while investment rates are low and largely uncorrelated with returns to capital. I then focus on financing constraints as a potential explanation for this apparent puzzle, and present evidence for the existence of financing constraints.

To quantify the extent to which financing constraints matter, I then develop and estimate a dynamic model of firm-level investment. The model allows me to deal with the main identification problem faced by work that studies financing constraints, namely to identify the investment opportunities and the constraints of a firm separately. The model also allows for other potential explanations of the observed phenomenon, in particular adjustment costs and uncertainty. I estimate the model using firm level data from Ghana. Counterfactual analyses are then carried out to quantify the importance of financing constraints. These counterfactuals indicate that removing the constraints would imply economically significant increases in investment that are associated with higher levels of consumption.

---

\*I am very grateful to Chris Udry, Chris Timmins, and Steve Berry for advice and support throughout this project. I also would like to thank Pat Bayer, Sigga Benediktsdottir, Hanming Fang, Garth Frazer, Nicola Fuchs-Schündeln, George Hall, Ethan Ligon, John Rust, participants at the SSRC-Fellows' conference in Santa Cruz, the Workshop on Economic Theory and Econometrics at Tor Vergata University (Rome), and workshops at Yale for very helpful comments. I thank Cletus Kosiba and his colleagues at the Association of Ghana Industries and Abena Oduro for exceptional support during my field work in Ghana, Samuel Okyere and Frank Tawiah for research assistance, and the interviewed Ghanaian entrepreneurs for their time and sharing their views during interviews. I thank Francis Teal and the Centre for the Study of African Economies, Oxford University, for sharing the data and I gratefully acknowledge funding from the Social Science Research Council (SSRC). Address: Department of Economics, Yale University, P.O. Box 208268, New Haven, CT 06520-8268. Email: matthias.schuelndeln@yale.edu  
This is work in progress. Updates will be made available on my web page: <http://pantheon.yale.edu/~mms49>

# 1 Introduction

Economic development requires the growth of productive firms. Theoretical considerations and existing empirical evidence however point to the existence of financing constraints that limit firms' investment abilities. Despite the potentially large welfare implications, very little is known about the cost of financing constraints to individual firms or about their aggregate implications. This motivates the research questions that are at the core of this paper: what is the cost, as measured along various dimensions, of financing constraints to firms, and what are the aggregate implications? I define as financially constrained a firm for which external funding is not a perfect substitute for internal finance.<sup>1</sup> The paper quantifies the effect that removing all constraints would have to individual firms. Thus, the paper quantifies the upper bound of the effect of potential policies that attempt to close the wedge between the cost of internal and external finance. Since growth is a main goal of economic policy, the results of this work have immediate policy relevance. Further, given the multitude of activities and the amount of money spent on support for enterprise development in developing economies - especially to enhance firms' ability to borrow in order to finance investment - the question is particularly relevant for, but not confined to, developing economies.

Specifically, I study the behavior of manufacturing firms in Ghana. I start out by demonstrating an apparent puzzle: I use firm level panel data to demonstrate that, on average, the marginal returns to capital in Ghanaian manufacturing are high during the period 1991-1997. However, investment rates are low, and there is only little evidence for a correlation between investment rates and returns to capital, especially for the group of firms with the largest returns. One of the main hypotheses put forward in the literature to explain low investment despite high returns to capital are financing constraints (e.g. Bigsten et al. 2000 for other African economies; Tybout 2000; at the macro level, Lucas, 1990, discusses capital market imperfections). Before turning to a quantification of the cost of financing constraints, I give evidence for the existence of these constraints in Ghanaian manufacturing. I show direct evidence from the survey for the existence of financing constraints, as

---

<sup>1</sup>This wedge between internal and external funding is caused by capital market imperfections, as for example informational asymmetries. This definition follows the definition of financing constraints in Fazzari et al. (1988, e.g. p. 142), one of the classic references. Note that, according to this definition, it is likely that all firms are constrained, for example if transaction costs matter (Kaplan and Zingales 1997). The question is therefore not: which firm is constrained? but: to what extent is a firm constrained?

well as econometric evidence that uses a version of a standard test for financing constraints (Fazzari et al. 1988).

While several other papers have shown that financing constraints matter for manufacturing firms, both in developed and developing economies, the effects of these constraints have, to the best of my knowledge, not been estimated. The central goal of this paper is therefore to quantify the effects of financing constraints along several dimensions, in order to help better understand the importance of financing constraints. To this end I develop and estimate in the main part of the paper a structural dynamic model that allows me to study firms' investment, growth, volatility, and exit in the presence of financing constraints. I explicitly model the firms' real activities, i.e. the production process and investment decisions, together with the financial side, i.e. the decision how to use profits (keep them to build up internal funds vs. dividend payments) and how to finance investment (internal vs. external funds). I further model the latent interest rate that the firms of different types face, where heterogeneity across types is both observed and unobserved. The model also allows for other potential explanations of the observed phenomena, in particular adjustment costs and uncertainty. Finally, the model incorporates the possibility of exit of firms.

By modeling and estimating the dynamic optimization problem of the firm that simultaneously includes both the real side and the financial side of the firms' activities, I can deal with the main identification problem faced by tests for and quantifications of financing constraints, namely to identify the investment opportunities and the constraints of a firm separately (e.g. Hubbard 1998). The identification of the production function and unobserved productivity relies on the assumption that capital is predetermined and labor is chosen as the solution to a static optimization problem. Evidence from the survey is presented to support this assumption. Given an estimate of the production function, the investment opportunities can be determined as the solution to a dynamic optimization problem. These can be used to identify the constraints that a firm faces. Intuitively, the separate identification of constraints that are common to all firms, e.g. adjustment costs, vs. financing constraints, that only apply to firms with low levels of internal funds, is achieved by the fact that some firms are able to invest optimally out of internal funds, while others are not.

The model is solved using dynamic programming methods and is estimated via simulation meth-

ods using the firm level panel data from Ghana. The estimation results indicate that the per-unit cost of credit decreases in the capital stock of a firm and increases in the amount that a firm borrows. These results are consistent with conventional models of imperfect credit markets. Counterfactual analyses are then carried out to answer the main research question, i.e. to quantify the importance of financing constraints. These counterfactuals indicate that removing the constraints would imply economically significant increases in investment that are associated with higher levels of consumption.

The results of the estimation are of interest for several reasons. The different potential explanations for low investment have important implications for individual firm dynamics, industry structure, as well as for policy at the macro level. Distinguishing between them and quantifying the relative importance of them is therefore important. For policy reasons, it is important to understand the determinants of financing constraints and quantify their extent and potential effects more fully. Policy implications are very different depending on the determinants of access to credit that turn out to be important. For example, if current size matters, firm growth and in particular entry will be difficult. Further, if productivity is at least partly observable and matters in the credit allocation process, then capital will be allocated more efficiently than it would be, if for example current cash flow matters most in the allocation process. In the latter case, permanent effects of transitory shocks can be expected (Banerjee and Duflo 2002). In an extreme case, when the constraint is proportional to some measure of net worth, Banerjee (2001) shows that this situation may lead to a poverty trap. For example, it is possible that small firms never reach their efficient size. This translates into industry structure and dynamics, e.g. firm size distribution, average productivity levels and growth, that I will explore in the last part of the paper.

Finally, support for small and medium sized enterprises is one of the primary focuses of development agencies. For example, lending to micro, small and medium enterprises (SMEs) by the World Bank Group was approximately \$2.8 billion in 2001 (IFC, 2002).<sup>2</sup> Among the questions then are: how is this money best spent, what is the potential impact of improving credit availability to firms, and which types of firms should be targeted? At the macro level, the effects of tax and interest

---

<sup>2</sup>And lending to SMEs is increasing: it increased by 65% since 1997, when total lending was \$1.7 billion (IFC, 2002).

rate policies, which may be smaller than is generally thought if adjustment costs or uncertainty are the main causes of low investment, could be explored with the estimates of the model.

The following section relates this paper to earlier work. The third section presents estimates of the returns to capital and relates them to investment. The fourth section presents evidence for the existence of financing constraints. In the fifth section a dynamic model of firm-level investment is developed. In the sixth section the solution, identification, and estimation of the model are discussed, while the estimation results are presented in the seventh section. The implied costs of financing constraints are estimated and other implications of these constraints are presented in the eighth section. The ninth section concludes.

## 2 Related work

Understanding investment is a central problem and an area of active research not just in industrial organization, but also in macro economics and financial economics. This paper is therefore related to several strands of the economics literature. To begin, there is now a large literature, both theoretical and empirical, about the existence of financing constraints in both developing and developed countries. The main problems leading to constraints that are identified in the theoretical literature can be split up into two groups: asymmetric information and enforcement problems. However, since I do not test one particular model of why firms might be financially constrained in the first place, I do not attempt to summarize the large literature about the informational problems that give rise to adverse selection and moral hazard that are often the basis of theoretical models of financing constraints (for a recent survey see for example Banerjee 2001). In development economics most of the empirical work is concerned with credit for households' consumption smoothing desire and for farm households' production processes (e.g. Rosenzweig and Wolpin 1993). In particular, little is known about the importance of financing constraints and the role different sources of credit play for enterprises other than in the agricultural sector at the household level.<sup>3</sup>

The classic work in the empirical literature that tests for financing constraints at the firm level

---

<sup>3</sup>For a survey on credit for household consumption smoothing see for example Besley (1995). Household enterprises are surveyed for example by Vijverberg and Mead (2000). Liedholm and Mead (1999) survey the literature on the dynamics of micro and small enterprises without focussing on credit constraints. Townsend and Paulson (2001) are primarily concerned with the role of financing constraints in the start-up of a firm.

is the work by Fazzari et al. (1988). A second standard approach to test for financial constraints is based on estimating Euler equations (Bond and Meghir 1994). This body of empirical work proceeds by estimating a standard investment equation or accelerator models (for other examples see Schiantarelli 1996, Gelos and Werner 2002). The question in this literature is: does adding cash flow (as a proxy for the change in internal net worth) to standard investment equations help explain capital expenditure for certain types of firms? With perfect credit markets, the financial structure of a firm is irrelevant to its real decisions (Modigliani and Miller 1958). However, if for example informational asymmetries or contract enforcement problems matter, then external funds will be more costly than internal funds and cash flow appears significantly in the regressions. One difficulty is that cash flow may be correlated with investment for other reasons, for example it may predict future profitability (e.g. Schiantarelli 1996). To deal with that possibility, Fazzari et al. (1988) propose to split the sample into firms that are likely to be more constrained and firms that are likely to be less constrained. Note also that it may be difficult to obtain measures of average Q, in particular in the context of developing countries, since the market value is not observed. Also, average Q might be a poor proxy for marginal Q, which is usually unobserved.<sup>4</sup> For detailed surveys see for example Hubbard (1998) and Schiantarelli (1996). An alternative to the above approach is to estimate Euler equations, e.g. Bond and Meghir (1994). The question is again whether investment is sensitive to cash flow. However, the properties of Euler equations make them difficult to use in the present context.<sup>5</sup> The findings using the above methodologies usually suggest that most types of firms face significant financial constraints (see Schiantarelli, 1996, for a more detailed overview).<sup>6</sup>

A second group of this literature looks at direct evidence for constraints. Bigsten et al. (2000)

---

<sup>4</sup>See also the debate about whether the Fazzari et al. (1988) method is valid in Kaplan and Zingales (1997, 2000) and Fazzari et al. (2000).

<sup>5</sup>First, estimates of Euler equations have poor quality with small samples and/or short panels as those that are available for African countries. Second, the parameters are not identified if the constraints are approximately constant over time, which is especially likely for short panels. Third, when the firm is at a debt ceiling, the Euler equation is misspecified. Both approaches also rely on sample splits, which poses the problem of potentially endogenous split-criteria. Most important in the context of African manufacturing may be that both models are misspecified when there are fixed cost of adjustment or irreversibility of investment.

<sup>6</sup>There is also a body of work that uses firm level and industry level data and makes use of cross-country differences in the development of financial markets which also finds evidence for financing constraints, e.g. Bond et al. (1997), Love (2001), Fisman and Love (2002).

estimate the determinants of demand for external formal funds (i.e. bank loans) explicitly using a selection model. They use direct survey questions regarding the reasons why firms do not apply for credit. They find that for their sample of African manufacturing firms small firms and unproductive firms are the most likely to be constrained. This approach however relies on strong assumptions about what kind of reason for not applying for a loan is a sign of credit demand. For example it is not obvious whether a firm that does not apply for a bank loan because the "interest rate is too high" is constrained or simply unproductive relative to the prevailing market interest rate. A further drawback is that informal credit is very important in the Ghanaian data used in this paper, but is not an alternative in the test by Bigsten et al. (2000).

Another direct approach is taken by Banerjee and Duflo (2002). They investigate the 'nature of credit constraints' by looking at the credit allocation rules of a particular (state owned) Indian bank. They exploit a change in government policy to investigate whether firms would like to obtain more credit at the going interest rate than they can actually obtain. They find that an increase in working capital leads to a more than proportional increase in profits and conclude that firms are credit constrained and that as a consequence there are significant productivity losses.

Standard models of firm dynamics are due to Jovanovic (1982), Hopenhayn (1992) and Ericson and Pakes (1995). In Jovanovic (1982), heterogeneous firms learn over time about their productivity and either expand or exit. In Hopenhayn (1992) firms experience persistent shocks to technology. He studies the properties of the stationary equilibrium, and the effect of changes in sunk entry costs or fixed costs per period on size distribution and turnover rates. Ericson and Pakes (1995) study investments in new processes with uncertainty in the outcome. Only very recently there have been two theoretical papers that combine aspects of the above mentioned dynamic investment literature with the literature on financing constraints. Cooley and Quadrini (2001) introduce financial frictions in a model of firm behavior to explain why growth, job creation/destruction, and exit are negatively related to size (age) of firms, conditional on age (size). Financial frictions are introduced via a cost per unit of new equity through shares and borrowing that is costly (above the risk-free interest rate) due to the cost of default. Gomes (2001) introduces financial frictions into a general equilibrium model to show that results from standard investment regressions are questionable, due in part to

the measurement error in marginal  $Q$  when it is approximated by average  $Q$ . In his paper financial frictions are modelled as a fixed cost of borrowing plus a per unit cost of new equity. Both papers study theoretical models that are calibrated to US data.

Summarizing, there exists now a considerable amount of empirical evidence for financing constraints. However, to identify financing constraints separately from other constraints is challenging (e.g. Hubbard 1998, Banerjee and Duflo 2002) and the cost of financing constraints to firms have, to the best of my knowledge, not yet been estimated from a representative survey. Therefore this paper goes beyond the mere question whether financing constraints exist. Instead, I study how much of the observed dynamic firm behavior is explained by financing constraints. My objective is to quantify the cost of these constraints. Further, I provide estimates for the relative importance of firm characteristics, e.g. the capital stock, that determine these constraints.

