Firm-Level Investment Under Imperfect Capital Markets in Ukraine*

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Abstract

This paper develops and estimates a model of firm level fixed capital investment when firms operating in a "constrained regime" cannot afford the optimal level of investment predicted by their intertemporal maximization problem. Investment functions for constrained and unconstrained firms derived from a structural dynamic model of investment are then used to construct the likelihood of observing particular type of firm. The empirical model represents a regime switching regression with unknown sample separation without an explicit selection equation. An alternative empirical specification based on an explicit selection equation is used to estimate sensitivity of investment to cash flow variables for constrained and unconstrained groups of firms. Parameters of the models are estimated using data from the Ukrainian manufacturing register in 1993-1998. Both specifications produce consistent results, which suggest a high average probability of financial constraints in the Ukrainian manufacturing sector. Cross-industry variation in the parameter estimates and implied probabilities of financial constraints are plausible given the institutional environment in these industries. Estimation results suggest that the probability of financial constraints ranges from 0.39 in the ferrous metallurgy to 0.79 in the power industry. From 1994 to 1998, the degree of financial constraints declined slightly with a significant improvement found only in the ferrous metallurgy.

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1 Introduction

Study of investment behavior and its determinants play an important role in macroeconomic analysis of resource allocation, theories of business cycles, and proper design of public policy, which are all the prerequisites for long-term growth. Asymmetric information, agency and transaction costs are the major reasons for the existence of a financial hierarchy in developed countries, in which firms rely heavily on internal finance for their investment projects. Obviously, these problems are much more severe in transition economies. Underdeveloped capital markets and high uncertainty make the costs of external project financing significantly higher than that of retained earnings. Not surprisingly, in many firm-level surveys managers report corporate profits as the main source for investments.

In this paper, I analyze firm-level investment behavior. It is hypothesized that many firms operating in a "constraint regime" cannot afford the optimal level of investment predicted by their intertemporal maximization problem. Suboptimal investment, in turn, has an adverse effect on the overall industry performance. Moreover, young and (potentially) fast growing firms are likely to be harmed the most. The suggested approach provides a general structural model, which does not rely on explicit assumptions about the sources of financial constraints. This allows identification of the subset of constrained firms within an industry and then analyzing their features.

2 Literature review

The economic literature contains several basic approaches to the modeling of capital investment. The most widely used "traditional" investment models are *the generalized accelerator*, *cash flow* (often combined with accelerator), *neoclassical* (including various modifications), and *Q-theory* (also known as securities value) models. Many recent empirical studies of investment behavior focused also on the direct estimation off the first-order conditions (Euler equations) derived from a dynamic optimization problems. This study belongs to the latter class of models.

Much of the earlier investment literature does not consider cash flow and other financial variables in the investment function.[1] According to neoclassical theory, a firm's desired capital stock is determined by factor prices and technology. Cash flow or other financial variables play no direct role in this theory. Thus, it was assumed that any desired investment project can be financed. Recently, many authors developing theories of capital market imperfections point in an opposite direction.[2] Over the past two decades many authors attempted to extend traditional investment models to account for external financial constraints. Theoretical models studying internal sources of investment financing versus external ones are generally based on an information asymmetry between borrowers and lenders. This asymmetry may significantly increase the cost of external funds through excessive risk premiums in the interest rates faced by borrowers. The availability of internal finance enhances firm's ability to raise outside funding by providing a signal to investors about the performance of the company under imperfect information.

An alternative view of information imperfections gave rise to the "agency costs" models, which emphasize conflicts of interests between managers and external shareholders. Extensive monitoring and reduced managerial flexibility resulting from the attempts of outside shareholders to control managers may lead to direct increases in the associated costs of "control" as well as to foregone profit opportunities.

Similar approaches relate the financial hierarchy to the conflict of interests between incumbent shareholders and outside investors. Other models point towards the importance of transaction costs. The difference between the costs of internal and external funds may be due to registration fees, underwriting discounts, and the selling expenses related to the procedure of bonds and stocks issuance. Also, the existence of financial hierarchy may be supported by the difference in taxation of dividends and capital gains.

A good survey of the early and recent theoretical models of investment and their empirical applications can be found in Chirinko (1993). The problem of external versus internal financing is discussed from a variety of prospectives in Myers and Majluf (1984),

[1] Sometimes this proposition is also referred to as "Modigliani-Miller Paradigm".

[2] With respect to R&D investments, however, the importance of internal finance was greatly acknowledged in early studies as well as due to Schumpeter's view of monopoly profit as a resource for innovative activity.

Calomiris and Hubbard (1990), Bernstein and Nadiri (1988), Sinai and Eckstein (1983), Kopcke (1985), Fazzari and Mott (1986).

Below I focus on the recent empirical literature investigating the impact of financial constraints on the firm's fixed capital investment. Hubbard (1998) in his review article admits that "the principal findings of these studies are that: (1) all else being equal, investment is significantly correlated with proxies for changes in net worth or internal funds; and (2) that correlation is most important for firms likely to face information related capital-market imperfections" (p. 193).

There are several ways of modeling financial constraints. The majority of these methods use the idea of sensitivity of investments to the changes in cash flow or other internal worth variables in a theory-driven investment equation. Under the null hypothesis of no financial constraints, coefficients for these variables should not be statistically significant. Rejection of the null is used as an indication of financial hierarchy. For example, this approach was employed in Fazzari and Athey (1987) by using two variables capturing the financial constraints: flow of internal finance and interest expense. The results support the hypothesis of the importance of financial constraints for the firms' investment. Hence, the authors conclude that "[t]o predict a firm's investment, it is not sufficient to know only the firm's desired path of capital accumulation in the absence of financial constraints. One must also determine whether all desired investment can be financed" (p. 482).

The methodology has a significant flaw, which was recognized by many authors. In particular, it is unclear "whether the investment cash-flow sensitivity is a signal of financial constraints or merely a signal of expected profit" (Chatelain (2002), p.6). Indeed, even if financial markets are perfect and there is no difference in the costs of external and internal financing, the future profitability of capital is likely to be reflected by the financial variables.

Fazzari et al. (1988) provide a solution to the problem by estimating an investment equation with financial variables for two separate groups of firms, classified by their dividend behavior. The authors conclude that "financial effects were generally important for investment in all firms, [b]ut the results consistently indicated a substantially greater sensitivity of investment to cash flow and liquidity in firms that retain nearly all of their income" (p.184).

The issue of firms' investment expenditures sensitivity to cash flows is more controversial then it seems at first. Recent papers by Kaplan and Zingales (1997; 2000) (henceforth KZ, 1997, 2000) and reply to their criticism by Fazzari et al. (2000) (henceforth FHP, 2000) raise many questions in this respect. The key point in these debates is whether "investment-cash flow sensitivities increase monotonically with the degree of financing constraints" (p.170, KZ, 1997). Both groups of authors use the same data to arrive at opposite conclusions. KZ (1997) found that the firms that are likely to be financially constrained exhibit the lowest sensitivity to the cash flow variable, while FHP (1988) found the opposite relationship. The response of FHP (2000) to KZ's (1997) critique questions the following points: (1) the suggested theoretical framework and its relevance to the methodology used in the original work of FHP, (2) the correctness of qualitative classification of the firms into groups according to the degree of their financial constraints, and (3) difficulties in interpreting the results proposed by KZ (1997).

