A Working Capital Theory of the Firm with Empirical Evidence

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Economics)
in The University of Michigan
2010

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This dissertation is dedicated to my mother, and father.

ACKNOWLEDGEMENTS

I am grateful to Albert Park, Dan Silverman, Jim Levinsohn, Jan Svejnar, Chris House and Andrei Levchenko for their advice, as well as Mary Hallward-Driemeier at DECRG, World Bank for data and institutional background. I would particularly like to thank Andrew Coleman for putting me on this exciting and relevant research path as well as Margaret Levinson for her mentorship and care. Three key people also contributed to enormously during the dissertation stage: Sara Lalumia, Mine Senses and Christopher Kurz. I would also like to thank the following people for their insightful comments and encouragement throughout the revisions: Aneeqa Aqeel, Oli Coibon, Jane Dokko, Rahul Mukherjee, Joo Youn Park, Bill Powers, Bob Rijkers, Fernanda Ruiz Nunez, Heidi Schierholz, Ashley Taylor and Lina Walker. A special thanks goes out to the seminar participants at the Universities of Michigan, Melbourne and the Minnesota International Economic Development Conference and the World Bank FPD and PREM network for their valuable input. I am also grateful for the support, mentorship and advice from Shanta Devarajan. All errors are my own.

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CHAPTER I

Introduction

A key assumption made in the standard theory of the firm is that there is no time difference between when costs are incurred and when revenue is received. This assumption is valid only under the assumption of perfectly functioning financial markets. However under imperfect financial markets, such as those that exist for the majority of developing economies, this assumption fails to capture the need for liquidity and therefore does not fully capture the effects of financial constraints on the dynamic behaviour of the firm. This dissertation formalizes a working capital theory of the firm that captures the effects of financial constraints on the behavior of the firm that the standard theory of the firm would otherwise not capture. The first chapter develops the working capital model of the firm and show that under very few assumptions, the dynamic model is easily tractable to a static solution. The model predicts that under financial constraints, firms would exhibit countercyclical investment behavior. Furthermore constrained firms are constrained particularly during times when there are positive price shocks and as such, this has large implications for growth. These predictions are supported by empirical analysis using a unique panel of Bangladeshi firms. The second chapter extends the working capital theory of the firm to examine the implications of financial constraints on exports. Exporting requires greater liquidity demands due to greater transport time. As such, the model shows that the established relationship between exporting and productivity differs under financial constraints. The result shows that export status is less dependent on productivity and more dependent on the availability of working capital when firms are constrained, and this is supported by empirical analysis and results. The third chapter utilizes the difference in the behavior between financially constrained and non-constrained firms to examine the effect of bribes on firm growth. Results suggests that a one-percent point increase in bribe payments will reduce the growth of financially constrained firm growth by 0.0007 percent, or 0.0002 percent in semi-annual growth. The interaction between financial constraints and bribes suggest that bribes can be distortionary even when bribes act as fixed costs. These results imply that corruption alone may not be detrimental to firm growth but when combined with limited access to finance, the cost of corruption seriously hampers the growth of firms.

CHAPTER II

Financial Constraints, Working Capital and the Dynamic Behavior of the Firm

2.1 Introduction

Financial constraints are a prevailing problem facing firms in developing countries where capital is scarce and financial institutions are underdeveloped.[1] The World Bank Investment Climate Surveys, covering more than 26,000 firms across 53 developing countries, find that the cost and access to finance[2] is considered by firms to be among the top 5 problems they face (Hallward-Driemeier and Smith (2005)). The functioning of financial markets and the availability of credit affect the ability of firms to grow. They also influence the firms' incentives to hire labor and invest, which in turn affect economic growth and poverty reduction.

An often ignored mechanism by which financial constraints can affect the firm is working capital. Working capital is needed to cover costs of operations before revenue is received. For example, the farmer needs to purchase seeds and fertilizer before his crop is harvested, the garment maker must buy fabric and pay workers before delivering the cloth-

[1] Constraints to external finance may arise due to a number of factors: credit market imperfections, scarcity of financial resources, volatile environments or the lack of contract enforcement mechanisms. (Stiglitz & Weiss(1981)).

[2] Cost to finance refers to the interest rate charged for loans. Access to finance refers to the need for collateral and the availability of loans.

ing and the stall owner must pay for produce before it can be sold. The need for working capital thus arise from the difference in the timing of when costs are incurred and when revenue is received. In some instances, financial arrangements can help overcome the timing problem, either through prepayment of accounts receivable (i.e. online shopping) or delayed payment of current liabilities (i.e. trade credit[3]), however the majority of production requires cash to purchase inputs before goods or services are delivered.[4]

Working capital accounts for a substantial proportion of firms' financial needs, particularly in developing countries. Working capital is therefore likely to be an important avenue by which financial constraints can affect firm behavior. Table 2.1 presents the amount of working capital relative to sales revenue held on average by a sample of firms in the US and in Bangladesh within similar manufacturing industries in 2002. Working capital is measured as the firms' net short term liquid assets: current assets (inventories, accounts receivable[5], cash and short term credit) minus current liabilities (accounts payable and any short term debt). On average, US firms hold approximately 22 percent of sales revenue as working capital while Bangladeshi firms hold on average 35 percent. Firms in Bangladesh rely more on non-cash working capital (mainly inventories) compared to US firms, which is consistent with less available credit. In Bangladesh, working capital is considerably greater than investment. The average cost of investment spending relative to sales is less than 5%.

Recent business cycle models of emerging economies have relied on working capital as a propagation mechanism to transmit interest rate shocks to real outcomes (see Neumeyer and Perri (2005); Oviedo (2004)). The responses to interest rate shocks are magnified in these models because the need for working capital imposes additional borrowing requirements. In these models, the firm is assumed to always borrow the entire cost of production. Internally generated revenue is not considered as a source of finance. My model incorpo-

[3]An interesting body of literature looks at the role of trade credit in financial development. See Fisman and Love (2004); Fisman (2001); Fisman and Love (2003); Burkart and Ellingsen (2004)

[4]In the 2003-2005 Bangladesh Panel Survey of Manufacturing Firms, the median percent of sales paid at delivery is 100 percent.

[5]Accounts receivable is money owed to the firm.

rates the option of internal finance. Accounting for the role of internal revenue is critical for understanding working capital, as the delay in revenue is the very mechanism that creates the need for working capital. Allowing for internally generated finance is also important considering that, empirically, the largest source of financing is from internal finance. This is particularly true for firms in developing countries. Amongst a sample of Bangladeshi manufacturing firms, approximately 75 percent of the financing of new investments and 60 percent of additional working capital come from internal funds (shown in Figure 2.1).[6]

Accounting for working capital and internal finance has real economic implications when financial constraints exist.[7] First of all, working capital directly affects the firm's decision making. A factory owner with limited cash must ration financial resources between purchases of different factor inputs at suboptimal levels. This alters the decision from one where finance is only needed for one factor. Second, working capital affects the firm's response to shocks when constrained. For example, if a credit constrained factory owner faces an increase in price for her output today, the urgency to increase output immediately to take advantage of the short-term profit opportunity will lead her to delay investment in order to purchase more production inputs. Third, working capital propagates the effects of financial constraints intertemporally through the accumulation of revenue. If poor firms cannot afford the inputs to produce at an optimal level, then revenue falls, limiting the ability to purchase inputs in the next period as well. As a result, financially constrained firms grow much more slowly and have lower expected profits. Not accounting for working capital understates the effects of financial constraints on the growth of the firm over time.

This paper has three goals. First, I extend the existing theory of firm behavior with financial constraints to allow delays in the receipt of revenue. This generates the need for

[6] In the US, Carpenter and Petersen (2002) has also found that small firms are constrained by internal finance.

[7] Although the need for working capital is observed in reality, the optimal behavior of the firm does not differ from a model without working capital when external credit is freely available to facilitate the intertemporal substitution required to solve the production timing problem. The only difference is that the cost of borrowing would enter additionally to the cost of purchasing inputs.

working capital. Although a large body of literature has looked at the effects of financial constraints on the firm, previous models start with the assumption that the firm requires financing for physical capital only [8], restricting *a priori* the effects to one factor of production and foregoing the possible allocation of finance between factors under financial constraints. This may be a reasonable starting assumption for firms in developed countries where short term credit is readily available but it is inappropriate for firms in developing countries where credit is scarce. Empirical studies have shown that firms facing financial constraints reallocate finances for working capital to smooth investment (Fazzari and Petersen (1993)). It is natural to ask what the reallocation of finances implies for production when funds are diverted away from short term purchases. In the model I develop, firms must choose between allocating cash for investment or for immediate production needs. Thus firms facing financial constraints need to trade off future production with present production in response to changes in production opportunities. Such substitution effects have been neglected by existing models.

The model produces an analytically tractable solution that characterizes the optimal constrained and unconstrained behavior of the firm. The results show that properly accounting for working capital and internal finance changes the predictions for firm behavior, especially those concerning the firm's response to demand shocks. Under financial constraints, the reallocation of financial resources between factors in response to shocks causes investment to be countercyclical. When current demand is high, constrained firms forgo investment to allocate scarce resources toward current production. When demand is low, firms produce less and have lower costs, relaxing the liquidity constraint and enabling them to allocate more resources to investment.

The model also describes the conditions under which firms would move between being constrained and unconstrained. Whether a firm is constrained depends on both its assets

[8] See Bond and Van Reenen (2007); Hubbard (1998); Love (2003); Lorenzoni and Walentin (2007); Tybout (1983); Whited (1992); Bigsten et al. (2005); Bloom et al. (2006); Bond et al. (2003); Bratkowski et al. (2000); Bond and Meghir (1994)

and on demand shocks. Financial constraints bind when firms wish to increase output but cannot finance a larger input bill. Firms may be unconstrained at moderate demand levels but become constrained when a higher than average demand shock occurs. As a result, output response to positive shocks is limited. Output response is not limited in response to negative shocks.

The key theoretical predictions of the working capital model are important as they imply that financial constraints limit output of constrained firms just when good production opportunities arise and cause constrained firms to disinvest just when investment should increase.

The second goal of this paper is to examine how financial constraints affect firm output, efficiency and growth over time when working capital is taken into account. I solve the model numerically and subject the model to simulated stochastic shocks over time to illustrate the extent to which financial constraints cause scale and production inefficiencies. Holding initial conditions and parameters constant across the working capital model and the standard investment model, simulations show that constrained firms on average produce 38 percent of optimal output versus the 60 percent predicted by a standard model.[9] Labor to capital ratios are higher than optimal under constraints and the costs of generating a dollar of revenue are higher for constrained firms than for unconstrained firms. These two factors create a loss in producer surplus; numerical results show that the constrained firm achieves on average only 8 percent of possible optimal profits. As firms must rely on internal finance to grow, the reduced profits substantially slow the growth of the firm over time. The time to reach maturity (in terms of being able to produce optimally) is estimated to be around 3 times longer than that predicted by standard investment models under the same financial constraints[10].

[9]The exact magnitude of the difference between models depends on parameter choice.

[10]Recall that a period references the time from production to receipt of revenue, i.e. turnover time. This would differ from industry to industry and may range from 30 days to a quarter or longer. For example, in construction the appropriate time frame of a period would be close to a year. For food manufacturing, a period may reference a month or a couple of weeks. Regardless of the time frame, numerical simulation shows, under standard parameterization, the working capital model predicts a longer time to maturity and

One of the empirical challenges in the literature has been to identify financially constrained firms. Many studies unsatisfactorily use endogenous firm characteristics such as size, outward orientation, or dividend payment as proxies to categorize affected firms (see Hubbard (1998)for review,Fazzari and Petersen (1993); Ganesh-Kumar et al. (2001)). My results suggest that firms' dynamic behavior can reveal whether they are credit constrained. Results also speak to the ongoing debate in the literature about whether investment cash-flow sensitivity indicate financially constrained firms(Kaplan and Zingales (1997, 2000); Fazzari et al. (1988, 2000); Fazzari and Petersen (1993))

Third, I take the model's predictions to the data by testing when constraints are likely to bind, and how investment and output of Bangladeshi manufacturing firms respond to demand shocks under financial constraints. The Bangladesh Survey Panel contains unique survey questions that enable me to estimate demand shocks at the firm level. I find strong empirical support for the model's predictions. Constraints bind when firms experience positive price shocks. This is consistent with the working capital model and in contradiction with the competing thesis that firms become more constrained during downturns.[11] There is evidence that investment of financially constrained firms is countercyclical. The output response to price shock is different for firms that are unconstrained and firms that are sometimes constrained.

The next section presents the working capital model of the firm and theoretical results. Section 2.3 illustrates the implications of working capital and financial constraints on long term growth by simulating the model over time. Section 2.4 outlines the estimation strategy and presents empirical results. Section 2.5 concludes.

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slower long run growth than the standard investment model.

[11] Accelerator model, such as Bernanke and Gertler (1989); Bernanke et al. (1996), borrowing is dependent on networth that decreases during downturns.

2.2 The Model

The introduction presented two key observations about firms in developing countries: working capital is an important component of financial requirements and internal finance is the primary source of finance. The model of the firm developed in this section captures both these components by introducing the demand for working capital due to a delay in the receipt of revenue. It is a partial equilibrium model designed to isolate the dynamic responses of the firm to output price or productivity shocks.

A representative firm seeks to maximize the present value of profits over an infinite horizon. The maximization problem is the following:

$$\max_{L_t, K_t} \quad E_t\left[\sum_{t=0}^{\infty} \beta^t \left(\beta P_t F(K_t, L_t) - wL_t - p^k I_t\right)\right]$$

$$s.t \quad wL_t + p^k I_t + b_t = P_{t-1}F(K_{t-1}, L_{t-1}) + (1+r)b_{t-1} \tag{2.1}$$

$$s.t \quad K_{t+1} = (1-\delta)K_t + I_t \tag{2.2}$$

$$s.t \quad b_t \geq bc$$

$$\lim_{t\to\infty} b_t = 0$$

$$K_0 \quad given$$

$$b_0 \quad given$$

The setup of the firm's maximization problem follows the standard dynamic model of the firm except for the delay in revenues. Production requires two factor inputs: capital and labor. Capital is a durable factor that brings a future stream of benefits. It evolves according to Equation (2.2). The depreciation rate, δ, is assumed to be less than one and time invariant. Labor is a short-term variable input that is perfectly elastically supplied. It can also represent raw materials, energy or other adjustable inputs.[12] At each time period, the firm chooses inputs to maximize the stream of expected profits subject to the budget

[12] There could also be other quasi-fixed inputs that share the characteristics of capital in the model.

constraint given by Equation (2.1), where bond holdings are denoted by b. The discount factor β is assumed to equal $\frac{1}{1+r}$. The price of investment, p^k, the wage, w, and the interest rate r are exogenous and time invariant.

Working capital is introduced via a one period delay in the receipt of revenue. The firm's profit, $\beta P_t F(K_t, L_t) - wL_t - p^k I_t$, discounts the value of revenue by one period due to the delay. The budget constraint, Equation (2.1), includes the revenue from last period's production $P_{t-1}F(K_{t-1}, L_{t-1})$ and thus takes into account of internally generated funds. The borrowing constraint bc is introduced as an exogenous parameter that can be any negative number including zero.[13] Capital has no adjustment costs and requires no time to install.[14] Capital stock can be re-sold at the prevailing market price. Thus, physical capital is assumed to be a liquid asset.[15] Firms can transfer financial resources across time through bonds or capital assets.

The only stochastic variable in the model is the output price given by P_t, where $P_t = \overline{P} + \varepsilon_t$ and $\varepsilon \sim (0, \sigma_\varepsilon)$ and is i.i.d. This variable may be interpreted alternatively as a technology shock or any exogenous shock that changes the value of output. The firm knows with certainty the price it will receive before input decisions are made. One can think of the firm as receiving orders for its product and signing contracts that set the price it will receive upon delivery of the order.[16] However, the firm faces uncertainty over the price

[13] Alternatively, limits to borrowing may be modeled through the cost of borrowing. However, I have chosen to depict borrowing constraints as a set amount because there is a tendency for firms in developing countries to be more constrained by access than by the cost of finance. Lacking in sufficient collateral, firms can rarely borrow as much as they wish at prevailing market interest rates. The borrowing constraint or the interest rate could also be modeled as endogenous to net worth or business cycles (such as Bernanke and Gertler (1989); Bernanke et al. (1996)). Although these alternative approaches would affect the likelihood of *when* constraints become binding, they do not take away from the key prediction of the firm's behavior *under* constraints as long as the working capital assumption holds (i.e the receipt of revenues are delayed)

[14] I explore a working capital model with one period time to build capital adjustment in another paper. The solution becomes forward looking -the choice of capital depends on the present returns to labor as well as the expected returns to labor and capital. When constraints are not binding, the model follows the same first order conditions as that of the Jorgenson model of investment. When constraints are binding, the behavior of the firm varies according to the magnitude of the shocks: encompassing precautionary savings behavior of cash during large negative shocks as well as the capital labor substitution as demonstrated by the model presented in this paper.

[15] This departs from the strict accounting definition of working capital (physical capital is not considered a current asset).

[16] If prices are not known, firms make all decisions based on expectations which are invariant to temporary

in future years. Table 2.2 shows the order in which production is undertaken and when revenue is received. Cash in hand is defined as the sum of revenue and bond holdings, $X_t = P_{t-1}F(K_{t-1}, L_{t-1}) + (1+r)b_{t-1}$.

2.2.1 Solution

To solve the infinite horizon maximization problem, I reformulate the problem as a Bellman equation. The budget constraint may be written in terms of cash in hand, X, that yields the transition equation of wealth over time: $X_{t+1} = (1+r)[X_t - w_tL_t - pkI_t] + P_tF(K_t, L_t)$ The cash in hand describes all of the financial resources available to the firm. The state variables are capital stock, K_{t-1}, and cash in hand, X_t. Control variables labor and capital are denoted as L_t and K_t. The associated Bellman equation is:

$$
\begin{aligned}
V(X, K_{-1}) = \max_{L,K} \quad & \beta P(\varepsilon)F(K,L) - wL - p^K(K-(1-\delta)K_{-1}) + \beta EV(X', K) \\
s.t. \quad & X' = P(\varepsilon)F(K,L) + (1+r)\left[X - wL - p^k(K-(1-\delta)K_{-1})\right] \\
s.t. \quad & X - wL - p^k(K-(1-\delta)K_{-1}) \geq bc
\end{aligned}
\tag{2.3}
$$

Denoting the multiplier in the borrowing constraint as υ^b , the first order conditions are the following:

$$
(\beta PF_L(K,L) - w)\left(1 + E\left[\frac{\partial V(x',P')}{\partial x'}\right]\right) = w\upsilon^b \tag{2.4}
$$

$$
\left(\beta PF_K(K,L) - p^k + \beta p^k(1-\delta)\right)\left(1 + E\left[\frac{\partial V(x',P')}{\partial x'}\right]\right) = p^k\upsilon^b \tag{2.5}
$$

Equations (2.4) and (2.5) show how the firm weighs the future value of cash $\left(1 + E\left[\frac{\partial V(x',P')}{\partial x'}\right]\right)$ against the shadow value of loosening the current period's borrowing constraint, υ^b, in its choice of factors. The solution can be simplified as follows: If υ^b equals zero, the firm is not constrained and input choices are governed by optimal conditions. If υ^b is nonzero, the firm is credit constrained in which case its behavior will be governed by constrained optimal conditions. We can then write the first-order conditions case-by-case:

---

shocks. Firms will only react to changes in their internal revenue or permanent changes in expectations.

Unconstrained:

$$\beta PF_L(K,L) = w \tag{2.6}$$

$$\beta PF_K(K,L) = p^k . \tfrac{(r+\delta)}{(1+r)} \tag{2.7}$$

L^* and K^* is the solution to the firm's maximization problem if and only if: Equation (4.1) and (4.2) hold and $x - wL* - p^k(K* - (1-\delta)K_{-1}) > bc$. Otherwise, the solution is given by Equations (4.3) and (4.4) below:

Constrained:

$$\tfrac{\beta PF_L(K,L)}{w} = \tfrac{\beta PF_K(K,L)}{p^k} + \tfrac{(1-\delta)}{(1+r)} \tag{2.8}$$

$$X = wL + p^k(K - (1-\delta)K_{-1}) + bc \tag{2.9}$$

Under non binding constraints, $X - wL^* + p^k\left(K^* - (1-\delta)K_{-1}\right) \geq bc$, the shadow value υ^b is equal to zero. The amount of cash in hand is irrelevant to the unconstrained optimal decision of the firm. Labor and capital are chosen such that the marginal product is equated to marginal cost as defined by Equations (4.1) and (4.2).

Under binding constraints, the firm cannot achieve optimal production and instead reach a constrained optimum. The firm needs to consider the expected benefits of cash the next period, $\left(1 + E\left[\frac{\partial V(x',P')}{\partial x'}\right]\right)$, along with the cost of binding constraints today, υ^b, when making factor input choices. As both the future benefit of cash and the present shadow value of cash enter the two first order conditions (Equation (2.4) and (2.5)), the ratio of the two conditions yields:

$$\frac{(\beta PF_L(K,L) - w)}{w} = \frac{\left(\beta PF_K(K,L) - p^k + \beta p^k(1-\delta)\right)}{p^k}$$

This ratio simplifies to Equation (4.3) above.

Note that even though the firm is optimizing dynamically, the forward looking terms cancel out and current actions can be described independently of expectations, which yields an analytically tractable solution. Under constraints, the firm need only compare the present opportunity cost of funds, w and p^k, and the relative returns, $(\beta PF_L(K,L) - w)$ and $\left(\beta PF_K(K,L) - p^k + \beta p^k(1-\delta)\right)$ between the two factors. The relative returns, that are the factor returns net of cost, are greater the further away factors are from optimal levels. The second first order condition is the binding cash constraint (Equation (4.4)).

The model's solution is unique as it provides the first order conditions for optimal *constrained* behavior of the firm. The solution is simplified as the return from production for constrained firms is strictly greater than the return from saving the money; so that by maximizing current profits, the firm is also maximizing future profits. (Constrained firms produce below optimal where marginal returns are higher than marginal cost). Not only is the return high for both inputs, but capital can also be sold and transformed into cash the next period.

2.2.2 Theoretical Predictions

One feature of the working capital model is that finance is needed for more than one factor of production. Under constraints, the firm is forced to choose between factors in its allocation of scarce cash, leading to countercyclical capital behavior. The substitution between factors is driven by binding constraints and changes in output price and not by changes in relative factor prices. These dynamics are unique to the working capital model and are not accounted for by standard investment models with financial constraints.[17] The working capital model also ties output demand to the demand for finances by the firm. As such, whether financial constraints are binding depends on the level of output demand. For firms near the margin of being constrained, firms have sufficient resources to finance a limited range of price realizations but not for realizations beyond their resources. Thus,

[17] Appendix 2 elaborates on the contrast between the working capital model and the standard model.

constraints are more likely to bind when output price increases. Output response to shocks is therefore differentiated between increasing and decreasing price shocks as firms move into and out of constrained states.

The firm's choice of labor and capital is entirely described by the set of Equations (4.1), (4.2), (4.3) and (4.4) given initial state variables. The solution implies that the growth of the firm is characterized by three phases: 1) *Always Constrained Phase:* at very low levels of cash and capital stock, the firm will always be constrained regardless of the price; firm behavior is defined by the Constrained FOCS; 2) *Sometimes Constrained Phase*: at medium levels of cash and capital stock, the firm is unconstrained when price is low but may become constrained when price is high; firm behavior is governed by the Unconstrained FOCs for a low range of prices and then switches to the Constrained FOCS when credit constraints become binding; and 3)*Never Constrained Phase*: at high levels of cash and capital stock the firm is never constrained regardless of the price shock; firm behavior always follows the Unconstrained FOCS. I derive two testable theoretical predictions from the working capital model that distinguishes it from other models.

Capital Countercyclicallity Under Always Constrained Phase

The first proposition is that capital responds to shocks countercyclically when constraints are binding. That is, positive price shocks are associated with a decrease in capital. However, the opposite is true when financial constraints binds (from inspection of the optimal first order conditions). The formal proof of the result is as follows:

Proposition: Given constraints are binding, $x < wL* + p^k(K* - (1-\delta)K_0) - bc$, where $L*$and $K*$is the solution to Equations 4.1 and 4.2: the change in capital due to a change in price will be negative $\frac{dK}{dP} < 0$.