### **3 Investment and the returns to capital in Ghanaian manufacturing**

#### **3.1 Data and background on Ghanaian manufacturing**

Panel surveys of manufacturing firms are now available for a small set of African countries.<sup>7</sup> They have been collected by the Regional Program on Enterprise Development in Africa (RPED, by the World Bank in cooperation with other institutions like the Centre for the Study of African Economies, Oxford University) over the last decade. These surveys with a short panel component and detailed data on production processes as well as the financial situation of the firms will help to shed some more light on the importance of financing constraints for enterprises.

I use panel data from the Ghanaian manufacturing firms surveys that cover the years 1991 - 1997. Each survey round covers roughly 200 representative firms. Firms exiting the survey were replaced. The survey covers four sectors: (1) food processing, (2) textiles and garments, (3) wood products and furniture, and (4) metal products and machinery. For details on the surveys see Teal (2002) and Rankin et al. (2002). Regarding the variables of highest interest to this study, note in particular that the data only contain information about levels of debt, not about positive financial

---

<sup>7</sup>One reason for the focus on household enterprises in most of the development economics literature certainly is that good data about non-farm, non-household enterprises in developing countries was rare until recently.

assets. In this paper debt is measured as total debt including informal borrowing and overdraft, but excluding trade credit.<sup>8</sup> The capital measure is the replacement value of the capital stock.<sup>9</sup> All the data has been deflated to 1991 Ghanaian Cedis, using firm-level deflators that are provided by the survey team (for details see Teal 2002).<sup>10</sup>

The period under consideration was a period of moderate growth rates for Ghana. Real GDP growth in Ghana (according to IFS) oscillated between 5.3% (1991) and 3.3% (1994), averaging 4.3% over the period 1991-1997. Manufacturing during this period was growing faster than total GDP, with total manufacturing growth of 7.2% on average (UN, statistical yearbook; for details see the appendix.). The share of the manufacturing sector (in % of total value added) is about 10.1% on average over the years 1991-1997. Thus, manufacturing is the second largest sector (UN, statistical yearbook). The largest sector is agriculture/hunting/forestry/fishing with 42.5%.<sup>11</sup>

### 3.2 Returns to capital

In this section I present production function estimates for the Ghanaian manufacturing firms which are used to calculate the marginal returns to capital.<sup>12</sup> I start with a random effects estimation of the production functions. I also estimate fixed effects models for comparison, despite the well

---

<sup>8</sup>Trade credit is excluded since there is evidence in the survey that trade credit is not an important source of financing for fixed investment (see table 8 in the appendix).

<sup>9</sup>The capital stock measure is imputed as described in Teal (2002). Teal (2002) assumes that the most recent capital data is the most reliable data. The procedure therefore involves working backwards from the most recent capital data using the annual information about investment. I complement this procedure and introduce depreciation. It is assumed that depreciation is 9%, which is the average of two different estimates of depreciation that I obtain from the raw data. For further details on this see the section on investment.

<sup>10</sup>1 million Cedis (1991) approximately equals 2500 USD. Inflation during the period 1991-1997 was 30% per year on average. While all data has been deflated as described above, this raises the possibility that some measurement error in variables cannot be avoided. Further, it may be difficult for firms to forecast inflation, which would introduce an additional layer of uncertainty on the decisions of the firms. However, although inflation fluctuates considerably and does not show a clear trend, it does not go below 10% and above 59%, and from direct survey responses (in which inflation does not appear to be a main problem - for more on this see section 4.1 below) and informal observations inflation appears to be something that Ghanaian entrepreneurs have learned to adjust to.

<sup>11</sup>For more detailed information about the Ghanaian economy, see for example Baah-Nuakoh (2003), and for information about the small enterprise credit, Aryeetey (1996).

<sup>12</sup>The number of controls included in the specification of the production functions that are presented here is restricted to include only capital and labor, which is done to be able to compare the results in this section to the results of the structural model that is estimated below. In related work, which is in progress, I estimate richer specifications which confirm the results presented here. Further, the available estimates of two papers that estimate rich production functions with a subset of the data that I use imply returns to capital of comparable size (Bigsten et al. 1998, Frazer 2001).

known problems associated with this approach.<sup>13</sup> The estimations are first done for a Cobb-Douglas specification. To relax the functional form assumptions, I also estimate the more flexible translog production function (Christensen et al. 1971):

$$\ln Y_{it} = \beta_0 + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \frac{1}{2} \ln^2 L_{it} + \beta_4 \frac{1}{2} \ln^2 K_{it} + \beta_5 (\ln L_{it}) (\ln K_{it}) + \varepsilon_{it}$$

To deal with the endogeneity of input use, I resort to recent advances in the methodology to estimate production functions consistently which are due to Olley and Pakes (1996), and Levinsohn and Petrin (2003) (see these papers for details and Griliches and Mairesse, 1995, for an overview). The idea is, very generally speaking, to use either observed investment (Olley and Pakes 1996), or intermediate input use (Levinsohn and Petrin 2003) as a proxy for unobserved productivity. These approaches leave the researcher with more of the variance in inputs than did previous responses to the simultaneity problem, as for example fixed effects estimations, and they also allow for changes in firm productivity over time. Roughly speaking, the underlying assumption is that given a fixed capital stock, investment or intermediate inputs are monotonically increasing in the productivity level of a firm, which is assumed to be the only unobservable that is known to the firm at the time of input choice. Since in my data in almost half of the firm/year observations investment is zero (details follow below), the estimator proposed by Olley and Pakes (1996) is not a useful alternative in the Ghanaian context, because it would require the researcher to omit observations with zero investment. Instead, I follow the methodology proposed by Levinsohn and Petrin (2003), using raw material inputs to control for unobserved productivity.

Because the specification treats capital and labor as the only inputs, i.e. omitting intermediate inputs, I use value added as the dependent variable  $Y$ . Value added and capital,  $K$ , are measured in millions of Ghanaian Cedis (deflated to 1991 values).  $L$  is measured as the employment level. Given the results from the production function estimation, the marginal returns to capital are then calculated as the partial derivative of value added with respect to capital.

---

<sup>13</sup>The argument is that while the fixed effect takes care of the endogeneity of inputs problem, the role of measurement errors in the inputs is magnified in particular for fixed inputs (e.g. Griliches and Mairesse, 1995; Levinsohn and Petrin 2003). The usual finding is that capital coefficients are very small, sometimes even negative. Combined with the finding of decreasing returns to scale, the results for the capital coefficients from fixed effects regressions are generally regarded as too small to be credible (e.g. Griliches and Mairesse, 1995).

The results using data for all sectors and for all size classes pooled are reported in Table 1. They indicate that the (annual) marginal returns to capital are large, between 32% and 35% (at the median) and between 86% and 178% (at the mean) for the random effects and the Levinsohn/Petrin estimates. Fixed effects estimates imply returns to capital that are zero or negative. However, as mentioned before, the fixed firm effects take away much of the variation in the data, and the role of measurement errors in the inputs, which is particularly likely in capital data, is magnified. As was to be expected, the argument against the use of fixed effects appears to apply for the data used in this study. This stresses the importance of more flexible approaches, as the Levinsohn/Petrin approach, to control for unobserved shocks to productivity. A closer look at the estimates will be taken in the section about investment below, where (in Table 3) returns are split up by size class and sector. The estimates presented there demonstrate that marginal returns are decreasing in the size (as measured in employment level) of the firm.<sup>14</sup>

Some evidence in support of the estimated returns to capital comes from a comparison of returns to labor and wages. The table reports the marginal returns to labor inputs as estimated from the Cobb-Douglas production functions, which are (at the median) between 0.17 and 0.25. The median wage in the data is 0.23 (in million Cedis).<sup>15</sup>

These estimates are comparable to results for Ghana and other African economies (with comparable data sets), that are found by Bigsten et al. (1998). In their study of five countries, Bigsten et al. (1998) estimate median annual marginal returns to capital of between 10% (Zambia) and 35% (Zimbabwe), and find 32% for Ghana. Focusing on micro enterprises in Mexico, McKenzie and Woodruff (2003) find even higher marginal returns to capital, in the order of 15% per month. To further aid interpretation of the estimates, a comparison to estimates for OECD countries might be helpful. Note, however, that almost all published statistics about returns to capital use average returns to capital. According to Chan-Lee and Sutch (1985), in 1982 average rates of return in

---

<sup>14</sup>Note that the decrease in marginal returns with an increase in the size of the firm is not simply due to the assumption on the functional form of the production function, given the firm heterogeneity with respect to the unobserved productivity term.

<sup>15</sup>The median wage is calculated as the median of the average wages (dividing total wage bill by number of employees) for firms with wage bills > 0 and firms with more than 10 employees. The latter requirement is introduced to avoid difficulties which are due to the fact that the wage of the entrepreneur is not explicitly included in the questionnaire and it appears that only some firm owners have included their own wage.

manufacturing were 10.6% in the US, while the lowest average returns in a OECD country were 5.5% (UK), and the highest, 20.7%, in Japan (these figures are calculated as profits divided by capital, not adjusting for depreciation). Over the period 1967 to 1995 the average return to capital for nonfinancial corporations in the US (after tax) was between 4.5% (in 1980) and 8.5% (in 1988) (Browne and Hellerstein 1997).

<b>Production function estimates and returns to capital</b>					
	Cobb-Douglas Random Eff.	Cobb-Douglas Fixed Eff.	Translog Random Eff.	Translog Fixed Eff.	Levinsohn/Petrin GMM (C-D)
$\beta_{labor}$	0.628 (0.069)	0.554 (0.096)	0.404 (0.261)	0.384 (0.312)	0.494 (0.038)
$\beta_{capital}$	0.310 (0.033)	-0.003 (0.146)	0.322 (0.100)	0.063 (0.194)	0.401 (0.868)
$\beta_{labor^2}$			0.090 (0.114)	0.091 (0.136)	
$\beta_{capital^2}$			0.008 (0.024)	0.084 (0.051)	
$\beta_{labor*capital}$			-0.013 (0.042)	-0.057 (0.051)	
constant	-0.534 (0.177)	0.177 (0.359)	-0.320 (0.310)	-0.086 (0.485)	-0.222 (2.079)
observations	918	918	918	918	907
p-value (F-test $H_0$ : C-D)			0.718	0.366	
p-value (Hausman test)	0.058		0.032		
marginal returns to capital (median/mean)	0.32/1.56	-0.01/-0.05	0.34/1.40	-0.03/-0.86	0.35/1.78
marginal returns to labor (median/mean)	0.25/0.51	0.19/0.41	0.18/0.52	0.20/0.43	0.17/0.35

Notes: Standard errors in parentheses; the std. errors for Levinsohn/Petrin GMM estimates are bootstrapped

Table 1: Production function estimates and returns to capital

### 3.3 Investment

The production function results presented in the preceding section imply that the gross returns to capital, i.e. before subtracting depreciation, are large. From the changes over time in the available raw capital data (deflated to 1991 values), I estimate the depreciation rate to be between 6% and 12%.<sup>16,17</sup> The firm's decision to invest involves a comparison of the net return to investment and the opportunity cost of capital. We do not know the exact opportunity cost of capital for the firm, but a good proxy should be a measure of the market interest rate. The real interest rate in Ghana in the period from 1991-1997 measured as the real discount rate was on average 5.9%. The real discounted interest on treasury bills was 2.2% on average and real 3 months time deposits earned, due to inflation, on average a negative real interest, namely -4% annually (source: IFS). Comparing the resulting net returns and the real interest rate we should therefore see a large fraction of firms investing.

The most striking feature of the investment data is that most firms do not invest. The investment rate, i.e. the ratio of investment to capital, is 0 for 53.8% of the firms years. 22.5% of firms have not made an investment in any of the years in the survey. Figure 2 shows a kernel density plot of the percentage of years in the survey with positive investment (only for firms which are in the survey for at least 5 years). The figure illustrates that micro and small firms do invest much less frequently than medium and large firms (for a more detailed description of investment behavior, including sources of investment finance, see the appendix).

Table 3 shows the correlation of the estimated returns and investment rates at the firm level

---

<sup>16</sup>The depreciation is estimated as the change in capital net of investment. Two approaches are followed to estimate the depreciation: The former estimate, 6%, is the median of  $1 - \frac{cap_t - inv_t}{cap_{t-1}}$  in the data. The latter estimate, 12%, is calculated as  $1 - \beta_{cap_{t-1}}$ , where  $\beta_{cap_{t-1}}$  is the parameter estimate for the coefficient in a regression of  $(cap_t - inv_t)$  on  $cap_{t-1}$ , without a constant, i.e.  $(cap_t - inv_t) = \beta_{cap_{t-1}} cap_{t-1} + \epsilon$ .

<sup>17</sup>Depreciation is difficult to measure, especially if measurement error can be expected to be a serious problem in the data. However, these numbers are in line with standard depreciation figures used in the literature for the US, e.g. Kydland and Prescott (1982). They argue that "[d]ifferent types of capital depreciate more rapidly than others, with durables depreciating more rapidly than plant and housing, and land not depreciating at all. As a compromise, we set the depreciation rate equal to 10 per cent per year" (p. 1361). The Bureau of Economic Analysis uses the following depreciation rates for the US (Fraumeni 1997, p. 18): For metalworking machines 12.3%, for special industrial machinery 10.3%, and for general industrial, including materials, handling equipment 10.7%.