The discussion above suggests that while there are no doubts that constrained firms' investments must be sensitive to the cash flow variable, interpretation of the coefficients' magnitude is a highly debatable issue. Hovakimian and Titman (2006) explain the controversy by the difficulties of measuring investment opportunities. "Specifically, if investment opportunities are not measured properly, then cash flows, in addition to conveying information about internal liquidity, may also reflect information about future investment opportunities" (p.358). To resolve the problem the authors propose exploring the relationship between voluntary divestitures funds and firms' investments. The authors find that voluntary divestitures may represent an important financing resource for financially constrained firms. Since it is unlikely that asset sales are strongly related to the investment opportunities, finding that firms' investment is more sensitive to the asset sales for constrained firms supports the literature that consider investment sensitivity to cash flows as a sign of financial constraints. It is worth noting that the model used in the present study does not rely on "Tobin's q" measure, nor does it assume any monotonic pattern in the investment sensitivity to cash flows for the firms with different degree of financial constraints. Hence, my results should contribute to a better understanding of the problem by investigating the features of the firms that would be identified as financially constrained.

Calomiris and Hubbard (1995) employ firm-level data for 1933-1938 that provided "a rare opportunity to measure the shadow price differential between internal and external finance" (p.476) due to a surtax on undistributed profit. The authors find that firms with a high shadow value on internal funds also revealed much greater sensitivity of investments to internal funds. As shown by Lamont (1997) in his study of non-oil subsidiaries of oil companies, a decrease in cash flow and collateral value may lead to a decrease in investments. Oliner and Rudebusch (1992) provide additional support for the hypothesis of information asymmetry as a major source of the financial hierarchy. Using panel data on U.S. firms from the late 1970s and early 1980s the authors find that while information asymmetry is definitely an important factor determining firms' capital investment, they have failed to find evidence in favor of the transaction costs argument.

3 Methodology

The motivation behind the methodology suggested in this section can be summarized by a citation from Greenwald et al. (1984): "In some circumstances, [...] it is the availability of capital and not its cost that determines the level of investment" (p.198). Similarly to Bond and Meghir (1994), I assume that in any period a subset of firms may operate in a constrained regime, when their investment expenditures are constrained by internally generated funds. Under fairly general conditions, observed investment of any firm in an industry is represented by the minimum of optimal and available amounts.

3.1 Theoretical model

Consider an N-firms competitive industry with a constant returns to scale Cobb-Douglas technology. Firms, $i = 1, ..., N$, operate through time, indexed by $t = 0, 1, ...$ and maximize net present value of future cash flows over an infinite horizon. Assuming that all factors of production are costlessly adjustable, except for capital stock, K_{it}, per-period profit of firm i can be written as $\pi_{it} = \varphi(Z_t)K_{it}$, i.e. it is linear in capital stock, where $\varphi(Z_t) > 0$ denotes marginal profitability of capital, which depends on a vector of factor prices. Let β and δ denote the discount factor and capital depreciation rate respectively. Gross investment, I_{it}, occurs at the beginning of each period and immediately becomes productive. Firms face a strictly convex adjustment cost function, $C(I_{it}, K_{it})$, which depends on both the level of investment and the current stock of capital.

Assumption 1: $C(0, K_{it}) = 0$, $\dfrac{\partial C(\cdot)}{\partial K_{it}} < 0$, $\dfrac{\partial C(\cdot)}{\partial I_{it}} > 0$, and $\dfrac{\partial^2 C(\cdot)}{\partial I_{it}^2} > 0$

Firm i's maximization problem can be written in the form of Bellman equation

$$V(K_{it-1}) = \max_{0 \leq I_{it} \leq A_{it}} \{\Pi(K_{it}, I_{it}) + \beta E[V(K_{it})]\} \tag{1}$$

where $\Pi(K_{it}, I_{it}) = \varphi(Z_t)K_{it} - I_{it} - C(I_{it}, K_{it})$, the expectation is taken with respect to future values of Z_t, and the capital stock evolves according to a deterministic equation of motion $K_{it} = (1-\delta)K_{it-1} + I_{it}$.

Assumption 2: There exist a finite upper bound on investment, which represents maximum total amount of own and external funds a firm can raise in a given period of time such that $A_{it} < \infty$ and $\dfrac{\partial A_{it}}{\partial K_{it}} > 0 \; \forall i, t$

First, consider optimal investment decisions by firm i when $A_{it} = \infty$. Similar to Bond and Meghir (1994), I can write the Euler equation for the DP problem of firm i as

$$(1-\delta)\beta E\left(\frac{\partial \Pi(\cdot)}{\partial I_{it+1}}\right) = \frac{\partial \Pi(\cdot)}{\partial I_{it}} + \frac{\partial \Pi(\cdot)}{\partial K_{it}} \tag{2}$$

Clearly, equation (2) governs optimal investment decisions of the firms with unrestricted policy set. Let I^*_{it} denote optimal investment derived from (2). If $I^*_{it} > A_{it}$, the firm (henceforth *constrained* firm) would maximize the right-hand side of its Bellman equation by investing exactly A_{it}.[3] Suppose that current period optimal investment, I^*_{it}, suggested

[3]Here I implicitly assume that standard regularity conditions for Bellman equation are satisfied.

by (2) is such that $I^*_{it} < A_{it}$. In this case, a firm (henceforth *unconstrained* firm) would choose to invest exactly I^*_{it} unless fixed capital 'stockpiling' is optimal. The latter case may occur if a currently unconstrained firm anticipates that the restriction on investment will be binding in the future. Such cases are ruled out by the following assumption.

Assumption 3: If $I^*_{i\hat{t}} \leq A_{i\hat{t}}$ for some $\hat{t}$, $I^*_{it} < A_{it}, \forall t > \hat{t}$

This assumption says that if a firm reaches such a point on its capital accumulation path where optimal investment is affordable, optimal investment must be affordable in all future periods as well. Loosely speaking, Assumption 3 does not allow an unconstrained firm to become constrained in the future, while opposite (constrained firm becomes unconstrained) is acceptable.