Proof: Fully differentiating Equations (4.3) and (4.4) with respect to the two choice variables,

L and K, and the parameter of interest P and X yields:

$$\frac{P}{w}\left[F_{LL}dL+F_{LK}dK\right]+\frac{F_L}{w}dP=\frac{P}{p^k}\left[F_{KL}dL+F_{KK}dK\right]+\frac{F_K}{p^k}dP \tag{2.10}$$

$$dX=wdL+p^k dK \tag{2.11}$$

Combine the two Equations (2.10) and (2.11) by substituting out dL yields the following:

$$\left(-F_{LL}\frac{p^k}{w}+F_{LK}+F_{KL}-F_{KK}\frac{w}{p^k}\right)dK = \left(\frac{F_{KL}}{p^k}-\frac{F_{LL}}{w}\right)dX+\left(\frac{w}{p^k}F_K-F_L\right)\frac{dP}{P} \tag{2.12}$$

$$\frac{dK}{dP} = \frac{\left(\frac{w}{p^k}F_K-F_L\right)}{P\left(-F_{LL}\frac{p^k}{w}+F_{LK}+F_{KL}-F_{KK}\frac{w}{p^k}\right)} \tag{2.13}$$

Equation (2.12) states that the total change in capital is decomposed into the change in cash, X , and the change in price, P. The change in capital due to the change in price can be expressed by Equation (2.13) as cash is predetermined and does not change due to price, $\frac{dX}{dP}=0$. The numerator is negative as Equation 4.3 rearranged is: $\frac{w}{p^k}F_K-F_L=-\frac{w(1-\delta)}{P}$. The denominator is positive as $F_{LL}<0$, $F_{KK}<0$ and $F_{KL}>0$. Thus $\frac{dK}{dP}<0$.

Capital behaves countercyclically under binding constraints due to two mechanisms. First, the difference between capital and labor as durable and non durable factors of production implies that the factors contribute differently to the next period's assets given by $PF(K,L)+(1-\delta)K$. Labor only contributes to the value of production whereas capital contributes to production *and* retains value after production for future use. A change in price alters the value of production but not the accumulated value. As a result, a current period price shock will affect the marginal rate of value substitution between labor and capital.[18] Secondly, a binding cash constraint forces the firm to choose between the two factors and thus consider

[18]Equation 4.3 can be rewritten as: $\frac{F_L}{F_K+\frac{(1-\delta)}{P}p^k}=\frac{w}{p^k}$. From inspection, a change in P changes the marginal rate of value substitution.

the marginal rate of value substitution.[19]

Figure 2.3 illustrates the changes to factor demand due to an increase in the price in LK space. Isovalue curves, like isoquants, depict the labor and capital combinations for the value that the factors generate, where value is defined as the sum of revenue and the depreciated value of capital: $PF(K,L) + (1-\delta)K$. The budget line is the cash constraint (Equation 4.4). The firm begins initially at point A where isovalue curve V1 is tangent to the budget line. An increase in the price enables the firm to produce the same output with relatively less labor than capital - the isovalue curve V2 becomes flatter. The new tangency point occurs at B and to the left of A where isovalue curve V3 lies tangent to the budget line.[20]

The reverse happens in response to a negative price shock. A decrease in demand decreases the marginal value of labor relative to the marginal value of capital. Firms do not adjust capital at the same rate as labor because the value of depreciated capital has not changed. The total change in capital, Equation (2.12), can be decomposed into an income effect, from the change in X, and a substitution effect from the stochastic changes in P. If the borrowing constraint was modeled as a function of net worth or the price, this will show up in Equation (2.12) as an additional term, i.e $dK = \Lambda dX + \Phi dP + \Omega dbc$. It follows that changes to the borrowing constraint act like an income effect that can accentuate or dampen the fundamental response to demand.[21]

[19] The ratio of the marginal rate of value substitution holds also for firms at the optimal. Unconstrained firms do not exhibit countercyclical investment behavior because they are able to increase both labor and capital in response to positive shocks due to non binding constraints. There, capital increases less relative to labor in accordance with the marginal rate of value substitution. To show that unconstrained firms also experience the same marginal rate of value substitution, the unconstrained optimal FOCs can be re- expressed as Equation (4.3). The capital FOC $\beta PF_K(K,L) = p^k.\frac{(r+\delta)}{(1+r)}$ is the simplified version of $\beta PF_K(K,L) + \beta p^k(1-\delta) = p^k$ where $p^k(r+\delta) = p^k(1+r) - p^k(1-\delta)$. Dividing labor FOC and the non simplified capital FOC will yield the result as Equation (4.3).

[20] This is holding cash in hand constant. Price changes are over time, and cash is invariant to price but varies with time. A change in cash would push the budget line out and the tangency point will expand likewise.

[21] For example, if the borrowing allowance increases with price, this is equivalent to an increase in cash - which is a change in income.

Asymmetric Output Response to Shocks

The response to price shocks described earlier is illustrated by Figure 2.2, which is calculated assuming a Cobb-Douglas production function, a borrowing allowance of zero and a specific set of parameters.[22] The first panel shows the behavior of a firm that has very low cash and capital and is always constrained. The last panel shows unconstrained optimal behavior. The middle panel shows the combination of the two when the firm switches from optimal to constrained behavior with increasing magnitudes of the price shock. In this example, the *Sometimes Constrained* firm has enough cash to afford optimal inputs at the mean price level equal to one. The firm is not constrained for shocks below the mean and becomes constrained for shocks above the mean. First, note in Figure 2.2, that as prove above, capital reacts countercyclically when firms are always constrained, but procyclically when never constrained.

The second proposition is that constraints bind with increasing price and as a result, output response to positive will be different from negative changes in the price. The asymmetry captured by the middle panel of Figure 2.2 is driven by constraints binding when the firm wants to expand production and not binding when the firm contracts. The left and right panels of Figure 2.2 clearly show that when firms are credit constrained, output is much less responsive to prices. Figure 2.4 illustrates the output response to a positive shock using isovalue curves and budget lines. Take two firms that are both producing optimally at point A in Figure 2.4. One firm is never financially constrained - it has ample internal finance or access to external credit. The firm uses the optimal amount of capital and labor to determine output. The other firm is on the margin of being financially constrained.[23] A positive shock shifts the isovalue curve outward and beyond the budget set of the credit constrained

[22] Here, the figure is intended to motivate the theoretical results. The choice of parameters is discussed in more detail in Section 2.3 when the model is simulated to examine output inefficiencies and the growth of the firm over time.

[23] The firm is limited in the sense that it can only just afford to produce optimally at point A where the shock level is equal to one. For any shock greater than one, the firm will be constrained, just as in the middle panel of Figure 2.2.

firm. While the firm without constraints can increase output to point NFC, the constrained firm can only increase as far as point FC. Thus, under positive shocks, the output of the credit constrained firm responds less than that of the unconstrained firm.

2.3 Loss in Producer Surplus, Inefficiency and Firm Growth

Financial constraints cause suboptimal input levels and distort the efficient relative factor ratio in response to shocks. Both of these effects contribute to lower output levels, leading to losses in producer surplus. As future production is dependent on revenue, the loss in profits in turn affects firm growth over time. The effects of financial constraints are magnified as working capital constraints become binding exactly when good production opportunities arise. I simulate the working capital model and the standard investment model using Matlab to illustrate the effects of financial constraints on output levels, efficiency, profits and long term firm value and growth.

The policy function is given by the first order conditions, Equations (4.1), (4.2), (4.3) and (4.4). A Cobb-Douglas production function $F(K_t, L_t) = K_t^{\alpha} L_t^{\gamma}$ is used where $\alpha + \gamma < 1$ to ensure a stationary solution. Parameters are set as follows: return on capital $\alpha = 0.30$, return on labor $\gamma = 0.60$, time discount factor $\beta = 0.9$ [24], rate of capital depreciation $\delta = 0.10$, standard deviation of the log price $\sigma = 0.1$, real interest rate $r = \frac{1}{\beta} - 1$, gross interest rate $R = \frac{1}{\beta}$, price of capital $p^k = 1$ and wage $w = 0.25$. The transitory shock is assumed to be lognormally distributed with a mean of one, that is $\ln P_{t+1} \sim N\left(-\frac{1}{2}\sigma^2, \sigma^2\right)$ where $E(\ln P_{t+1}) = -\frac{1}{2}\sigma^2$. This implies $E[P_{t+1}] = 1$). To generate average statistics, I simulate the model over 40 time periods with 1000 different simulated paths and 21 different values of the borrowing constraint bc (from 0 to 2000). This generates a total of 840000 observations for each model.

[24] Cooper Prescott and Miles assume $\beta \approx 0.96$

A first order effect of financial constraints is that output levels are restricted, $Q_c < Q^*$. I calculate the ratio between constrained outcomes and the optimal level (in accordance with the simulated path of shocks) to illustrate the average loss due to financial constraints. Table 2.3 shows that under the working capital model, when firms are in the *Always Constrained* phase they produce on average[25] only 38% of optimal output. During the *Sometimes Constrained* phase, they produce only 87%. In contrast, the standard model with constraints predicts that output will be 60% of the optimal level. Suboptimal output levels lead to lower profit levels. Under the working capital model with binding constraints, profits are only 8% of the optimal level. This is about half of the 15 percent predicted by the standard model. These results suggests that the opportunity cost of producing suboptimally due to financial constraints is much greater when working capital is taken into account.

The loss in producer surplus[26] due to suboptimal production is illustrated in Figure 2.5. The output of the 3 phases from Figure 2.2 is re-plotted with price on the y-axis and quantity on the x-axis to show the difference in supply between phases. Given price, P, the loss in producer surplus is defined by the triangular shaped area bounded by constrained supply, unconstrained supply and price. This loss is attributed to the firm producing at output level which are not profit maximizing, or analogously, not cost minimizing. Financial constraints restrict firms from producing at minimum cost and inefficiencies arise due to producing below scale and additionally, due to factor composition. Table 2.4 summarizes the cost per dollar of revenue and the labor to capital ratios. Compared to the unconstrained case, the cost of producing one dollar of revenue is around 15 percent higher under binding constraints, and 10 percent under sometimes constrained for the working capital model. Also, the labor to capital ratio is 20 percent higher than the unconstrained optimal ratio. Note that these ratios are not directly comparable to the standard capital adjustment model as the firm's optimization problem differs in capital choice.[27] These results illustrate that finan-

[25]Averages are taken over all values of the borrowing parameter.

[26]There is also a loss in consumer surplus due to suboptimal supply. I emphasize producer surplus because I model the behavior of firms.

[27]Under the standard model, financial constraints effect only capital accumulation (and labor is always at

cial constraints causes inefficiencies due to non cost minimizing input levels and distorted factor ratios.

The losses in output and profits informs us about the static losses caused by financial constraints. Dynamically, the loss in profits persists over time as output determines revenue, which in turn affects production possibilities the next period. As a results, the growth of the firm is hampered and the time to maturity becomes extended. Here, maturity is defined as state where the firm is able to produce optimally scale in response to shocks. The longer the firm remains constrained, the greater the losses in the long term value of the firm.

The growth path of the firm is simulated starting at the same initial conditions with no credit available and is illustrated in Figure 2.6. The standard capital adjustment model growth path, the far left line, is much steeper that that of the working capital model, the dotted line. As expected, the working capital model predicts a much slower long run growth path than the standard model. In the same figure, the effect of a positive and a negative shock of two standard deviations introduced at period ten on the growth path of the working capital model is shown. A positive shock puts the firm on a higher growth path and a negative shock puts the firm on a lower path resulting in a longer time to maturity.[28] This suggests that under financial constraints, the growth path of the firm will be much more variable in a stochastic environment.

Another indicator for the long run growth rate of the firm is the time to maturity. The longer the time taken, the slower the rate of growth. Maturity for the standard model can be easily identified as the steady state capital level. After reaching this level, the firm can fully

optimal relative to capital stock and shocks). Constrained firms invest more relative to unconstrained firms as capital is below steady state. This causes the cost per revenue dollar under constraints for the standard model to be higher than that of the working capital model. Under the working capital model, both capital and labor are below the unconstrained optimal and therefore the firm cannot devote resources to accumulate capital. The differences in the optimization problem between the two models is also reflect in the labor to capital ratios. For the standard model firms under constraints have a smaller labor to capital ratio than unconstrained firms, consistent with capital accumulation below steady state. For the working capital model, labor to capital ratios are greater under constraints than unconstrained, consistent with firms turning to labor and stalling investment to increase production under constraints.

[28] The change in the entire growth path due to a shock also suggests that working capital may also act a propagation mechanism for shocks. Shocks are carried for at least one period past the time the shock occurs as revenue is received one period later.

respond to any transitory shocks.[29] With the working capital model, the firm's ability to produce at optimal scale depends on the magnitude of the demand shock. I define maturity as reaching a threshold cash level that allows production at optimal scale 90% of the time. That is, to be considered 'matured' the firm does not need to have enough cash to meet high demand shocks with only have a 10% probability of occurring.[30] This measure recognizes the fact that financial constraints affect the response to stochastic shocks and not just the static level of output or capital stock.

The average time to maturity from the simulated data is shown in Table 2.5. The standard model predicts that on average, the firm matures in 2.35 periods (which includes the 1 period required for capital to install). Under the same conditions, the working capital model predicts that on average maturity takes 8.38 periods (which includes the 1 period delay in the receipt of revenue). The variation for the time to maturity is much greater under the working capital model - the standard deviation is 6.43 versus 2.80 periods for the standard model. This may be attributable to the sensitivity of the firm's growth path to shocks, as noted earlier and as seen in Figure 2.6. These numbers suggest that the standard model may seriously understate the effects of financial constraints on firm growth. For example, if the periods were defined as quarters, the standard model predict maturity at 6 months while the working capital model predicts maturity in 2 years.

The delay to maturity is largely attributed to the time spent in the *Sometimes Constrained* phase. Figure 2.7 illustrates the time to maturity as function of the amount the firm can borrow (the borrowing allowance). The difference between total time to maturity and the time to leave the *Always Constrained* phase equals the time the firm is in the *Sometimes Constrained* phase. For the standard capital adjustment model, the firm is constrained every period right up to reaching steady state.[31] For the working capital model, the continuously bounded stage is shorter (the average time is 2.22 periods) but firms are

[29] This is as investment is invariant to transitory shocks and labor is self financing.

[30] Cash threshold calculated as $X_{treshold} = wL(A,K)\mid_{A=1.1274,K=\bar{K}} + p^k(K(A,K)\mid_{A=1.1274,K=\bar{K}} - (1-\delta)\bar{K})$ noting that unconstrained labor and capital is not a function of cash.

[31] In the absence of permanent shocks

still vulnerable to restricting constraints on average for another 6 periods. This contributes to the prolonged effects of financial constraints on firm growth.

Long term value is the sum of profits across time and Figure 2.8 shows the median bands of the ratio between constrained long term value and the non constrained long term value for both the working capital model and the standard model, across different borrowing allowances. At a borrowing allowance of zero, constrained firms have only 63% of the value of non constrained firms. Even though constrained firms eventually catch up in terms of capital stock and ability to respond to positive shocks, they can never catch up to the long term value of unconstrained firms of the same age. Dynamically, financial constraints have a permanent effect on firm value in the long run.

To summarize, financial constraints restrict optimal output which results in loss of producer surplus. Inefficiencies arise not just from producing below scale (shown by cost per dollar of revenue) but also from distortions to factor composition (shown by labor to capital ratios). Financial constraints have a persisting effect over time. The value of the firm is inevitably lower as the constraints inhibit it from making the most out of profitable production opportunities. Furthermore, the predicted effects of financial constraints are much more severe in the model with working capital than in the standard model.

2.4 Empirical Analysis

The predicted behavior of firms under financial constraints is different in the working capital model than in the standard model. The effects of financial constraints on output levels, efficiency and firm growth are much more severe in the working capital model. I test the predictions unique to the working capital model using firms level panel data from Bangladesh. First, the need to finance working capital implies that firms are more likely to become financially constrained when demand shocks increase. Second, under binding constraints, investment responds countercyclically to demand shocks. Third, the timing of when constraints bind imply that output response to positive demand shocks will differ from negative demand shocks for firms near the margin of being constrained. If these predictions are consistent with what we see in the data, this lends support for the working capital model of financial constraints and offers suggestive evidence for the simulated results of the model.

2.4.1 The Bangladesh Panel Survey

Firms in Bangladesh have very little access to external finance. The country's investment climate is considered one of the worst amongst all the developing countries.[32] Foreign inflows are minimal due to investor's concerns about political instability and high levels of corruption. Domestic private investment is also low, partly due to the dominance of state owned enterprises[33] but largely due to the underdeveloped banking sector in Bangladesh. There are very few private banks.[34] The private banks offer more competitive interest rates than the four state owned banks that dominate the financial sector but they suffer from capital inadequacy and insider trading. Foreign bank activities are usually restricted to offshore and foreign trade business. Stock markets are still in a stage of infancy - the Dhaka Stock Exchange and the Chittagong Stock Exchange opened only in 1995. The market capitalization of the stock exchanges relative to GDP in 2004 was only 4.2%. It is clear that financial constraints are particularly salient for Bangladeshi firms.

The Bangladesh Panel Survey, part of the group of Enterprise Surveys, is conducted by the World Bank and is unique in that it is a panel data set taken semi-annually over the years 2003 to 2005.[35] There are 259 privately owned firms in the panel representing six different manufacturing sectors. Surprisingly few firms drop out of the survey. There are 241 firms

[32]Bangladesh has consistently been classified as an under performer in attracting foreign direct investment by the UN Conference of Trade and Development. The Inward FDI Performance Index 2002-04 ranks Bangladesh 122 out of 140 countries. (Country Report, EIU 2005)

[33]The public sector owns approximately 40% of Bangladesh manufacturing and utility assets.

[34]There are approximately 30 private commercial banks, 10 foreign banks and 5 development financial institutions.

[35]Enterprise Surveys were previously called the Investment Climate Surveys (ICS). The Bangladesh Panel Survey was carried out by the World Bank in conjunction with the South Asia Enterprise Development Facility and the Bangladesh Enterprise Institute.

that are present in all 6 periods. Firms were sampled from the two major cities, Dhaka and Chittagong, and are representative of the industrial composition of the Bangladesh economy. More than half the sample is in either the Garment or Textile industry, 28% and 26% respectively. The rest of the sample is distributed in Food (15%), Leather (12%), Electronics (9%) and Chemicals (10%). There is substantial variation in firm size. The interquartile range is 264 employees with the median at 150. About 37% of firms have fewer than 100 employees, and 85% have fewer than 500 employees. There is a tendency for firm surveys in developing countries to over sample larger firms, which may not be representative of the microenterprises that often characterize developing economies.

The panel contains several indicators for financial constraints. My first measure of financial constraint is the manager's subjective assessment of whether access to financing is a problem. They report on a scale from 0 to 4 with 1 corresponding to a minor problem and 4 corresponding to a severe problem.[36] I define the dummy $acc = 1$ if the firm described access to finance as moderate to severe problem.[37] The second measure uses the composition of the sources of finance. As shown in Figure 2.1, firms report the share of finance from each of 14 different sources. I define a second financial constraint dummy, $internalF = 1$ if 100% of financing comes from internal funds and the firm reported at least some problem with access to financing.[38] A firm that finances operations entirely from internal funds is one that does not utilize external credit. Under the model's framework, this implies either the firm is matured and does not need external finance (and these firms are not considered financially constrained by $internalF$), or the firm is financially constrained. I also include indicators typically used in the literature such as age and size of the firm (Cooley and Quadrini (2001); Cabral and Mata (2003)). The dummy $age5 = 1$ if the firm is 5 years old or less and $size100 = 1$ if the number of employees is 100 or fewer. The mea-

[36] The access to finance question is asked only in years 2004-2005. Missing values were supplemented with predicted values from age, size and bank loan variables. The prediction matched 76% of the actual values.

[37] Moderate to severe problem corresponds to responses of 2, 3 or 4.

[38] Internal finance is available for all years but the response rate dropped to approximately 50% in 2004. Missing values were supplemented with predicted values from access. The predicted values matched 60% of the actual values.

sures that utilize financial composition and subjective assessment indicate that a substantial proportion of the firms are financially constrained, consistent with the poor investment climate of Bangladesh; 67% are constrained according to the internal finance indicator and 44% according to the access to finance indicator. The proportion of firms constrained according to indicators *age*5 and *size*100 are considerably lower, 15% and 38% respectively. This suggests that age and size may not adequately identify financially constrained firms, or perhaps these measures are less appropriate for developing countries. There is considerable overlap between the indicators, particularly between the first two indicators. (See Table 2.6.) Internal finance and access to finance indicators exhibit movement by firms into and out of being financially constrained whereas the age and size indicators do not. (Transitional probabilities are shown in Table 2.7.)

Firms report percentage price changes for output price and raw material prices. The price index is constructed by setting base year price equal to 10 and adding subsequent percentage price changes.[39] Considering that more than half of the firms in the sample trade (either through exporting, importing or both), I assume that firms are price takers. Under this assumption, price changes reflect demand shocks.

Summary statistics of key outcome variables are given in Table 2.8. Constrained firms have lower output, capital stock, labor, investment and output growth than unconstrained firms and the difference is statistically significant. While there are differences between outcome variables, there are no significant difference in price variables. Table 2.9 shows there is no significant difference between the two groups in changes in output price, raw material price or wage but there is a small difference in the change in interest rate. Looking at firm characteristics (see Table 2.10), constrained firms have fewer workers which is consistent with expectations. Contrary to expectation, there is no significant difference in age. This may reflect the weaker correlation between age and freedom from financial constraint in developing countries. The distribution over sectors is similar between constrained and

[39] Although the survey asks for the firm to report the top 3 output (or raw material) price changes, very few reported the second or third top output price. I use the top output price to proxy for firm level price changes.

unconstrained firms.

2.4.2 When Do Constraints Bind?

The working capital model predicts that constraints are more likely to bind when price shocks increase than when shocks decrease, as shown by the middle panel of Figure 2.2. This prediction is driven by the need for more working capital during high demand and by the assumption that credit available to the firm is invariant to price shocks. If credit availability changes with price, as is assumed in models where borrowing is dependent on net worth, constraints will be less likely to bind when output price increases and more likely to bind when price decreases. Empirically testing when constraints bind is important not only to test a key implication of the working capital model but also to test the borrowing assumption, a point about which there is no consensus in the literature. Furthermore, understanding when constraints bind would help policy makers identify when alleviating financial constraints is most crucial.

According to the model, the state of being constrained should depend on wealth, the state variables capital and cash, the price shock and other parameters. The empirical specification is as follows:

$$CnstrIN_{it} = \lambda_0 + \lambda_1 \triangle shock_{it} + \beta_1 lnK_{i,t-1} + \beta_2 lnR_{i,t-1} + \beta_3 \triangle X_{it} + \varphi time + \varepsilon_{it}$$

The dependent variable, $CnstrIN = 1$ if the firm was not constrained in the previous period and is constrained in the current period. Internal finance and access to finance were used in the analysis as the constraint indicators, because age and size never switch from unconstrained to constrained. Controls for firm characteristics are: sectors, log age, change in log wage and change in interest rates averaged over sector and time. Change from firm specific mean of log output price is used as the change in shock. The expected sign for the coefficient λ_1 for the response to price changes is positive.

Empirical results are shown in Table 2.11. Across all specifications, the estimates for λ_1 are positive and significant at the 5% level. As predicted by the working capital model, and contrary to conventional wisdom, positive price shocks are associated with movements into a constrained state. In other words, constraints bind precisely when good opportunities arise.

2.4.3 Investment Response to Shocks

The model's prediction is that when financial constraints are binding, investment reacts countercyclically to demand shocks. Motivated by the solution to the firm's dynamic problem that states that the firm's choice of inputs depends only on the state variables, the stochastic factor, and the exogenous parameters, I estimate the following specification:

$$\begin{aligned}\triangle lnK_{it} &= \alpha_0 + \alpha_1 cnstr + \alpha_2 \triangle shock_{it} + \alpha_3 cnstr * \triangle shock_{it} \\ &+ \beta_1 lnK_{it-d} + \beta_2 cnstr * lnR_{it-d} + \beta_3 lnR_{it-d} + \beta_4 \triangle X_{it} + \varphi time + \varepsilon_{it}\end{aligned}$$

The dependent variable is the change in log capital stock. Initial capital stock, reported present value of machinery, equipment, land, buildings and leasehold improvement, comes from the 2002 Investment Climate Assessment (ICA) survey.[40] Capital investment in each period is the net spending[41] on additional machinery, equipment, vehicles, land and buildings. The lagged log value of capital and revenue, R, are used for the state variables, capital stock and cash in hand respectively. Revenue is interacted with the constraint variable, $cnstr$, as cash should only matter when the firm is constrained. The stochastic variable is the change in log output price, *shock*. I also control for industrial sector, lagged firm size,

[40]The 2003-2005 panel is linked to the 2002 Investment Climate Assessment (ICA) survey. The ICA surveyed 1000 firms and has a more comprehensive and detailed survey questionnaire. The panel survey follows up firms interviewed in the 2002 ICA and firms are matched according to identification numbers. Comparing establishment years reported 2002 ICA and 2003 wave of the panel suggests that there may be matching errors. Approximately 40% of the firms have discrepancies in the establishment year. There are 52 firms with a discrepancy of over 5 years. These firms were left out of the sample in empirical analysis.