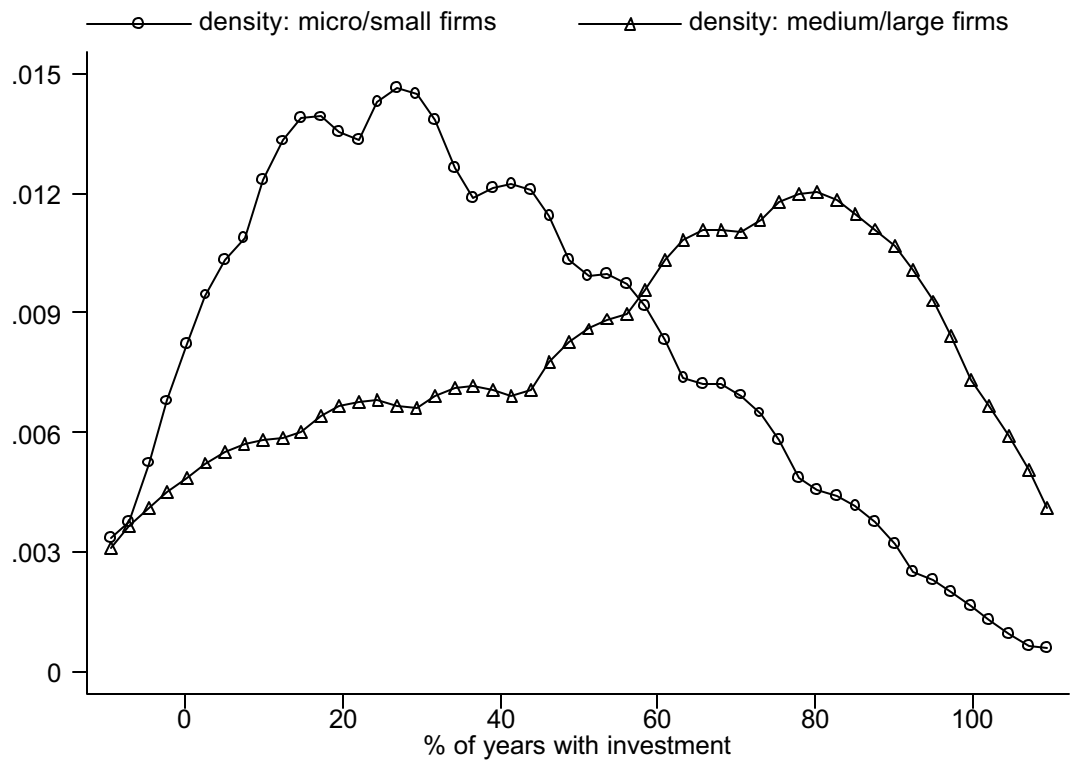


Table 2: Kernel density estimates of % of years with positive investment, for firms that are surveyed for at least 5 years

for the different size classes and sectors. There is weak evidence of a positive correlation between the returns to capital and investment. Looking at the full sample, the correlation is 0.08. However, no clear picture emerges about the the relation between returns to capital and investment. For example in the furniture/wood sector, where returns are 22% at the median, the investment rate is 0.09 at the median, which is about the size of the estimated depreciation, and there is no correlation at all between returns and investment rate. With respect to the different firm sizes (as measured by employment<sup>18</sup>) I find a statistically significant positive correlation only for small firms, while for the firms with the highest returns to capital, the micro firms, I cannot detect a correlation between returns and investments. There is no significant positive correlation between returns to capital and an investment dummy.<sup>19</sup>

	(gross) returns to capital (at median )	inv. rate ( $I/K$ ) (median - mean)	correlation returns & inv. rate
<i>by sector</i>			
food/bakery	37 %	0.0 - 0.16	0.06
garment/textiles	47 %	0.0 - 0.18	0.14*
furniture/wood	22 %	0.0 - 0.09	-0.003
metal/machines	29 %	0.0 - 0.12	0.15*
<i>by size (employment)</i>			
micro (1-5 employees)	74 %	0.0 - 0.14	-0.02
small (6-29 employees)	36 %	0.0- 0.13	0.15*
medium (30-99 employees)	28 %	0.0 -0.17	0.07
large (>100 employees)	10 %	0.04 - 0.05	0.13
all firms	33 %	0.0 - 0.13	0.08*

Notes: (1) In this table I use the returns to capital estimated from the random effects translog production function estimates with data of all sectors and size classes pooled  
(2) \* indicates statistically significant correlation at the 10% level

Table 3: Correlation investment and returns to capital

<sup>18</sup>More precisely: employment level in the first period that the firm is surveyed.

<sup>19</sup>One could argue that large returns in one year will not immediately cause investment. However, even when I take averages over all years there is only mixed evidence for a positive correlation.

## 4 Some evidence for financing constraints

### 4.1 Suggestive direct evidence

One of the leading hypotheses put forward in the literature to explain low investment rates despite apparently high returns to capital are credit constraints (for Africa see e.g. Bigsten et al. 1999, 2000, Tybout 2000). Among the potential alternative explanations are adjustment costs, uncertainty, and uncertainty in combination with irreversibility and/or learning.<sup>20</sup>

The survey allows me to present some direct evidence regarding the importance of credit as a problem. Without putting too much weight on a answer to a rather broad, direct question that asks "what was your biggest problem last year?", it is at the very least suggestive to see how many respondents name credit as one of the problems (see Table 4).<sup>21</sup> The information contained in Table 4 demonstrates that by their own assessment, a large fraction of firms regards credit as one of the major problems in their operations. This clearly motivates the further investigation into credit as a potential explanation for low investment. The appendix provides an econometric analysis of the covariates of self-stated credit problems.

---

<sup>20</sup>Other potential explanations for low investment when returns to capital appear to be high are the time required to plan large projects, or that firms cannot handle higher investment levels, for example because of a lack of human resources to handle the investment (Browne and Hellerstein 1997)

<sup>21</sup>Note that the survey questionnaire allows for more than 20 different categories, and instructions for the interviewer explicitly state that answer categories should not be read, but that the answer should be coded after the entrepreneur answered the open ended question.

To judge the usefulness of this question note that there is some evidence from a related study (Steel 1996) that the response that "credit is a problem" indicates that firms would be willing to take out a loan at market rates but cannot, i.e. these answers appear to reveal actual demand for credit at market interest rates. Steel (1996) reports results from a comparable survey, in which 79% and 83% of micro and small (in this case defined as having 6-49 employees) enterprises, respectively, stated that credit was a major problem, while for both size classes 79% stated that they were "very interested" in a loan at market rates. Further, 32% of micro enterprises and 60% of small enterprises in that survey recently applied for a loan, but only 19% of micro enterprises and 43% of small enterprises ever received a loan.

Is credit a "big problem"?					
	1991	1992	1993	1995	1997
credit is biggest problem	53 %	47%	45%	44%	34%
credit is 2nd biggest problem (% of answers)	17 %	17%	15%	15%	15%
credit is 3rd biggest problem (% of answers)	6%	5%	8%	13%	12%
credit not one of three biggest problems	24%	31%	32%	42%	46%

Source: Ghana RPED surveys

Table 4: Credit a big problem? Own assessment of entrepreneurs.

## 4.2 A modified version of a standard test for financing constraints

As mentioned before, arguably the most commonly used test for financing constraints involves regressing investment rates, i.e. investment divided by the capital stock, on a proxy for marginal Q (the ratio of the market value of a marginal unit of capital to its replacement cost) and on a measure of cash flow divided by capital (Fazzari et al. 1988). In the standard investment model marginal Q summarizes all information relevant for investment and a firm should invest when Q is high. If the firm does not have internal funds available it should use external funds to finance this investment. Cash flow should therefore not enter significantly in the investment regression if the cost of external and internal financing are the same. However, cash flow might be correlated with future profitability and therefore could be significant in the investment regression even if external funds are not more costly than internal financing. To deal with this possibility, Fazzari et al. (1988) suggest splitting the sample into firms that are more likely to face financing constraints and those that are less likely to face these constraints. They then test whether the coefficient on cash flow is larger for firms that are likely to be constrained and interpret a significant difference as evidence of financing constraints.

I perform a modified version of this test to provide further evidence for the presence of financing constraints in the sample of Ghanaian manufacturing firms. I regress the investment rate (at the beginning of each period) on a measure of cash flow (actual sales of produced output as opposed to output valued at market prices) divided by the capital stock and a measure of investment opportunities. I cannot calculate average Q (which is usually used as a proxy for marginal Q) since firms in the sample are not listed on the stock market and I cannot otherwise value them directly.

Instead, I use an estimate of the marginal returns to capital to capture investment opportunities.

The key difficulty is usually to split the sample along meaningful lines. In the present case however, I have an a-priori criterion that is based on the firm managers' own assessment, namely their answer to the question "what was your biggest problem last year". In the first set of regressions ( Table 5, (2)-(5)). I split the sample into firms that always, i.e. in all waves that they are in the sample, say credit is the main problem and firms that never regard credit as the main problem. This is done with a random effects specification as well as with fixed effects. In the second set of regressions ( (6)- (7) ) I split the sample into firms that in at least half of the waves that they are in the sample say credit is the main problem (labelled "credit was often a problem") and the remaining firms ("credit was rarely a problem). Regressions (8) and (9) confirm these results with a split by firms that mention credit as one of the three main problems in all the survey waves ("credit always a problem") and the remaining firms.

The results (see Table 5) indicate that cash flow significantly predicts investment. Past returns to capital on the other hand are negatively correlated with investment in most of the regressions.<sup>22</sup> Looking at the separate subsamples, the results indicate that indeed for the firms that say that credit is their biggest problem, the coefficient on cash flow is much larger than for the remaining firms (0.029 vs. 0.001 in the random effects specification and 0.031 vs. 0.002 in the fixed effects specification). Finally, when I restrict the effect of the returns to be the same across both subsamples, the interaction of the profit rate with an indicator which is equal to one if credit is always the biggest problem is highly significant. Overall the results give additional evidence that financing constraints are present at least for a subsample of the firms.

---

<sup>22</sup>This negative coefficient might appear strange at first. However the coefficient on returns to capital can be expected to be downward biased. This is due to the following argument: the degree to which a firm is financing constrained is unobserved and enters the error term, but it is negatively correlated with the capital stock, hence positively correlated with the marginal return to capital (under standard assumptions on the production function), and negatively correlated with investment.

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Investment Rate (I/K)	baseline	credit was never main problem	credit was always main problem	credit was never main problem, FE	credit was always main problem, FE	credit was rarely a problem	credit was often a problem	credit was never a problem	credit was always a problem	interact
Last period's returns to cap (TL_RE)	-0.015 (0.007)*	-0.004 (0.016)	-0.136 (0.026)**	0.032 (0.093)	-0.118 (0.027)**	-0.000 (0.009)	-0.033 (0.011)**	0.006 (0.031)	-0.045 (0.013)**	-0.015 (0.007)*
Cashflow rate	0.003 (0.000)**	0.001 (0.001)	0.029 (0.002)**	0.002 (0.001)	0.031 (0.002)**	0.002 (0.000)**	0.005 (0.001)**	-0.003 (0.007)	0.009 (0.001)**	0.003 (0.000)**
Capital	-0.000 (0.000)	-0.000 (0.000)	0.013 (0.009)	-0.000 (0.000)	0.006 (0.030)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Credit always problem										0.018 (0.002)**
* Cashflow rate										-0.282 (0.070)**
Credit always problem										0.104 (0.059)
Constant	0.106 (0.061)	0.158 (0.083)	-0.175 (0.125)	0.016 (0.174)	-0.325 (0.132)*	0.042 (0.077)	0.045 (0.068)	0.071 (0.093)	0.086 (0.088)	0.104 (0.059)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year dummies	no	no	no	yes	yes	no	no	no	no	no
Observations	692	114	84	114	84	274	360	38	239	692
Number of firm	175	38	22	38	22	74	79	18	61	175
R-squared				0.12	0.85					
Standard errors in parentheses										
* significant at 5%; ** significant at 1%										

Table 5: A test for financing constraints

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

### 5.1 Production process and the objective of the firm

The preceding sections suggest that financing constraints are important in preventing productive firms from investing. To be able to quantify the cost of financing constraints I develop in this section a dynamic model of firm-level investment. The model starts from the description of individual firm dynamics as in Hopenhayn (1992). The output of a firm is determined by the production function

$$Y_{t,i} = f(K_{t,i}, L_{t,i}, \omega_{t,i})$$

where  $K_{t,i}$  and  $L_{t,i}$  are capital and labor inputs respectively, and  $\omega_{t,i}$  is a firm specific productivity shock which the firm observes at the time it makes decisions about labor inputs. Specifically, I employ the Cobb-Douglas specification

$$Y_t = \mu_s L_t^{\alpha_L} K_t^{\alpha_K} e^{\omega_t}$$

where the subscript  $s$  in  $\mu_s$  indicates that the average productivity varies by sector  $s$ , with  $s \in \{\text{food/bakery; garment/textiles; furniture/wood; metal/machines}\}$ . Here and in what follows I suppress subscripts  $i$  for clarity.

The firm is uncertain about future productivity levels. As in Hopenhayn (1992),  $\omega$  is assumed to follow a Markov process with conditional distribution  $F(\omega'|\omega)$ . It is assumed that expected discounted profits are increasing in  $\omega$ .<sup>23</sup> I assume the following specification for  $\omega$ :

$$\omega_{t+1} = \rho\omega_t + \varepsilon_t, \quad \text{with } \varepsilon_t \sim iid N(0, \sigma_\omega^2).$$

The empirical work will focus on the behavior of smaller firms. Therefore, I model the firm not as a profit maximizer, but a utility maximizer with a utility function that exhibits constant relative risk aversion  $\gamma$ , i.e.  $u(d_t) = \frac{d_t^{1-\gamma}}{1-\gamma}$ , where  $d_t$  are dividends. This modeling approach is followed to introduce a consumption smoothing motive, which is particularly important if I consider the smallest of the firms in my sample.<sup>24</sup> The firm derives utility from dividends  $d$  that are paid out every period, and the firm's objective is to maximize the discounted sum of future utilities that is derived from the stream of dividends over an infinite time horizon. Denote the one period discount factor as  $\beta$ , with  $0 < \beta < 1$ , then the objective is

$$\max E_0 \sum_{t=0}^{\infty} \beta^t u(d_t)$$

A distinguishing feature of the model versus standard models is the explicit modeling of the firm's ability to accumulate financial assets  $A_t$ . This is essential once there is a wedge between the internal and the external cost of raising funds (for investment and/or consumption), to which I will return later. Firms make a decision about (financial) asset accumulation via their decision about the use of profits. The profit in each period can either be paid out as a dividend (and be consumed) or can be used to accumulate financial assets, which can be used for investment in the current or future periods. Dividends in future periods may be paid out of the accumulated financial assets.

## 5.2 Exit

At the end of each period, the firm decides whether it exits the market or stays in the market for the next period. While in Hopenhayn (1992) the firm has to pay a fixed cost per period, which is

---

<sup>23</sup>Formally, what is required for this is that  $Y$  and  $F$  are strictly increasing in  $\omega$ , and that prices for inputs and outputs are fixed and independent of quantities.

<sup>24</sup>Without the consumption smoothing motive, firms would be able to go through a year with zero dividends. However, given that for a self-employed firm owner in this model the dividend is equal to his consumption, zero dividend years would imply zero consumption, which this self-employed firm owner will avoid at all cost. Therefore I choose to model utility in a way that assigns infinitely small utility to zero consumption.

necessary to have exit in the model, I assume the equivalent, namely that the firm owner has an outside option which she foregoes while she operates the firm.

The total outside option depends on the capital stock of the firm, and the stock of financial assets the firm owns. In particular, the outside option increases in the current capital owned by the firm owner (which can be resold) and decreases in the debt of the firm, since the firm is assumed not to be able to simply default on all the loans without consequences for outside activities.