Below I derive an empirical version of the investment function. Assuming a symmetric adjustment cost function, $C(I_{it}, K_{it}) = \frac{1}{2}bK_{it}\left(\frac{I_{it}}{K_{it}}\right)^2$, the Euler equation (2) can be written as

$$\begin{aligned} \frac{I_{it+1}}{K_{it+1}} = & -\left(\frac{1}{b} - \frac{1}{b(1-\delta)\beta}\right) - \frac{1}{b(1-\delta)\beta}\varphi(Z_t) \\ & + \frac{1}{(1-\delta)\beta}\left(\frac{I_{it}}{K_{it}} - \frac{1}{2}\left(\frac{I_{it}}{K_{it}}\right)^2\right) \end{aligned}$$

or

$$\begin{aligned} \tilde{I}_{it} &= \left(\frac{1}{b} - \frac{1}{b(1-\delta)\beta}\right) - \frac{1}{b(1-\delta)\beta}\varphi(Z_t) \\ &+ \frac{1}{(1-\delta)\beta}\left(\frac{I_{it}}{K_{it}} - \frac{1}{2}\left(\frac{I_{it}}{K_{it}}\right)^2\right) \\ &= f_u(\tilde{I}_{it-1}, \varphi(Z_t)|b, \delta, \beta) \end{aligned} \tag{3}$$

where $\tilde{I}_{it} = \frac{I_{it}}{K_{it}}$, and (b, δ, β) is a vector of structural parameters to estimate. This function represents optimal investment pattern. Whenever optimal investment is not affordable, that is in case when $I^*_{it} < A_{it}$, firm i's investment is given by the upper bound A_{it} itself.

In every time period the maximum amount of financial resources available for fixed capital investment consists of own resources (retained earnings) and externally raised (via direct borrowing or by means of corporate securities) funds. Let $0 \leq s_{it} \leq 1$ denote a fraction of current period profit firm i is able to use for investment in period t.

Assumption 4: All firms within the same industry and across all time periods are able to retain the same share of current period profits for reinvestment into fixed capital, $s_{it} = s \forall i, t$

Suppose that the amount of external funds that firm i can raise is known up to a parameter values function of observed (by potential lender/investor) variables approximating cash flows, i.e. *External Funds* $= h(y_{it})$, where y_{it} is observed vector of firm's financial credit-worthiness.

Assumption 5: $h(y_{it}) = \gamma y_{it}$, where y_{it} is observed revenue of the firm i in period t.

Then the upper bound on the current period policy choice, A_{it} is given by

$$A_{it} = s\varphi(Z_t)K_{it} + \gamma y_{it} - \frac{1}{2} b K_{it} \left(\frac{I_{it}}{K_{it}} \right)^2 \tag{4}$$

Since a constrained firm's optimal choice is to invest the maximum available amount, I can write $I_{it} = A_{it}$ and rearrange (4) as follows

$$\tilde{I}_{it} = s\varphi(Z_t) + \gamma \tilde{y}_{it} - \frac{1}{2} b \tilde{I}_{it}^2$$

where $\tilde{I}_{it} = \dfrac{I_{it}}{K_{it}}$, $\tilde{y}_{it} = \dfrac{y_{it}}{K_{it}}$.

Finally, solving for $\tilde{I}_{it}$ yields investment equation for the constrained case

$$\begin{aligned} \tilde{I}_{it} &= -\frac{1}{b} + \left(\frac{1}{b^2} - 2\frac{s}{b}\varphi(Z_t) + 2\frac{\gamma}{b}\tilde{y}_{it} \right)^{\frac{1}{2}} \\ \tilde{I}_{it} &= f_c(\varphi(Z_t), \tilde{y}_{it} | b, s, \gamma) \end{aligned} \tag{5}$$

3.2 Empirical specification

Let $\Theta = (b, s, \beta, \gamma)$ and let u_{it}^u and u_{it}^c denote additive expectational errors in the observed investment. Then the observed investment of firm i must be given by

$$\tilde{I}_{it} = \min\{f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta) + u_{it}^u, f_c(\varphi(Z_t), \tilde{y}_{it}|\Theta) + u_{it}^c\} \tag{6}$$

In order to estimate parameters of the model I use a maximum likelihood estimation procedure. Under distributional assumptions on the error terms in (6) it is possible to derive a likelihood function for a regime-switching regression with unknown sample separation and without an explicit selection equation.

Assumption 6: Unobservables in the empirical versions of investment equations are independently identically distributed as follows $u_{it}^u \overset{i.i.d.}{\sim} N(0, \sigma_u^2)$ and $u_{it}^c \overset{i.i.d.}{\sim} N(0, \sigma_c^2)$.

Note that the assumption above implies that $u_{it}^u - u_{it}^c \overset{i.i.d.}{\sim} N(0, \sigma_u^2 + \sigma_c^2)$. Let $r_{it} \in \{u, c\}$ denote indicator of the investment regime. Then likelihood of observing particular level of investment can be written as

$$p(\tilde{I}_{it}, r_{it}) = p(\tilde{I}_{it}|r_{it} = u) \Pr(r_{it} = u) + p(\tilde{I}_{it}|r_{it} = c) \Pr(r_{it} = c) \tag{7}$$

In turn,

$$\begin{aligned} p(\tilde{I}_{it}|r_{it} = u) &= p(\tilde{I}_{it} = f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta) + u_{it}^u) \\ &= \frac{1}{\sigma_u}\phi\left(\frac{\tilde{I}_{it} - f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta)}{\sigma_u}\right) \end{aligned} \tag{8}$$

While,

$$\begin{aligned} \Pr(r_{it} = u) &= \Pr(f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta) + u_{it}^u \leq f_c(\varphi(Z_t), \tilde{y}_{it}|\Theta) + u_{it}^c) \\ &= \Pr(u_{it}^u - u_{it}^c \leq f_c(\varphi(Z_t), \tilde{y}_{it}|\Theta) - f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta)) \\ &= \Phi\left(\frac{f_c(\varphi(Z_t), \tilde{y}_{it}|\Theta) - f_u(\tilde{I}_{it-1}, \varphi(Z_t)|\Theta)}{(\sigma_u^2 + \sigma_c^2)^{\frac{1}{2}}}\right) \end{aligned} \tag{9}$$

Then overall likelihood for observed investment by firm i in period t can be written as

$$\begin{aligned} & li(\tilde{I}_{it}|\tilde{I}_{it-1}, \varphi(Z_t), y_{it}, \Theta) = \\ & \Phi\left(\frac{f_c(\cdot|\Theta) - f_u(\cdot|\Theta)}{(\sigma_u^2 + \sigma_c^2)^{\frac{1}{2}}}\right)\frac{1}{\sigma_u}\phi\left(\frac{\tilde{I}_{it} - f_u(\cdot|\Theta)}{\sigma_u}\right) \\ & + \left(1 - \Phi\left(\frac{f_c(\cdot|\Theta) - f_u(\cdot|\Theta)}{(\sigma_u^2 + \sigma_c^2)^{\frac{1}{2}}}\right)\right)\frac{1}{\sigma_c}\phi\left(\frac{\tilde{I}_{it} - f_c(\cdot|\Theta)}{\sigma_c}\right) \end{aligned} \tag{10}$$

In order to estimate parameters of the model, I use MLE, i.e.

$$\hat{\Theta} = \arg\max_{\Theta}\left\{\frac{1}{NT}\sum_{i=0}^{N}\sum_{t=1}^{T}\log\left[li(\tilde{I}_{it}|\tilde{I}_{it-1}, \varphi(Z_t), y_{it}, \Theta)\right]\right\} \tag{11}$$

3.3 Alternative empirical specification

Obviously, identification of structural parameters in the model above relies heavily on the functional form assumptions. In order to address the problem using alternative approach, similar to Hovakimian and Titman (2006), I suggest using an explicit selection equation. This model, however, requires *ad hoc* assumptions about the characteristics of the firms that are most likely to be financially constrained.