[41]Net investment is the additional spending minus sales of additional machinery, equipment, vehicles, land and buildings.

change in log wages, sector- and time-specific interest rates, and a linear time trend.

The model predicts that investment is countercyclical when the firm is in the always financially constrained phase. I use two different methods to measure binding constraints: First, I define the firm as consecutively constrained if the firm is financially constrained in periods t and $t-1$, and second, I define the firm as consistently constrained if it is constrained for all periods the indicator is observed. The consecutively constrained indicator is firm- and time- variant whereas the consistently constrained indicator varies across firms only.

The empirical test is to see if the investment of constrained firms responds negatively to a price shock while the investment of unconstrained firms responds positively. That is, the coefficient on the interaction between the financial constraint indicator and the price shock, α_3, should be negative and greater than the coefficient for the price shock, α_2. In addition, α_2 should be greater than zero. Results are shown in Table 2.12 for both semi-annual and annual changes in capital stock. I find that investment of unconstrained firms responds positively to an increase in output price. A 10 percent increase in the output price leads to between 15 to 30 percent increase in capital semi-annually or 20 to 35 percent annually. This is significant at the 5 percent level across all specifications using different indicators for financial constraints. The coefficient α_3 is negative across all specification, consistent with the model.

Of the 6 different indicators of financially constrained, only two indicators consistently show significant difference in response to output shocks between constrained and unconstrained firms both in semi-annual changes and annual changes: the Internal Finance 'Consistently constrained for all periods' and $Age5$, the indicator for when the age of the firm is less than 5 years old . These are shown in estimates (2), (6), (8) and (12). The model's predictions for countercyclicality are during the firm's 'Always Financially Constrained' phase. As such, it makes sense that this phase maybe better captured when a) the firm is consistently only financing through internal funds and b) the firm is very young. Interestingly, this also suggests that Access to Finance, as a qualitative assessment by the manager, and the size of the firm are not very good indicators for firms that are extremely financially constrained.

Of the estimates (2), (6), (8) and (12), in all estimates except for estimate (8), investment is significantly countercyclical when the firm is constrained. Estimate (2) and (6) suggest that a 10 percent increase in the output price leads to a decrease in semi-annual investment of around 0.3 and 0.4 percent respectively. Estimate (8) shows that on an annual level, firms that are internally financed would only increase investment by 5 percent, compared to unconstrained firms that respond by an increase of 35 percent. However, the strongest result is in estimate (12) where the estimated coefficient suggests that a 10 percent increase in the output price leads to a decrease in annual investment of around 11 percent. The difference in the result between estimate (8) and (12) may be due to the internal finance indicator capturing firms that may be less financially constrained than those captured by age. This may also explain the difference in the size of the estimated coefficients in the semi-annual regressions (2) and (6) where the effect is larger using age.

There are at least two reasons why evidence of investment countercyclicallity is not found in all of the regressions. First, disinvestment may not occur if secondary markets for machinery, equipment and vehicles are thin. If capital cannot easily be liquidated, the firm faces disincentives to invest and may be unresponsive to shocks. Secondly, identifying financial constrained firms using proxies may inadequately capture the firm's true financial position.

Investment cashflow sensitivity is estimated by the coefficients for lagged revenue and interacted lagged revenue. For unconstrained firms, the coefficient β_3 is close to zero and not significant for the majority of the specifications, as expected. This indicates that, consistent with the first order condition, cash on hand does not enter the unconstrained firm's optimal decision. Contrary to the predictions of the working capital model, there is very little evidence that the investment of constrained firms is sensitive to cashflow. One potential explanation is that the part of the total change in capital due to the change in cash (the first term on the right hand side of Equation 2.12) is dominated by the part due to the change in price. In other words, the income effect is small relative to the substitution effect.[42] A second possible explanation is that the cash positions of firms are not accurately measured by last period's revenue.

My empirical strategy assumes that price shocks measure demand shocks. It is possible that instead, price shocks reflect supply shocks, either changes in technology or in factor prices. If price shocks represent technology shocks, the model's predictions and the interpretation of the results are unchanged. If price shock reflect changes in factor prices, particularly a change in the price of capital, investment would appear to behave countercyclically. However, there is no theoretical basis to suggest that the direction of the response to factor price changes will differ between constrained and unconstrained firms, unless the shocks are different between the two groups. From summary statistics of price changes in Table 2.9, we see that there are no significant differences in the changes of output price, wages nor raw material prices between constrained and unconstrained firms. Furthermore, these are controlled for in the regression. In summary, even though it is possible that prices may reflect supply shocks, supply shocks cannot explain the significant difference in investment response between constrained and unconstrained firms.

2.4.4 Output Response to Shocks

Section 2.4.2 has shown that constraints are more likely to bind when positive production opportunities arise. This implies that financial constraints limit the firm's output response to positive shocks but do not affect the firm's response to negative shocks. The empirical specification to test the output response of financially constrained firms is as

[42]This is consistent with the need to capture investment opportunities in investment cashflow sensitivity regressions as emphasized in the literature.

follows:

$$
\begin{aligned}
\triangle lnQ_{it} &= \alpha_0 + \alpha_1 \triangle shock^{+}_{it} + \alpha_2 \triangle shock^{-}_{it} \\
&\quad + \alpha_3 cnstr_{it} * \triangle shock^{+}_{it} + \alpha_4 cnstr_{it} * \triangle shock^{-}_{it} \\
&\quad + \beta_1 lnK_{it-d} + \beta_2 cnstr * lnR_{it-d} + \beta_3 lnR_{it-d} + \beta_4 \triangle X_{it} + \varphi time + \varepsilon_{it}
\end{aligned}
$$

The change in log output is percentage growth and is measured as the difference from the firm specific mean. I categorize firms into; *Always Constrained* and *Sometimes Constrained* using internal finance and access to finance as the financial indicators.[43] All other explanatory variables are the same as those in the investment specification. The specification was estimated using OLS with robust standard errors clustering on firms. Positive shocks are defined as shocks above firm mean and negative shock defined as below mean.

The empirical test is to see whether sometimes constrained firms respond differently to positive shocks than unconstrained firms. Unconstrained firms increase output in response to positive shocks, so α_1 is expected to be positive. *Sometimes Constrained* firms are limited in their ability to expand, so α_3 is expected to be negative. Unconstrained and *Sometimes Constrained* firms are predicted to respond to negative shocks in the same way, so α_4 is not expected to be significant. According to the model, *Always Constrained* firms may have a different response to negative shocks as these firms are producing at a much steeper part of the production function.

Results are shown in Table 2.13. When the financial constraint dummy is defined based on access, virtually all of the estimated coefficients are insignificant. When the internal finance measure is used, the results are broadly consistent with the working capital model. First, the response to positive shocks is significantly different for unconstrained and *Sometimes Constrained* firms. Unconstrained firm increase output but *Sometimes Constrained*

[43] Recall that age and size variables do not indicate the firms transitioning into being financial constrained. *Always Constrained* is defined as a dummy equal to one when the firm is constrained for all periods and is time invariant. Likewise, *Sometimes Constrained* is defined as a dummy equal to one when firms are constrained at least once but less than for all periods.

firms do not. Second, unconstrained and *Sometimes Constrained* firms do not differ in their response to negative shocks. This is indicated by the insignificant coefficient on the $SometimesCnstr * NegativeShock$. Third, consistent with theory, results indicate that output growth of constrained firms is sensitive to cashflow whereas the output growth of unconstrained firms is not.

2.5 Conclusion

Finance is scarce in developing countries where poverty hinges precariously on economic growth. How firms develop within an environment of limited access to external credit, and how financial constraints affect the behavior of the firm are of crucial importance to understanding investment and growth. Existing models have mainly been developed for and tested using data from developed economies, yet, despite the vast differences in context, these models are continually applied to developing countries. As a result, economic factors that are not necessarily relevant to developed economies but are crucial for developing countries are overlooked. A clear example of this is the largely neglected role of working capital. In countries such as the US, working capital is mostly irrelevant due to the abundance of short term credit availability. However, in developing countries where external credit is virtually non-existent, entrepreneurs have to resolve the time delay between incurring the cost of production and the receipt of revenue themselves. The need for working capital becomes very relevant when access to credit is scarce.

This paper develops a basic dynamic working capital model of the firm with financial constraints. By taking into account the need to finance both working capital and investment, and the possibility of financing from internally generated funds, the model provides insights into the effects of financial constraints on the firm's operations that are not captured by existing models. First, the working capital model shows that in addition to scale inefficiencies caused by constrained suboptimal output levels, financial constraints also distort optimal factor ratios in response to demand shocks. Investment becomes countercyclical to shocks under binding constraints. Not only are profits lower but the cost of generating a dollar of revenue are higher for the constrained firm than for an unconstrained firm. Secondly, not only is the constrained firm earning less at each period, but the suboptimal level of revenue it generates negatively affect production and growth over time. Thirdly, financial constraints prevent the firm from taking advantage of production opportunities. The working capital model relates the demand for financing to the demand for inputs to production. Firms are bound by constraints precisely when they wish to expand and are not bound during times of contraction.

The model offers a flexible theoretical framework of the firm under financial constraints. The assumptions of the model are very general - the only modifications to standard assumptions are the timing of revenue receipt and the absence of adjustment costs to investment. The theoretical predictions for investment response to price shocks do not rest on any assumptions regarding the functional form of the production function. The solution is analytically tractable and captures the essential predictions of existing models but offers additional insights into the effects of financial constraints. While this paper has focused on presenting a parsimonious model to illustrate the inclusion of the concept of working capital, the model can be easily modified with investment adjustment costs[44], borrowing constraints as functions of other variables, or incorporated into a general equilibrium framework. Although the interest of this paper has been on the firm's dynamic response to demand shocks, the model may yield interesting insights into other areas such as firm behavior in response to interest rate changes[45], output volatility over the business cycle[46], sector development with limited access to external credit [47] and the effects of trade

[44]In another paper, I develop an extension of the working capital model to include time to build capital adjustments to look at precautionary savings by the firm.

[45]The model allows the firm to choose between internal finance (vulnerable to real shocks) and external credit (vulnerable to interest rate shocks).

[46]The working capital model exhibits propagation of temporary shocks past the period when the shock occurred, even though the shock is i.i.d.

[47]Differences in factor intensities between industries could generate different rates of growth but also different sector responses to shocks under financial constraints.

liberalization under financial constraints[48].

In this paper, I empirically test three predictions in particular: constraints bind when prices increase, the countercyclical behavior of capital under binding constraints and the asymmetric output response. These predictions differ from the commonly used Jorgenson model of investment with financial constraints and allow comparisons of the working capital model to the standard model. I find that the working capital model's predictions are consistent with empirical evidence. These findings suggest that studying the dynamic behavior of firms may be a promising strategy for identifying which firms are credit constrained. Furthermore, these two predictions provide a means of identification of constrained firms that does not rely on the occurrence of a natural experiment or endogenous firm characteristics.

[48]Financial constraints restrict expansion to markets, therefore under trade liberalization where market opportunities %%% I develop this in another paper.

Appendix

Contrast With the Standard Model of Financial Constraints

Standard model of financial constraints

The standard model utilizes the Jorgenson model of investment with financial constraints (see Bond and Meghir (1994) for review). Capital takes one period to install and the firm chooses current labor inputs and the next period's capital. The implicit assumption is that there is no delay in the receipt of revenue and the model is given as:

$$\max_{L_t, K_{t+1}} \quad E_t \left[\sum_{t=0}^{\infty} \beta^t \left(P_t F(K_t, L_t) - wL_t - p^k I_t \right) \right]$$

$$s.t \quad wL_t + p^k (K_{t+1} - (1-\delta)K_t) + b_t = P_t F(K_t, L_t) + (1+r)b_{t-1} \tag{2.1}$$

$$s.t \quad K_{t+1} = (1-\delta)K_t + I_t \tag{2.2}$$

$$s.t \quad b_t > bc$$

$$\lim_{t \to \infty} b_t = 0$$

$$K_0 \quad given$$

$$b_0 \quad given$$

There are four characteristics of the standard model that contrasts with a model with working capital:

1) Labor is always at optimal regardless of financial constraints. This is an equilibrium condition as the marginal product of labor is immediately received to not only cover the cost of labor but also to fund capital.[49] Take for instance that a firm does not have enough cash to purchase steady state capital (where $E[MPK] = p^k(r+\delta)$ the rental cost of capital). The firm at optimal labor where $MPL = w$, chooses to decrease a dollar's worth of labor and put it towards capital. Although capital has increased by a dollar, capital is funded by

[49]This implies that there must be a slight timing difference between when labor decisions are made and when capital decisions are made.

revenue which has declined by more than a dollar. Overall, the decrease in labor will lead to a decrease in capital.

2) Firms under this model do not switch between constrained and not constrained states due to transitory shocks. With the Jorgenson model, firms are constrained until they reached steady state capital stock and then are never constrained (unless there are permanent shocks). The firm cannot become constrained again after reaching steady state as the firm only need to investment the depreciated amount of steady state capital at each period. Even under an extreme negative shock, the revenue from production at steady state capital stock would strictly cover the cost of the depreciated value of capital, that is $P_t F(K*, L_t) \gg \delta K*$.

3) Investment is strictly procyclical to shocks. The budget constraint, Equation 2.1, dictates the level of investment and as such, a change in revenue will lead to a change in investment in the same direction.

4) Output response is symmetrical under the capital adjustment model with financial constraints. Labor is always optimally chosen and as such, output responds fully to demand shocks.[50] The capital adjustment model does not allow for firms to move in and out of financially constrained states and as such firms under this framework will never find themselves suddenly limited under a (transitory) positive shock.

Overall, the standard model of financial constraints will understate the effects of financial constraints on firm growth and responses to shocks because of these four characteristics compared to the working capital model of financial constraints.

[50] The curvature of the production function however will cause increases to be less than decreases in output.

Table 2.1: Working Capital Requirements

US				Bangladesh				
Industry	*N.firms*	$\frac{NonCashWC}{Sales}$	$\frac{WC}{Sales}$	*Sector*	*N.firms*	$\frac{NonCashWC}{Sales}$	$\frac{WC}{Sales}$	$\frac{I}{Sales}$
Chemical[t]	152	12.82%	17.35%	Chemical	85	26.19%	31.91%	3.15%
Food	114	7.46%	11.20%	Food	147	41.87%	48.12%	4.34%
Electronics	199	16.72%	30.31%	Electronic	91	24.02%	28.24%	1.24%
Shoe	28	20.82%	27.79%	Leather	99	35.65%	39.18%	4.60%
Apparel	58	18.09%	23.55%	Garment	306	18.54%	21.46%	1.88%
-	-	-	-	Textiles	252	37.88%	42.69%	4.61%
Weighted Average			21.94%	Weighted Average			34.24%	3.28%

Note: $Non-CashWC$: inventory + accounts receivable -accounts payable, WC: inventory+cash+accounts receivable - accounts payable $\frac{I}{Sales}$:Investment to sales. Short term credit available to the firm is not observable on accounting sheets whereas short term debt is accounted for by accounts payable.

Source:US Firm Data: Jan 2002.Aswath Damodaran, 'Working Capital Ratios by Sector', calculated using Value Line database of 7091 firms. Available from http://pages.stern.nyu.edu/~adamodar . [t]Chemicals is the weighted average of Basic Chemicals, Diversified Chemicals and Specialty Chemicals. Bangladesh Firm Data: Investment Climate Assessment Bangladesh 2002, Enterprise Surveys, World Bank.

Table 2.2: Time line of Production and Receipts

	Period 1	Period 2
State	Initial Capital Stock: K_0	New: $K_1 = I_1 + (1-\delta)K_0$
	Initial Cash Stock: X_1	New: $X_2 = P_1 F(K_1, L_1) + (1+r)\left(X_1 - wL_1 - p^k(K_1 - (1-\delta)K_0\right)$
	Realized Price: $P_1 = \bar{P} + \varepsilon_1$	Realized Price: $P_2 = \bar{P} + \varepsilon_2$
Choice	Make input choices: $L_1$and K_1	Make input choices:L_2 and K_2
	Pay input costs: $wL_1 + p^k(K_1 - (1-\delta)K_0)$	Pay input costs: $wL_2 + p^k(K_2 - (1-\delta)K_1)$
	Produce: $F(K_1, L_1)$	Produce: $F(K_2, L_2)$

Note: At the start of the period, the firm has capital and cash. The price that the firm will receive for its product is realized and then it decides on input choices of labor and capital. The next period, the firm receives the revenue which, along with savings, constitutes cash for the next period's production.

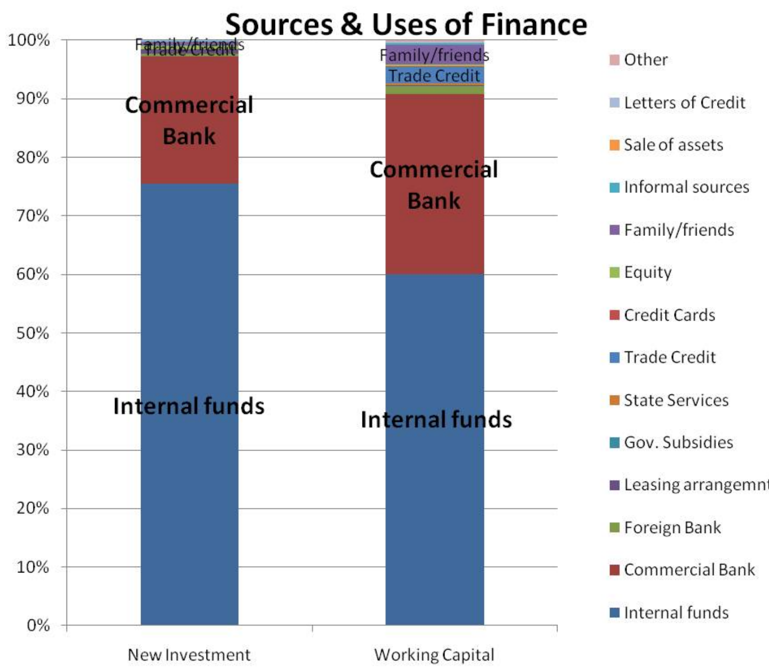


Figure 2.1: Sources and Uses of Finance - Bangladesh

Source: Bangladesh Panel Survey 2003-2005, Enterprise Surveys, World Bank.

Note: Survey instrument for sources of financing was introduced for the 2004-2005 rounds only. Average percentage calculated across all rounds.

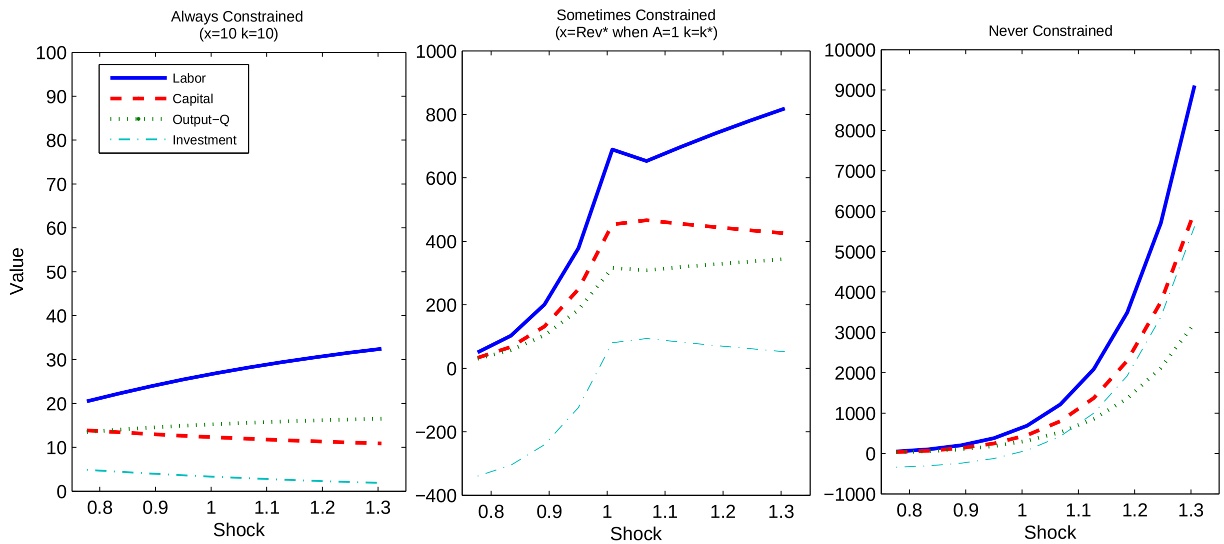


Figure 2.2: Response of the Firm to Shocks- Three Phases

Parameters: $P_t F(K_t, L_t) = P_t K_t^{\alpha} L_t^{\gamma}$, $\alpha = 0.30$, $\gamma = 0.60$, $\beta = 0.9$, $\delta = 0.10$, $\ln P_{t+1} \sim N\left(-\frac{1}{2}\sigma^2, \sigma^2\right)$, $\sigma = 0.1$, $E(P_{t+1}) = 1$, $p^k = 1$, $w = 0.25$.

Sometimes Constrained: nitial cash is set such that firm can afford optimal solution when the shock is equal to one.

Note: Panel A illustrates responses in output, labor, capital and investment to price shocks when firm behavior is dictated by constrained first order conditions. Panel B illustrates these same variables when the firm switches from unconstrained to constrained states. Panel C is the behavior of the unconstrained firm. Note that the scale of the y-axis differs across the three panels.

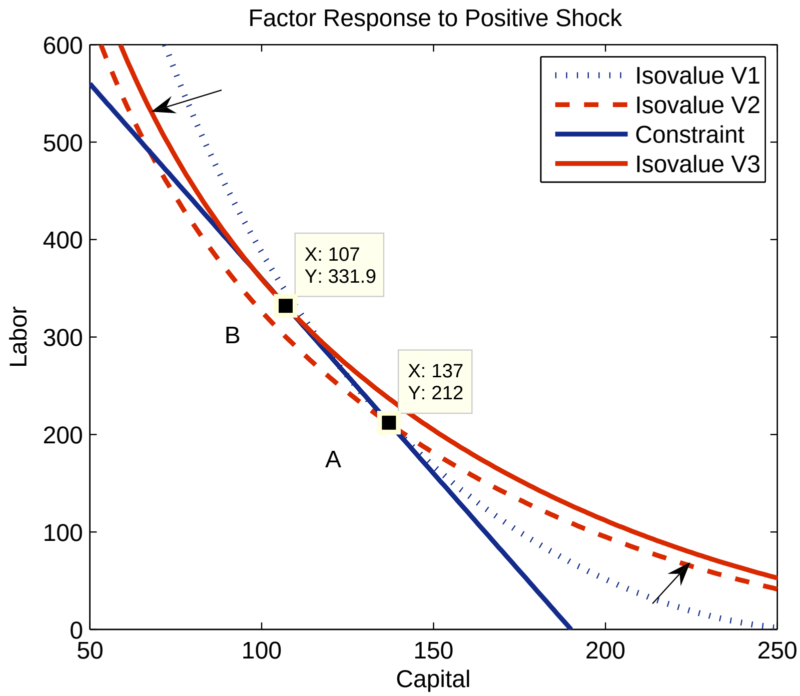


Figure 2.3: Factor Response to Positive Shock

Note: $V = AK^{\alpha}L^{\gamma} + (1-\delta)p^k K$. Isoquants: $L = \left(\frac{V-(1-\delta)p^k K}{AK^{\alpha}}\right)^{\frac{1}{\gamma}}$ Budget lines: $L = \frac{1}{w}\left(X + (1-\delta)p^k K - p^k K - bc\right)$ $\alpha = 0.30$ $\gamma = 0.60$ $p^k = 1$ $w = .25$ $X = 100$ $K = 100$ $\delta = .10$ Shock is 1.7

A price increase causes the isovalue curve to pivot from V1 to V2 and the new tangency point B is to the left of the initial starting point A.