The assumptions about exit are as follows: (a) Firms can only exit if the outstanding debt is smaller than the capital stock (i.e.  $K_t + A_t > 0$ ); this reflects the strong requirements about collateral that are observed in the actual data and were confirmed during the interviews during the field work. (b) The firm gets to keep  $(K_t + A_t)$  for future consumption purposes; (c) in addition, the firm receives an outside option value which is constant over time; this can be thought of as a wage that the entrepreneur can earn in the labor market. Since I assume risk aversion, the firm will smooth consumption. Once it exits, the firm has a constant stream of income from the outside option which means that it will not borrow, hence the relevant interest rate is the risk free interest rate,  $r$ . Together with the assumption that  $\beta = 1/(1+r)$ , i.e.  $\beta$  is the inverse of the rate at which the firm can deposit positive assets, this implies that the entrepreneur, once exited, will consume in every period a constant fraction of his wealth  $(K_t + A_t)$  plus the outside option:

$$c_t^{outside} = c^{outside} = (1 - \beta) \cdot (K_t + A_t) + outside\ option$$

and the value of consuming this  $c^{outside}$  forever can be calculated as:  $\frac{1}{1-\beta}u(c^{outside})$ .

### 5.3 Investment

If the firm stays in the market, it has to decide on the amount it invests this period. Investment has a one period lag, i.e. investment decisions of this period will translate into capital next period, while the investment must be financed immediately. Financing may come from various sources: (a) current profits, (b) accumulated financial assets, which are retained profits of past periods, (c) loans; or a combination of (a),(b), and (c).

Investment is costly, due to the direct cost of capital inputs plus an additional quadratic ad-

justment cost ( $AC$ ) which is modeled as follows (Hayashi 1982):

$$AC(K_{t+1}, K_t) = \frac{\nu}{2} \left( \frac{K_{t+1} - (1 - \delta)K_t}{K_t} \right)^2 K_t$$

Hence, the total cost of investment ( $TCI$ ) is:

$$TCI(K_{t+1}, K_t) = K_{t+1} - (1 - \delta)K_t + AC(K_{t+1}, K_t)$$

Note that this formulation symmetrically also includes disinvestment. While this paper does not want to focus on irreversibilities (see for example Pindyck 1991), this formulation acknowledges that disinvestment is costly. While disinvestment in the data is rare, only 64% of all investment in equipment is made using new equipment (Table 9 in the appendix). This suggests that there is a market for used equipment and not all investment is necessarily irreversible.

The capital stock depreciates at an exogenous rate  $\delta$ .<sup>25</sup> The law of motion for the capital stock is therefore:

$$K_{t+1} = (1 - \delta)K_t + I_t$$

## 5.4 Credit

Of key interest is the cost of credit. Currently I assume that there is only one source of credit.<sup>26</sup> Debt in the model occurs when  $A_t < 0$ . The following specification of the per unit cost of credit assumes that the per unit cost of outside financing cannot be cheaper than that of internal financing. As a consequence a firm will use up its internal funds before it uses external funds, and a firm will not have debt and positive assets at the same time. The per unit cost of credit is modeled as a function of the risk free interest rate,  $\mathbf{r}$ , and firm characteristics. I choose the following specification with a logarithmic functional form<sup>27</sup>:

$$\ln(r_i - \mathbf{r}) = \beta_0 + \beta_1 \cdot K_{t,i} + \beta_2 \cdot K_{t,i}^2 + \beta_3 \cdot (debt/K)_{t,i} + \beta_4 \cdot debt_{t,i} + \beta_5 \cdot debt_{t,i}^2 + \eta_i$$

<sup>25</sup>Alternatively, one could model the depreciation as a random process, e.g. as a Poisson process.

<sup>26</sup>A characteristic of credit markets in Africa is that formal and informal lenders are very different in the type of firms they lend to, and potentially in the cost of credit. In future work, I want to model the cost of formal and informal credit separately. This is not done currently because of the additional complexity it adds to the estimation. However, the current approach is a sufficiently accurate description of credit markets with formal and informal lenders if all firms face the same hierarchy of finance, e.g. all use up all formal sources first before resorting to informal sources.

<sup>27</sup>I use firm index  $i$  again to stress the firm level fixed effect.

This specification deserves some explanation. Economic theory does not suggest one particular specification. Different models of information asymmetries that give rise to borrowing constraints have different implications for the form of the per unit cost of capital. Since the purpose of the paper is not to test one specific model, I can be somewhat agnostic about the structural form that explains the wedge in the cost between internal and external funding. The specification of  $r_i$  chosen here tries to nest the following special cases of credit constraints: (a) all investment is out of own profits/wealth (which would imply  $r_i = \infty$ ), (b) the availability of collateral decreases the cost of credit ( $r_i$  decreasing in  $K_i$ ); (c) there is an upper limit to borrowing ( $r_i$  increasing in  $debt_i$  - this can only be achieved approximately with this specification).

I allow for unobserved firm heterogeneity with respect to the ability to obtain a credit by introducing a firm fixed effect  $\eta_i$ . It is assumed that  $\eta_i \sim iid N(0, \sigma_\eta^2)$ .<sup>28</sup>

In addition to the per unit capital cost there is an additional cost of a new credit. This is introduced to account for the fact that the transactions involved in searching and securing a loan are costly, while renewal of an existing loan can be expected to be substantially less costly. To let this cost vary by the amount that is borrowed, I specify that every unit of new credit costs an interest of  $r^n$  in addition to  $r_i$ . Call the resulting cost  $NC(A_{t+1,i}, A_{t,i})$ . Therefore, the additional cost introduced by this is  $NC(A_{t+1,i}, A_{t,i}) = r^n (A_{t+1,i} - A_{t,i})$  if  $(A_{t+1,i} - A_{t,i}) > 0$  and 0 otherwise.

The above model so far implies the following intertemporal budget constraint if the firm stays in the market:

$$A_{t+1,i} = (1 + r_{t,i}) \cdot (Y_{t,i} - wL_{t,i} + A_{t,i} - TCI(K_{t+1,i}, K_{t,i}) - NC(A_{t+1,i}, A_{t,i}) - d_{t,i})$$

with

$$r_{t,i} = \begin{cases} x & \text{if } A_{t+1,i} \geq 0 \\ x + \exp(\beta_0 + \beta_1 \cdot K_{t,i} + \beta_2 \cdot K_{t,i}^2 + \beta_3 \cdot (debt/K)_{t,i} + \beta_4 \cdot debt_{t,i} + \beta_5 \cdot debt_{t,i}^2 + \eta_i) & \text{if } A_{t+1,i} < 0 \end{cases}$$

---

<sup>28</sup>Note that the approach to the estimation taken below does allow me to introduce other variables that potentially influence the cost of credit, as for example age, sector, or location of the firm, without any conceptual difficulties. Potentially, I could also include unobserved firm characteristics that are not data but are the results of the simulation approach taken, e.g. the productivity of a firm. This is currently not done for computational reasons but will be done in future extensions of this work.

Finally, note the simplifications and underlying assumptions of the model. Single firm dynamics are studied, but there are currently no general equilibrium effects. Ideally, I would also like to introduce aggregate shocks (for example to demand), but this appears not yet to be feasible with firm level data until longer panels are available.<sup>29</sup> I also assume competitive markets/price taking of firms. This may be problematic for larger firms, but should be a good first approximation for the smaller firms that I focus on. Further, there is no price uncertainty, and prices are constant.

Summarizing, the timing is as sketched in Figure 1.

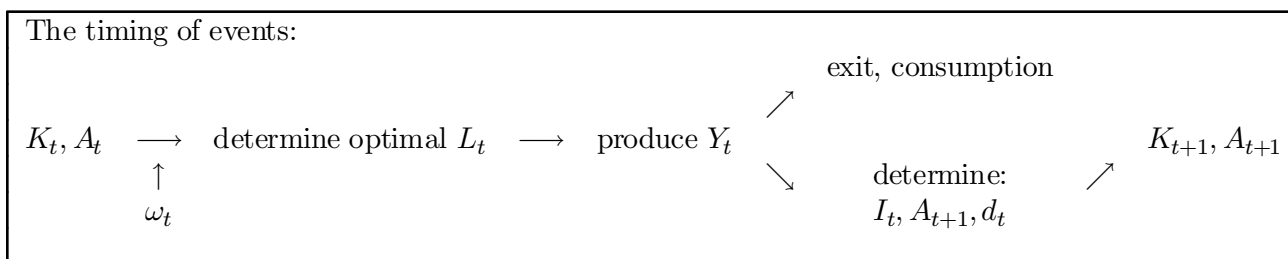


Figure 1: The timing of events

## 6 Solving the model and estimation

### 6.1 The solution

Due to its complexity the model is solved numerically, using dynamic programming techniques. The state variables in this model are the capital stock  $K_t$ , the stock of financial assets  $A_t$ , the productivity shock  $\omega_t$ , and  $I_{\{stay\},t}$ , where  $I_{\{stay\},t}$  is an indicator variable which is equal to 1 if the firm is in the market at time  $t$ , and it is 0 if the firm has exited the market. The choice variables of the firm are  $A_{t+1}$ ,  $K_{t+1}$ ,  $I_{\{stay\},t+1}$ , and  $d_t$ . The dividend  $d_t$  does not add any complexity, however, since it is determined as a residual. Further, separate solutions have to be computed for the different sectors, and one additional dimension is added through the credit-fixed-effects. Finally, note that  $L_t$  is chosen optimally within the period, given  $K_t$  and  $\omega_t$ , but it does not enter the dynamic problem of the firm. Since this feature of the model is very useful for identification of the parameter estimates, as will be explained below, I will present and discuss supportive evidence for

<sup>29</sup>Since there are no time effects in the model as it stands now, large aggregate shocks will move the estimates of the aggregate productivity,  $\mu_s$ , up (positive aggregate shocks) or down.

the validity of this assumption in detail there.

The fact that I have to solve the model using numerical methods adds the following additional (computational) constraints:  $K_t \in [\underline{K}, \overline{K}]$ ,  $A_t \in [\underline{A}, \overline{A}]$ ,  $\omega_t \in [\underline{\omega}, \overline{\omega}]$ . The bounds are chosen as follows: for  $K_t$  and  $A_t$  the upper bounds  $\overline{K}$  and  $\overline{A}$  are 1.5 times the observed maximum capital in the data, while the lower bound is  $\underline{K} = 0$  and  $\underline{A} = -\overline{A}$ . For productivity  $\omega_t$ , bounds are chosen by using the estimated mean  $\omega$  from the production function estimates  $\pm 2$  standard deviations.

I solve the dynamic programming problem using value function iteration and a logarithmically spaced grid for  $K_t$  and  $A_t$ , and a linearly spaced grid for  $\omega_t$ . In the simulations (see section 6.2) I interpolate the decision rules, using linear interpolation, to diminish the importance of the discretization and to get more accurate simulations. I do not use equidistant grid points for  $K_t$  and  $A_t$  since the distributions of capital and assets are very skewed. The autoregressive process  $\omega_{t+1}$  is discretized using the method suggested by Tauchen (1986).

## 6.2 Estimation of the structural parameters

The estimation procedure for the structural parameters is of a nested fixed point algorithm type (Rust 1987). An outer algorithm calculates the criterion function and searches for its minimum, while 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 solution to the dynamic problem is the fixed point of the value function iteration.

The model is estimated using the firm level data from Ghana. I restrict the sample to firms that are in Ghanaian private ownership, i.e. I drop firms that are foreign or state owned. This is done to have a more homogeneous group of firms. It turns out that the foreign or state owned firms are by far the largest firms in the sample. For the same reason I also drop the nine largest firm-year observations, which have a capital stock larger than 2.5 million USD (1991).

Given the richness of the stochastic model and the additional difficulty that arises because of the partial observability of an endogenous variable (as noted earlier, the data only contains information about levels of debt, not about positive financial assets) it does not exhibit closed form solutions for the criterion function in a Maximum Likelihood Estimation or GMM framework. Econometric methods based on simulations can be used to overcome this difficulty. A natural

estimation method for this kind of model, where the solution often is presented via simulations, is the Method of Simulated Moments (McFadden 1989, Pakes and Pollard 1989, Ingram and Lee 1991). One advantage of the Method of Simulated Moments (MSM) over Simulated Maximum Likelihood is that MSM does not require that the number of simulations goes to infinity to achieve consistency (e.g. Adda and Cooper 2003), a property which is particularly useful if the simulations are computationally intensive as in the present case.

The Method of Simulated Moments estimator is defined as follows<sup>30</sup>:

$$\begin{aligned} \hat{\theta}_{Sn}(W) = \arg \min_{\theta} & \left\{ \sum_{i=1}^n \left[ M'(x_i) - \frac{1}{S} \sum_{s=1}^S m'(x_i, u_{si}, \theta) \right] \right\} \times W \times \\ & \times \left\{ \sum_{i=1}^n \left[ M(x_i) - \frac{1}{S} \sum_{s=1}^S \tilde{m}(x_i, u_{si}, \theta) \right] \right\}. \end{aligned} \quad (1)$$

where  $n$  is the number of observations,  $S$  is the number of simulations,  $W$  is a weight matrix,  $u$  is a random variable and  $u_{si}$ ,  $s = 1, \dots, S$ ,  $i = 1, \dots, N$ , are draws from the distribution of  $u$  (which are held fixed throughout estimation),  $M(x_i)$  is a vector of functions of the observed data,  $\tilde{m}(x_i, u, \theta)$  is an unbiased simulator of the conditional vector of moments such that:

$$E_u [\tilde{m}(x_i, u, \theta)] = E [M(x_i) | x_i].$$

The specific vector of moments,  $M(x_i)$ , used in this paper is discussed in the section on identification below. The asymptotic properties of the estimator are stated in the appendix.

Firm behavior is simulated from age zero to the age at which I actually observe a given firm. This solves the potential endogeneity problems, e.g. capital appears in the cost-of-credit function, but is obviously endogenous to the cost of credit for a given firm. Simulating firm behavior up to the age at which a firm is observed also deals in a natural way with the initial conditions problem. It turns out to be easier to determine initial conditions at age zero than those at the age at which firms are observed. This deserves some more discussion. A major difficulty with the data is that I do not know the asset position of the firm if the firm has positive financial assets. In accordance with the theoretical model, I assume that firms use up their internal funds first and hence that if I observe a firm with debt outstanding, that I in fact observe their financial asset position, i.e. there

---

<sup>30</sup>The presentation of the estimator follows Gouriéroux and Monfort (1993) and Adda and Cooper (2003).

are no positive assets to balance the debt. However, I do not observe the amount of non-negative assets of a firm with no outstanding debt. Instead of assuming a certain distribution of the level of these assets at the point in time at which I start to observe the firm, I make the assumption that firms invest all their available financial assets at the time that they enter the market, hence financial assets at age 0 are either zero or negative. For the simulations I can then use as initial conditions of financial assets for a firm at age 0 the empirical joint distribution of (non-positive) assets and capital stocks of those firms in the survey which are up to 3 years old at the time of the first interview.<sup>31</sup> Simulating the firms' behavior starting at age 0 then allows me to track in the simulations the financial assets position of a firm and provides a natural way to find the initial conditions for firms that I observe only at an age larger than one. Regarding productivity, I assume that the mean of the initial distribution is equal to  $\mu_s$ , which is the parameter that also governs the productivity process in later periods. The variance of the initial distribution of productivity is one of the estimated parameters.