Assume that the empirical Euler equation is given by the specification similar to the one derived in Bond and Meghir (1994)

$$\tilde{I}_{it} = \alpha_1\tilde{I}_{it-1} + \alpha_2\tilde{I}^2_{it-1} + \alpha_3\tilde{y}_{1it-1} + \alpha_4\tilde{y}_{2it-1} + d_t + v_i + \varepsilon_{it} \tag{12}$$

where $\tilde{I}_{it} = \dfrac{I_{it}}{K_{it}}$; y_{1it} is a variable approximating cash flows divided by capital stock; y_{2it} is total output normalized by capital stock, which represents control for imperfect competition as suggested by Bond and Meghir (1994); d_t and v_i are time- and firm-level effects; $(\alpha_1, \alpha_2, \alpha_3, \alpha_4)$ are reduced form parameters to estimate; and ε_{it} is the econometric error term. If firms are not constrained financially, the coefficient α_3 should be zero.

As suggested by Hovakimian and Titman (2006), equation (12) can be estimated for two groups of firms: unconstrained and constrained. Then the difference in coefficients (if any) can be used to test the importance of financial constraints for the firms' fixed capital investment. In order to decide which firm belongs to which regime (unconstrained or constrained) one can use an explicit selection equation.

Consider the following model

$$\tilde{I}^u_{it} = f(X_{it}, \bar{\alpha}_u) + \varepsilon^u_{it}, \tag{13}$$

$$\tilde{I}^c_{it} = f(X_{it}, \bar{\alpha}_c) + \varepsilon^c_{it}, \tag{14}$$

$$r^*_{it} = W_{it}\bar{\alpha}_r + \varepsilon^r_{it} \tag{15}$$

where equations (13) and (14) are empirical investment functions for unconstrained and constrained firms respectively. Equation (15) is the selection equation governing the probability of being in one of the two regimes. Note that both (13) and (14) are assumed to have the same functional form as in equation (12). Differences between them are captured by coefficients $\bar{\alpha}_c$ and $\bar{\alpha}_u$ as in traditional literature on financial constraints. These are common sample selection models where we observe $\tilde{I}_{it} = \tilde{I}^u_{it}$ if latent variable $r^*_{it} \le 0$ and $\tilde{I}_{it} = \tilde{I}^c_{it}$ otherwise.

Assumption 7: Joint density of $(\varepsilon^u_{it}, \varepsilon^c_{it}, \varepsilon^r_{it})$ is given by $p(\varepsilon^u_{it}, \varepsilon^c_{it}, \varepsilon^r_{it}) = N(\mathbf{0}, \Sigma)$, where
$\Sigma = \begin{pmatrix} \sigma_{uu} & \sigma_{uc} & \sigma_{ur} \\ \sigma_{uc} & \sigma_{cc} & \sigma_{cr} \\ \sigma_{ur} & \sigma_{cr} & 1 \end{pmatrix}$

It is straightforward to derive a likelihood function.

$$\begin{aligned}
&p(\tilde{I}_{it}, r_{it}|X_{it}, \alpha_c, \alpha_u) = \\
&\Pr(r^*_{it} \le 0|\varepsilon^u_{it} = \tilde{I}^u_{it} - f(X_{it}, \bar{\alpha}_u)) \Pr(\varepsilon^u_{it} = \tilde{I}^u_{it} - f(X_{it}, \bar{\alpha}_u)) \\
&+ \Pr(r^*_{it} > 0|\varepsilon^c_{it} = \tilde{I}^c_{it} - f(X_{it}, \bar{\alpha}_c)) \Pr(\varepsilon^c_{it} = \tilde{I}^c_{it} - f(X_{it}, \bar{\alpha}_c)) = \\
&\Pr(r^*_{it} \le 0|\varepsilon^u_{it} = \tilde{I}^u_{it} - f(X_{it}, \bar{\alpha}_u)) \frac{1}{\sigma_{uu}} \phi\left(\frac{\tilde{I}^u_{it} - f(X_{it}, \bar{\alpha}_u)}{\sigma_{uu}}\right) \\
&+ \Pr(r^*_{it} > 0|\varepsilon^c_{it} = \tilde{I}^c_{it} - f(X_{it}, \bar{\alpha}_c)) \frac{1}{\sigma_{cc}} \phi\left(\frac{\tilde{I}^c_{it} - f(X_{it}, \bar{\alpha}_c)}{\sigma_{cc}}\right)
\end{aligned} \tag{16}$$

Consider $\Pr(r^*_{it} \le 0|\varepsilon^u_{it} = \tilde{I}^u_{it} - f(X_{it}, \bar{\alpha}_u))$. Using a standard result for joint normal density,

$$p(\varepsilon_{it}^r|\varepsilon_{it}^u) = N\left(\frac{\sigma_{ur}}{\sigma_{uu}}, 1 - \frac{\sigma_{ur}}{\sigma_{uu}}\right)$$

Then

$$\begin{aligned}
&\Pr(r_{it}^* \leq 0|\varepsilon_{it}^u = \tilde{I}_{it}^u - f(X_{it}, \bar{\alpha}_u)) = \int 1(W_{it}\bar{\alpha}_r + \varepsilon_{it}^r \leq 0)p(\varepsilon_{it}^r|\varepsilon_{it}^u) \\
&= \int 1\left(W_{it}\bar{\alpha}_r + \frac{\sigma_{ur}}{\sigma_{uu}}(\tilde{I}_{it}^u - f(X_{it}, \bar{\alpha}_u)) + \left(1 - \frac{\sigma_{ur}}{\sigma_{uu}}\right)^{\frac{1}{2}} \tau_{it} \leq 0\right) p(\tau_{it})
\end{aligned}$$

where $\tau_{it} \overset{i.i.d.}{\sim} N(0,1)$. Then,

$$\Pr(r_{it}^* \leq 0|\varepsilon_{it}^u) = \Phi\left(\frac{-W_{it}\bar{\alpha}_r - \frac{\sigma_{ur}}{\sigma_{uu}}(\tilde{I}_{it}^u - f(X_{it}, \bar{\alpha}_u))}{\left(1 - \frac{\sigma_{ur}}{\sigma_{uu}}\right)^{\frac{1}{2}}}\right)$$

Similarly,

$$\Pr(r_{it}^* > 0|\varepsilon_{it}^c) = 1 - \Phi\left(\frac{-W_{it}\bar{\alpha}_r - \frac{\sigma_{cr}}{\sigma_{cc}}(\tilde{I}_{it}^c - f(X_{it}, \bar{\alpha}_c))}{\left(1 - \frac{\sigma_{cr}}{\sigma_{cc}}\right)^{\frac{1}{2}}}\right)$$