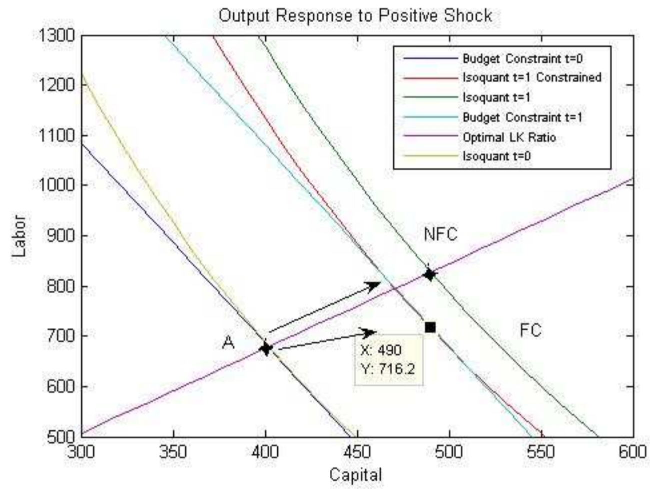


Figure 2.4: Output Response to Shocks

Parameters:same as Figure 2.2 *Initial Conditions:*Shock $= 1$ at $t = 0$, Shock$= 1.02$, at $t = 1$. Cash: cost of optimal inputs when Shock=1

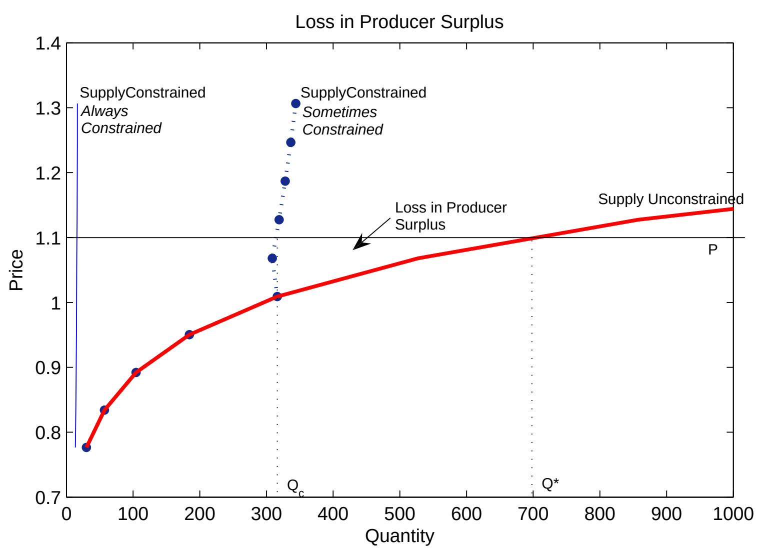


Figure 2.5: Loss in Producer Surplus

Note: Loss in Producer Surplus: Same 3 cases as those in Figure 2.2, with Shock as the y-axis and Output on the x-axis. Average Loss in Producer Surplus calculated as $Loss_{i,t,bc} = \left(\frac{(P*-\bar{P})*(Q*-\bar{Q})}{2}\right)$ Sum across time and averaged over simulated paths.

Table 2.3: Comparing Constrained Outcomes to Unconstrained

	Model	$\frac{Q}{Q*}$	$\frac{L}{L*}$	$\frac{K}{K*}$	$\frac{Profit}{Profit*}$	*N.Obs*
Always Constrained	Working Capital	38%	37%	33%	8%	18159
	Standard	60%	56%	58%	15%	23276
Sometimes Constrained	Working Capital	87%	86%	85%	64%	115833
	Standard	na	na	na	na	
Never Constrained	Working Capital	99%	99%	99%	95%	685008
	Standard	100%	100%	100%	100%	795724

Note:*Always Constrained*: firms are consistently under binding constraints. *Sometimes Constrained*: firms shift between nonbinding and binding constraints depending on demand shock. *Never Constrained*: firms that never run into binding constraints 90% of the time. This is also why even under the never constrained phase, the working capital model does not predict 100% of optimal. ***Measurement:***Percentages are calculated as the constrained outcome variable divided by the corresponding unconstrained outcome for the simulated prices series over time. The average is taken over all borrowing constraints and all observations within constrained phases.

Table 2.4: Production InefficiencyCost per Dollar of Revenue and Labor to Capital Ratio

	Working Capital Model			Standard Capital Adjustment Model		
	Cost per Dollar of Revenue	Labor to Capital Ratios	*N.obs*	Cost per Dollar of Revenue	Labor to Capital Ratios	*N.obs*
Always Constrained	0.825	1.910	25655	0.973	1.63	28276
Sometimes Constrained	0.787	1.581	129337		Not Applicable	
Never Constrained	0.712	1.525	685008	0.730	1.88	811724

Note: Medians reported. Cost per Revenue Dollar calculated as $\frac{wL+p^kI}{PQ}$.

Table 2.5: Time to Maturity

model	mean	sd	min	max	N
Standard	2.35	2.80	1	14	840000
Working Capital	8.38	6.43	2	27	840000

Note: The standard investment model is the Jorgenson model of investment with financial constraints.

Simulation:40 time periods, 1000 different simulated paths and 21 different borrowing parameters (from 0 to 2000). Time to maturity: Standard model is steady state capital stock, for Working Capital model is the cash required to respond to 90% of the shock.

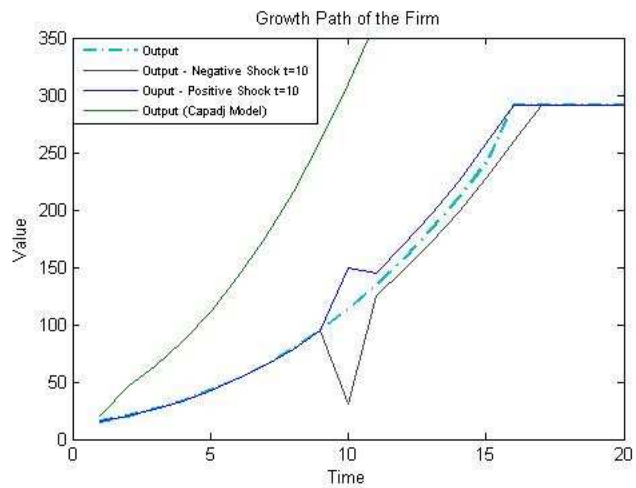


Figure 2.6: Growth Path of the Firm

Note:Initial conditions: Cash=10 and Capital=10. The growth path predicted by the working capital model is much flatter than the path predicted by the standard investment model. A positive shock (of 2 standard deviations) shifts the path upward, whereas a negative shock shifts the path downward.

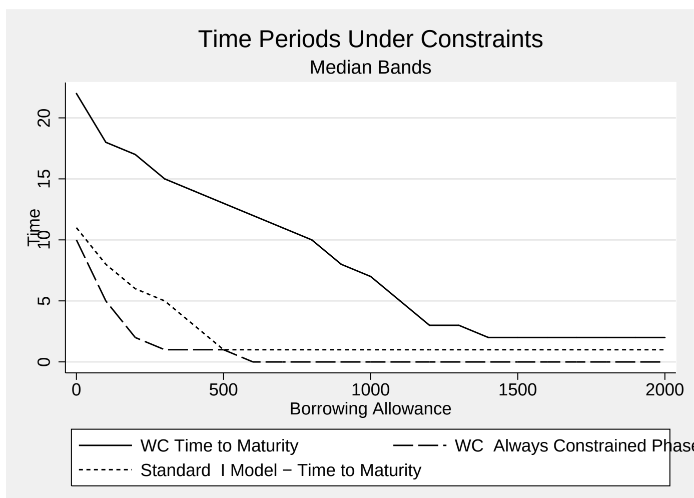


Figure 2.7: Period of Time Under Constraints

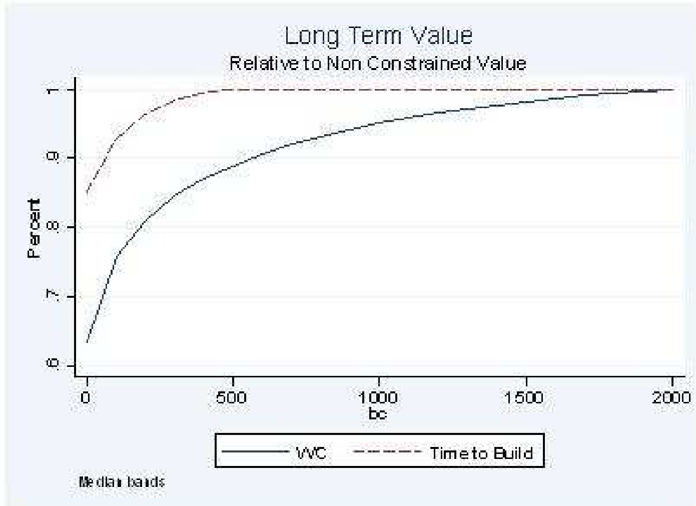


Figure 2.8: Long Term Value of the Firm and the Effects of Financial Constraints

Note: Long Term Value calculated as sum of profits over 40 periods. All firms reach maturity by the end of the 40 periods, as such the value after 40 would be the same across all firms regardless of borrowing constraints.

Table 2.6: Overlap Between Financially Constrained Indicators

Indicators Jointly Equal to 1			
	Internal Finance	Access to Finance	Age is less than 5yr
Access to Finance	76.69%		
Age is less than 5yr	45.55%	48.97%	
Size is less than 100 employees	55.77%	60.19%	55.24%

Measurement: $internalF = 1$ if 100 percent of financing comes from internal funds and the firm reported access to financing as some problem; $acc = 1$ if the firm reported access to finance as a moderate to severe problem ; $age5 = 1$ if the firm is 5 years old or less and $size100 = 1$ if the number of employees is 100 or less. *Note:*To illustrate the relationship between the internal finance and access to finance indicator, this table is shown with the original values of these indicators before supplementing predicted values for missing observations.

Table 2.7: Transition Probability of Financial Indicators

Internal Finance				Access to Finance			
$t \diagdown t+1$	0	1	Total	$t \diagdown t+1$	0	1	Total
0	71.08	28.92	100.00	0	71.10	28.90	100.00
1	24.20	75.80	100.00	1	26.48	73.52	100.00
Total	38.12	61.88	100.00	Total	51.77	48.23	100.00

Table 2.8: Summary Statistics

	Not Constrained	Constrained	Total	Difference	t-statistic
Value of Output	10.582	9.603	9.937	0.979	9.626
Capital Stock	10.223	9.301	9.614	0.922	8.694
Revenue	10.649	9.664	9.999	0.985	9.650
Labor Costs	8.422	7.487	7.804	0.935	11.060
Change in Capital Stock (semi-annual)	0.065	0.032	0.045	0.034	2.658
Change in Capital Stock (annual)	0.110	0.061	0.084	0.049	2.483
Output Growth (semi-annual)	0.099	0.040	0.063	0.058	1.128

Note:Financial constraint indicator is internal finance, variables defined in logs. The null hypothesis that the difference in means between constrained and unconstrained firms is equal to zero is rejected for all variables at the 5% significance level.

Table 2.9: Summary Statistics- Prices

Semi-annual change	Not Constrained	Constrained	Total	Difference	t-statistic
Output Price	-0.009	-0.019	-0.015	0.010	1.522
Raw Material Price	0.068	0.079	0.074	-0.010	-1.644
Log Wages	0.046	0.079	0.066	-0.033	-0.810
Interest rate*	-0.003	0.001	0.000	-0.004	-7.978

Note: Financial constraint indicator is internal finance, variables defined in logs. * Due to low response rate, the interest rate is calculated as the average over sector and time. The null hypothesis that the difference in means between constrained and unconstrained firms is equal to zero cannot be rejected for all variables at the 5% significance level except for interest rates.

Table 2.10: Summary Statistics - Firms Characteristics

	Not Constrained	Constrained	Total	Difference	t-statistic
N. Workers	369.93	221.53	271.92	148.41	8.54
Age	16.68	15.15	15.67	1.53	1.91
Garment	0.24	0.31	0.28	-0.07	-2.47
Textile	0.33	0.25	0.27	0.08	2.96
Food	0.16	0.14	0.15	0.02	0.98
Leather	0.09	0.14	0.12	-0.05	-2.44
Electronics	0.04	0.09	0.07	-0.05	-3.36
Chemical	0.14	0.08	0.10	0.07	3.68

Note:Sector variables are indicator variables. The null hypothesis that the difference in means between constrained and unconstrained firms is equal to zero is rejected for all variables at the 5% significance level except for age.

Table 2.11: Constraints and Shocks

DPROBIT- Robust standard errors				
Cluster Standard Errors on Firm id				
Reported Marginal Effects				
Become Constrained	Access		Internal Finance	
shock	0.389	0.387	0.322	0.312
	(2.17)**	(2.22)**	(2.30)**	(2.27)**
Initial R	0.018	0.016	0.013	0.011
	(2.98)***	(2.52)**	(2.33)**	(2.13)**
Initial K	-0.007	-0.006	-0.012	-0.008
	(1.48)	(1.15)	(2.57)**	(1.91)*
time trend	-0.027	-0.057	0.018	0.016
	(4.35)***	(3.32)***	(1.41)	(3.01)***
Control for Firm Characteristics	no	yes	no	yes
Observations	1217	1216	1216	1217
N.firms	250.00	250.00	250.00	250.00
Pseudo R2	0.02	0.03	0.03	0.02
Log likelihood	-533.08	-527.38	-348.78	-351.99

Robust z statistics in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2.12: Investment Response to Shocks

OLS

Dependent Variable: Change in Log Capital Stock

Shock: Change in Log Output Price

	Semi Annual Changes						Annual Changes					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	0.076	0.103	0.106	0.080	0.051	0.114	0.135	0.196	0.235	0.184	0.154	0.240
	(0.78)	(1.20)	(1.60)	(1.02)	(0.59)	(1.69)*	(0.74)	(1.34)	(1.80)*	(1.28)	(0.89)	(1.96)*
Constraint	0.098	0.119	0.020	0.077	0.095	-0.048	0.249	0.261	0.057	0.173	0.197	-0.042
	(1.05)	(1.58)	(0.25)	(1.22)	(1.17)	(0.74)	(1.41)	(1.90)*	(0.39)	(1.38)	(1.18)	(0.28)
Shock	0.200	0.301	0.179	0.160	0.188	0.156	0.263	0.350	0.253	0.272	0.323	0.251
	(2.71)***	(2.83)***	(2.99)***	(2.10)**	(2.30)**	(2.53)**	(2.30)**	(2.44)**	(2.35)**	(2.24)**	(2.43)**	(2.85)***
Cnstr*shock	-0.185	-0.304	-0.154	-0.104	-0.143	-0.160	-0.205	-0.300	-0.155	-0.203	-0.290	-0.363
	(1.84)*	(2.48)**	(1.30)	(1.04)	(1.44)	(1.77)*	(1.58)	(1.94)*	(1.10)	(1.60)	(1.99)**	(2.26)**
Lagged Capital	-0.012	-0.014	-0.012	-0.012	-0.011	-0.011	-0.018	-0.021	-0.019	-0.018	-0.017	-0.016
	(1.98)**	(2.11)**	(1.93)*	(1.97)*	(1.89)*	(1.82)*	(1.80)*	(1.99)**	(1.85)*	(1.82)*	(1.71)*	(1.62)
Cnstr*Lagged Rev	-0.014	-0.017	-0.004	-0.009	-0.009	0.004	-0.032	-0.032	-0.011	-0.020	-0.020	0.001
	(1.55)	(2.30)**	(0.45)	(1.40)	(1.17)	(0.52)	(1.81)*	(2.22)**	(0.70)	(1.61)	(1.25)	(0.04)
Lagged Revenue	0.014	0.015	0.008	0.010	0.011	0.006	0.025	0.022	0.012	0.016	0.020	0.009
	(2.17)**	(2.63)***	(1.53)	(1.78)*	(1.82)*	(1.28)	(1.85)*	(1.72)*	(1.10)	(1.34)	(1.39)	(0.87)
Time trend	-0.019	-0.018	-0.019	-0.019	-0.025	-0.019	-0.040	-0.039	-0.041	-0.040	-0.047	-0.041
	(3.71)***	(3.37)***	(3.74)***	(3.80)***	(3.93)***	(3.79)***	(3.73)***	(3.50)***	(3.78)***	(3.78)***	(3.84)***	(3.89)***
Firm characteristics	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	979	979	979	979	979	979	777	777	777	777	777	777
R-squared	0.05	0.06	0.04	0.04	0.04	0.04	0.09	0.08	0.07	0.07	0.07	0.07
N.Firms	202.00	202.00	202.00	202.00	202.00	202.00	198.00	198.00	198.00	198.00	198.00	198.00

Robust t statistics in parentheses* significant at 10%; ** significant at 5%; *** significant at 1%

(1) , (7) Internal Finance:Consecutively binding. $cnstr_{t-1} \& cnstr_t = 1$(varies with time and across firms)

(2), (8) Internal Finance: Consistently constrained for all periods indicator is observed. (firm specific)

(3), (9) Access to finance reported as problem(moderate to extreme): Consecutively binding (varies with time and across firms)

(4), (10) Access to finance reported as problem(moderate to extreme): Consistently constrained for all periods indicator is observed. (firm specific)

(5), (11) Number of employees less than 100: Consecutively binding (varies with time and across firms)

(6), (12) Age of firm is less than 5 years old: Consecutively binding (varies with time and across firms)

Table 2.13: Output Response to Shocks

OLS - Robust Standard Errors				
Changes from Mean				
Dependent Variable: Log Output (Quantity)				
Shocks: Log Output Price				
	Internal Finance		Access	
	(1)	(2)	(3)	(4)
Constant	0.010	0.400	-0.408	-0.535
	(0.03)	(1.67)*	(0.76)	(1.00)
Always Cnstr	-0.854	-1.155	-0.137	-0.150
	(1.81)*	(3.01)***	(0.17)	(0.20)
Sometimes Cnstr	-0.946	-1.279	-0.620	-0.403
	(2.58)**	(4.29)***	(1.10)	(0.74)
Positive Shock	2.109	1.476	-1.215	-0.542
	(1.59)	(4.20)***	(0.94)	(0.38)
Always Cnstr*Positive Shock	-2.576	-1.920	3.309	2.856
	(1.28)	(1.30)	(1.03)	(0.89)
Sometimes Cnstr*Positive Shock	-2.923	-1.762	0.505	0.272
	(1.95)*	(2.46)**	(0.35)	(0.18)
Negative Shock	-5.988	-3.407	0.391	-0.804
	(2.24)**	(4.92)***	(0.17)	(0.38)
Always Cnstr*Negative Shock	4.705	1.695	2.826	3.685
	(1.62)	(1.33)	(0.65)	(0.94)
Sometimes Cnstr*Negative Shock	4.424	1.323	-2.277	-1.595
	(1.61)	(1.37)	(0.98)	(0.72)
Lagged Log Capital Stock	-0.092	-0.113	-0.094	-0.115
	(4.11)***	(4.60)***	(4.59)***	(5.06)***
Lagged Log Revenue	0.076	-0.001	0.110	0.078
	(3.93)***	(0.03)	(2.26)**	(1.76)*
Always Cnstr*Lagged Log Revenue	0.053	0.088	-0.014	0.007
	(1.19)	(2.22)**	(0.16)	(0.08)
Sometimes Cnstr*Lagged Log Revenue	0.072	0.102	0.044	0.026
	(2.51)**	(3.87)***	(0.86)	(0.53)
Time trend	0.041	0.042	0.043	0.047
	(3.13)***	(1.90)*	(3.29)***	(2.20)**
Control for Firm Characteristics	no	yes	no	yes
Observations	954	953	954	953
R-squared	0.16	0.21	0.17	0.22
N.firms	200.00	200.00	200.00	200.00

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

CHAPTER III

Why Liquidity Matters to the Export Decision of the Firm

3.1 Introduction

The growth of exports is a key priority for many developing countries as a means to access foreign earnings and to stimulate economic growth[1]. Yet, among developing countries, access to external finance is a major problem. The World Bank Investment Climate Surveys, covering more than 26,000 firms across 53 developing countries, find that the cost and access to finance is considered by firms to be the top 5 problems they face (Hallward-Driemeier and Smith (2005)). An important question to ask is how do financial constraints affect the export decision of the firm. This questions is particularly relevant in light of the recent financial crisis, where the freeze on credit coincided with a drop in world exports of more than 30 percent[2] that cannot be entirely explained by the drop in aggregate demand.

To understand how financial constraints affect export status, the first step is to ask what are the financing needs of an exporting firm. Take for example, a firm owner who has to decide between selling to domestic or foreign markets. She/he would face export specific costs such as the costs of licensing or getting entry to markets.[3] However, beyond these additional costs, the owner also faces a significant difference in timing between domestic

[1] See Roberts and Tybout (1997)Roberts and Tybout (1997)

[2] Quarterly trade data from WTO, compiled from data sourced from IMF, International Financial Statistics; Eurostat, Comext Database; National statistics; Global Trade Atlas.

[3] Costs to exporting also include shipping and transportation, custom duties and many more. These are discussed in Hummels (1999).

sales and foreign sales. I show that in the case of Bangladesh, exporting to Hamburg can take up to 39 days. With domestic sales, goods would be delivered faster and the payment for the goods received within a shorter time. With foreign sales, although the goods will fetch a higher price, the goods will take longer to deliver and the payment will be received with a longer delay. I also show that most firms receive payment only after their goods have been delivered. The decision to export involves the owner asking themselves whether they would be able to remain liquid during the period before payment is received. Operating liquidity in financial metric terms is working capital. As such, to address how financial constraints affect the export decision of the firm, it is necessary to understand how working capital affect the export decision of the firm.

This paper makes two contributions to this question. First, I articulate a dynamic working capital model of the firm's export decision. Second, I test the empirical predictions of the model using a unique panel dataset of Bangladeshi firms and find robust evidence that financial constraints provide a significant barrier to exports.

The theoretical model builds upon the dynamic working capital model of the firm Chan (2008) and extends it to the export decision of the firm. To my knowledge, there are no existing trade models that have formalized the role of working capital in exporting decisions.

Working capital underlies two fundamental concepts in trade: costs to entry and the role of distance in determining trade volumes. The extra working capital demands from exporting over domestic sales due to shipping time, formalizes the concept of sunk cost or the cost of entry which many trade models are premised upon (see Alessandria and Choi (2007); Arping and Diaw (2008); Das et al. (2007); Bernard et al. (2006); Bernard and Jensen (2004)). Furthermore, as the amount of working capital directly reflects transportation time, the greater the distance, the greater the working capital demands in exporting. Therefore, the model also speaks to the area of trade research on how distance determines trade volumes as well as on how time can act as a trade barrier (see Hummels (2001); Clark et al. (2004); Islam et al. (2005) for research in this area).

The main theoretical result is that the export decision of the firm is determined by both productivity and working capital and their relative importance depends on whether the firm is financially constrained or not. The model shows that exporting depends primarily on productivity *if the firm is not financially constrained.* When firms are financially constrained, however, a lack of working capital can severely restrict a firm's willingness and ability to engage in exports. The implication is that among the population of firms, there will exist low productivity firms that never export regardless of their cash positions, and cash-poor firms that do not export regardless of their productivity levels.

To assess the importance of this mechanism, I use a unique firm-level dataset which allows two key aspects of the model to be examined: a) a direct test of the interaction between financial constraints, working capital and productivity in determining the export status of the firm, and b) the relationship between working capital and the export distance that underlies the rationale behind the theoretical model. The 2002 Bangladesh Investment Climate Survey is one of the few panel datasets available that contain firm level financial information, their access to credit and detail information on exports. The empirical results provide support for the model's predictions that the affects of working capital and productivity will differ between financially constrained and unconstrained firms. Specifically, for financially constrained firms, productivity matters less than for unconstrained firms while working capital matters much more. The correlation between working capital and export distance is shown empirically to be positive and significant, lending support for the working capital model of the firm's export decision.