Given that exit is an option to firms, a firm may exit before the age at which I observe it. Consistent with the way the survey data is gathered, exiting firms in the simulations are replaced by another simulated firm.

The minimum of the criterion function is found using a combination of a randomized algorithm (simulated annealing, see Goffe 1996, Goffe et al. 1994) and a simplex algorithm. The strength of the simulated annealing algorithm is that it is able to escape local minima and to find the global minimum even for criterion functions that are very difficult to minimize. However, this randomized algorithm requires a very large number of iteration steps to find the minimum. Therefore, I switch to the simplex algorithm, using the current minimum of the simulated annealing algorithm as starting values, once the stepsize in the simulated annealing algorithm is reduced sufficiently.<sup>32</sup>

---

<sup>31</sup>Strictly speaking, I would have to consider only firms that are up to one year old. However, to increase the number of observations that can be used to construct the initial conditions, I use firms that are in business for 1, 2 or 3 years at the time when they are first interviewed.

<sup>32</sup>The computations are done using a Matlab program as the main program, while the computationally intensive subroutines are programmed in C.

### 6.3 Identification

The simultaneous estimation of the production side and the investment side of the model allows me to address the main identification problem, namely to identify the investment opportunities and the constraints of a firm separately.<sup>33</sup> To identify the production side, the main identifying assumption is that capital is predetermined at the beginning of the period and decisions about labor inputs are static and do not enter the dynamic problem of the firm. Using this assumption, for which supporting evidence will be given below, identification of the production process can be achieved in a way which is similar in spirit to Olley and Pakes (1996) and Levinsohn and Petrin (2003): Controlling for predetermined capital, and given input and output prices, labor inputs  $L_t$  are a strictly monotonically increasing function of productivity  $\omega_t$ .<sup>34</sup> Once I have identified the productivity of a firm from this step, I can calculate the optimal investment that this firm should make in the absence of any constraints as the solution to the dynamic firm optimization problem. The actually observed investment of firms that have enough financial assets at hand to make this investment identifies the constraints associated with investment, e.g. adjustment costs. On the other hand, the actually observed investment and credit take up of firms that are already in debt, and hence do not have enough cash at hand to make the optimal (in the absence of constraints) investment identifies the cost of credit. The exogenous variation that brings firms in different positions with respect to their internal financing abilities, i.e. their asset stock, is due to the succession of (exogenous) productivity shocks that the firms experienced, which determine the ability to retain profits for future investment purposes. To a lesser extent, some exogenous variation in asset levels is due to the initial endowments of firms.

To estimate the determinants of cost of credit I face a selection issue, since only realized loan contracts are observed. However, modeling the production process and the investment decisions explicitly has the further advantage that it also deals with this selection issue, since I can infer from the production side the firms that have a demand for external funds.

---

<sup>33</sup>Roughly speaking, the problem is that a researcher cannot tell from a sample of observations on firms and investment decisions, whether firms that do not invest are constrained in their financing, or whether they simply lack profitable projects and investment opportunities.

<sup>34</sup>Note that since estimation proceeds via the simulated method of moments estimator, I do not explicitly control for unobserved productivity, as one would have to do in a reduced form setup.

**The choice of moments** To actually implement the above described identification strategy, informative moments that capture the essence of the identification strategy have to be chosen. Econometric theory does not tell the researcher which moments to choose, nor will I be able to prove identification, i.e. the existence of a unique global minimum of the criterion function (1) - a problem commonly encountered with complex structural models. The following set of moments, some of which play a role in related empirical work, are among the moments currently employed. A complete list of moments used is given in the appendix. Given that there is little formal guidance for the choice of moments, I also present some graphs that demonstrate that changes in different parameter values affect different moments, which is essentially the foundation of identification.

For the identification of the production function I have to rely on moments related to the variables  $L, K$ , and  $Y$ ; for example, the means of these variables as well as their relation to each other (as for example  $L/K$ ). Further, to identify the level and variance of productivity, i.e. the parameters  $\mu$  (average productivity) and  $\omega$  (idiosyncratic part of productivity), I can employ proxies for the productivity that come out of the data (i.e. the actual data as well as the simulated data). Most importantly, given the assumption on labor inputs being a static decision, the average return to capital,  $Y/K$ , is strictly increasing in the productivity  $\omega$ . It might appear especially difficult to separately identify  $\alpha_K$  and  $\alpha_L$  just from observations on  $L, K$ , and  $Y$  given that an increase in both parameters results in increases in all three outcome variables. Thus, it could be that a specific outcome can be the result of high  $\alpha_K$ , and low  $\alpha_L$ , or vice versa. However, while Figure (6) in the appendix demonstrates that this intuition is generally right, that figure also demonstrates that the moments chosen appear to result in a criterion function with a unique minimum. To identify the differences in the production function parameters across sectors, I use the average returns to capital ( $Y/K$ ) interacted with the sector. For the identification of the Markov process for productivity I can use covariances of the observed choice variables and outcomes  $Y_t, K_t, I_t, L_t$ , and  $A_t$  over time, i.e. for example the covariances of average returns to capital over time:  $cov(Y_t/K_t; Y_{t-1}/K_{t-1})$ .

The next task is to identify the real constraints that the firm faces. In the current model this means identifying the adjustment cost parameter. As argued above, the key here is to identify firms that have investment opportunities when only the productivity is considered, i.e. ignoring

constraints on the firms ability to pursue those opportunities, and then relate their actual investment behavior, and their firm characteristics, to these investment opportunities. Since  $Y/K$  is strictly increasing in the productivity  $\omega$  and since the production function is Cobb-Douglas, marginal returns to capital are  $\alpha_K Y/K$  and hence there is a one-to-one relation between average and marginal returns to capital. Therefore,  $Y/K$  is a valid proxy for the marginal returns to capital. Moments that relate this proxy for returns to investment are therefore useful moments to identify adjustment costs. I chose, for example, the covariance between  $Y/K$  and  $I$ , as well as the covariance between  $Y/K$  and  $I/K$ . Further, the fraction of zero investment observations can help identify the adjustment costs.

Finally, to identify the financial constraints, i.e. the cost of credit function, the general idea for implementation of the above identification strategy is to use interactions of the investment and productivity related moments with the asset level and other firm characteristics. As discussed above, the investment rate is largely determined by measures of investment possibilities, such as the average return to capital. On the other hand, if financial constraints are important, characteristics of firms with low own resources for financing determine investment as well. This suggests interacting the available measures of investment possibilities with the information about the firm's financial position. To identify the extent to which firm characteristics drive the cost of credit, the comovements of actual investment data relative to the available proxies for investment opportunities with firm characteristics are employed as moments. As an example, I use the covariance between  $K$  and  $I/(Y/K)$ , and the covariance between  $A/K$  and  $I/(Y/K)$ , both calculated separately for firms with  $A \geq 0$  and firms with  $A < 0$ . To support the choice of moments, consider figures (7) and (8) in the appendix. They demonstrate that the effects of changes in the parameters of the cost of credit function associated with  $K$  and  $debt/K$  on the two moments  $cov(K, I/(Y/K))$  and  $cov(A/K, I/(Y/K))$  are very different. Also, the fraction of new credit observations, which helps in particular to identify the new credit cost parameter, is used. The same covariances over time may also be used.

Other moments that are used are the number of observed exits, and, related, the covariances of exit and capital as well as the covariance of exit and asset stock. To give some support for

the assertion that adjustment costs and cost of credit can be separately identified by the chosen moments, consider Figure (9) in the appendix. While generally increases in adjustment cost and cost of credit have similar effects (increases in both parameters result in decreases in investment), this figure suggests that there is a unique minimum of the criterion function when only these two parameters are varied, and hence the set of moments chosen appear to be able to identify them separately.

#### **6.4 The assumption on labor**

Are labor inputs really not entering the dynamic problem of the firm? Given the importance of the modeling assumption (for identification of the productivity) that labor can be adjusted freely in response to observing the productivity shock, I will now present some evidence for this. For details refer to the respective table in the appendix.

First, consider hiring. The average unemployment rate over the years 1991-1995 was 35.6% in Ghana. This suggests that hiring of labor in general should not be a problem. It might still be that qualified labor is harder to find, though. The survey asks respondents directly various questions regarding hiring (most of the questions were just asked in one wave). From this information we know that for 83% of firms (in waves 1 and 3) shortage of skilled labor was not an obstacle to capacity utilization at all, while it was a severe obstacle for 5.1% of the firms (Table 13). Further, only 9.3% of firms (in wave I) say that they are subject to hiring restrictions. Among the micro and small firms only 4.4% say they are subject to hiring restrictions. And of those firms that are subject to hiring restrictions, 70% (12 out of 17) are not at all negatively affected by those restrictions. Asked whether labor regulations are an obstacle to firm expansion, 92% of firms answer "not at all".

Now consider firing (refer to table 14). One good indicator whether firing might be a problem is whether workers are unionized. Unionization is particularly prevalent in medium and large firms, i.e. with 30 or more employees. Overall, in 49.9% of firms, there is no worker unionized, and in 88.6% of small firms, there is no worker unionized. Only in 0.9 % of micro and small firms are more than 75% of workers unionized. However, in 28.8% of medium and large firms, more than 75% of workers are unionized. Closely related to these numbers are probably the fact that 47.1%

of medium and large firms are subject to some layoff restrictions, and 54.3% of firms in this group have layoff benefit requirements, while less than 10% of micro and small firms are, respectively, subject to some layoff restrictions or have layoff benefit requirements. Finally, one could object that training requirements prevent firm owners from hiring and firing in response to shocks. However, only 28% of workers received training within their current firm and only 20% of firm managers say that training is required for new equipment. And, conditional on training required, the median time of training necessary is only 4 weeks (Table 15).

Summarizing, there is evidence from macro data and direct evidence in the survey data that hiring labor in response to a positive productivity shock is not a problem for firms and existing regulations are not an obstacle to firm growth. On the other hand, with respect to firing, while less than 10% of micro and small firms are subject to layoff restrictions, about 50% of medium and large firms are subject to those restrictions and layoff benefit requirements. But although 12% of firms with those requirements say that these layoff requirements are a severe problem, more than 50% of firms with existing layoff restrictions say that these do not have a negative effect at all.

## 7 Estimation results

I restrict the attention to the main parameters of interest. Therefore, I derive information about the following parameters from the data and other outside sources: For wages, I calculate the median of the median annual wage paid by firms, which is rounded to 0.23 (in Million 1991 Ghanaian Cedis). The interest on positive financial assets is set equal to 0.06, which is the average real discount rate over the time period under consideration (IFS). I set the coefficient of risk aversion  $\gamma$  equal to 1.5<sup>35</sup>, and the discount rate  $\beta$  equal to  $1/(1+0.06) = 0.9434$ . Finally, I set the depreciation parameter  $\delta$  equal to 0.09, which is the rate of depreciaton that I estimate from the raw data (see the section on investment). As noted earlier, this value is also comparable in size to standard values used in

---

<sup>35</sup>This value is chosen as a compromise between several available estimates and parameter values used in the literature. In an early classic paper, Binswanger (1981) estimates only moderate risk aversion of around 0.3 for households in rural India. Recent estimates from auctions range from 0.44 - 0.67 (summarized in Holt and Laury 2002). Arrow (1971) suggests a risk aversion of 1, Browning and Crossley (2001) use a coefficient of relative risk aversion of 2, while Mehra and Prescott (1985) let the coefficient of relative risk aversion vary between 0 and 10. In future work, robustness checks on this assumption will be done.

other work.

The parameter space of the model presented above is relatively large, considering that the solution and estimation procedures are computationally very intensive. In a first estimation step, I therefore had to reduce the number of parameters. The parameter estimates I present here are from this simplified version of the above model, which nevertheless keeps all the main features. In particular, I reduce the number of parameters in the cost-of-credit function (I drop the squared terms) and do not estimate fixed costs and no fixed firm credit effects. Given these current simplifications and given that some computational constraints will be relaxed in the ongoing work, all the estimation results are preliminary. The results are presented in Table 6. For comparison, this table also contains production function estimates from simple OLS pooled regressions as well as estimates using the Levinsohn/Petrin estimator that both use the same sample of firms.<sup>36</sup>

---

<sup>36</sup>Note that OLS and GMM estimates are slightly different from the results presented earlier, which is due to small changes in the composition of the sample that were mentioned before, and in particular to the fact that several observations have to be dropped due to missing values, e.g. for the asset position.

	OLS pooled	L/P GMM	estimates from dynamic model
<hr/> Production function estimates <hr/>			
$\alpha_L$	0.65 (0.06)	0.50 (0.05)	0.65 (0.02)
$\alpha_K$	0.31 (0.03)	0.32 (0.59)	0.29 (0.01)
constant $\log(\mu)$	-0.62 (0.16)	-0.19 (0.91)	
constant $\mu$			0.76 (0.26)
$\sigma_\omega$			0.16 (0.07)
$\rho$			0.91 (0.27)
$\sigma_{initial \omega}$			0.36 (0.24)
<hr/> cost-of-credit function parameters: $\beta_0 + \beta_1 \cdot K + \beta_2 \cdot (debt/K) + \beta_3 \cdot debt$ <hr/>			
$\beta_0$			-0.76 (0.06)
$\beta_1$			-0.51 (0.17)
$\beta_2$			0.08 (0.09)
$\beta_3$			0.38 (0.10)
<hr/>			
per unit new credit costs ( $r^n$ )			0.025 -
adjustment cost parameter ( $v$ )			4.94 (0.02)
<hr/>			
obs.	684	677	684
<hr/> Notes: (1) Standard errors are in parentheses; (2) $debt = -A > 0$ <hr/>			

Table 6: Estimation results

The production function estimates from the dynamic model are comparable in size to the OLS and GMM estimates. It is interesting to note that the estimates indicate a high degree of serial correlation of the idiosyncratic productivity shocks. Further, I estimate a substantial variance in the initial distribution of productivity.

All the parameters in the cost-of-credit function have the expected sign. In particular, the cost of one unit of credit decreases in the capital stock that is already available to the firm, and increases with the amount of debt that a firm wishes to incur. Further, a larger debt/capital ratio increases the cost of a unit of credit. These results are consistent with conventional models of credit markets.

The interest rate schedule that is the result of the estimated parameters can best be illustrated by a graph (see figure 2). Clearly, this graph shows that financing constraints exist, i.e. there is a substantial wedge between the internal and the external cost of finance. To take an example, the results imply that a firm with little capital, e.g. 0.5 million Cedis (which is approximately the 25th percentile of capital stocks), would face an interest rate of about 46% for the first Cedi it wishes to borrow. The interest rate increases fast as  $A$  increases, quickly going to infinity which implies that small firms will not be able to borrow at all beyond a small amount. The interest rate decreases with available capital and firms with about 5 million Cedis of capital are the ones that are able to borrow at rates that are close to the risk free interest rate. Considering that 55% of firms have a capital stock of less than 5 million Cedis, this implies that more than half of the firms cannot borrow at the risk free interest rate at all. However, once a firm with 5 million Cedis of capital wishes to borrow more than about 2 million Cedis, interest rates start to increase again rapidly. The estimates imply that the interest rates rises steeply after that, effectively ruling out any borrowing.