Finally, I can write the overall likelihood function as

$$\begin{aligned}
&p(\tilde{I}_{it}, r_{it}|X_{it}, \alpha_c, \alpha_u) = \\
&\Phi\left(\frac{-W_{it}\bar{\alpha}_r - \frac{\sigma_{ur}}{\sigma_{uu}}(\tilde{I}_{it} - f(X_{it}, \bar{\alpha}_u))}{\left(1 - \frac{\sigma_{ur}}{\sigma_{uu}}\right)^{\frac{1}{2}}}\right) \frac{1}{\sigma_{uu}}\phi\left(\frac{\tilde{I}_{it} - f(X_{it}, \bar{\alpha}_u)}{\sigma_{uu}}\right) \\
&+ \left[1 - \Phi\left(\frac{-W_{it}\bar{\alpha}_r - \frac{\sigma_{cr}}{\sigma_{cc}}(\tilde{I}_{it} - f(X_{it}, \bar{\alpha}_c))}{\left(1 - \frac{\sigma_{cr}}{\sigma_{cc}}\right)^{\frac{1}{2}}}\right)\right] \frac{1}{\sigma_{cc}}\phi\left(\frac{\tilde{I}_{it} - f(X_{it}, \bar{\alpha}_c)}{\sigma_{cc}}\right)
\end{aligned} \tag{17}$$

4 Data

To estimate the model I use firm-level data from the Ukrainian industrial register in 1993-1998. In addition to directly observable capital, investment, labor, sales, and output variables, empirical specifications require controlling for the marginal profitability of capital. To obtain this information for each of the narrowly defined 5-digit subindustries within broader 2-digit industries, I estimate the equation

$$va_{ijt} = a_{0jt} + a_{1jt} K_{ijt} + \omega_{ijt}$$

where va_{ijt} stands for value added reported by the firms in 5-digit subindustry j in period t. Note that coefficients are allowed to vary both across industries and over time and are identified from cross-sectional variation within each of the 5-digit sub-industries.[4] Then estimated coefficients $\hat{a}_{1jt}$ are used as a proxy in place of marginal profitability of capital. Table 1 summarizes data on the number of firms within each 2-digit industry and some of their characteristics.

Table 1: Summary statistics by industry, 1993-1998

Variable	# firms	# 5-digit industries	Average $\hat{\varphi}$	Average State Share	Average Cap.Util.
Power	334	21	0.035	0.88	0.87
Ferr. Metallurgy	120	12	0.039	0.45	0.66
Chemical	159	34	0.067	0.34	0.69
Machinery	1286	136	0.022	0.41	0.58
Woodworking	263	21	0.021	0.43	0.59
Const. materials	733	48	0.018	0.31	0.67
Light	553	39	0.022	0.19	0.70
Food	1844	36	0.076	0.25	0.71

Table 2 represents detailed summary statistic of key variables.

5 Results

The first empirical specification was estimated using the simplex method of optimization.[5] Results of the estimation are presented in Table 3.

[4]When a sub-industry contains few firms, I assume that marginal profitability of capital is the same as average for more aggregated 3-digit industry.

[5]ML function was found to be not globally concave and I used a grid search over a range of starting values.

Table 2: Summary statistics, 1993-1998

		Capital, USD 1995		
Industry	Min	Max	Average	St.Dev.
Power	21,068	438,026,071	13,071,200	26,063,764
Ferrous Metallurgy	192,685	331,883,801	27,840,167	51,498,904
Chemical	5,790	166,424,206	10,996,869	25,016,524
Machinery	1,287	128,206,878	2,758,785	7,328,929
Woodworking	3,866	14,598,295	727,377	1,424,829
Construction materials	1,323	25,450,051	1,108,804	2,062,392
Light	903	23,558,580	724,546	1,961,364
Food	462	220,705,018	663,964	2,571,917
		Investment, USD 1995		
	% of 0	Max	Average	St.Dev.
Power	0.9	5,293,876	62,194	240,867
Ferrous Metallurgy	3.5	1,544,827	77,302	175,368
Chemical	11.3	2,268,459	28,431	140,089
Machinery	18.4	1,744,077	5,032	32,083
Woodworking	26.3	189,097	2,177	10,840
Construction materials	22.2	337,219	2,845	13,859
Light	26.2	732,516	2,026	19,787
Food	13.0	1,564,619	5,569	35,688
		Output, USD 1995		
	Min	Max	Average	St.Dev.
Power	2,485	661,377,035	21,359,056	49,391,461
Ferrous Metallurgy	17,815	1,139,257,784	56,586,139	129,795,282
Chemical	2,131	337,937,832	12,510,262	33,647,613
Machinery	468	138,850,171	3,032,067	8,774,947
Woodworking	982	72,512,437	1,517,765	4,861,674
Construction materials	504	46,343,407	1,446,167	3,447,403
Light	566	43,150,293	1,204,703	2,951,759
Food	433	114,379,035	2,553,983	5,469,708
		Labor units		
	Min	Max	Average	St.Dev.
Power	39	8,166	1,732.19	1,312.54
Ferrous Metallurgy	31	33,541	3,195.95	4,868.65
Chemical	29	13,625	1,334.39	2,243.30
Machinery	5	148,720	978.63	2,685.28
Woodworking	33	3,655	410.67	484.70
Construction materials	14	4,053	335.22	420.14
Light	18	10,728	519.40	667.54
Food	15	3,410	237.10	260.29

Table 3: Estimation results (empirical specification 1), 1993-1998

	Power	Ferr Met	Chemic	Machin	Wood work	Const Mat	Light	Food
b	4.14	10.91	7.17	5.50	2.98	3.02	1.54	2.41
(s.e.)	(.11)	(1.48)	(1.44)	(.09)	(.42)	(.07)	(.05)	(.04)
DF	1.208	.999	1.130	1.166	1.126	1.146	1.190	1.195
(s.e.)	(.012)	(.001)	(.031)	(.008)	(.018)	(.008)	(.013)	(.005)
s	.896	.990	.197	.182	.178	.333	.648	.220
(s.e.)	(.026)	(.446)	(.048)	(.003)	(.022)	(.009)	(.018)	(.004)
γ	.0003	.210	.0025	.0014	.0012	.002	.001	.0014
(s.e.)	(.0001)	(.023)	(.0001)	(.0000)	(.0000)	(.0001)	(.0002)	(.000)
σ_c	.0032	.029	.0009	.0007	.0006	.0011	.0023	.0033
(s.e.)	(.0001)	(.001)	(.0001)	(.0000)	(.0001)	(.0000)	(.0000)	(.0000)
σ_u	.0665	.0018	.072	.108	.109	.112	.162	.120
(s.e.)	(.0013)	(.0001)	(.010)	(.001)	(.010)	(.002)	(.006)	(.001)
E[P(c)]	0.79	0.40	0.61	0.63	0.66	0.68	0.78	0.76
f-val	-3.57	-3.76	-3.87	-4.06	-4.17	-3.85	-3.70	-3.31
# obs	1,641	600	795	4,560	1,315	2,387	1,627	9,220

As can be seen from Table 3, all coefficients are statistically significant and have the expected signs. Parameter b is a multiplier in the adjustment cost function. Ferrous metallurgy and chemical industries have the highest estimates of the parameter. The lowest values were found for light, food processing and woodworking industries. Given that b affects the cost of changing capital stock, ranking of industries in terms of its values appears reasonable. In particular, it is conceivable that woodworking, construction materials, and food processing firms have similar capital intensity of production technologies and hence fairly close estimates of the parameter.