The paper is structured as follows: the next section discusses the relevant literature for both theoretical firm models and empirical work in the area of export and finance[4], Section 3.3 motivates the need for the working capital model of export decision by taking a preliminary look at the data to examine the distribution of productivity between exporting and non-exporting firms and also to look at the additional working capital demands that

[4]The literature on the area of trade credit , such as Fisman and Love (2003); Fisman (2001); Fisman and Love (2004); Fisman and Raturi (2004); Burkart and Ellingsen (2004) reviewed in Chan (2008).

exporting imposes, Section 3.4 develops the working capital model of the firm's export decision, Section 3.5 examines the empirical results and then the conclusion.

3.2 Relevant Literature

The role of firm productivity as a determining factor for the export status of the firm has been researched extensively both theoretically through the heterogeneous firm models of Melitz (2003); Bernard et al. (2003) and empirically in the work of Pavcnik (2002); Bernard et al. (2003); Bernard and Jensen (2004). It is, however, ambiguous as to whether the existence of financial constraints changes the relationship between productivity and exporting.

The literature on the interaction of trade and financial factors has existed for some time Kletzer and Bardhan (1987), but the emphasis has been on incorporating finance into the theory of comparative advantage to explain trade patterns across countries. Only more recently has the new trade literature begun to consider the role of finance in heterogeneous firm models (see Manova (2006, 2008); Chaney (2005); Suwantaradon (2008)). Existing models of exporting decisions such as Manova (2006); Chaney (2005); Suwantaradon (2008) assume a set percentage of borrowing and do not account for the accumulation of internal finance that affect financial constraints and reduce the demand for borrowing. Their models assume that all firms are affected by financial constraints, due to the set borrowing requirement, and therefore financial constraints will *always* influence exporting decisions, regardless of differences in internal financing between firms. This is a restrictive assumption as it is important to take into account of both good financial health, when firms do not require to borrow, and when firms are financially constrained so as to accurately capture the impact of financial constraints on the distribution of firms in the aggregate.

Existing models also assume that allocation of credit is perfectly aligned to productivity. This assumption drives the result of these models: exports with financial constraints simply raises the productivity cutoff across all firms. Existing models assume no time difference between inputs and revenues and as such, the financing of the inputs responds directly to the input choice. This, coupled with the assumption that credit is perfectly aligned with productivity, drives the existing models' result.[5] However, existing literature has shown that the allocation of credit does not correspond perfectly to productivity (see Hsieh and Klenow (2009); Banerjee and Duflo (2005)). The assumption of direct correspondence is thus too strong as it does not allow for the existence of distortions in the allocation of credit. The assumptions made by existing theoretical models, static borrowing demand and direct correspondence between allocation of credit and productivity, lead to essentially the same result as predicted by Melitz (2003) with the caveat that financial distortion raises the productivity cut off level across all firms.

The empirical literature using micro level data on the relationship between exporting and finance is limited due to both the availability of firm level datasets as well as the topic being an emerging area of research. Of note, one of the few studies is Greenaway et al. (2007) that uses a large UK panel dataset. They show that financial health of firms positively affect export decisions. Another more recent study, Berman and Hericourt (2009) uses cross section of firm level data across 9 developing countries and they find that access to finance is important to the firm's decision to enter exports. Furthermore, they find that financial constraints create a disconnection between firms' productivity and their export status: productivity is only a significant determinant of the export decision if the firm has a sufficient access to external finance. While the existing empirical work show that there are significant relationships between exporting and financial factors, neither studies relate these empirical findings to a model that explains the underlying economic relationships that drive these results.

[5]The working capital model differs from the existing models in that the firm's maximization problem at time t is bounded by predetermined internal revenues- that is, revenue is a state variable. Even if credit is perfectly aligned to productivity in the working capital model, this would not detract from the predictions that are driven uniquely by the timing difference between inputs and receipt of revenues.

3.3 Why might working capital restrictions affect exporting decisions?

The Bangladesh Investment Climate Assessment 2002 surveyed 990 firms and collected annual recall data for 2000 and 2001 for key variables, except for access to finance questions that are only reported for 2002. A total of six manufacturing industries are represented: Garments, Textiles, Food, Leather, Electronics and Chemicals. The distribution of firms within each of these industries is representative of the composition of the Bangladeshi economy, with 57 percent of the observations in the garments and textiles industry. The dataset contains financial information that allows working capital to be measured at the firm level. Working capital is defined in the data as the sum of inventories, accounts receivable and cash on hand.[6] Working capital can be though of as current assets or the liquidity of the firm. A unique characteristic of the dataset is that it contains country destinations of exports. This allows us to look at whether the distance to country destinations is correlated with working capital at the firm level.

There are three major observations from the data that indicate working capital is particularly important for exporting. First, there are substantial additional costs to exporting in the form of custom duties and procedures. Table 3.1 shows that average official costs are 84,935 takas (approximately $1,456 USD) and average unofficial costs total 32,895 takas (approximately $564 USD). In light of the average value of exports is only 139,981 takas (approximately $2,399 USD), total custom costs are a substantial cost to firms in Bangladesh. In addition to these costs, exporting firms also hire clearance agents to help get them through customs -around 90% of exporting firms use a clearance agent at an average cost of 0.82% of the value of the freight. These costs plus the time delays in customs would require the firm to have adequate working capital in order to just get their goods through customs.

Second, exporters do not get paid until their goods are delivered to the export destina-

[6] Working capital is measured according to the accounting definition: current assets (inventories, accounts receivable, cash and short term credit) minus current liabilities (accounts payable and any short term debt). Note that working capital data is only reported for 2002

tion for a much larger proportion of their sales than non-exporters. Table 3.2 shows that on average, 89 percent of the sales for exports is paid upon delivery (median is 100 percent) compared to 65.74 percent for non-exporting firms (median 75 percent).[7] Therefore, exporters would require to cover a greater percentage of their costs with their own working capital than non-exporters. Furthermore, the longer the time period is between production and delivery, the greater the amount of working capital is required.

Last, delivery times are longer for exporters than non- exporters. Turnover time differs from industry to industry. It ranges from a month in garments to 4 months for shrimp farming (Arnold (2004)). For firms that export, clearing customs, transiting to overseas destination and clearing foreign customs all add to the amount of time firms have to wait before receiving payment for their goods. The time to clear domestic customs is on average around 9 days, with a maximum of 14 according to the 2002 Bangladesh ICA (see Table 3.1) For transiting time, Bangladesh exports are shipped using international shipping lines that run on regular schedules. The time in transit consists of: overland to port, a feeder journey from Chittagong or Dhaka to Singapore to meet up with the international shipping line, and then the destination port to customer location. According to Arnold (2004) , the greatest delays are caused in the exchange from feeder to mainline vessel as schedules may not synchronized and containers may wait in the transshipment port for several days. His estimate of ocean transit times from Bangladesh, using a variety of shipping companies, is between 25-35 days. Figure 3.1 shows the transit times for APL shipping (the world's sixth largest container transportation and shipping company) which corroborates the Arnold (2004) estimate. Without even counting for time needed to clear foreign cus-

[7] A proportion of sales is also bought on credit, and here, non-exporting firms appear to extend more credit than exporting firms. Extending credit to customers would further delay the receipt of revenues from when the cost of production was incurred. On average, amongst those that do extend credit to customers, 43.77 days of credit is extended with a median of 30 days. This is funded mainly from retained earnings (median of 60%, with the rest from micro lenders or informal lenders). This implies that those firms that extend credit to their customers are doing so because they have enough cash or access to finance. They charge their customers extra for the credit for the delay in the receipt of payment and the delay is not crucial for completing the exchange. Unlike the delays caused by shipping across large geographical distances which are unavoidable and crucial to completing the transaction between the exporter and the customer.

Table 3.1: Costs to Customs

2002 Bangladesh ICA	Mean	Standard Deviation
Average days to clear customs	8.87	10.69
Maximum number of days to clear customs	14.10	13.76
Official costs (takas)	84935	440869
(USD)	1456	7556
Unofficial costs (takas)	32895	221242
(USD)	564	3792
Value of exports (takas)	139981	321491
(USD)	2399	5510
Percent that use clearing agent	89	
Cost of agent as % of the value of freight	0.8132	3.109

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank
Note: The exchange rate in 2002 average is 0.017137961 takas=1 USD

Table 3.2: Timing of payment for sales

Mean	% of Sales paid before delivery	% Sales paid at delivery	% Sales bought on credit	Number of Obs
Non-Exporting Firms	5.57	65.74	28.43	561
Exporting Firms	2.87	89.42	7.66	421
Total	4.41	75.89	19.53	982

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank

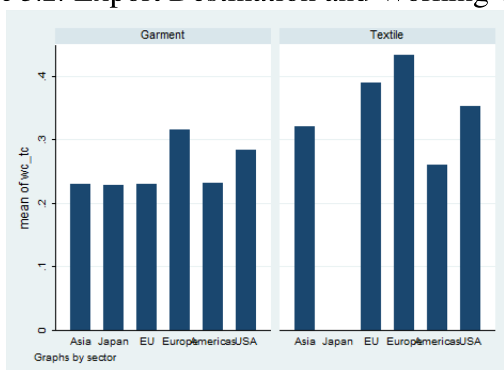
toms and inland delivery, selling to European markets from Bangladesh can add an extra month to the product cycle. Considering that production of garments only requires about a month to process, exporting essentially would double the amount of working capital required.

Among exporting firms, Figure 3.2 shows that the amount of working capital is increasing with the distance of export destination. This relationship is particularly stark with Europe and the EU - destinations that have the longest shipping transit times from Bangladesh. This suggests that if firms require additional working capital the longer the transit time or the greater the distance of the export destination.

Figure 3.1: Ocean Transit Times (Days) from Chittagong

Source: APL Limited (American President Lines Ltd.) at http://www.apl.com/services/documents/sells_mkt_ia_chtct2.pdf

Figure 3.2: Export Destination and Working Capital



Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank
Notes: Average of the percentage of working capital to total costs (sum of total wage cost, raw material cost, energy costs and other costs). Other sectors and regions drop due to lack of observations.

3.4 A Model of Export Decision with Working Capital

The previous section motivates the importance of working capital in the firm's export decision. This section presents a dynamic model of the firm's export decision that allows for differences in liquidity to affect export decisions. The purpose of articulating an export model where working capital is required for production is to show how productivity and cash interact to jointly determine export status of the firm, and as a result, the presence of financial constraints distorts the selection of the most productive firms into exports through the time demand for liquidity required for exporting. The interaction is highly intuitive: the firm exports if it has met both productivity and cash requirements for exporting. This implies that among the population of firms, there will exist low productivity firms that never export regardless of their cash positions, and likewise, cash poor firms that do not export regardless of their productivity levels. The interaction of productivity and cash as necessary conditions to enter exports would give rise to lower correspondence between productivity and export status of the firm than the correspondence predicted by earlier models.

Take a representative firm within an industry with the production function $F(K_t, L_t)$. At each period, the firm chooses inputs in labor and capital as well as the percentage of output, ψ, to sell to international markets[8] to maximize all future stream of profits. Capital takes one period to install. Labor is inelastically supplied. Productivity, A_i, is exogenously given and differs across firms. Firms know their productivity level and makes production decisions based on the uncertainty of output and prices in the domestic and foreign markets.[9]

The firm also has access to financial services where it can borrow or save, b, at interest rate r.[10] The standard assumptions apply where wages, w, the price of capital, p^k, and the interest rate, r are assumed to be exogenous and non time varying. The discount factor given by $\beta = \frac{1}{(1+r)}$ and the depreciation rate of capital given by δ. Entry to export markets requires a fixed cost, f , each period, which can be viewed as a license, permit or agent's fee to export.

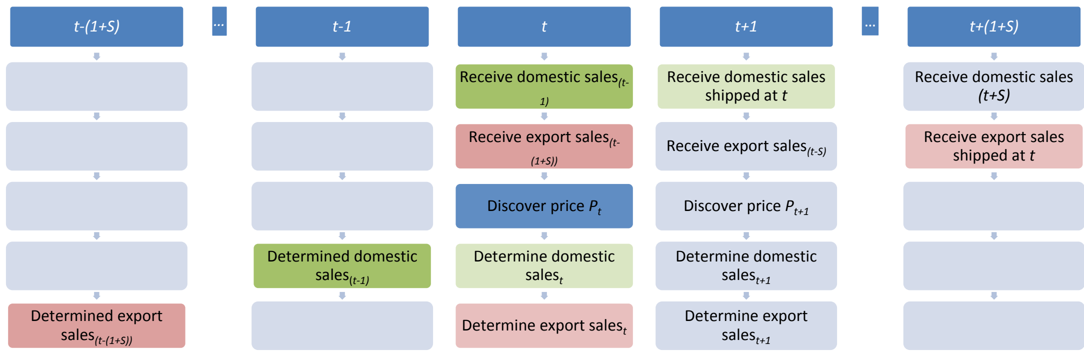
To incorporate the need for working capital, time delays between production and receipt of revenue are introduced. The time delays are as follows: selling to domestic markets requires one period to receive the revenue and selling to international markets requires S periods in addition to the one period delay that is normally incurred through domestic sales. That is, exporting requires additional time for products to be shipped and received overseas over that of domestic sales. Figure 3.1 shows the timing of production and receipt of

[8] Likewise, $(1-\psi)$ percent is sold to domestic markets

[9] This departs from current literature where firms only realize their productivity after paying a fixed cost Melitz (2003); Manova (2006); Suwantaradon (2008). The rationale is that firms are privy to more information about their own operations and how productive they are more so than knowing the price conditions on foreign markets.

[10] Note, this follows the international finance literature in that b represent bond holdings and positive implies savings and negative implies borrowing.

Figure 3.1: Time line for Production and Receipt of Revenue



Note: Price P_t represents both domestic price P^D and foreign price P^F.

revenue. At each period, the firm receives the revenue from past sales: past sales includes any domestic sales from period $(t-1)$ and any export sales from period $(t-(1+S))$. At each period, the firm also decides on production to be sold domestically and/or exported - the revenue from which will be received either at the next period $(t+1)$ or at $t+(1+S)$ periods later. All costs of production are incurred at the time of production, regardless of whether products are going to export or domestic markets, but the production choice affects the transitional equation at the present period and at $(1+S)$ period when export revenues arrive.

At each period, the firm discovers the prices for output; the domestic price, P_t^D and the foreign price, P_t^F. Both prices are stochastic over time. For simplicity, the present value of the foreign price is assumed to be always greater than domestic price so that there is an incentive for firms to enter exports, $\beta^S P^F - P^D > 0$.[11] The availability of export markets can be thought of as an additional mechanism to transfer resources over time: domestic sales get P^D and returns are delivered at time $t+1$ while international sales get P_t^F but incurs a fixed cost and returns are delivered at time $t+1+S$.[12] Intuitively, the extra time

[11]Relaxing this assumption will simply allow more instances where firms will choose not to export because it isn't as profitable. The objective of this paper is to highlight how financial constraints affect export behavior, and thus it is important for firms to have an incentive to export in the first place.

[12]The firm also has available bonds, that earns interest, r, that is received also at $t+1$. It is implicitly assumed that the rate of return from domestic production is greater than the interest rate - or else there is no incentive to produce. In other words, P^D is bounded from below such that there is always an incentive to produce.

required for exports costs the firm the discount rate β^S on revenue which is increasing with time S. The delays imply that at each period, the firm has a stock of wealth made up of revenues that are due from past production and any bond holdings from last period. This stock of wealth is the firm's working capital, X_t:

$$\begin{aligned} X_t &= (1-\psi_{t-1})P^D_{t-1}AF(K_{t-1},L_{t-1}) \\ &\quad +\psi_{t-(1+S)}P^F_{t-(1+S)}AF(K_{t-(1+S)},L_{t-(1+S)}) \\ &\quad +(1+r)b_{t-1} \end{aligned}$$

The cash the firm has at any particular point will not include *all* export sales pending from all previous periods but only the export sales due at that period. The revenue for export sales is only realized as cash at the period the firm receives it. Working capital is liquidity, and pending payments that are not received cannot be used to pay for inputs.[13]

The firm chooses labor, investment and percentage of production to export according to how much working capital it has. Therefore, the firm's budget constraint is given by:

$$wL_t + p^k\left(K_t-(1-\delta)K_{t-1}\right)+\{f_t|\psi_t>0\}+b_t = X_t$$

Financial constraints are introduced as a limit on how much the firm can borrow at any particular time. The firm is restricted to borrow only up to a percentage, φ, of it's total wealth: $b_t \geq -\varphi X_t$.[14]

[13]It is possible that pending payments could be used as collateral to borrow more, but this scenario will be left for further research. The focus of this paper is to look at cash strap firms in developing countries where any kind of credit is difficult to obtain even on cash collateral.

[14]This setup differs from the existing literature in three ways: 1) borrowing is endogenously chosen, 1) the probability of exiting export markets is not assumed a priori, 2) the amount the firm produces for domestic and international markets is chosen endogenously by the firm in response to relative prices and 3)the time required to trade and the resulting liquidity requirements are modeled explicitly. I take out the assumption of monopolistic competition, where exporting firms can influence price levels, and substitute this with financial constraints as this may be a more realistic assumption for firms in developing countries.

Define π^D as the current value profit from only domestic sales; $\pi^D = \beta P^D A_i F(K,L) - C(K,L,K_{-1})$. Likewise, define π^E as the current value profit from sales where exports are non-zero;

$\pi^E = \left((1-\psi)\beta P^D + \psi\beta^{1+S}P^F\right)AF(K,L) - C(K,L,K_{-1}) - f$. Variable costs are denoted by $C(K,L,K_{-1}) = wL + p^k(K-(1-\delta)K_{-1})$. The dynamic maximization problem of the firm can be described by the value function defined below:

$$
\begin{aligned}
V(X,K_{-1}) = \max_{\psi=0,\psi>0} \Bigg\{ & \max_{L,K} \pi^D + \beta E\left[V\left(X',K\right)\right] + \nu\left[(1+\varphi)X - C(K,L,K_{-1})\right] \\
& s.t.\, X' = P^D A_i F(K,L) \\
& + \psi_{-s}P^F_{-s}A_i F(K_{-s},L_{-s}) + (1+r)\left[X - C(K,L,K_{-1})\right], \\
& \\
& \max_{L,K,\psi} \pi^E + \beta E\left[V\left(X',K\right)\right] + \nu\left[(1+\varphi)X - C(K,L,K_{-1}) - f\right] \\
& s.t.\, X' = (1-\psi)P^D A_i F(K,L) \\
& + \psi_{-s}P^F_{-s}A_i F(K_{-s},L_{-s}) + (1+r)\left[X - C(K,L,K_{-1}) - f\right] \Bigg\}
\end{aligned}
$$

Following Bond and Van Reenen (2007), the borrowing constraint for domestic, $(1+\varphi)X - C(K,L,K_{-1}) \geq 0$ and for exports, $(1+\varphi)X - C(K,L,K_{-1}) - f \geq 0$, is embedded in the value function where ν denotes the shadow value of loosening borrowing constraint.

The firm's maximization problem involves 2 steps due to discontinuity introduced by the fixed cost of exporting. First, given the cash available and output prices, the firm determines the output levels that will maximize profits under domestic sales as well as for export sales. Under export sales, the firm also determines the optimal amount to export if exporting. Second, the firm then chooses between the two profits to determine whether to export.

3.4.1 Domestic Sales

The firm's dynamic problem in the domestic sales case reduces to only two possible solutions, as established in Chan (2008); the firm is either not financially constrained, in which case it produces at the optimal, or it is constrained, in which case, it produces as much as it can given cash on hand. The first order conditions are repeated below:

Unconstrained:

$$\beta P^D F_L(K,L) = w \tag{3.1}$$

$$\beta P^D F_K(K,L) = p^k \cdot \frac{(r+\delta)}{(1+r)} \tag{3.2}$$

L^{D*} and K^{D*} is the solution to the firm's maximization problem if and only if:

Equation (4.1) and (4.2) hold and $(1+\varphi)X - wL^{D*} - p^k(K^{D*} - (1-\delta)K_{-1}) > 0$.

Otherwise, the solution is given by Equations (4.3) and (4.4) below:

Constrained:

$$\frac{\beta P^D F_L(K,L)}{w} = \frac{\beta P^D F_K(K,L)}{p^k} + \frac{(1-\delta)}{(1+r)} \tag{3.3}$$

$$X = \frac{1}{(1+\varphi)}\left[wL + p^k(K - (1-\delta)K_{-1})\right] \tag{3.4}$$

Let $V^{*D}(A_i)$ denote the value of the value function of optimal domestic profits as a function of A and let $X^{D*}(A_i)$ denote the minimum cash requirement for unconstrained profits to occur. Note that both profits and cash requirements are increasing with technology, A. Let $V^{\overline{D}}(A_i, X_i)$ denote the value of the value function where profits are at constrained optimal (where $X_i < X^{D*}(A_i)$). It is necessarily so that constrained optimal profits is lower than unconstrained profits: $V^{*D}(A_i) > V^{\overline{D}}(A_i, X_i)$.

3.4.2 Export Sales

The firm's dynamic problem in the export sales case can also be similarly reduced to two scenarios. Let Σ denote the expected sum of all future shadow values up till the period export revenue is received; $\Sigma = E\left[\nu_{S-1}(1+\varphi)\right] + ...E\left[\nu'(1+\varphi)\right]$. This can be interpreted as the opportunity cost of liquidity due to exporting. The first order conditions under export sales are given by:

$$
\begin{aligned}
\frac{\partial V}{\partial L}: \quad & \left(\left((1-\psi)P^D + \psi\beta^S P^F\right)\beta A F_L - w\right)\left(1 + E\left[\frac{\partial V'}{\partial X'}\right]\right) \\
& = \nu w + \psi\beta^{1+S}P^F A F_L.\Sigma && (3.5) \\
\frac{\partial V}{\partial K}: \quad & \left(\left((1-\psi)P^D + \psi\beta^S P^F\right)\beta A F_K - \beta(r+\delta)p^k\right)\left(1 + E\left[\frac{\partial V'}{\partial X'}\right]\right) \\
& = \nu p^k + \varphi\beta\nu'(1-\delta)p^k + \psi\beta^{1+S}P^F A F_K \Sigma && (3.6) \\
\frac{\partial V}{\partial \psi}: \quad & \left((-\beta P^D + \beta^{1+S}P^F\right) A F(K,L) \\
& +\beta E\left[\frac{\partial V'}{\partial X'}\frac{\partial X'}{\partial \psi}\right] \\
& +\beta^{1+S}E\left[\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}\frac{\partial X^{(1+S)}}{\partial R^F}\frac{\partial R^F}{\partial \psi}\right] && (3.7) \\
either \quad & \nu \neq 0 \Rightarrow (1+\varphi)X - C(K,L,K_{-1}) - f = 0, \\
or \quad & \nu = 0 \Rightarrow (1+\varphi)X - C(K,L,K_{-1}) - f > 0
\end{aligned}
$$

Identical to the case of optimization of domestic sales, the choice of labor and capital is governed by their respective marginal cost when unconstrained and governed by the binding budget constraint when constrained. Unlike the case of domestic optimization, optimizing export sales involves taking into consideration of the additional future periods until export sales revenue are received.