The described interest rate schedule is consistent with collateral requirements: Firms can borrow relatively easy as long as their own capital stock is large relative to the amount they want to borrow. However, as the debt approaches the size of the firm's capital stock, interest rates are prohibitively high. The estimates suggest that this effect is larger for small firms, while larger firms have ways to borrow up to the size of their own capital stock. Note that collateral requirements are not imposed on the model anywhere, but the effects shown are purely coming out of the estimates.

The result that current size matters will have strong effects on growth and furthermore, entry into a market will be difficult. Some of these implications are explored in the following sections.

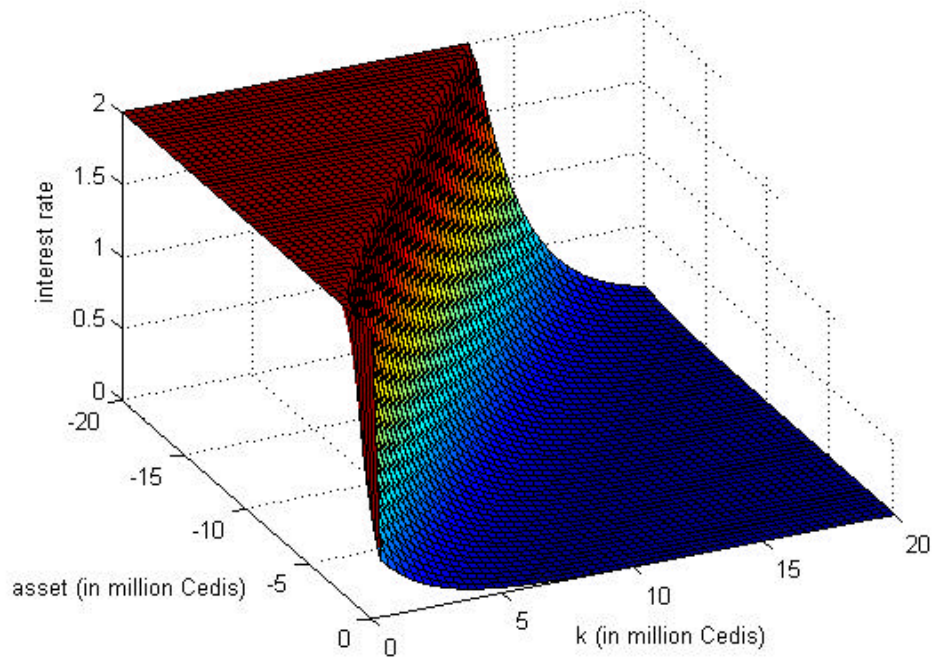


Figure 2: The interest rate schedule (truncated above at 2); range of capital shown is up to approximately 70th percentile of firms' actual capital stocks; 1 unit = 1 Million Cedis (2500 USD)

## 8 Implications

### 8.1 Quantifying the impacts of the constraints

The parameter estimates of the dynamic model now put me in a position to answer the main question of the paper: what is the cost of financing constraints to firms? In this section, I use the estimates to do some counterfactual analyses. I look in particular at the effect of changes in the cost of credit.

I remove all financing constraints and set the cost of external financing equal to the cost of internal financing and compare simulated data under the two scenarios. In particular, in terms of the model, I set the parameters  $\beta_1, \beta_2$ , and  $\beta_3$  equal to zero, and the parameter  $\beta_0$  equal to some very small number, such that the interest rate is  $r = \underline{r}$  [recall that the estimated cost of credit function is:  $\underline{r} + \exp(\beta_0 + \beta_1 \cdot K_{t,i} + \beta_2 \cdot (debt/K)_{t,i} + \beta_3 \cdot debt_{t,i})$ ]. This exercise quantifies the upper bound of the effect of potential policies that attempt to close the wedge between the cost of internal and external finance.

The results (summarized in Table 7) imply that the capital stock and the investment activities increase by 24% and 29 %, respectively, once the constraints are removed completely. The mean consumption increases by 15%.

	with constraints	without constraints	$\frac{\text{without constraints}}{\text{with constraints}}$
mean capital	70.58	87.39	1.24
mean investment	9.86	12.75	1.29
mean output	180.46	227.28	1.26
debt (conditional on debt>0)	20.04	22.55	1.13
fraction of firms with debt	13.7%	30.0%	2.19
mean dividend (consumption)	42.42	48.78	1.15
results from simulation of 6840 obs.; simulated age distribution is the age distribution in data			
1 unit in this table equals 1 million Cedis, approx. 2500 USD (1991)			

Table 7: The effect of removing the constraints

## 8.2 Financing constraints and the firm size distribution

One particular feature of the manufacturing sector in many African economies is the "missing middle", i.e. the existence of lots of small firms, together with a few very large, but only few middle sized firms, which has been debated frequently in development economics (e.g. Sleuwaegen and Goedhuys 2002). Most empirical findings in developed countries point to a negative relation between firm size and growth rates, but this would rule out the phenomenon of the missing middle. The present framework can be used to better understand the role that financing constraints play in explaining this specific form of the firm size distribution. The results of the estimation clearly show that current size matters. This will have an effect of firm growth. The following graph (Figure 3), which graphs the density for the lower tail of the capital distribution, demonstrates the rightward shift in the firm size once the constraints are removed.

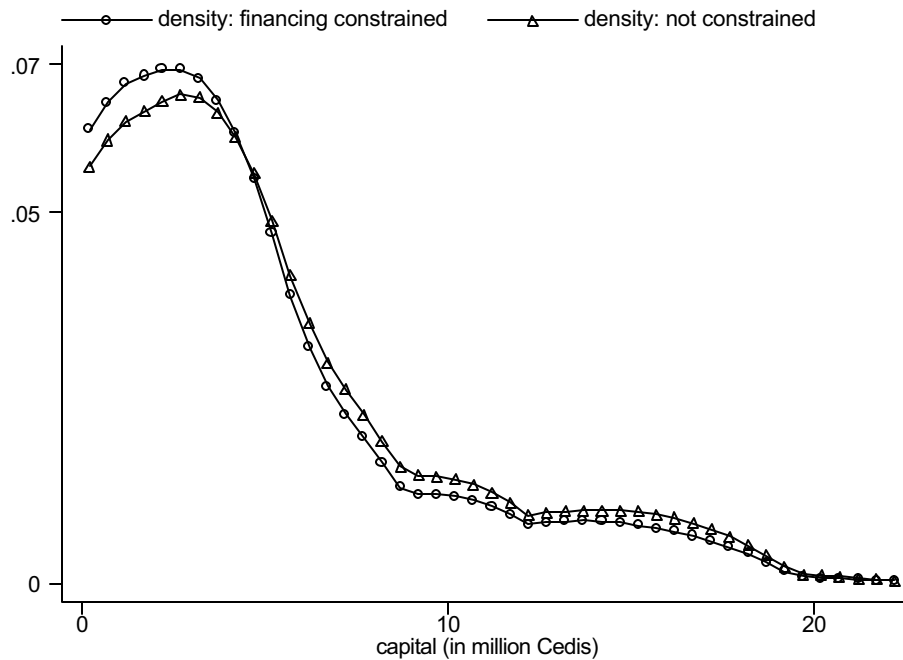


Figure 3: The effect of removing constraints on the firm size distribution

### 8.3 Future work: Methodological implications for production function estimation

The model can also be used to illustrate a potential pitfall in the estimation of production functions that rely on a method that was also employed in the first part of this paper, namely the estimator suggested by Olley and Pakes (1996), and the variant thereof by Levinsohn and Petrin (2003). The procedure proposed by Olley and Pakes (1996) assumes that investment is strictly increasing in the productivity of the firm (similarly, Levinsohn and Petrin, 2003, rely on the ability to use intermediate inputs in the optimal amounts). This assumption may be violated if there are significant financial constraints for a firm.<sup>37</sup> Using the present model, it is possible to demonstrate the effect of the constraints on investment, i.e. it is possible to study the validity of the assumptions of Olley and Pakes (1996).<sup>38</sup> This is done by graphing investment as a function of capital and productivity (Figure 4). As is evident from the graph, in a cross section investment is not strictly increasing in productivity conditional on capital. This is due to the fact that for some productive firms the cost of financing is so high that they only invest little, while some less productive firms with low financing costs, due to sufficient internal funds, invest more.

Now consider the same graph once I fix a particular asset level (and considering one particular credit fixed effect) such that the cost of financing for all firms with the same level of capital is the same (Figure 5). The resulting graph is now supportive of the assumptions in Olley and Pakes (1996), i.e. investment is increasing in productivity.

The size of the potentially resulting bias can be illustrated by simulations. A potential solution may be to introduce asset levels in the setup used by Olley and Pakes (1996). This will be explored further in future research.

---

<sup>37</sup>Regarding the assumptions in Levinsohn and Petrin (2002), it may be that not only (1) the invertibility of intermediate input function breaks down, but also (2) the GMM assumption does no longer hold, since capital may react to old shocks, because it is slow to adjust when there are credit constraints. This violates the assumption that only the new information in the productivity shock is important.

<sup>38</sup>Intermediate inputs are not modeled in this paper, so that it is not possible to present results regarding the method of Levinsohn and Petrin (2002).

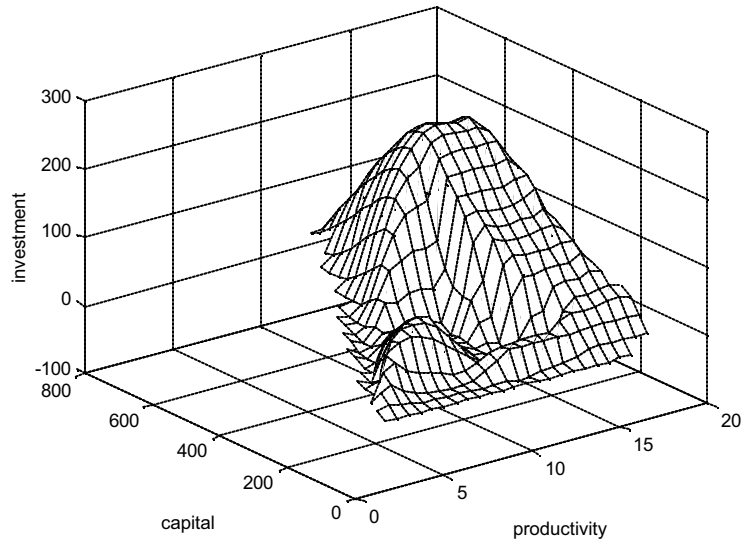


Figure 4: Investment as a function of productivity and capital

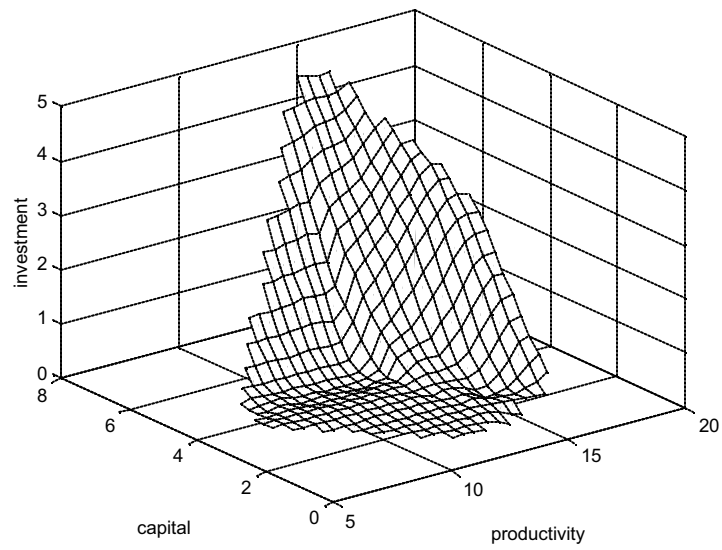


Figure 5: Investment as a function of productivity and capital for fixed asset level

## 9 Conclusion

This paper provides new evidence for the existence of financing constraints to firms and is the first to quantify the cost of these constraints. In my main contribution to the literature, I propose and estimate a dynamic model of firm-level investment that simultaneously models the real side and the financial side of the firm. This allows me to separately identify the determinants of the cost of credit, which is unobserved in the data, and alternative reasons for low investment that are common to all firms, as for example adjustment costs. The approach also deals with the selection problem that only realized debt levels but not desired debt levels are observed.

The paper has four major results. First, I demonstrate that the returns to capital in a large fraction of Ghanaian manufacturing firms are substantial, thus providing evidence that investment opportunities exist. On the other hand investment is low and uncorrelated with returns for the firms with the largest returns. To solve this apparent puzzle, I focus on financing constraints as an explanation. Second, the paper provides new evidence for the existence of financing constraints. This evidence comes from econometric evidence using a modified version of a standard test for constraints and from the estimates of the dynamic model and is supported by evidence from a direct survey question. Third, 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 owned by a firm. This is consistent with conventional models of credit markets. Fourth, the cost of financing constraints are economically significant. Counterfactual analyses indicate that removing the constraints would imply economically significant increases in investment that are associated with higher levels of consumption.

Although "governments, and other development agencies, have made the development of credit markets a focus for policy intervention" (Besley, 1995, p. 2127) remarkably little is known empirically about the cost of financing constraints due to imperfect credit markets. Those that promote credit markets development seem to accept the view that financing constraints exist. However, to understand whether the large scale interventions that are observed (see for example the World Bank spending quoted earlier) are justified and to be able to carry interventions out cost-efficiently, researchers and policy makers alike must be able to quantify the effects of these constraints and to

investigate the effect of different potential policies. The structural framework that I have proposed and the estimates of this model are a first step in this direction for investigations at the firm level. While the results of this work cannot identify one particular reason for the existence of financing constraints for firms, the results provide an estimate for the loss in investment and consumption that is due to the constraints. Thus, this study demonstrates empirically the economic significance of these financing constraints. For policy purposes, the results clearly support the need to address the problem of financing constraints. The results also identify firm characteristics, namely the size of the capital stock, that are associated with higher costs of credit. Future work will focus on identifying the specific reasons why financing constraints exist to be able to evaluate particular policy interventions.