The real discount factor, $DF = \dfrac{1}{(1-\delta)\beta}$ is positive and slightly greater than 1 for all industries, but ferrous metallurgy.

Parameter s stands for the fraction of own profits redirected for fixed capital investment purposes. The highest proportion of own profits is reinvested by firms in the ferrous metallurgy and power industries. Firms in woodworking, machinery and chemical industries have the lowest parameter values.

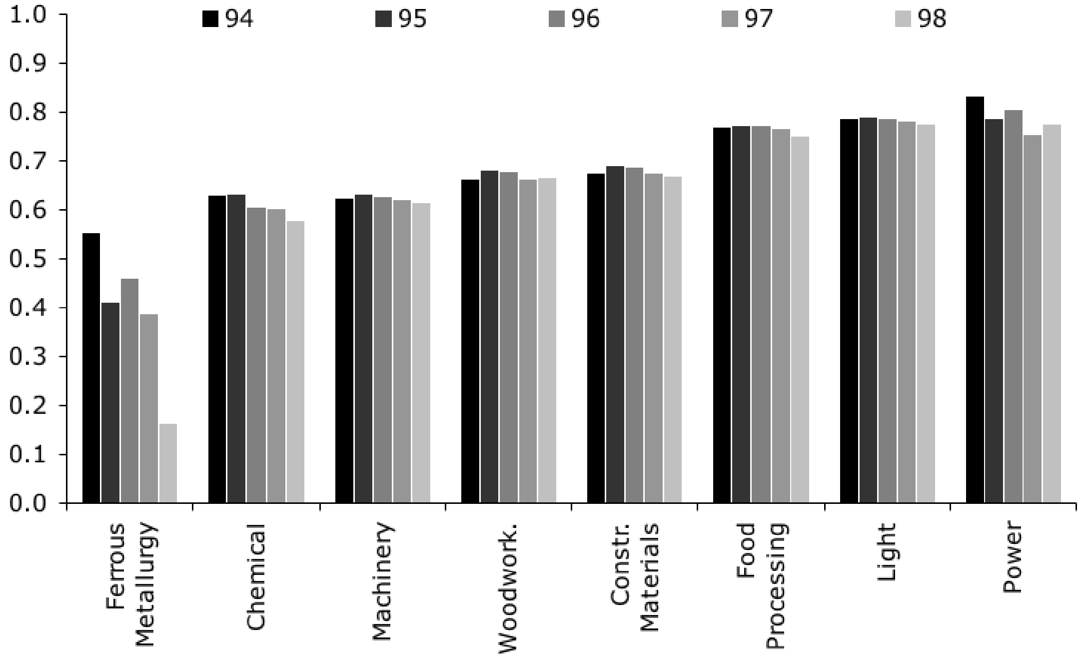
Parameter γ could be interpreted as significance of the observed cash flows for attracting outside funds when firms operate in a constrained regime, i.e. $\gamma = \dfrac{\partial A_{it}}{\partial y_{it}}$ from (4). The lowest values for power and light industries seem to be consistent with their institutional environment. Most of the firms in the power industry were state-owned between 1993 and 1998. Under state management observed cash flows were less important, since most of the investments were financed by the government or by reinvesting own profits. This is consistent with the estimate of parameter s for power industry, which is second highest in the manufacturing sector (0.896). For the light industry there exists well-documented evidence that about 90 percent of revenues were generated via toll (give-and-take-row-materials) schemes. Low transparency of operations and in-kind payments for inputs and outputs do not convey much information about the financial creditworthiness of firms. This lack of transparency could not be helpful in attracting external resources for investment. Surprisingly, a high value of the parameter for the ferrous metallurgy may also be related to this industry specificity. Ferrous metallurgy in Ukraine is one of the major export-oriented industries. Export operations typically require adopting better accounting standards and are conducted in foreign currency. Therefore, in ferrous metallurgy observed cash flows are reasonably good signals of the firms' value and should be important for outside lenders/investors.

Overall, estimates of the structural parameters seem to be consistent with known institutional peculiarities of the Ukrainian manufacturing sector.

An important feature of the main empirical specification is the ability to evaluate the probability of constrained regime for each firm in every time period. Figure 1 summarizes such information. Industries are ranked from the least (left) to the most constrained (right) as suggested by the estimates of mean probability of operating in a constrained regime. For each industry, five bars represent mean constrained probability in a given year.

Ferrous metallurgy appears to be the least (0.4), while power (0.79) and light (0.78) are the most constrained industries. A low level of financial constraints in the ferrous metallurgy is consistent with the export orientation of the firms, which generate transparent and stable cash inflows providing a good signal of the firms' creditworthiness. It is worth noting that Ukrainian exporters typically receive government guarantees, which may

Figure 1: Probability of constrained regime across industries, average 1993-1998



further attract investors.

In the power sector a high degree of financial constraints may be a consequence of state ownership playing a particularly harmful role for the industry, which provides essential services to residential and industrial customers. On the one hand, overwhelming domination of state ownership does not help in attracting private investment leaving own profits as the primary source for investment as discussed above. Apparently, these funds were insufficient to generate optimal capital accumulation pattern. On the other hand, by directly interfering with management decisions government authorities were able to implicitly subsidize large groups of consumers by repeatedly restructuring their debt arrears. Nontransparent barter transactions in the light industry were the most likely reason for the difficulties associated with attracting outside investors forcing managers to rely primarily on their own resources.

The significant probability of constrained regime in the food processing industry is puzzling. Frequent administrative interventions by the Ukrainian government may partially explain the low investment attractiveness of the food processing firms for the outside investors. Over the sample period, government often introduced price regulation for the most socially sensitive groups of food products. In fact, considerable investment activity in the food processing industry began in 2000 and 2001 primarily due to the foreign firms seeking better access to the Ukrainian markets.