The first order condition for exports dynamically captures the timing differences between domestic sales and export sales and also show why this matters under financial constraints. One way to see this, is by simplifying the first order condition by substituting in $\frac{\partial X'}{\partial \psi} = -P^D AF(K,L)$ and $\frac{\partial X^{(1+S)}}{\partial R^F}\frac{\partial R^F}{\partial \psi} = P^F AF(K,L)$ into the first order condition for ψ, Equation (3.7). This yields:

$$\frac{\partial V}{\partial \psi} \;=\; A\beta F(K,L)\left[\left(\beta^S P^F - P^D\right) - E\left[\frac{\partial V'}{\partial X'}\right]P^D + \beta^S E\left[\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}\right]P^F\right] \qquad (3.8)$$

The entire term in the square brackets can be interpreted as the net price of exporting which has two components: i) the difference in price between exporting and domestic, given by$\left(\beta^S P^F - P^D\right)$, and ii) the value of the timing of the different revenue streams, given by $-E\left[\frac{\partial V'}{\partial X'}\right]P^D + \beta^S E\left[\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}\right]P^F$. An increase in the percentage of exports will increase export revenue via the $+\beta^S E\left[\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}\right]P^F$ term at time $(1+S)$ while a decrease in the marginal domestic revenue, via the $-E\left[\frac{\partial V'}{\partial X'}\right]P^D$ term at the next period. Each of these revenue streams are weighted by the corresponding value of cash at that point: $\frac{\partial V'}{\partial X'}$, the expected change in the value function due to additional cash at the next period and $\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}$, the expected change in the value function due to additional cash at time exports arrive, $(1+S)$. The second component, $-E\left[\frac{\partial V'}{\partial X'}\right]P^D + \beta^S E\left[\frac{\partial V^{(1+S)}}{\partial X^{(1+S)}}\right]P^F$, is only relevant when financial constraints are binding as that is the only time when additional liquidity brings value to the value function.[15]

The additional time dimension of the export sales maximization problem makes the solution less tractable than the domestic case. However, the export maximizing solution can be characterized similarly as domestic sales into unconstrained and constrained scenarios:

Unconstrained

If constraints are never binding during the S periods it takes for interna-

[15]Cash, X, in of itself does not contribute to the value function but only when financial constraints bind.

tional sales to be received, i.e. $\nu = \nu' = ...\nu^S = 0$, then:

$$\frac{\partial V}{\partial \psi} = A\beta F(K,L)\left(\beta^S P^F - P^D\right) \qquad \psi = 1$$

$$\begin{aligned}
\psi\beta^{1+S}P^F AF_L &= w \\
\psi\beta^{1+S}P^F AF_K &= p^k.\frac{(r+\delta)}{(1+r)}
\end{aligned}$$

Constrained

$$\left(\beta^S P^F - P^D\right)\left(1+E\left[\frac{\partial V'}{\partial X'}\right]\right) = \beta^S P^F \Sigma \tag{3.9}$$

$$wL + p^k(K-(1-\delta)K_{-1}) + f = (1+\varphi)X \tag{3.10}$$

$$\frac{\left(\left((1-\psi)P^D + \psi\beta^S P^F\right)\beta AF_L - w\right)}{\left(\left((1-\psi)P^D + \psi\beta^S P^F\right)\beta AF_K - \beta(r+\delta)p^k\right)} = \frac{\nu w + \psi\beta^{1+S}P^F AF_L\Sigma}{\nu p^k + \varphi\beta\nu'(1-\delta)p^k + \psi\beta^{1+S}P^F AF_K\Sigma} \tag{3.11}$$

Equation 3.9 comes from a derivation of the first order condition from exports, given by:

$$\frac{\partial V}{\partial \psi} = A\beta F(K,L)\left(\left(\beta^S P^F - P^D\right)\left(1+E\left[\frac{\partial V'}{\partial X'}\right]\right) - \beta^S P^F \Sigma\right) \tag{3.12}$$

[16]

Thus the solution to the export maximization problem is as such:

- If there are no binding future constraints for all future periods up to $(1+S)$, i.e.$\Sigma = 0$, then the marginal value of increasing export sales is strictly positive. Exports in this

[16]This utilizes a backward iteration of $\frac{\partial V}{\partial X} = E\left[\frac{\partial V'}{\partial X'}\right] + \nu(1+\varphi)$ that allows us to summarize the change in the value function at time $(1+S)$ in terms of the history of shadow values leading up to it: $E\left[\frac{\partial V^{1+S}}{\partial X^{1+S}}\right] = E\left[\frac{\partial V'}{\partial X'}\right] - \Sigma$.

case will be the maximum amount possible which is 100 percent; $\psi = 1$.

- If there are binding future constraints in the period up to $(1+S)$, the extent that financial constraints are binding during that time will determine the amount of exports. The choice of ψ affects the size of Σ, the shadow values ν and ν' as well as $E\left[\frac{\partial V'}{\partial X'}\right]$. The choice of labor, capital and export percentage will be determined where all three equations are satisfied. Exports in this case can take on values between 0 and 100 percent due liquidity constraints.

Let $V^{*E}(A_i)$ denote the value of the value function of optimal domestic profits as a function of firm specific technology A_i and let $X^{E*}(A_i)$ denote the minimum cash requirement for unconstrained profits to occur. Additionally, let $V^{\overline{E}}(A_i, X_i)$ denote the value of the value function where profits are at constrained optimal (where $X_i < X^{E*}(A_i)$). It is necessarily so that constrained optimal profits are lower than unconstrained profits: $V^{*E}(A_i) > V^{\overline{E}}(A_i, X_i)$

The cash requirement, $X^{E*}(A_i)$, to satisfy $\Sigma = 0$ can be calculated by iterating backwards the budget constraint from the period when export revenue is received. At that period, cash on hand must be greater than expected cost. ie $X_{t+s} > \frac{1}{(1+\varphi)} E_t[Cost_{t+s}]$ for constraints to not bind. Likewise for the period before that, and so on and so forth. The minimum cash required for constraints to not bind for each period thus can be given as: [17]

Let C^F denotes the cost to produce optimally at foreign prices.

[17] The cash threshold is defined for where the firm also expects to export in the future. An alternative scenario is that, due to higher than mean expected price realizations, the firm is able to export once but expects to return to domestic sales only as prices return to expected mean. In this scenario, the cash threshold , $X^{E*}_{FD}(A_i)$, will be lower. $X^{E*}_{FD}(A_i) = C^F + f - \beta^{1+S} P^F_t A_i F(K,L) - E_t\left[\beta P^D_{t+1} A_i F(K,L) - C^D\right]\left(\sum_{s=1}^{S} \beta^s\right) + E_t\left[C^D\right] \frac{1}{(1+\varphi)} \beta^{1+S} - \omega$

Price expectations are iid such that: $E_t[P_{t+1}] = E_t[P_{t+2}] = \ldots = E_t[P_{t+T}]$. Expected costs at time t are the same: $E_t\left[C^F_{t+1}\right] = E_t\left[C^F_{t+2}\right] = \ldots = E_t\left[C^F_{t+T}\right]$ where C^F denotes the cost to produce optimally at foreign prices and C^D the cost at domestic prices.

$$
\begin{aligned}
X^{E*}(A_i) &= C^F + f - \beta^{1+S} P_t^F A_i F(K,L) \\
&\quad + E_t\left[C^F + f\right]\left(\sum_{s=1}^{S}\beta^s\right) \\
&\quad + E_t\left[C^F + f\right]\frac{1}{(1+\varphi)}\beta^{1+S} - \omega \qquad (3.13) \\
Given: &\quad \omega = \beta^S P_{-1}^F A_i F_{-1} + \beta^{S-1} P_{-2}^F A_i F_{-2} + \ldots + P_{-(1+S)}^F A_i F_{-(1+S)}
\end{aligned}
$$

The characteristics of the cash threshold as defined by Equation 3.13 is intuitive as all costs enter positively; an increase in production costs and fixed costs will raise the cash threshold. Revenues enter negatively; if foreign price, P^F, increases, the amount of cash required to export will decline. ω denotes the current value of foreign sales revenue that is going to be delivered in the future, between $t = 0$ and $t = (1+S)$, from past production. If the firm has never exported before then $\omega = 0$. If the firm has exported before (and the greater the value of ω is), the lower the initial amount of cash required to export. This captures how firms are more likely to export, if they have exported before. The motivation here, however is not a learning story as is often forwarded by existing trade story (ie Clerides et al. (1998)), but one of liquidity and the timing of when cash arrives - firms that have exported before will have more liquidity to export in the present period.

The cash requirements also show that in addition to the fixed cost f required to export, the firm requires additional liquidity to cover the longer delays in exporting. The term $E_t\left[C^F + f\right]\left(\sum_{s=1}^{S}\beta^s\right)$ is the cost of production for exporting sales during the interim. The greater the distance, S, the greater the cash required for the firm to not run into binding liquidity constraints. Thus it captures the role of distance in exporting and relates this to the liquidity demands. The borrowing allowance φ also affects the cash threshold: if it decreases, the threshold also increases as firms cannot rely on external borrowing to finance production but need to finance internally.

The cash threshold is an increasing function of firm productivity A_i as cost of production, C, increases with inputs L and K which themselves are increasing functions of productivity. Intuitively, greater productivity increases the level that optimal scale of production is reached.

3.4.3 Exporting Decision

The exporting decision rests on choosing between domestic sales or export sales depending on which value stream is greater. The value streams depend on the state variables A_i and X_i.[18]

First, looking at technology A_i, let's assume that the firm's cash level X_i is greater than the minimum cash requirement to export, $X^{E*}(A_i)$. The firm picks the maximum of the two unconstrained optimal value streams: $V^{*D}(A_i)$ or $V^{*E}(A_i)$. As cash is not a binding constraint both at the present time period and in the future, the firm need only compare current profits: $\pi^{D*} = \beta P^D A_i Q^{D*} - C^{D*}$ to $\pi^{E*} = \beta^{1+S} P^F A_i Q^{E*} - C^{E*} - f$. The productivity threshold, $\bar{A}$, is defined where $\pi^{D*} = \pi^{E*}$:

$$\bar{A} = \frac{C^{E*} - C^{D*} + f}{\beta^{1+S} P^F Q^{E*} - \beta P^D Q^{D*}}$$

The productivity threshold exhibits some intuitive characteristics in terms of it's parameters. An increase in the foreign price P^F or a decrease in the domestic price, P^D, lowers the threshold as this causes exporting to be more profitable relative to domestic sales. Likewise, an increase in the fixed cost, f, raises the productivity bar for firms to be profitable exporting over domestic sales. An increase in the delay, S, such as through shipping distance, increases the threshold through the discount rate.

The productivity threshold is important in that it defines the minimum technology level required for the firm to be profitable in exporting. It would not be profitable for a firm with technology below the threshold to export, regardless of it's cash position. This threshold holds even under financial constraints as a firm that is not profitable exporting without

[18] Recall that all firms are assumed to face the same prices, wages and interest rates.

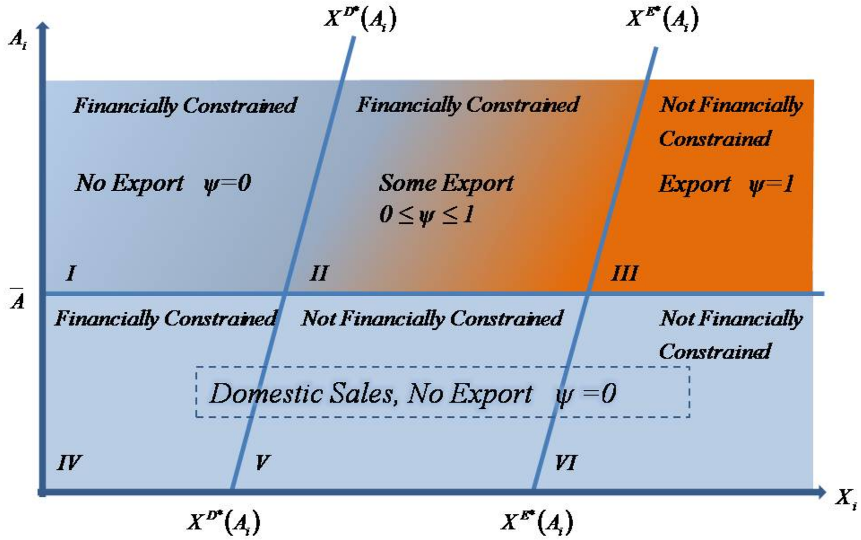
constraints, will not be profitable exporting *with* constraints.

However, productivity alone does not determine whether the firm exports. While the productivity threshold separates firms with the ability to export from those that cannot, whether the firm has the means to do so will depend on the level of cash, X_i. Clearly, if the firm meets both productivity and cash requirements, $A_i > \bar{A}$ and $X_i > X^{E*}(A_i)$, the firm will export. Also, if the firm does not meet productivity requirements, $A_i < \bar{A}$, then the firm will not export regardless of the cash position, X_i. Therefore, out of the set of solutions dependent on the state variables A_i and X_i, the situation where the firm meets productivity requirements, $A_i > \bar{A}$, but does not have the cash, $X_i < X^{E*}(A_i)$, is the only combination left to fully map out the solution.

Previously, in the sections on domestic sales and export sales, the minimum cash levels required for unconstrained optimal were defined as $X^{D*}(A_i)$ and $X^{E*}(A_i)$ respectively. If the firm has cash levels below the minimum domestic "unconstrained optimal", that is $X_i < X^{D*}(A_i)$, then the firm would necessarily not choose to export as the value of exporting is lower than domestic sales, $V^{\overline{D}}(A_i, X_i) > V^{\overline{E}}(A_i, X_i)$. This will hold regardless of productivity levels, A_i. Intuitively, if the firm cannot afford to produce at optimal for domestic markets, it would not produce for export markets where there are even greater demands on liquidity due to fixed cost of exporting and the longer delays in the receipt of revenues, even if $A_i > \bar{A}$.

Take the situation when the firm's cash level is above the minimum domestic unconstrained optimal but below the minimum export unconstrained optimal, that is $X^{D*}(A_i) < X_i < X^{E*}(A_i)$ and $A_i > \bar{A}$. In this case, the firm has more than enough liquidity to sell at domestic optimal, but not enough to sell at the export unconstrained optimal. The firm needs to compare between unconstrained optimal domestic sales, $V^{D*}(A_i, X_i)$, with constrained export sales, $V^{\overline{E}}(A_i, X_i)$, where export percent is less than 100 percent. This situation gives rise to two interesting outcomes: either a) the firm chooses to export, but it will export at less than 100 percent which is unusual to observe when there is a fixed cost to export, or

Figure 3.2: Summary of Model Results



Note: FC -Financially constrained, NFC - Not financially constrained.

b) the firm chooses to sell to domestic markets even though it meets productivity requirements.

The export decision mapped accordingly to the interaction between the two state variables A_i and X_i can be summarized by Figure 3.2. All firms below the productivity threshold needed to be profitable in export sales do not export regardless of cash levels; that is, if $A_i < \overline{A}$, then exports will equal zero, $\psi = 0$, for all values of X_i (Areas IV, V and VI in Figure 3.2). All firms that above the productivity threshold, and are not financially constrained to export, will export 100 percent; that is, if $A_i > \bar{A}$ and $X_i > X^{E*}(A_i)$, then exports will equal one, $\psi = 1$ (Area III in Figure 3.2). Area I in Figure 3.2 demarcate values of cash that constrain firms from producing at domestic unconstrained optimal levels and thus will not export despite productivity levels that are above the threshold; if $A_i > \bar{A}$ and $X_i < X^{D*}(A_i)$, then exports will equal zero,$\psi = 0$. Area II demarcate values of cash that constrain firms from producing at unconstrained export optimum, but allow the firm to produce at unconstrained domestic optimum. Here, export able firms will choose to mix export sales with some domestic sales depending on the level of cash on hand; that is, if $A_i > \bar{A}$ and $X^{D*} < X_i < X^{E*}(A_i)$, then export values will take on values between zero and one, $0 \leq \psi \leq 1$. Within Area II, cash is the greater driver of the export status of the firm. For example, take two firms with the same cash level X_i where $X^{D*} < X_i < X^{E*}(A_i)$ and both has productivity levels higher than the threshold. The firm that has lower A_i would have a higher likelihood of exporting as it has lower liquidity requirements to export. (See cash threshold requirements Equation 3.13 that the higher the A_i the greater the the cash is required to produced at unconstrained optimal)

The results of the working capital model with exports is unique in that it captures the tension between time and payoff that arises under financial constraints. The firm faces a tradeoff between getting a higher price but waiting longer, or getting a lower price but getting it sooner in its decision between exporting and domestic sales when financial constraints are present. Under severe financial constraints, such as in Area I in Figure 3.2, firms choose to sell to domestic sales as liquidity constraints demands that payoffs be received sooner - *eventhough* the option of selling at a higher price is available. Under severe financial constraints, firms cannot afford to wait the longer time it takes to export. As financial constraints become less restrictive, such as in Area II in Figure 3.2, the firm will mix both domestic and export sales to maximize payoff and the timing of when revenue is received to ensure adequate working capital for future production.

The decision to export under financial constraint is analogous to a decision in investing in an illiquid investment. This occurs as liquidity becomes important when firms are financially constrained. When liquidity is important, firms would not strictly specialize in domestic or exports so as to not put all their liquidity in one longer term illiquid investment. Instead, they would choose to spread the ‘liquidity investment’ over both domestic and export sales.

The working capital model with exports is essentially a model of liquidity for the firm, that draws parallels with models of liquidity in the household savings literature (ie. Deaton (1991)). Additionally, the working capital model provides an alternative explanation to recent trade research that attribute the negative correlation of domestic sales with exports to decreasing returns to sales Nguyen and Schaur (2010) and Ruhl and Willis (2008) .

The results of the export working capital model of the firm shows that the export decision of the firm is determined by both productivity and working capital. The model exhibits the characteristic results of Melitz (2003) in heterogeneous firm models of export, where exporting depends on productivity but also highlights the fact that this only occurs if the firm is not financially constrained. The working capital model shows that under financial constraints, the lack of working capital can yield different export outcomes even if the firm is productive enough to export. Liquidity constraints can constrain export potential firms to not export and/or export less than 100 percent. Therefore, the correspondence between productivity and exporting is much weaker

3.5 Empirics

This section examine empirical evidence in support of the model. First some stylized facts are presented: 1) the most productive firms do not necessarily self select into exporting and there does not appear to be a productivity cut-off above which all firms export, 2) significant differences exist in physical and working capital between exporters and non-exporters even within the same industry and 3) access to finance differs significantly between exporters and non-exporters and credit does not appear to be allocated according to productivity.

The Bangladeshi dataset allows two key aspects of the model to be empirically tested: a) whether the export status of the firm is determined by both productivity and working capital and that their effects depends on whether the financial constraints are present, and b) whether there is a relationship between working capital and the export distance.

3.5.1 Stylized Facts

3.5.1.1 Productivity of exporters and non-exporters in the data: Self selection not evident.

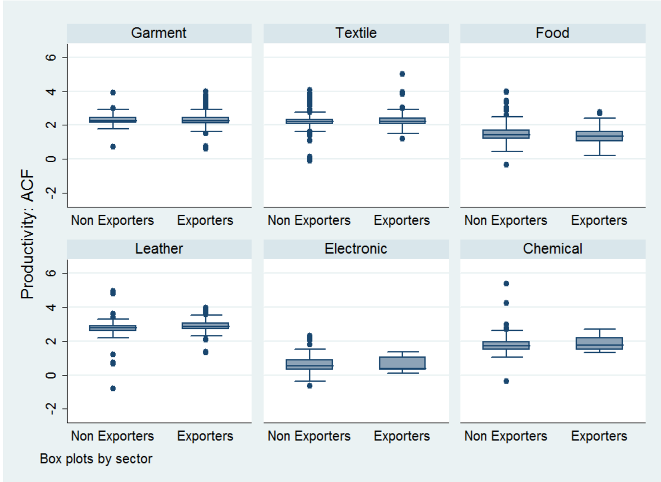
Productivity is measured as total factor productivity estimated according to Ackerberg et al. (2006) as the method allows for more generally plausible assumptions as to the dynamic data generating process of the inputs used to estimate the production function. [19] A possible caveat to estimated productivity is that estimates of the production function with a large proportion of financially constrained firms could potentially underestimate factor coefficients as firms are not operating at optimal scale. This potentially could bias the size of the TFP estimate but not the distribution of tfp overall. However, the consequences of estimating production functions with firms operating sub-optimally is not clear and is left as possible future research.

The dominant trade theory at the firm level (Melitz (2003); Bernard et al. (2003)) predicts that, within each industry, the firms at the upper distribution of productivity above a certain cut off will export while those that are below will produce only for the domestic market. Trade liberalization induces a self-selection of the most productive firms into exports. However, this self selection is not evident in the data and it does not appear that export firms are necessarily the most productive. Figure 3.1 on the next page shows the distribution of productivity for exporters and non exporters in each industry.[20] If there is evidence of self selection, the productivity levels of exporting firms would be within a range that is distinctively higher than the range of non exporting firms. However, the productivity range of exporters overlap non-exporters in each industry. The distortion to self selection

[19] TFP was also calculated using OLS, RE, FE and using the Levinsohn and Petrin (2003) method. The OLS estimate suffer from endogeneity issues and both fixed effects and random effects estimates relies on strong assumptions on ω_{it} and has not worked well in practice. The LP estimates relies strictly on specific assumptions on the data generating process of the inputs to production that may not hold generally (see Ackerberg et al. (2006)) and is prone to suffer collinearity. See Appendix 3.6.1 on page 90

[20] Furthermore, Table 3.12 in Appendix 3.6.2 shows that the median productivity level do not substantially differ between exporters and non-exporters and, in fact, shows that mean productivity is higher for domestic firms than for exporting firms in all sectors except for Leather and Chemical.

Figure 3.1: Distribution of Productivity and Export Status



Source: Bangladesh 2002 ICA, World Bank. Productivity as measured by estimated total factor productivity using Ackerberg et al. (2006). See 3.6.1 on page 90 For table of inter quartile range

due to financial constraints as articulated by the working capital model (see Figure 3.2) in fact provides an explanation to the non correspondence seen in in the date (Figure 3.1).

3.5.1.2 Differences between Exporting and Non-Exporting Firms: Working Capital, Physical Capital and Size.

Table 3.3 examines firm characteristics that differentiate exporters and non-exporters. Along with the established differences in size and age[21], the difference in means between exporting and non-exporting firms in output, physical capital and working capital are also examined. Two main patterns emerge: First, the direction of the differences between exporting and non-exporting firms are not the same across all sectors. Exporting firms are on average older than non exporting firms except for Electronics and Chemicals sector. The same reversal of the difference is seen in output, physical capital, physical capital per worker and working capital per worker.[22] This suggests that between industries, age and

[21] Differences in firm size and age has been shown to be persistent in different empirical studies both of the US and in developing countries (Bernard and Jensen (2004); **?**).

[22] While this may not be the case for physical capital, physical capital per worker and working capital per worker if we considered Textiles as an abnormality, for age and output this remains true.

physical capital may have different effects in determining whether a firm exports. Secondly, working capital and labor are the only two variables where exporters consistently have a higher mean than non-exporters across all sectors. The significance of the differences are even sharper when samples are taken according to productivity cutoffs and the direction of the differences remain unchanged.

3.5.1.3 Access to Finance: Non-exporters are more financially constrained than exporting firms and credit not necessarily allocated according to productivity.

Under perfect financial markets, firms are able to borrow to facilitate production and to overcome the time delays in the receipt of revenue. However, when access to credit is limited, the amount of cash on hand will affect the firm's decision to enter international markets where the time delays are much longer than domestic sales. Table 3.4 compares financial indicators between exporting and non-exporting firms. Access to finance is a subjective variable where respondents are asked to rank the problem from 0, being no problem to 4 as a severe problem. There is a smaller percentage of exporters who reported access to finance as a problem than the percentage of non-exporters. Furthermore, non-exporters report greater severity of the problem. Respondents are also asked where they sourced their financing for investment and for working capital and report the percentage from each category.[23] Exporters source a smaller percent of their finances internally for both investment and working capital; indicating that exporters do indeed have better access to credit. The last financial indicator is whether the firm has an overdraft facility or a line of credit available to them, and if yes, to report the percent of the line unused. Here, a larger proportion of non-exporters than exporters have overdraft facilities or credit lines however, out of those that do have credit lines, the average percent of credit lines used by

[23] There are 14 categories the respondents are asked to choose to fill in: a. Internal funds or retained earnings b. Local commercial banks (loan, overdraft) c. Foreign-owned commercial banks d. Leasing or hire purchase arrangement e. Government subsidies f. Investment Funds/Special Development Financing/ Or Other State Services g. Trade credit (Supplier or customer credit) h. Credit cards i. Equity (Capital, sales of stock) j. Family, friends k. Informal sources (e.g. money lender) l By selling other assets m. Letters of credit n. Other (specify source):

Table 3.3: Differences between non-exporters and exporters by sector

	Garments					Textiles				
	Non-Exporters	Exporters	Total	diff	t-stat	Non-Exporters	Exporters	Total	diff	t-stat
Age	7.311	7.465	7.442	-0.154	-0.302	9.516	11.53	9.979	-2.014	-2.470
Log Output	11.41	11.26	11.28	0.15	1.830	11.14	11.05	11.12	0.09	0.633
Number of Workers	418.5	471.1	463.1	-52.6	-1.099	340.5	405.7	355.9	-65.2	-1.329
Log Physical Capital	8.771	9.19	9.126	-0.419	-3.759	10.46	9.894	10.33	0.566	3.531
Log Working Capital	8.974	9.107	9.087	-0.133	-1.163	9.458	9.532	9.475	-0.074	-0.469

	Food					Leather				
	Non-Exporters	Exporters	Total	diff	t-stat	Non-Exporters	Exporters	Total	diff	t-stat
Age	15.31	33.37	17.74	-18.06	-4.071	15.36	18.3	17.38	-2.94	-2.173
Log Output	9.884	11.07	10.04	-1.186	-4.223	10.01	11.33	10.92	-1.32	-6.630
Number of Workers	126.4	426.9	167.3	-300.5	-3.839	107.8	189.7	164.8	-81.9	-3.013
Log Physical Capital	8.439	10.49	8.715	-2.051	-7.953	9.027	10.42	9.985	-1.393	-5.156
Log Working Capital	7.655	10.08	7.983	-2.425	-8.876	8.605	9.786	9.413	-1.181	-4.810

	Electronics					Chemicals				
	Non-Exporters	Exporters	Total	diff	t-stat	Non-Exporters	Exporters	Total	diff	t-stat
Age	13.18	12	13.15	1.18	0.402	20.38	18.97	20.17	1.41	0.520
Log Output	9.678	11.21	9.719	-1.532	-4.311	10.41	12.58	10.78	-2.17	-7.718
Number of Workers	100.8	198.8	103.5	-98	-0.765	159.5	636	241.3	-476.5	-5.319
Log Physical Capital	8.137	9.371	8.17	-1.234	-6.922	9.505	11.82	9.911	-2.315	-8.790
Log Working Capital	7.886	10.06	7.943	-2.174	-3.850	9.046	11.64	9.501	-2.594	-8.841

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank

Table 3.4: Indicators of Financial Constraints

	Non-exporting	Exporting	Total
Access to Finance: Moderate to Severe (2-4) Problem	0.6643	0.6095	0.6407
Access to Finance: Major to Severe (3-4) Problem	0.4506	0.3619	0.4125
Finances for Investment 100% internally financed*	0.262	0.1887	0.2305
Finances for Working Capital 100% internally financed*	0.1907	0.1321	0.1655
Overdraft facility or line of credit	0.6715	0.6506	0.6626
If yes, % currently unused	22.31	30.36	25.63

Source: Bangladesh Investment Climate Assessment survey: 2002, World Bank. Note: All variables are indicator variables except for percent of credit line unused. *100% internally financed and also reported access to finance as a problem.

non-exporters is higher. This suggests that non-exporters are closer to their borrowing limit than exporters or that exporters generally do not use this type of credit as much. Overall, these statistics suggest that non-exporters have less access to finance than exporters.