## References

- [1] Adda, Jérôme and Russell Cooper (2003): *Dynamic Economics: Quantitative Methods and Applications*. MIT press.
- [2] Arrow, Kenneth (1971): *Essays in the Theory of Risk-Bearing*. North-Holland. Amsterdam.
- [3] Aryeetey, Ernest (1996): Credit for Enterprise Development. In: Ernest Aryeetey (Editor): *Small Enterprise Credit in West Africa*. British Council/New Leaf Press, 7-25.
- [4] Aryeetey, Ernest (1996): Trends in the Growth of Financial Services for SMEs in West Africa after Economic Reforms. In: Ernest Aryeetey (editor): *Small Enterprise Credit in West Africa*. British Council/New Leaf Press, 26-45.
- [5] Aryeetey, Ernest (1996): *Small Enterprise Credit in West Africa*. (Editor) British Council/New Leaf Press.
- [6] Aryeetey, Ernest, Jane Harrigan and Machiko Nissanke (eds.) (2000): *Economic Reforms in Ghana*. Africa World Press, Trenton, NJ.
- [7] Athey and Laumas (1994): Internal Funds and Corporate Investment in India. *Journal of Development Economics* 45,287-303.

- [8] Aw, Bee Yan, Xiaomin Chen and Mark J. Roberts (2001): Firm-level evidence on productivity differentials and turnover in Taiwanese manufacturing. *Journal of Development Economics* 66, 51-86.
- [9] Baah-Nuakoh, Amoah (2003): The Industrial Sector. Studies on the Ghanaian Economy, Vol. 3. Woeli Publishing Services, Accra.
- [10] Banerjee, Abhijit (2001): Contracting Constraints, Credit Markets and Economic Development. Manuscript, MIT.
- [11] Banerjee, Abhijit and Esther Duflo (2002): The Nature of Credit Constraints: Evidence from an Indian Bank. Manuscript, MIT.
- [12] Besley, Timothy (1995): Savings, Credit and Insurance. J. Behrman and T.N. Srinivasan (Eds.): Handbook of Development Economics, Vol III
- [13] Besley, Timothy and Stephen Coate (1995): Group Lending, repayment incentives and social collateral. *Journal of Development Economics*.
- [14] Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J. Gunning, M. Soderbom, A. Oduro, R. Oostendorp, C. Patillo, F. Teal, A. Zeufack (2000): Credit Constraints in Manufacturing Enterprises in Africa. Center for the Study of African Economies, University of Oxford, WPS/2000.24; also: in: *Journal of African Economies*, (2003) 12-33.
- [15] Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J. Gunning, A. Isaksson, A. Oduro, R. Oostendorp, C. Patillo, M. Soderbom, F. Teal, S. Appleton, and A. Zeufack (1998): Rates of Return on Physical and Human Capital in Africa's Manufacturing Sector. Center for the Study of African Economies, University of Oxford, WPS/1998.12; *Economic Development and Cultural Change* 48(4), 801-827.
- [16] Bigsten A.; Collier P.; Dercon S.; Gauthier B.; Gunning J.W.; Isaksson A.; Oduro A.; Oostendorp R.; Pattilo C.; Soderbom M.; Sylvain M.; Teal F.; Zeufack A. (1999): Investment in Africa's Manufacturing Sector: A Four Country Panel Data Analysis. *Oxford Bulletin of Economics and Statistics*, 61 (4) 489-512.

- [17] Binswanger, Hans (1981): Attitudes Toward Risk: Theoretical Implications of an Experiment in Rural India, *Economic Journal*, 91, 867-890.
- [18] Bond, Stephen and Costas Meghir (1994): Dynamic Investment Models and the Firm's Financial Policy. *Review of Economic Studies* 61, 197-222.
- [19] Bond, Stephen, Julie Elston, Jacques Mairesse, and Benoit Mulkey (1997): Financial Factors and Investment in Belgium, France, Germany and the UK. A Comparison using Company Panel Data. NBER Working Paper 5900.
- [20] Browne, Lynn and Rebecca Hellerstein (1997): Are We Investing too Little? *New England Economic Review*, Nov/Dec, 29-50.
- [21] Browning, Martin and Thomas Crossley (2001): The Life-Cycle Model of Consumption and Saving, *Journal of Economic Perspectives*, 15 (3), 3-22.
- [22] Caballero, Ricardo & Robert Pindyck (1991): Uncertainty, Investment, and Industry Evolution, *International Economic Review* 37, 3, 641-662.
- [23] Calomiris, Charles, and Glenn Hubbard (1990): Firm Heterogeneity, Internal Finance, and 'Credit Rationing'. *Economic Journal* 100, 399, 90-104.
- [24] Christensen, Laurits, Dale Jorgenson, and Lawrence Lau (1971): Conjugate Duality and the Transcendental Logarithmic Production Function. *Econometrica* 39 (4), 255-256.
- [25] Collier, Paul and Jan Willem Gunning (1999): Explaining African Economic Performance, *Journal of Economic Literature* 37, 64-111.
- [26] Cooley, Thomas and Vincenzo Quadrini (2001): Financial Markets and Firm Dynamics. *American Economic Review* 91 (5) 1286.-1310.
- [27] Cooper, Russell and John Haltiwanger (1998): On the Nature of Capital Adjustment Costs. Manuscript.

- [28] Ericson, Richard and Ariel Pakes (1995): Markov-Perfect Industry Dynamics: A Framework for Empirical Work. *Review of Economic Studies*, 62 (1) 53-82.
- [29] Fafchamps, Marcel (1997): Trade Credit in Zimbabwean Manufacturing. *World Development* 25, 5, 795-815.
- [30] Fafchamps, Marcel, Jan Willem Gunning and Remco Oostendorp (2000): Inventories and Risk in African Manufacturing. *Economic Journal* 110, 861-893.
- [31] Fafchamps, Marcel and John Pender (no year): Precautionary Saving, Credit Constraints, and Irreversible Investment: Theory and Evidence from Semi-Arid India. Manuscript.
- [32] Fazzari, Steven, Glenn Hubbard and Bruce Peterson (1988): Financing Constraints and Corporate Investment. *Brookings Papers on Economic Activity* 141-195.
- [33] Fazzari, Steven, Glenn Hubbard and Bruce Peterson (2000): Investment-cash flow sensitivities are useful: a comment on Kaplan and Zingales. *Quarterly Journal of Economics*, 695-704.
- [34] Fine, Ben and Kwabia Boateng (2000): Labour and Employment under Structural Adjustment. In: Ernest Aryeetey, Jand Harrigan and Machiko Nissanke (eds.): *Economic Reforms in Ghana*. Oxford: James Curry; Accra: Woeli Publishing Services; Trenton, NJ : Africa World Press, 227-245.
- [35] Fisman, Raymond (2001): Trade Credit and Productive Efficiency in Developing Countries. *World Development* 29, 2, 311-321.
- [36] Fraumeni, Barbara (1997): The Measurement of Depreciation in the U.S. National Income and Product Accounts. *Survey of Current Business*, July 1997, 7-23.
- [37] Frazer, Garth (2001): Linking Firms and Workers: Heterogeneous Labor and Returns to Education. Manuscript. Yale University.
- [38] Gelos, Gaston and Alejandro Werner (2002): Financial Liberalization, Credit Constraints, and Collateral: Investment in the Mexican Manufacturing Sector. *Journal of Development Economics*, 67, 1-27.

- [39] Goffe, William (1996): SIMANN: A Global Optimization Algorithm using Simulated Annealing. *Studies in Nonlinear Dynamics & Econometrics* 1 (3).
- [40] Goffe, William, Gary Ferrier and John Rogers (1994): Global Optimization of Statistical Functions with Simulated Annealing, *Journal of Econometrics* 60 (1/2), 65-100.
- [41] Gomes, Joao (2001): Financing Investment. *American Economic Review* 91 (5), 1263-1285.
- [42] Griliches, Zvi and Jacques Mairesse (1995): Production functions: the search for identification. NBER Working Paper 5067.
- [43] Gouriéroux, Christian and Alain Monfort (1996): Simulation-Based Econometric Methods. Oxford University Press.
- [44] Holt, Charles and Susan Laury (2002): Risk Aversion and Incentive Effects. Manuscript, Georgia State University.
- [45] Hopenhayn, Hugo (1992): Entry, Exit, and Firm Dynamics in Long Run Equilibrium. *Econometrica* 60, 5, 1127-1150.
- [46] Hopenhayn, Hugo and Richard Rogerson (1993): Job Turnover and Policy Evaluation: A General Equilibrium Analysis. *Journal of Political Economy* 101, 5, 915-938.
- [47] Hubbard, Glenn (1998): Capital-Market Imperfections and Investment. *Journal of Economic Literature* 36, 1, 193-225.
- [48] Hubbard, Glenn, Anil Kashyap, and Toni Whited (1995): Internal Finance and Firm Investment. *Journal of Money, Credit and Banking* 27, 3, 683-701.
- [49] IFC (2002): Review of Small Business Activities 2001.  
([http://www.ifc.org/sme/acrobat/sme\\_annual\\_2001.pdf](http://www.ifc.org/sme/acrobat/sme_annual_2001.pdf))
- [50] Judd, Kenneth (1998): Numerical Methods in Economics. MIT Press.
- [51] Lee, Bong-Soo and Beth Ingram (1991): Simulation Estimation of Time-Series Models. *Journal of Econometrics*, 47, 197-205.

- [52] Jovanovic, Boyan (1982): Selection and the Evolution of Industry, *Econometrica* 50 (3), 649-670.
- [53] Kaplan, Steven and Luigi Zingales (1997): Do Investment-cash flow sensitivities provide useful measures of financing constraints. *Quarterly Journal of Economics*, 169-215.
- [54] Kaplan, Steven and Luigi Zingales (2000): Investment-cash flow sensitivities are not valid measures of financing constraints. *Quarterly Journal of Economics*, 707-712.
- [55] Kydland, Finn and Edward C. Prescott (1982): Time to Build and Aggregate Fluctuations. *Econometrica*, 50 (6) 1345-1370.
- [56] Levinsohn, James and Amil Petrin (2003): Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies*, 70, 317-341.
- [57] Liedholm, Carl and Donald Mead (1999): Small Enterprises and Economic Development: The Dynamics of Micro and Small Enterprises. Routledge, London.
- [58] Liu, Lili (1993): Entry-Exit, Learning, and Productivity Change: Evidence from Chile. *Journal of Development Economics* 42, 217-242.
- [59] Lucas, Robert E. (1990): Why Doesn't Capital Flow from Rich to Poor Countries? *American Economic Review, Papers and Proceedings*, 80 (2), 92-96.
- [60] Martinelli, Cesar (1997): Small Firms, Borrowing Constraints, and Reputation. *Journal of Economic Behavior & Organization* 33, 91-105.
- [61] McFadden, Daniel (1989): A Method of Simulated Moments for Estimation of Discrete Response Models Without Numerical Integration, *Econometrica*, 57, 992-1026.
- [62] McKenzie, David and Christopher Woodruff (2003): Do Entry Costs Provide an Empirical Basis for Poverty Traps? Evidence from Mexican Microenterprises. BREAD Working Paper No. 20.

- [63] Mehra, Rajnish, and Edward C. Prescott (1985): The Equity Premium: A Puzzle, *Journal of Monetary Economics* 15, 145-161.
- [64] Modigliani, Franco and Merton Miller (1958): The Cost of Capital, Corporation Finance and the Theory of Investment. *American Economic Review*, 48 (3), 261-297.
- [65] Nabi, Ijaz (1989): Investment in Segmented Capital Markets. *Quarterly Journal of Economics*, 104, 3, 453-462.
- [66] Olley, Steven and Ariel Pakes (1996): The Dynamics of Productivity in the Telecommunications Equipment Industry, *Econometrica* 64, 6, 1263-1297.
- [67] Pakes, Ariel, and David Pollard (1989): Simulation and the Asymptotics of Optimization Estimators, *Econometrica*, 57, 1027-1057.
- [68] Pindyck, Robert (1991): Irreversibility, Uncertainty, and Investment. *Journal of Economic Literature* 29, 3 1110-1148.
- [69] Roberts, Mark and James Tybout (1996): Industrial Evolution in Developing Countries. Micro Patterns of Turnover, Productivity, and Market Structure (eds.). Oxford University Press.
- [70] Rosenzweig, Mark R. and Kenneth I. Wolpin (1993): Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India, *Journal of Political Economy*, 101(2), 223-244.
- [71] Rankin, Neil, Måns Söderbom, and Francis Teal (2002): The Ghanaian Manufacturing Enterprise Survey 2000. Oxford University.
- [72] Rust, John (1987): Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher. *Econometrica*, 55 (5), 999-1033.
- [73] Schiantarelli, Fabio (1996): Financial Constraints and Investment: Methodological Issues and International Evidence. *Oxford Review of Economic Policy*, 12, 2, 70-89.

- [74] Seck, Diery and Yasim El Nil (1993): Financial Liberalization in Africa. *World Development* 21, 11, 1867-1881.
- [75] Sleuwaegen, Leo and Micheline Goedhuys (2002): Growth of Firms in Developing Countries, Evidence from Côte d'Ivoire. *Journal of Development Economics*, 68, 117-135.
- [76] Steel, William (1996): Demand for Finance by SMEs in West Africa: How can the Constraints be Broken? In: Ernest Aryeetey (Editor): Small Enterprise Credit in West Africa. British Council/New Leaf Press, 46-55.
- [77] Tauchen, George (1986): Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions. *Economics Letters* 20, 177-181.
- [78] Teal, Francis (2002): A Note on the Data for Ghanaian Manufacturing Firms: 1991-1997. Manuscript, University of Oxford.
- [79] Townsend, Robert and Anna Paulson (2001): The Nature of Financial Constraints: Distinguishing the Micro underpinnings of Macro Models. Manuscript, University of Chicago.
- [80] Tybout, James (2000): Manufacturing Firms in Developing Countries: How well do they do, and why? *Journal of Economic Literature* 38, 11-44.
- [81] Vijverberg, Wim and Donald Mead (2000): Household Enterprises. In: M. Grosh and P. Glewwe, eds., *Designing Household Survey Questionnaires for Developing Countries: Lessons from 15 years of Living Standards Measurement Study*. Vol. 2, 105-138, Vol. 3, 349-408, World Bank, Washington D.C.