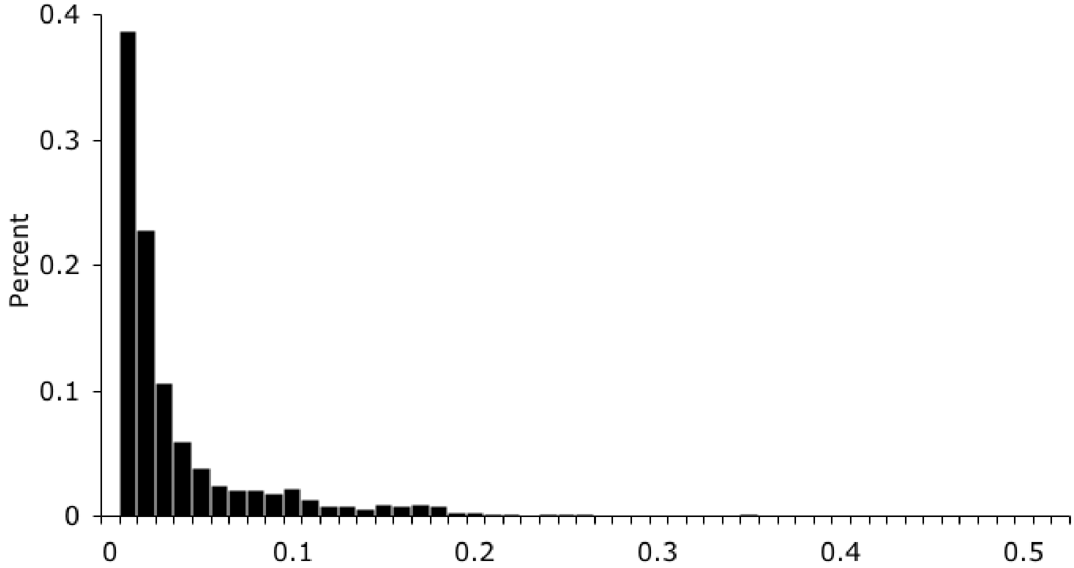
The most progress in reducing financial constraints was achieved in the ferrous metallurgy, which is not surprising as many firms in this industry were considered as the most financially viable over the entire transition period. The considerable variation of the probability of constrained regime over time in the power sector may be related to the iterative restructuring attempts undertaken by several governments in 1994-1998. The problems of non-payments by the residential sector has resulted in significant debt arrears accumulated over previous years. The situation was aggravated by the absence of effective bankruptcy law enforcement. This have attracted attention of several international and Ukrainian think-tanks. Unfortunately, the declaration of new reforms and restructuring programs was typically followed by fairly modest success in their actual implementation, thus, causing waves of positive expectations and disappointment among investors and firms' management.

Overall, the probability of operating in a constrained regime was very high for the entire Ukrainian manufacturing sector. When we compare changes over time there was slight progress in reducing restrictions on firms' investment.

An important question is whether the individual probabilities of constrained regime varied considerably over time. Intuition suggests that a firm's access to financial resources is unlikely to change significantly on an annual basis as it typically takes longer to establish a reputation. It is also known that the supply of external financial resources in Ukraine was persistently low. In the empirical specification of the model I do not impose any restrictions on the evolution of individual probabilities over time. Therefore, I can use estimates of the individual probabilities to address the question. Standard deviations of the estimated probabilities of a constrained regime for each firm in the sample are represented by the histogram on Figure 2.

According to Figure 2, about 92 percent of firms have standard deviation of estimated probabilities below 0.1. Hence, the vast majority of firms in the Ukrainian manufacturing sector faced by stable financial constraints in 1993-1998, which is consistent with the

Figure 2: Histogram of standard deviations for estimated probabilities, 1994-1998



aggregate statistics from Figure 1.

Estimates of the individual probabilities of a constrained regime provide an opportunity to study properties of the constrained and unconstrained firms. I used available data to investigate the relationship between the firms' characteristics and the estimates of the probability of financial constraints. In particular, I use the following specification

$$\widehat{\Pr}(const)_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 \hat{\varphi}_{it} + \beta_3 LP_{it} + \beta_4 \Delta L_{it} + \beta_5 CU_{it} + \beta_6 STSH_{it} + \sum_{j=6}^{9} \alpha_j d_t + \sum_{r=10}^{16} d_{ind} + \omega_{it} \tag{18}$$

where

- K_{it} is firm-level capital stock, normalized by its maximum value in the industry.
- $\hat{\varphi}_{it}$ is marginal profitability of capital, estimated at the 5-digit industry level.
- LP_{it} is labor productivity computed as output per unit of labor, normalized by its maximum value in the industry.
- ΔL_{it} is the percent change in the labor force from the previous year.
- CU_{it} is the level of capacity utilization.

- $STSH_{it}$ is the share of state ownership.
- d_t is time dummy.
- d_{ind} is industry dummy.

The results of the estimation are presented in Table 4. Note that the reported coefficients are rather correlation coefficients than parameters having causal interpretation.

Table 4: Properties of constrained firms, 1993-1998

Variable	Estimated Pr(*constrained*)	
	2-dig dummies	5-dig dummies
Capital stock	-0.016	-0.018
(s.e.)	(0.002)	(0.003)
$\hat{\varphi}_{jt}$	0.103	0.090
(s.e.)	(0.008)	(0.011)
Labor productivity	0.041	0.101
(s.e.)	(0.036)	(0.043)
Labor change	0.069	0.061
(s.e.)	(0.038)	(0.038)
Capacity utilization	0.006	0.005
(s.e.)	(0.002)	(0.002)
State share	-0.040	-0.112
(s.e.)	(0.015)	(0.017)
year 1995	-0.004	-0.005
(s.e.)	(0.002)	(0.002)
year 1996	-0.006	-0.015
(s.e.)	(0.002)	(0.003)
year 1997	-0.023	-0.037
(s.e.)	(0.003)	(0.004)
year 1998	-0.039	-0.055
(s.e.)	(0.004)	(0.004)
industry dummies	yes	yes
R^2	0.67	0.69
Number of obs	15,587	15,587

As expected, larger firms (in terms of their capital stock) face a smaller estimated probability of constrained regime. The marginal profitability of capital and labor productivity are both positively related to the probability of constrained regime. Increases in the labor force has positive correlation with the constrained regime probability most likely because firms may substitute for suboptimal capital investment by increasing the labor force. Firms with a higher capital utilization rate appear to be more constrained, which is intuitively appealing.

State ownership seems to be negatively related to the probability of financial constraints. One possible explanation is that unlike in the power industry, where state ownership on average was about 88 percent, in other industries most of the state-owned firms are rather larger firms that were considered to have strategic significance (therefore, not privatized) and, hence, eligible for state aid. Besides, in other industries, unlike in the power sector, government does not have such strong incentives to subsidize consumers by directly affecting management decisions.

Overall, the results in Table 4 are consistent with the hypothesis that it is smaller and fast growing firms who are most likely to be financially constrained in their investment decisions.

To further explore the importance of financial variables for the firm-level investment decisions, I estimated a second empirical specification, where the firms are 'selected' into a particular regime based on an explicit selection equation. In particular, I assume that the selection equation (15) is given by specification (18) above, i.e. $W_{it} = (K_{it}, \hat{\varphi}_{it}, LP_{it}, \Delta L_{it}, CU_{it}, STSH_{it}, d_t, d_{ind})$. Recall that regime equations (13) and (14) are represented by empirical version of Euler equation (12).

One clarification of the coefficients in the selection equation is necessary. Positive coefficients in the selection equation imply that an increase in the corresponding variable would increase the probability of the facing a constrained regime, while negative coefficients indicate that an increase in relevant variable reduces probability of observing constrained regime. Table 5 summarizes estimation results.