It is not only important to verify whether exporters have better access to finance than non-exporting firms but also to see whether access is allocated according to firm productivity. As discussed in the introduction, the results of existing theoretical models is driven by a direct correspondence between productivity and the amount of credit the firm has access to. It is this correspondence that supports the self selection of the most productive firms into exports even under financial distortion. Table 3.5 shows the average productivity according to each financial variable. There is no significant difference in average productivity between firms that report access to finance as a problem and between firms that fund investment wholly from internal finance. Productivity is slightly higher for those who can borrow to fund working capital[24] and those who have overdraft facilities. The difference in productivity however, does not appear large and the size of the standard deviations imply considerable overlap in the TFP distribution between constrained and not constrained categories. Therefore there is no strong evidence to suggest that credit is allocated along

[24]That is, firms that do not fund working capital wholly internally.

Table 3.5: Productivity by Financial Constrained Indicator Variables

	Average Productivity		
Indicator variable=	No	Yes	t-stat
Access Mod-Severe	4.212	4.127	1.123
	(1.15)	(1.068)	
Access Major-Severe	4.18	4.126	0.7616
	(1.131)	(1.05)	
100% Internally financed Investment	4.177	4.115	0.7433
	(1.107)	(1.105)	
100% Internally financed Working Capital	4.193	4.012	1.906
	(1.108)	(1.09)	
Overdraft Facility/Credit line available	3.978	4.256	-3.8719
	(0.9985)	(1.151)	

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank

productivity lines.

3.5.2 Working Capital and Distance to Export Destination

The 2002 Bangladesh dataset is unique in that the survey asked firms to list their main export destinations and amount exported to each of these destinations for years 2000, 2001 and 2002. From this, a weighted export distance can be calculated for each firm. The availability of data on the distance of the export destination allows a simple test of the relationship between working capital and the export distance by exporting firms. This relationship is a key component of the model: the greater the export distance, the longer the delay in the receipt of payments and the greater the demand for working capital required.[25]

The empirical question is whether the amount of working capital, X, is significantly and positively correlated with export distance among exporting firms controlling for factors that also determine the amount of working capital. If working capital does not vary with distance, than this puts into doubt whether the working capital is driven by delays in the receipt of revenues, or is simply a function of costs. The empirical specification is motivated by the determinants for the amount of cash required to export from Equation

[25] See previous sections as well as refer to Table 3.2 on page 58 that shows when payments are made and Figure 3.1 on page 59 for transit times.

3.13. Working capital demand increases with time delay S , cost of production C_t, expected cost of production C_{t+1} (to ensure that costs are covered in the interim between production and when revenue is received upon delivery) and with productivity A. The time delay, S , is proxied by the distance to export destination, $distance$. Whether the firm will export in the interim periods during the delays also affect how much working capital is needed. Therefore, working capital demands would also increase with expected relative foreign to domestic price, p.

The stock of working capital kept on hand would decrease with supply of liquidity: the amount the firm can borrow which is measured as short term liabilities, and past export production, proxied by years of exporting, $years\,exporting$.[26]

The empirical specification is as follows:

$$\begin{aligned} X_t &= \alpha_0 distance_{t+1} + \alpha_1 C_t + \alpha_2 C_{t+1} + \alpha_3 A_t \\ &\quad + \alpha_4 years\,exporting + \alpha_5 credit_t + \alpha_6 p_{t+1} + \varepsilon_t + \mu_i \end{aligned}$$

Distance enters the specification as one period ahead as the export distance is realized after the firm makes it's export decision based on current working capital levels.[27] The destination for exports would systematically differ according to industry, and the interaction between sectors and export distance were also included to improve fit.

The specification was estimated using fixed effects and the results are shown in (the full set of estimates are shown in Appendix 3.6.5 in Table 3.14). Column (1) shows the estimation with no other control variables and there is no significant correlation between

[26] Financial constraint variable was not included as this would restrict the sample to one year, and cannot estimate the relationships. Furthermore, the discount rate β could be proxied by reported interest rates but interest rates were also only available for 2002.

[27] This specification is an approximation given different industries will have different turnover time. The Bangladesh data has a majority of garment and textile firms reflecting the Bangladesh economy and the specification on the timing of working capital and export distance one year ahead fits this particular dataset. Specification using the same time period, i.e. X_t and $distance_t$ yields a negative and insignificant coefficient - that supports the specification for distance as a forward variable.

Table 3.6: Working Capital and Distance to Export Destination

Lagged Log Working Capital	(1)	(2)	(3)	(4)
Log weighed distance to export destination	0.382	0.464*	0.668**	0.739**
	(0.237)	(0.241)	(0.338)	(0.349)
Controls for Cost, Productivity, Short Term Liabilities, Years Exporting, Export Price to Domestic Price,		Yes		Yes
Interact sectors*Log distance	No	No	Yes	Yes
Observations	848	780	848	780
R-squared	0.007	0.091	0.017	0.099
Number of firms	459	438	459	438
Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$				

Notes: 2002 ICA World Bank (with recall data from 2000, 2001.). Regressed using fixed effects for the sample exporting firms only. Distance data from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), at http://www.cepii.fr/anglaisgraph/bdd/distances.htm using distance measured from the capital city. Up to five countries were reported in the survey (only for 2001 and 2002) and the weighted average distance was calculated by the proportion of export revenue of each country. Productivity calculated from structural estimation of the production function (see Ackerberg et al. (2006)). None of the coefficients for the interactive terms for sector and log distance were significant and are not reported. Log Yrs Exporting is averaged across products. Full regression in Appendix 3.14 in Table 3.14

working capital and the distance to export destination. Column (2) includes controls for cost, productivity and other variables, and columns (3) and (4) include interaction between sectors and export distance.

The estimated results shows that the correlation between working capital and export distance is positive and significant when relevant controls are included. Furthermore, the coefficients for the control variables: Lagged cost, current cost and productivity are correctly signed and significant (see in full estimate results in Appendix 3.14 in Table 3.14). The results show that the size of the estimated coefficient for distance is much larger than the estimated coefficients for cost and productivity. The *distance* variable may also be proxying for additional transport costs associated with shipping longer distances. However, the significant and positive coefficient suggests that the distance to the export destination could be the largest factor in determining the liquidity needs of the firm, and this could be due to the delays in the receipt of revenues associated with longer shipping times.

3.5.3 Export Status of the Firm

The model in the Section 3.4 provides a set of theoretical predictions that could be put to the data: i) when firms are financially constrained, export status is driven by the level of working capital and less by productivity (Areas I, II and IV in Figure 3.2) and ii) when firms are not financially constrained (Areas III, V and VI in Figure 3.2), export status of the firm is driven by productivity and changes in working capital does not change the export status of the firm. Thus the main test of the theoretical model is to see whether cash only affects export decisions when firms are financially constrained and at the same time, whether productivity affect export decisions when firms are not financially constrained. Let fc be a dummy that indicates whether the firm is financially constrained, that is whether $X_i < \bar{X}$.[28] [29] The empirical specification is as follows:

$$E_i = \beta_0 fc_i + \beta_1 fc_i * X_i + \beta_2 X_i + \beta_3 fc_i * A_i + \beta_4 A_i + controls_i$$

The test involves four predictions on the estimated coefficients: a) the interaction between financial constraints and working capital, β_1, is positive and significant, b) the coefficient for working capital only, β_2, should not be significantly different from zero, c) the coefficient for productivity when not constrained, β_4, should be positive and significant and d) the coefficient for productivity under constraints β_3 is the negative of β_4 and significant in order for productivity to not affect exports under financial constraints. That is:

[28] Note that financial access questions are only available for 2002, and thus the number of observations available for estimation is 990.

[29] See Chan (2008) for further examination of the financial access variable including sources of variation that determines access to finance.

$$
\begin{aligned}
H_0: \quad & \beta_1 > 0 \\
& \beta_2 = 0 \\
& \beta_3 = -\beta_4 \\
& \beta_4 > 0
\end{aligned}
$$

The 2002 Bangladesh dataset contains information on the percentage of sales that are exported. Out of the 974 firm observations, only 76 firms reported exporting less than 100 percent. The majority of firms report zero exports with about a third of the firms reporting 100 percent exports. The model does not offer any qualifications on how many firms in the population would export less than 100 percent. However, the fact that the model does predict that there will exist firms who will choose to export less than 100 percent, even in the presence of exporting fixed cost, is a unique and important characteristic of the model. The small number of observations of export percentage makes identification difficult and as a result, the dependent variable used is a export status dummy, E, that is equal to one if the firm engaged in any exports.

The financial constraint variable, fc, is a dummy that is equal to one if the firm reports access to finance as a problem (from minor to major severity) and finances working capital entirely from internal finance (that is, does not use any borrowing from any other sources). The rationale behind interacting these two conditions is that firms may report access to finance as a problem when they actually do have access to borrowing. The measure does however, leave out firms that are able to borrow but remain financially constrained due to reaching borrowing limits or quotas. In this sense, it may not capture all possible financially constrained firms.

Working capital, X , is measured according to the accounting definition: current assets (inventories, accounts receivable, cash and short term credit) minus current liabilities (accounts payable and any short term debt). Productivity, A, is measured as total factor productivity estimated according to Ackerberg et al. (2006) and the production function is estimated for each sector.[30] Controls for other variables in the model that were available from the dataset are: export price to domestic price ratio, log labor cost, log weighted input price, age and sector dummies are also included (base sector as Garments).[31]

The results of export status is shown in Table 3.7 (full results in Appendix 3.6.4 in Table 3.13). Results show that under financial constraints, working capital is significant and positive in determining export status of the firm, and this result remains robust even with additional controls across all three specifications. The effects of working capital, without the interaction with financial constraints, is small or insignificant in determining export status. This suggests that working capital increases the likelihood of a firm exporting mainly when the firm is financially constrained. A 10 percent increase in working capital raises the probability of exporting by over 10 percent for a financially constrained firm but by only about 3 percent for a firm that is not constrained. All estimates pass joint significance tests of β_1 and β_3. A possible explanation as to why working capital for non financially constrained firms remains significant under additional controls, even though the size is small (in regressions (2) and (3)), could be due to the financial constraint measure not capturing all possible firms that are constrained.

The estimates for productivity for all regressions are signed according to the model's prediction, that is, β_2 is negative and β_4 is positive. However the size and significance of the coefficients vary across the 3 regressions. Joint significance test of β_2 andβ_4 can reject the null for specifications (1) and (2). In the specification (3), both coefficients for productivity are jointly insignificant when sector specific dummies are included. This could be due to the small sample size within each sector in the dataset. However, in other empirical studies, such as Greenaway et al. (2007) where empirical specifications always include controls for

[30]Estimates using Levinsohn- Petrin (LP2) does not change sign nor significance, but do to some extent change the size of the coefficients. See Appendix for productivity measures.

[31]See Appendix 3.6.3 for table of variables used in estimation.

Table 3.7: Export Status Estimation Results

Probit	Export Status		
	(1)	(2)	(3)
Financially Constrained	-0.4867***	-0.420***	-0.314
	(0.0917)	(0.137)	(0.202)
FC*Log Working Capital	0.1070***	0.101***	0.0682**
	(0.0317)	(0.0281)	(0.0298)
FC*Productivity	-0.1284	-0.169*	-0.126
	(0.0937)	(0.0966)	(0.107)
Log Working Capital	0.0162	0.0288**	0.0298**
	(0.0112)	(0.0123)	(0.0124)
Productivity	0.3353***	0.355***	0.0621
	(0.0357)	(0.0477)	(0.0419)
Controls	No	Yes	Yes
Sector dummies	No	No	Yes
Observations	959	936	936
Pseudo Rsqr	0.149	0.261	0.391
Log pseudolikelihood	-557.6	-472.7	-389.6

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank

Notes: Only 2002 data used for estimation, Bootstrap standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Reported marginal effects, Base line for Equation (3) is Garments.

sectors, they too find that the estimated coefficient for productivity is not significant and their sample contains 23,641 observations. This could be due to the fact that there is more variation in productivity between sectors than between firms within a sector, and this may be in part due to how productivity is estimated. Specification (3) show that within sectors, productivity does not affect export status at all -regardless of whether firms are constrained or not.

In the first and second regression, without sector dummies, the productivity coefficient is large and highly significant, in accordance to theory. The coefficients for the interacted productivity and financial constraint is substantially sized, and only significant in the regression with additional controls. The estimates with additional controls resonates more due to specification and better fit. The results from regression (2) suggest that productivity matter less to the export status of financially constrained firms than unconstrained firms, but the effect does not completely negate the effects of productivity.

Looking at the estimates overall, results provide support for the model's predictions that the effects of working capital and productivity will differ between financially constrained and unconstrained firms. Intuitively, working capital matter more for financially constrained firms, and productivity matters less when firms are unconstrained.

3.6 Conclusion

Empirical evidence suggests that, particularly in developing countries, financial factors matter for exporting. By extending firm trade models to include dynamic borrowing constraints points to the importance of working capital, as well as productivity for determining the decision to export, the percentage of output that will be exported and their destination. As such, the working capital model adds an important caveat to the established literature on the relationship between productivity and the export decision of the firm. Testing this model empirically with a unique dataset from Bangladesh supports the proposition that working capital and productivity affect export status of the firm and their effects are differentiated by financial constraints. Empirical results also confirm the relationship between working capital and the distance to export destination. The empirical results provide support for the model's predictions that the affects of working capital and productivity will differ between financially constrained and unconstrained firms. Specifically, for financially constrained firms, productivity matters less than for unconstrained firms while working capital matters much more. The correlation between working capital and export distance is shown empirically to be positive and significant, lending support for the working capital model of the firm's export decision.

There are many exciting directions future research in this area need to explore, both at the micro and macro level. On a macro level, the partial equilibrium model of working capital of the firm can be incorporated into general equilibrium models to look at the propagation of the effects of financial constraints across the economy and across countries. Further research and exploration into the dynamic interaction between the financing needs due to time delays and the financial structure of countries has the potential to add insights to international trade patterns. The distortion that financial constraints introduces to the self-selection of the most productive firms into exporting warrants further investigation as to how this may affect overall industry productivity and thereby the aggregate growth of the economy. In terms of theories of development, if the results of the model is drawn analogously for an economy represented by a single firm, this could potentially prescribe a development path where trade liberalization may play a very minor role at low levels of wealth. This may provide further impetus for developing countries to move quickly in the development of functioning financial systems that allocate financial resources closely in line with productivity and the availability of short term credit and trade credit so that the most productive firms enter exports, and aggregate industry productivity improvements can be reaped from trade liberalization.

On micro level, the working capital model exhibits distortions to factor ratios (also see Chan (2008)) and this could potentially lead to different sectors that export within an economy than those predicted by comparative advantage trade theories. Of particular significance is the need to develop theoretical models and empirical tools that will allow the analysis of the firm at sub optimal production levels, and this is crucial in the study of developing economies where financial constraints are the norm. The estimation of productivity under these conditions warrants urgent attention.

Appendix

3.6.1 Production Function Estimation

The production function is estimated using the ACF method[32], Levinsohn and Petrin (2003)[33] (LP) as well as OLS, fixed effects, random effects by industry. The OLS estimate suffer from collinearity and is shown as a comparison. Fixed effects and random effects estimates relies on strong assumptions on ω_{it} and has not worked well in practice. The LP estimates relies strictly on specific assumptions on the data generating process of the inputs to production that may not hold generally (see Ackerberg et al. (2006)) whereas the ACF estimates allows for more generally plausible assumptions as to when inputs are chosen, and that certain inputs, such as labor, is 'less variable' than other inputs, such as materials.

The ACF method is derived from Ackerberg et al. (2006). The production function is assumed to take the form:

$$y_{it} \quad = \quad \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it}$$

Capital is decided at time $t-1$. Assuming that labor is "less variable" than materials, suppose that $l_{it}$is chosen at time $t-b$ after $k_{it}$was chosen at $t-1$ but before m_{it} was chosen at t. Assume that ω_{it}evolved according to a first order Markov process between sub periods $t-1$,$t-b$ and t. Given these timing assumptions, the firm's material input demand at t will depend on $l_{it}$and k_{it}chosen prior to period t: $m_{it} = f_t(\omega_{it}, k_{it}, l_{it})$. Inverting this function will yield:

$$y_{it} \quad = \quad \beta_k k_{it} + \beta_l l_{it} + f_t^{-1}(m_{it}, k_{it}, l_{it}) + \varepsilon_{it}$$

An estimate, $\hat{\Phi}_{it}$ of the composite term $\Phi_t(m_{it}, k_{it}, l_{it}) = \beta_k k_{it} + \beta_l l_{it} + f_t^{-1}(m_{it}, k_{it}, l_{it})$ can be obtained at this first stage. This represents output net of ε_{it}. Given the first-order

[32] Stata code developed by Sivadasan and Balasubramanian (2007)
[33] Utilizing the Stata program `levpet` developed by authors.

Markov assumption on ω_{it},

$$\omega_{it} = E[\omega_{it}|I_{it-1}] + \xi_{it} = E[\omega_{it}|\omega_{it-1}] + \xi_{it}$$

$\xi_{it}$is mean independent of all information known at $t-1$. The first moment condition is derived on the timing assumption that $k_{it}$was decided at $t-1$ and thus uncorrelated with information set I_{it-1}.

$$E[\xi_{it}|k_{it}] = 0$$

The second moment conditions is derived on the timing assumption that lagged labor l_{it-1} was chosen at time $t-b-1$ and is thus also in the information set I_{it-1}. Thus we get two moment conditions to identify β_k and β_l:

$$E[\xi_{it}| \begin{matrix} k_{it} \\ l_{it-1} \end{matrix}] = 0$$

$$E[\xi_{it} \cdot \begin{pmatrix} k_{it} \\ l_{it-1} \end{pmatrix}] = 0 \tag{3.1}$$

First, use OLS to estimate initial values of (β_k, β_l) and compute: $\omega_{it}(\beta_k, \beta_l) = \hat{\Phi}_{it} - \beta_k k_{it} - \beta_l l_{it}$. Secondly, non-parametrically regress $\omega_{it}(\beta_k, \beta_l)$ on lag $\omega_{it-1}(\beta_k, \beta_l)$ and constant term to obtain $\xi_{it}(\beta_k, \beta_l)$. Finally, we can obtain estimates (β_k, β_l) from minimizing the sample analogue to the moment conditions in 3.1 using the implied $\xi_{it}(\beta_k, \beta_l)$.

$$\tfrac{1}{T}\tfrac{1}{N}\sum_t \sum_i \xi_{it}(\beta_k, \beta_l) \cdot \begin{pmatrix} k_{it} \\ l_{it} \end{pmatrix}$$

Implementation with Bangladesh Data:

In Sivadasan and Balasubramanian (2007), the ACF method is implemented using capital, skilled labor and unskilled labor with electricity as the intermediate input/proxy. The Bangladesh data has labor, capital, raw materials and well as energy costs. The variability over time of each of these variables within firms in increasing order are: labor, capital, materials and energy. I estimate the production function using two specifications: 1) using materials as an intermediate input and 2) including materials as an input and using energy as the proxy:

$$
\begin{aligned}
1.\quad y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it} \\
m_{it} &= f_t(\omega_{it}, k_{it}, l_{it}) \\
2.\quad y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \\
e_{it} &= f_t(\omega_{it}, k_{it}, l_{it}, m_{it})
\end{aligned}
$$

The estimates are given in Table 3.8 and Table 3.9 using the full panel Bangladesh data from 2003-2006 (semi-annual). The estimated coefficients for OLS and FE do not differ greatly in their magnitude. The estimates produced ACF1 using materials as an intermediate input yield unusually large coefficients and ACF2 using electricity as proxy appear to produce more realistic estimates.

Average productivity calculated by each estimation method is reported in Table 3.10 and the correlation matrix is given in Table 3.11. The productivity estimate from RE is almost perfectly correlated with the OLS estimate; and the OLS estimate is the naive estimate that suffers from collinearity. Thus, ACF2 estimate and possibly LP2 may provide good proxy for productivity.