## A More about investment

Sources of investment in equipment:	all firms	micro/small firms (1-29 employees)	medium/large firms (> 30 employees)	years
Investment in equipment				
yes	47.5 %	38.8 %	58.7 %	
obs.	1085	592	475	1992-1997
Proportion of money coming from				
company retained earnings	69.5%	74.7%	65.3%	
personal savings	7.9%	8.7%	7.5%	
borrowed from friends or relatives	3.7%	7.2%	1.0%	
bank loan or overdraft	9.2%	3.9%	12.9%	
supplier credit	2.3%	1.4%	3.1%	
borrowed from money lender	-	-	-	
borrowed from parent or holding company	0.9%	0.2%	1.4%	
sale of equipment	0.2%	-	0.3%	
new partner	-	-	-	
other	3.9%	3.0%	4.8%	

Table 8: Funding sources for investment in equipment

	all firms	micro/small firms	medium/large firms	years
Form of acquired equipment				
new	64.3%	65.0%	63.0%	
used	23.5%	26.0%	21.9%	
mixed	12.2%	9.0%	15.1%	
obs	499	223	270	1992-1997

Table 9: Form of newly purchased equipment

Years with positive investment (% of years in survey)	all firms	micro/small firms	medium/large firms
0	23.3%	27.8%	17.9%
$0 < x \leq 15$	8.5%	11.1%	5.7%
$15 < x \leq 30$	11.1%	16.7%	4.9%
$30 < x \leq 45$	10.7%	13.9%	7.3%
$45 < x \leq 60$	12.6%	11.1%	14.6%
$60 < x \leq 75$	11.1%	9.7%	13.0%
$75 < x \leq 90$	7.0%	4.2%	10.6%
100	15.6%	5.6%	26.0%
obs	270	144	123

Table 10: Percentage of years with positive investment

Years with positive investment of firms being surveyed at least 5 times (% of years in survey)	all firms	micro/small firms	medium/large firms
0	10.7%	11.8%	8.9%
$0 < x \leq 15$	15.4%	17.2%	12.5%
$15 < x \leq 30$	15.4%	22.6%	3.6%
$30 < x \leq 45$	16.8%	18.3%	14.3%
$45 < x \leq 60$	10.7%	11.8%	8.9%
$60 < x \leq 75$	12.8%	9.7%	17.9%
$75 < x \leq 90$	12.8%	8.5%	23.2%
100	5.4%	2.2%	10.7%
obs	149	93	56

Table 11: Percentage of years with positive investment for firms being in survey at least 5 years

## B Covariates of self-stated credit problems

The information about self-stated credit problems can be used to explore correlations of firm characteristics and self-stated credit constraints. To this end, I estimate probit models where in specification (1) the dependent variable is 1 if credit is the biggest problem, while in (2) it is 1 if credit is one of the three biggest problems.<sup>39</sup> I also use the panel dimension of the data (dependent variable in that case is 1 if credit is the biggest problem). The results (see Table 12) indicate that in particular measures of firm size are highly negatively correlated with self-stated credit problems: both capital and employment level appear significantly in at least one specification. Employment is significant throughout. The interpretation of the two measures of the level of debt, the absolute debt level and the debt ratio is particularly difficult because of their close relationship with one another and because of the obvious endogeneity concerns. Higher debt is associated with higher probability of self-stated credit problems.<sup>40</sup> Overall, the results are informative about the variables that need to be included in a dynamic structural model.

---

<sup>39</sup>For the ordered probit - specification (3) - the dependent variable is 3 if credit is mentioned as the biggest problem, it is 2, if credit is the second biggest problem, 1 if it is third biggest problem and 0 if credit was not mentioned as a problem.

<sup>40</sup>(for interpretation of the sign on debt and debt squared, note that "debt"  $\leq$  0)

	(1)	(2)	(3)	(4)
	Credit biggest problem?	Credit one of 3 big problems?	ordered probit	panel probit
capital	-0.280 (0.160)	-0.109 (0.084)	-0.075 (0.070)	-0.421 (0.215)*
employees	-0.005 (0.002)**	-0.009 (0.002)**	-0.007 (0.001)**	-0.004 (0.002)*
employees squared	0.000 (0.000)*	0.000 (0.000)**	0.000 (0.000)**	0.000 (0.000)
firm age	-0.023 (0.013)	-0.020 (0.015)	-0.015 (0.012)	-0.029 (0.018)
Age squared	0.001 (0.000)*	0.001 (0.000)*	0.000 (0.000)	0.001 (0.000)
Profit rate	-0.011 (0.010)	0.017 (0.012)	0.001 (0.008)	-0.012 (0.012)
debt	-1.601 (1.810)	-6.508 (2.100)**	-3.347 (1.487)*	-2.033 (2.128)
Debt squared	-0.385 (1.797)	-9.277 (2.968)**	-3.369 (1.366)*	-0.311 (2.097)
Debt rate	0.111 (0.366)	0.341 (0.365)	0.279 (0.313)	-0.007 (0.455)
Accra	0.054 (0.118)	-0.154 (0.120)	-0.078 (0.105)	
Food Processing/ Bakery	0.490 (0.180)**	0.327 (0.179)	0.401 (0.160)*	
Furniture/Wood	0.550 (0.169)**	0.399 (0.168)*	0.490 (0.150)**	
Metal/Machines	0.458 (0.173)**	0.194 (0.171)	0.318 (0.153)*	
Year dummies	yes	yes	yes	
Constant	-0.229 (0.218)	0.624 (0.221)**		0.185 (0.200)
Observations	539	539	539	539

Standard errors in parentheses  
\* significant at 5%; \*\* significant at 1%

Table 12: covariates of credit problems

## C Properties of the Method of Simulated Moments estimator

The Method of Simulated Moments estimator has the following asymptotic properties:<sup>41</sup>:

When  $n$  goes to infinity and  $S$  is fixed, then  $\hat{\theta}_{Sn}(W)$  is consistent,  $\sqrt{n} [\hat{\theta}_{Sn}(W) - \theta_0]$  is asymptotically normally distributed, and the asymptotic variance-covariance matrix is equal to

$$Q_S(W) = (1 + \frac{1}{S}) \Sigma_1^{-1} \Sigma_2 \Sigma_1^{-1} \quad (2)$$

with

$$\begin{aligned} \Sigma_1 &= D'WD \\ \Sigma_2 &= D'W \text{var}_0 [M(x) - E_u [\tilde{m}(x_i, u, \theta)]] WD \\ D &= \frac{\partial E_u [\tilde{m}(x_i, u, \theta)]}{\partial \theta'} \end{aligned}$$

The optimal choice for the weight matrix  $W$  is:

$$W^* = \{\text{var}_0 [M(x) - E_u [\tilde{m}(x_i, u, \theta)]]\}^{-1}$$

Using this optimal weight matrix, the asymptotic variance-covariance matrix is:

$$Q_S(W^*) = (1 + \frac{1}{S}) \left[ D' \{\text{var}_0 [M(x) - E_u [\tilde{m}(x_i, u, \theta)]]\}^{-1} D \right]^{-1}$$

---

<sup>41</sup>The presentation of the estimator follows Gouriéroux and Monfort (1993) and Adda and Cooper (2003).

## D Hiring and firing

	all firms	micro/small firms	medium/large firms	year
Subject to hiring restrictions?				
yes	9.3%	4.4%	15.7%	
obs.	193	113	70	1991
Negative effects of existing hiring restrictions?				
1 (not at all)	12	3	8	
2	2	-	2	
3	2	1	1	
4	-	-	-	
5 (severe)	1	1	-	
obs.	17	5	11	1991
Limits on temporary hiring?				
yes	10.4%	1.8%	20.0%	
obs.	193	113	70	1991
Negative effects of existing limits?				
1 (not at all)	14	1	10	
2	5	1	4	
3	-	-	-	
4	-	-	-	
5 (severe)	-	-	-	
obs.	19	2	14	1991
How severe are labor regulations as obstacle to firm expansion?				
1 (not at all)	182	114	59	
2	10	3	7	
3	2	-	2	
4	1	-	-	
5 (severe)	2	-	2	
obs.	197	117	70	1991
Shortage of skilled labor as an obstacle to capacity utilization				
1 (not an obstacle)	83.0 %	86.5 %	78.2 %	
2 (moderate obstacle)	11.9 %	9.5 %	15.0 %	
3 (severe obstacle)	5.1 %	4 %	6.8 %	
obs.	352	200	147	1993-1995

Table 13: Evidence concerning hiring restrictions

	all firms	micro/small firms	medium/large firms	year
Subject to layoff restrictions?				
yes	25.4%	9.7%	47.1%	
obs.	193	113	70	1991
Negative effects of existing layoff restrictions?				
1 (not at all)	21	5	12	
2	9	-	9	
3	9	3	6	
4	1	-	1	
5 (severe)	6	2	4	
obs.	46	10	32	1991
Layoff benefit requirements?				
yes	27.5%	8.9%	54.3%	
obs.	193	113	70	1991
Negative effects of existing layoff benefit requirements?				
1 (not at all)	27	4	19	
2	9	1	8	
3	9	3	6	
4	1	-	1	
5 (severe)	4	2	2	
obs.	50	10	36	1991
Percentage of work force that is unionized				
0%	49.9%	88.6%	19.5%	
>0% and $\leq$ 25%	1.0%	1.8 %	0.4%	
>25% and $\leq$ 50%	2.8%	1.4 %	4.1%	
>50% and $\leq$ 75%	4.7%	0.9 %	7.9%	
>75% and <100%	16.6%	0.9 %	28.8%	
100%	25.1%	6.4%	39.3%	
obs.	495	220	267	1991-1997

Table 14: Evidence concerning firing restrictions

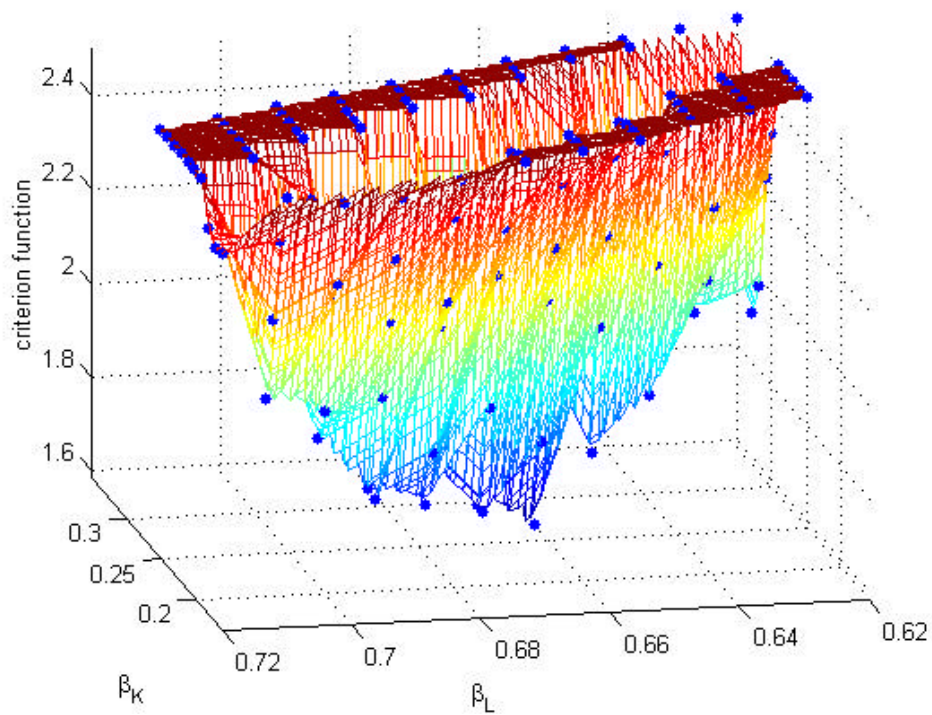
	all firms	micro/small firms	medium/large firms	year
Training required after setting up plant?				
yes	24.3%	10.9%	44.3%	
obs.	169	101	61	1991
Training required for additions to plant equipment?				
yes	20.2%	14.6%	27.5%	
obs.	13	41	40	1991
Duration of training for additions to plant equipment in weeks?				
median	4.3	4.3	4.3	
mean	11.2	11.3	11.1	
obs.	13	5	8	1991
Worker questionnaire:				
Did you receive any job training in past?				
within this firm	27.8%	37.3%	24.0%	
outside this firm	36.8%	24.5%	41.5%	
no	35.5%	38.2%	34.5%	
obs.	936	306	595	1997

Table 15: Evidence concerning on-the-job training

## E Identification - some illustrations

The value of the criterion function (1) as a function of  $\alpha_L$  and  $\alpha_K$ :

Figure 6: criterion function as a function of production function parameters  
 $\times 10^{-3}$



Identification of cost of credit function:

Figure 7: identification of the cost of credit function parameters

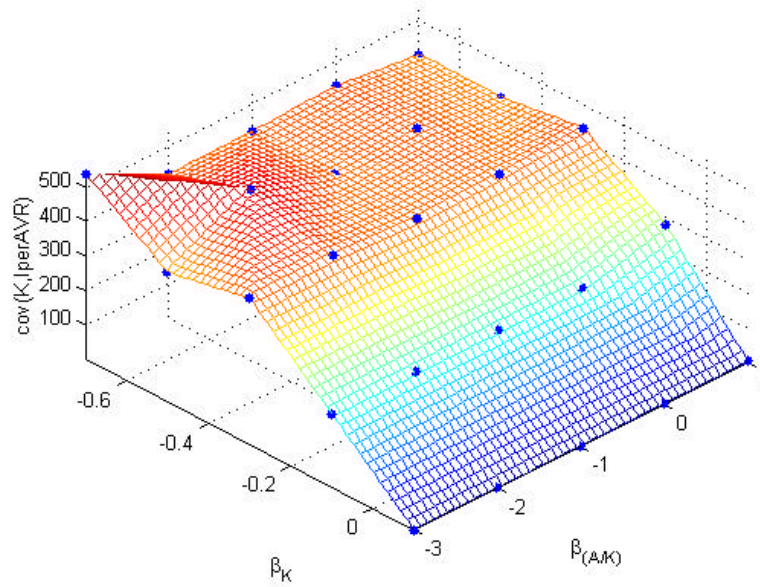


Figure 8: identification of the cost of credit function parameters (cont'd)

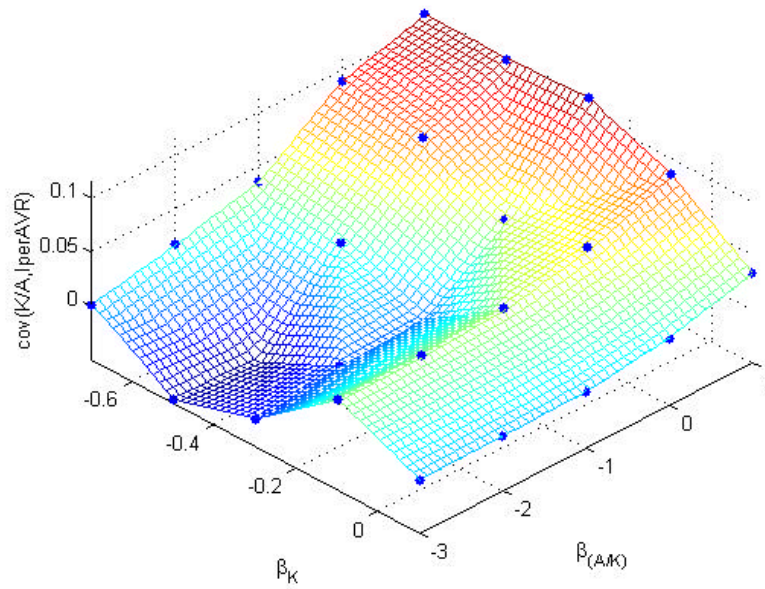


Figure 9: criterion function as a function of adjustment costs and cost of credit