Estimation results for the second empirical specification are consistent with the ones obtained using the original structural model. In particular, larger firms are less likely to be financially constrained. State ownership has the same effect. It is associated with a lower probability of constrained regime. Characteristics of fast growing firms, like marginal profitability of capital, labor productivity and higher capacity utilization rates are all

Table 5: Estimation results (empirical specification 2), 1993-1998

	Selection equation	Regime	
		Constrained	Unconstrained
Constant	-1.077	0.0004	0.0148
(s.e.)	(0.111)	(0.0000)	(0.0007)
Size	-0.755		
(s.e.)	(0.036)		
$\hat{\varphi}$	0.961		
(s.e.)	(0.070)		
Labor productivity	1.397		
(s.e.)	(0.029)		
Labor change	0.007		
(s.e.)	(0.0004)		
Capacity utilization	0.331		
(s.e.)	(0.016)		
State share	-0.061		
(s.e.)	(0.144)		
$\tilde{I}$		0.006	0.270
(s.e.)		(0.002)	(0.066)
$\tilde{I}^2$		0.755	-0.332
(s.e.)		(0.006)	(0.219)
$\tilde{y}_1$ $(Sales_{it}/K_{it})$		0.0002	-0.0006
(s.e.)		(0.0000)	(0.0002)
$\tilde{y}_2$ $(Output_{it}/K_{it})$		0.0001	0.0005
(s.e.)		(0.0000)	(0.0001)
Time dummies	Yes	No	No
Industry dummies	Yes	No	No

associated with operating in a constrained regime. Firms that experience larger growth in labor force are more likely to be constrained.

There is considerable difference in the coefficients of the regime equations. As expected, the coefficient on the cash flow variable ($\tilde{y}_1$) (sales divided by capital stock), is positive and statistically significant for the firms classified as constrained. Surprisingly, firms operating in an unconstrained regime have a negative and statistically significant coefficient on the proxy variable for cash flows, while one could expect this coefficient to be not significantly different from zero. The results for an additional specification for regime equations that includes the level of sales variable normalized by its maximum value at industry level is presented in Table 6. The coefficients on both the new variable 'Sales' and old proxy for cash flow $\tilde{y}_1$ appear to be positive and statistically significant for the constrained group of firms. For the unconstrained firms, the proxy for cash flows is still negative, while coefficient on the variable 'Sales' is no longer significantly different from zero.

In addition to the aggregate regression specifications in Tables 5 and 6, I run similar regressions at the industry level. The results on cash flow and 'Sales' variables for each industry are listed in Table 7.

The industry-level estimation results are consistent with the predictions from the aggregate specification. Both proxies for cash flow $\tilde{y}_1$ and $Sales$ have positive coefficients for constrained firms. Unconstrained firms in most cases have a negative coefficient on y_1, which is sometimes not statistically significant. This is the same puzzling result as was found at aggregate level. Coefficients on $Sales$ are rarely statistically significant.

Overall, estimation results for the regime-switching specification with explicit selection equation are consistent with the literature, which finds that cash flow variables are more important for financially constrained firms.

6 Conclusions

In this study I develop and estimate a model of firm level fixed capital investment when access to the external financial resources may be limited and retained earnings may be

Table 6: Estimation results (empirical specification 2), 'sales' variable in level included, 1993-1998

	Selection equation	Regime	
		Constrained	Unconstrained
Constant	-0.993	0.0004	0.0143
(s.e.)	(0.112)	(0.0000)	(0.0008)
Size	-0.886		
(s.e.)	(0.037)		
$\hat{\varphi}$	0.941		
(s.e.)	(0.070)		
Labor productivity	1.368		
(s.e.)	(0.029)		
Labor change	0.007		
(s.e.)	(0.0004)		
Capacity utilization	0.325		
(s.e.)	(0.016)		
State share	-0.141		
(s.e.)	(0.145)		
$\tilde{I}$		0.0026	0.2717
(s.e.)		(0.0017)	(0.0663)
$\tilde{I}^2$		0.7663	-0.3358
(s.e.)		(0.0059)	(0.2191)
$\tilde{y}_1$ $(Sales_{it}/K_{it})$		0.0002	-0.0006
(s.e.)		(0.0000)	(0.0002)
$\tilde{y}_2$ $(Output_{it}/K_{it})$		0.0001	0.0005
(s.e.)		(0.0000)	(0.0001)
Sales		0.0013	0.0053
(s.e.)		(0.0001)	(0.0054)
Time dummies	Yes	No	No
Industry dummies	Yes	No	No

Table 7: Estimation results (empirical specification 2), 'sales' variable in level included, industry-specific, 1993-1998

	Power		Ferrous Metallurgy	
	Constrained	Unconstrained	Constrained	Unconstrained
$\tilde{y}_1$	0.00005	-0.00087	0.00071	-0.00504
(s.e.)	(0.00003)	(0.00038)	(0.00008)	(0.00297)
Sales	0.0018	0.01345	0.00139	-0.03392
(s.e.)	(0.00045)	(0.01787)	(0.00036)	(0.0491)
	Woodworking		Construction Materials	
$\tilde{y}_1$	0.00006	-0.00154	0.00019	-0.00124
(s.e.)	(0.00002)	(0.00211)	(0.00003)	(0.00174)
Sales	0.00036	-0.00038	0.00088	0.00436
(s.e.)	(0.00018)	(0.02071)	(0.00013)	(0.01463)
	Chemical		Machinery	
$\tilde{y}_1$	0.00033	-0.00196	0.00015	-0.0011
(s.e.)	(0.00007)	(0.00149)	(0.00001)	(0.00103)
Sales	0.00167	0.05075	0.00065	-0.00969
(s.e.)	(0.00023)	(0.02577)	(0.00006)	(0.00453)
	Light		Food Processing	
$\tilde{y}_1$	-0.00003	-0.00151	0.00029	-0.00087
(s.e.)	(0.00001)	(0.00062)	(0.00002)	(0.0003)
Sales	0.00073	0.00911	0.00341	0.01745
(s.e.)	(0.00012)	(0.0075)	(0.00057)	(0.01618)

insufficient to secure optimal investment choice. Under a set of assumptions I show that observed investment is given by the minimum of optimal and affordable amounts. Structural parameters of the model are estimated using regime switching regression with unknown sample separation and without an explicit selection equation. To estimate structural parameters of interest I use data from the Ukrainian manufacturing register in 1993-1998. In addition to the main empirical specification I estimate an alternative model where sample separation is governed by an explicit selection equation. Estimation results from both models are consistent with each other.

The overall level of financial constraints in the Ukrainian manufacturing sector in 1993-1998 was very high. Firms faced a 65 percent probability of operating in a constrained regime on average. The average probability of financial constraints varies across industries from a low of 39 percent to a high of 79 percent. The financial constraints relaxed slightly over the time period. Variation in the estimates of structural parameters and implied probabilities are consistent with known peculiarities of the institutional environment in the industries under consideration. Cross-industry analysis reveals that the least constrained industry is ferrous metallurgy. Power sector has the highest degree of financial constraints. According to the estimation results, small fast growing firms are more likely to be financially constrained. This finding is in line with the results of the earlier literature on firm level fixed capital investment.

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