Table 3.8: Production Function Estimates by Sector

	ACF1	ACF2	LP1	LP2	OLS	FE	RE
Garments							
	ACF1	ACF2	LP1	LP2	OLS	FE	RE
lnl	0.925	0.311	0.227***	0.0718	0.258***	0.202***	0.249***
	.	.	(0.0532)	(0.131)	(0.0568)	(0.0396)	(0.0243)
lnk	0.149	0.085	0.181***	0.0413***	0.0684***	0.0167	0.0642***
		.	(0.0603)	(0.0141)	(0.0163)	(0.0276)	(0.0136)
lnm		0.603	0.466***	0.596***	0.620***	0.552***	0.598***
		.	(0.109)	(0.0269)	(0.0275)	(0.0193)	(0.0135)
Observations	861	861	861	861	861	861	861
# of firms						303	303
Textiles							
	ACF1	ACF2	LP1	LP2	OLS	FE	RE
lnl	0.413	0.245	0.327***	0.399**	0.326***	0.126***	0.295***
	.	.	(0.0438)	(0.167)	(0.0390)	(0.0442)	(0.0267)
lnk	0.753	0.114	0.0536	0.0506*	0.0534**	-0.0233	0.0868***
			(0.0897)	(0.0284)	(0.0250)	(0.0393)	(0.0187)
lnm		0.616	0.462**	0.653***	0.652***	0.290***	0.620***
		.	(0.209)	(0.0298)	(0.0271)	(0.0415)	(0.0180)
Observations	730	730	730	730	730	730	730
# of firms						250	250
Food							
	ACF1	ACF2	LP1	LP2	OLS	FE	RE
lnl	1.176	0.315	0.300***	0.698**	0.345***	0.421***	0.363***
	.	.	(0.0314)	(0.335)	(0.0311)	(0.101)	(0.0326)
lnk	0.294	0.132	0.0236	0.0683***	0.0708***	-0.0277	0.0725***
		.	(0.157)	(0.0231)	(0.0263)	(0.0593)	(0.0236)
lnm		0.665	0.565***	0.374	0.669***	0.511***	0.643***
		.	(0.207)	(0.272)	(0.0316)	(0.0451)	(0.0212)
Observations	427	427	427	427	427	427	427
# of firms						147	147

Notes: *** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses

Table 3.9: Production Function Estimates by Sector

	ACF1	ACF2	LP1	LP2	OLS	FE	RE
Leather							
lnl	0.927	0.192	0.166***	0	0.184***	0.261	0.189***
	.	.	(0.0556)	(0.367)	(0.0540)	(0.186)	(0.0617)
lnk	0.306	-0.005	0	0.0247	0.0394	0.106	0.0467
		.	(0.222)	(0.0352)	(0.0314)	(0.115)	(0.0356)
lnm		0.705	0.671***	0.646***	0.680***	0.674***	0.670***
		.	(0.0480)	(0.0586)	(0.0405)	(0.0832)	(0.0352)
Observations	275	275	274	274	275	275	275
# of firms						99	99
Electronics							
	ACF1	ACF2	LP1	LP2	OLS	FE	RE
lnl	0.722	0.422	0.275***	0.285*	0.279***	0.0576	0.169***
	.	.	(0.0383)	(0.168)	(0.0328)	(0.0362)	(0.0277)
lnk	0.348	0.001	0.0496	0.00273	0.0168	-0.0454	0.0183
		.	(0.135)	(0.0239)	(0.0209)	(0.0343)	(0.0193)
lnm		0.853	0.704***	0.691***	0.733***	2.568***	1.943***
		.	(0.212)	(0.0308)	(0.0253)	(0.506)	(0.182)
Observations	268	268	268	268	268	268	268
# of firms						91	91
Chemicals							
	ACF1	ACF2	LP1	LP2	OLS	FE	RE
lnl	0.775	0.143	0.225***	0	0.228***	0.237***	0.346***
		.	(0.0731)	(0.260)	(0.0652)	(0.0845)	(0.0579)
lnk	0.528	0.082	5.84e-08	0.168***	0.140**	0.321***	0.278***
		.	(0.245)	(0.0649)	(0.0643)	(0.0864)	(0.0386)
lnm		0.759	0.284	0.660***	0.660***	0.334***	0.438***
		.	(0.193)	(0.0744)	(0.0564)	(0.0277)	(0.0268)
Observations	222	222	222	222	222	222	222
# of firms						80	80

Notes: *** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses

Table 3.10: Productivity Measures: Summary Statistics

Calculated TFP	ACF1	ACF2	OLS	FE	RE	LP1	LP2
Garment	4.546	2.300	2.567	4.090	2.894	3.359	4.155
	(0.668)	(0.316)	(0.314)	(0.344)	(0.316)	(0.363)	(0.352)
Textile	2.896	2.221	2.042	7.664	2.201	4.020	1.678
	(0.816)	(0.401)	(0.391)	(1.030)	(0.395)	(0.523)	(0.399)
Food	2.782	1.479	1.860	3.873	2.010	3.405	3.198
	(1.488)	(0.499)	(0.486)	(0.663)	(0.489)	(0.589)	(0.780)
Leather	3.684	2.825	2.680	1.729	2.688	3.247	4.001
	(0.998)	(0.506)	(0.503)	(0.532)	(0.503)	(0.512)	(0.562)
Electronic	4.140	0.589	2.054	2.568	1.946	2.060	2.517
	(1.010)	(0.492)	(0.352)	(0.463)	(0.369)	(0.356)	(0.364)
Chemical	1.833	1.781	1.781	3.156	2.037	6.882	2.585
	(0.908)	(0.486)	(0.472)	(0.682)	(0.542)	(1.129)	(0.534)
Total	3.502	1.999	2.220	4.540	2.397	3.684	3.060
	(1.300)	(0.724)	(0.515)	(2.114)	(0.563)	(1.212)	(1.118)
Observations	2786	2783	2783	2783	2783	2783	2783

Notes: Reported means with standard deviation in parentheses

Table 3.11: Correlation Matrix of TFP Measures

	ACF1	ACF2	OLS	FE	RE	LP1	LP2
ACF1	1						
ACF2	0.2486*	1					
OLS	0.5947*	0.7498*	1				
FE	-0.1046*	0.2700*	-0.0402*	1			
RE	0.6124*	0.7743*	0.9582*	0.0344*	1		
LP1	-0.2637*	0.3435*	0.0323*	0.2835*	0.1374*	1	
LP2	0.6113*	0.3989*	0.7011*	-0.5176*	0.7352*	-0.0918*	1

3.6.2 Productivity Distribution Between Exporters and Non Exporters by Sector

Table 3.12: Interquartile Range and Median of Productivity by Industry

	Productivity:TFP	25th percentile	Median	75th percentile
Garments	Non-Exporters	2.14	2.24	2.47
	Exporters	2.09	2.24	2.46
Textiles	Non-Exporters	2.06	2.2	2.34
	Exporters	2.04	2.22	2.42
Food	Non-Exporters	1.19	1.42	1.71
	Exporters	1.02	1.35	1.62
Leather	Non-Exporters	2.55	2.77	2.88
	Exporters	2.68	2.83	3.03
Electronics	Non-Exporters	0.31	0.517	0.892
	Exporters	0.293	0.363	1.06
Chemical	Non-Exporters	1.48	1.71	1.95
	Exporters	1.48	1.75	2.18

3.6.3 Variable Description

Variable	Description
FC	Indicator variable: Finances for Working Capital 100% internally financed and the firm access to finance as a problem (of any levels)
lnwc	Log Working Capital. Working capital as defined by accounting definition: current assets (inventories, accounts receivable, cash and short term credit) minus current liabilities (accounts payable and any short term debt)
FC*Log Working Capital	Interactive term: financial constraint and log working capital.
Productivity: ACF	Total factor productivity estimated according to Ackerberg et al. (2006)
FC*Productivity	Interactive term: financial constraint and productivity total factor productivity estimated according to Ackerberg et al. (2006)
Export Price to Domestic Price ratio	Ratio of export price to domestic price. For firms where ratio is missing, filled in with average ratio taken across year and sector.
Log Labor Cost	Total wage bill divide by the number of employees.
Log Input Price	Weighted average price of top three most important inputs.
Age	Years since establishment.

3.6.4 Export Status

Table 3.13: Export Status Estimation Results

Probit	Export Status		
	(1)	(2)	(3)
Financially Constrained	-0.4867***	-0.420***	-0.314
	(0.0917)	(0.137)	(0.202)
FC*Log Working Capital	0.1070***	0.101***	0.0682**
	(0.0317)	(0.0281)	(0.0298)
FC*Productivity	-0.1284	-0.169*	-0.126
	(0.0937)	(0.0966)	(0.107)
Log Working Capital	0.0162	0.0288**	0.0298**
	(0.0112)	(0.0123)	(0.0124)
Productivity	0.3353***	0.355***	0.0621
	(0.0357)	(0.0477)	(0.0419)
Export Price to Domestic Price ratio		0.185***	-0.0506
		(0.0207)	(0.0984)
Log Labor Cost		-0.0479	0.00266
		(0.0430)	(0.0349)
Log Input Price: Weighted		0.0163*	0.0320***
		(0.00990)	(0.0100)
Age		-0.000668	0.00246
		(0.00142)	(0.00160)
Control for sectors	no	no	yes
Observations	959	936	936
Pseudo Rsqr	0.149	0.261	0.391
Log pseudolikelihood	-557.6	-472.7	-389.6

Source: Bangladesh 2002 Investment Climate Assessment Survey, World Bank
Notes: Only 2002 data used for estimation, Bootstrap standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Reported marginal effects, Base line for Equation (3) is Garments.

3.6.5 Working Capital and Distance to Export Destination

Table 3.14: Working Capital and Distance to Export Destination

Lagged Log Working Capital	(1)	(2)	(3)	(4)
Log weighed distance to export destination	0.382	0.464*	0.668**	0.739**
	(0.237)	(0.241)	(0.338)	(0.349)
Lagged Log Total Cost		0.339***		0.322***
		(0.107)		(0.108)
Log Total Cost		0.233**		0.222**
		(0.0917)		(0.0929)
Lagged Total Factor Productivity		0.212*		0.205*
		(0.111)		(0.112)
Log Short Term Liabilities		-0.00735		0.00681
		(0.116)		(0.117)
Log Yrs Export		0.160		0.174
		(0.117)		(0.120)
Export Price to Domestic Price ratio		0.0230		0.0229
		(0.0220)		(0.0222)
Interact sectors*Log distance	No	No	Yes	Yes
Constant	5.971***	-1.877	4.267*	-3.054
	(2.112)	(3.031)	(2.479)	(3.664)
Observations	848	780	848	780
R-squared	0.007	0.091	0.017	0.099
Number of firms	459	438	459	438

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Notes: 2002 ICA World Bank (with recall data from 2000, 2001.). Regressed using fixed effects for the sample exporting firms only. Distance data from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), at http://www.cepii.fr/anglaisgraph/bdd/distances.htm using distance measured from the capital city. Up to five countries were reported in the survey (only for 2001 and 2002) and the weighted average distance was calculated by the proportion of export revenue of each country. Productivity calculated from structural estimation of the production function (see Ackerberg et al. (2006)). None of the coefficients for the interactive terms for sector and log distance were significant and are not reported. Log Yrs Exporting is averaged across products.

CHAPTER IV

Financial Constraints, Corruption and Growth: Firm Level Evidence

4.1 Introduction

Access to finance and corruption are two major issues faced by firms in developing countries. According to enterprise survey data of developing countries, these two issues consistently rank in the top 10 problems reported by firms.[1] Bangladesh is a prime example of a country that faces both severe access to finance problems and corruption issues. In 2009, Bangladesh ranked 139 out of 180 in the world in the Corruption Perception Index and at the same time ranked 71 out of 183 in the ease of getting credit to in the Doing Business ranking.

While access to finance and corruption have been shown to independently affect firm growth (seeBeck et al. (2004); Carpenter and Petersen (2002); Fisman and Love (2004) for the former and Fisman and Svensson (2007) for the latter), the interaction of the two has not been examined. These two issues may have interactive effects on growth as corruption pose additional costs that require liquidity, and therefore the effects of these costs would differ between firms that have the liquidity and those that are financially constrained.

[1] According to World Bank Enterprise Surveys. These surveys have been conducted since 2002, in over 117 developing countries and asks firms to rate investment climate issues across 31 investment climate indicators. See https://www.enterprisesurveys.org/ for more information on surveys.

Whether corruption is necessarily bad for growth has been debated in the literature for several decades.[2] On one hand, bribes pose an additional tax to production and thus pose a negative distortion to growth. Beginning with Mauro (1995), cross country studies have found a negative relationship between corruption and GDP. With the increasing availability of micro firm level data[3], studies have looked at the effects of corruption in comparison to the effects of taxation at the firm level (Shleifer and Vishny (1993), Fisman and Svensson (2007)). These studies show that the negative effects of corruption is greater than those of taxation.

On the other hand, corruption can be seen as an efficient allocative mechanism in an environment where bureaucratic holdups are rife. Corruption impose additional costs to doing business but this also implies that only the most productive firms would be able to pay the higher cost of production. The presence of corruption does not necessarily have a negative effect on growth as the higher costs imply that services are allocated to the most productive firms (see Lui (1985); Lien (1990)).

The debate may be informed by looking at the interaction of corruption and the access to finance on growth. The effect of corruption on firm growth may be delineated between financially constrained firms and firms that have the financial means to pay bribes. For financially constrained firms, production choices are bounded by liquidity and making bribe payments is taking money away from productive inputs and thus bribes would have a direct negative effect on growth. For firms that are are not financially constrained, these payments do not interfere with their optimal production choices, and therefore bribes could have a positive correlation with growth.

The interactive relationship between financial constraints and the payment of bribes could be potentially be important as it suggests that corruption alone may not be detrimental to firm growth but that corruption negatively hampers growth when combined with limited

[2] See Bardhan (1997) fro review of the literature

[3] For example, the question on informal payments has become a standard question in the World Bank Enterprise Surveys questionnaire.

access to finance. It also could inform policy in unique ways. For example, the issue of financial constraints need not only be through improving the supply of credit, but may also include decreasing the demands on liquidity such as minimizing the unnecessary costs imposed on firms in the form of bribes.

In this paper, I forward an application of the working capital model of the firm Chan (2008) to examine how the effects of bribes could differ between financially constrained and unconstrained firms. I then examine whether there is any support of this differentiation in the empirical data. The next section forwards the approach and empirical strategy based and Section 4.3 describes the firm level panel dataset used and presents summary statistics. Section 4.4 presents the empirical findings.

4.2 Approach and Empirical Strategy

Bribes can be thought of as a fixed cost or marginal cost depending on what the bribe is used for. For example, the amount to bribe an official to pass an inspection may be more dependent on how rich the firm is, whereas the amount to bribe to procure the correct licenses and permits that are required each year may be more of a fixed cost. Bribes differ from production costs in that these payments don't contribute in any productive way other than allow the firm to obtain the necessary licenses or pass the necessary inspections to operate.[4] The cost of the bribe may vary from firm to firm and the variation would depend largely on how responsive a corrupt official is to extract bribes according to the observable characteristics of the firm. In this paper, I look at bribe payments for the procurement of licenses, that are required each year to operate a business. They are relatively small amounts compared to overall costs spent on productive inputs.[5] It is more likely that that these bribes for licenses do not affect the marginal decisions of the firm. Business licenses

[4]However, again, this may vary depending on what the bribe is used for. In the case of getting a bank loan, the bribe facilitates the procurement of a productive input.

[5]For example, in the Bangladesh Panel Survey, the cost of wages per year are approximately 22000 takas over 2003-2005. The bribe payment for a DCC business license is on average about 500 takas.

are required by all businesses to operate, and given the sheer volume of licenses that needs to be processed, it seems unintuitive that bureaucrats would cater each bribe for each firm that applies for a license. Or it could also be that firms do not know how much they would be charged extra in bribes if they produced more, so while there may be marginal effects charged by the bureaucrat, firms cannot incorporate this in their decision making. Or simply, the size of the bribes compared to other costs are not significant enough to consider in their marginal decisions.

In a country such as Bangladesh, the payment of bribes is associated with most types of transactions.[6] As such, bribes are synonymous to an additional cost or tax that enters into the firm's budget constraint. The working capital model of the firm Chan (2008) is useful to apply to this case because the model predicts that equilibrium can only be of two outcomes: firms are either bounded by their working capital in a constrained equilibrium, or they are at optimal and not bounded by liquidity. If bribes enter the budget constraint as a fixed cost, than according to the model, bribes affect the decisions of the firm when firms are bounded by their liquidity, but not so when not financially constrained. That is, bribes can distort the decisions of the firm even if bribe payments are fixed costs under financial constraints.

Under financial constraints,[7] any changes to one cost need to be offset by changes to other costs. For example, take for instance a firm that only has 1000 dollars and it needs to pay wages, the electric bill and materials. If the price of electricity went up, the firm necessarily has to reduce it's bill in either wages or materials. This substitution between factors of production under financial constraints drives the countercyclicality of investment to price shocks in Chan (2008). Similarly, this can be applied to bribes. Bribes puts additional demands on liquidity. If the firm is constrained, and the cost of bribes increased, liquidity has to move away from productive inputs and toward bribe payments

[6]Even activities such as checking in for a flight may render some bribe payments for better seating allocation, as I observed during a trip to Dhaka.

[7]Financial constraints defined as a situation where the firm operates below optimal scale as it is bounded by it's working capital., and do not have adequate liquidity to pay for inputs.

(necessary to get the license in order to continue operating). This means that higher levels of bribe payments is associated with lower growth rates for financially constrained firms.

When a firm is not liquidity constrained, optimal production is not bounded by their working capital. If bribes increase, holding all other things constant,[8] this should not alter the optimal input nor output choice - optimal first order conditions need to hold with no changes in prices. The firm would simply pay the bribe, and stay on the unconstrained optimal equilibrium. Bribes, as a fixed cost, should have very little association with growth if the firm is not constrained. Furthermore, a positive relationship could be observed empirically as higher bribe payments would be associated with high growth among non-financially constrained firms. This is as within the group of unconstrained firms, those that are higher growth firms tend to be better performers and as such are more able to pay higher bribe amounts than lower growth unconstrained firms.

The solution to the discrete infinite time dynamic working capital model of the firm Chan (2008) is contained in two parts: if the firm is not constrained, it follows standard first order conditions and operates at optimal. If the firm is constrained, it is forced to operate within it's budget constraint and operates under a constrained optimal. The first order conditions is reproduced below:

Unconstrained:

$$\beta PF_L(K,L) = w \tag{4.1}$$

$$\beta PF_K(K,L) = p^k.\tfrac{(r+\delta)}{(1+r)} \tag{4.2}$$

L^* and K^* is the solution to the firm's maximization problem if and only if: Equation (4.1) and (4.2) hold and $x - wL* - p^k(K* - (1-\delta)K_{-1}) > bc$. Otherwise, the solution is given by Equations (4.3) and (4.4) below:

[8] Including holding the state of being not financially constrained.

Constrained:

$$\frac{\beta PF_L(K,L)}{w} = \frac{\beta PF_K(K,L)}{p^k} + \frac{(1-\delta)}{(1+r)} \tag{4.3}$$

$$X = wL + p^k(K - (1-\delta)K_{-1}) + bc \tag{4.4}$$

Where X denotes working capital and equal to last period's revenue and any bond holdings, $X_t = P_{t-1}F(K_{t-1}, L_{t-1}) + (1+r)b_{t-1}$.

Borrowing limit is denoted by bc which is a limit on the amount a firm can borrow[9].

Introducing bribes as a fixed cost that enters the budget constraint, Equation 4.4, becomes:

$$X = wL + p^k(K - (1-\delta)K_{-1}) + bc + bribes$$

Thus, unconstrained output is a function of external parameters, $Y_{it} = H(P, p^k, r, \delta, w, \alpha, \gamma)$[10] while constrained output is a function of external parameters *plus* working capital X, borrowing constraint bc and the amount of bribes *bribes*: $Y_{it}^{fc} = H(P, p^k, r, \delta, w, \alpha, \gamma X, bc, bribes)$. Thus, the change in output is only dependent on bribes under a constrained optimum and not under unconstrained optimum.

Denoting firm growth by g_{it}, the amount of bribes paid by γ, firm financial constraint by fc and Z_{it} as the controls for the parameters, the empirical strategy is quite straightforward:

$g_{it} = \beta_0 + \beta_{nfc}\gamma_{it} + \beta_{fc}fc_{it-1} * \gamma_{it} + \delta Z_{it} + \eta_{it}$

If bribes only affect firm growth when the firm is under financial constraints, then the coefficient β_{fc} is expected to be negative and significant. The coefficient β_{nfc} for the effect of bribes on unconstrained firm growth should be close to zero and potentially positively signed.

[9] Note the borrowing constraint is expressed in debt. For example, $bc = -1000$ where the firm can borrow up to 1000. See Chan (2008) for details.

[10] Where P is output price, p^k is price of capital, w is wage rate, $\delta$is depreciation, α and γ are the factor return parameters for labor and capital.

4.3 Data

The data used is the Bangladesh Enterprise Panel Survey that was conducted in 6 rounds over the period of 2003 to 2005. The survey was initiated by the World Bank in conjunction with the Bangladesh Enterprise Institute. A total of 250 firms were interviewed across 6 industries in both Dhaka and Chittagong. The panel dataset provides more consistency in the reported bribe data over previous studies where only cross sectional datasets were utilized. It also allows lagged explanatory variables.

Information on bribe payments was collected for the procurement of permits and licenses. In particular: the Register Joint Stock Company license (RJSC), (CCIE), the Dhaka City Corporation (DCC) business license to operate, the Environmental Permit and the Building, Fire and Safety Permit (BFS). Firms were first asked whether they needed the following licenses or permits to continue operation, and than asked whether an informal payment was expected to obtain and how much. There is some reluctance to report amount of bribes: for DCC license, 59 out of 337 (approximately 17 percent) that reported a bribe was expected did not report the amount of bribe.[11] It is not clear whether the reports of amounts may be upwardly bias (to exaggerate the cost of bribes on the firm) or downward bias (to hide wrong doing). Unfortunately, with all data of this nature, there needs to be some caution in interpreting the validity of findings. However, as the same firm is asked the same question 6 times over a period of 3 years, this provides some consistency in the responses to the sensitive nature of the survey questions.

The estimation only uses the bribe amounts from the DCC license as, of the 5 licenses and permits, only the DCC license was required by 96 percent of the firms sampled and this response in requirement that did not change from year to year. Additionally, the data shows that other licenses and permits were not always required by firms and the reporting of needing the license changes substantially across the years (by the same firm). In terms

[11] These were dropped from the sample so that those who answered no, the bribe amount is zero and those who answered yes, the bribe amount is the amount reported. The results do not alter by including these observations.

of As such, the bribe information from the DCC license is a better proxy for bribes than utilizing the total of all the bribe amounts across all licenses and permits.[12]

As my measure of firm growth, I use reported sales data which was collected at each round of the panel. An advantage of the panel data is that it allows the growth rate of the firm to be calculated, it is measured as the difference in log sales: $log(Sales_t) - log(Sales_{t-1})$.

The indicator for whether a firm is financially constrained utilizes two key survey instruments: first, firms were asked what percentage of their working capital comes from internal finance and secondly, firms report subjective measures on the severity of access to finance problems. The variable for financially constrained, fc_{it}, is equal to 1 if a firm uses 100 percent internal finance for working capital and report access to finance as some sort of problem. The intuition is that if a firm uses 100 percent internal financing and does not report access to finance as a problem, than such a firm does not need to borrow. On the other hand if a firm uses less than 100 percent internal financing, they obviously can borrow - even if they reported access to finance as a problem. Granted, a firm may borrow and still wish to borrow more at the going rate (thus still be financially constrained), however, leaving these firms out would only work against finding a significant difference between constrained and unconstrained firms.

The size of the firm may be correlated with how much bribe payments the firm makes (as larger organizations are more visible). Additionally, size also affects growth. I include lagged $log(Number\ workers)$ to control for the size of the firm. Likewise, age of the firm is also included (*lnage*) in harmony with previous firm-level studies Fisman and Svensson (2007). Older firms tend to have established relationships with bureaucrats and banks and therefore bribe payments may be correlated with age. Studies have shown that firms that export tend to grow faster, I include a dummy (*export*) to control for exporting firms. Unique to the Bangladesh Panel Survey is the reporting of output and input prices changes.

[12]See Appendix Table 4.3 for response rates to license and bribe questions. The results with smaller sample sizes for other licenses yield no significant estimates.

Table 4.1: Summary Statistics

	Sales Growth	Bribes ('000 takas)	Size	Age	Wages ('000 takas)	Export	Percent of Sample
Not Financially Constrained ($fc_{i,t-1} = 0$)	5.96% (75.84)	0.242 (.871)	373 (382)	18 (13)	28.39 (35.73)	50%	37.38%
Financially Constrained ($fc_{i,t-1} = 1$)	7.83% (84.23%)	0.648 (1.883)	224 (224)	16 (13)	19.91 (19.63)	44%	62.62%
Total	7.27%	0.501	268	17	22.44	46%	
Number of Observations	1233	888	1237	1237	1237	1237	1517

Source: Bangladesh Panel Survey 2004:1-2005:2

Notes: Means reported with standard deviation in brackets. BRIBES: the amount of informal payment expected to obtain DCC license. The average exchange rate over the period of 2003-2005 is 61.17 takas to the USD, 1000 takas is approximately equivalent to $16.35 Size is the number of workers in the firm,

Both *lnP* and *lnPut* are included to control for changes in growth of sales due to price fluctuations. Year, city and industry controls are also included.

Summary statistics are shown in Table 4.1. An average, financially constrained firms are smaller in the number of workers, and are younger. As such, it isn't surprising that financially constrained firms also have a higher growth rate than unconstrained firms. They tend to also pay larger amount of bribes - which is somewhat surprising as bribes are usually influenced by characteristics of the firm that are easily observable by the bureaucrat such as age and size. If indeed growth is easily observed by bureaucrats and this influences the amount of bribes they charge, then this possible source of endogeneity would bias estimates upwards and work against finding a significant negative result between bribes and growth.

4.4 Estimation

As a benchmark, I estimated the regression without interacting the financial constrained variable with the bribe amount, shown in column (1) , (2), (5) and (6) in Table 4.2. The results without fc interaction show a weak and insignificant association between bribes and firm growth. This could be due to confounding effects from both financially constrained and unconstrained firms.[13]

The results for bribes interacted with financial constraints, shown in Column (3), (4), (7) and (8) provide support for the hypothesis that bribes retard firm growth when firms are financially constrained. Both random effects and fixed effects models were used to estimate. Across all specifications, the estimated coefficient for the interacted bribe variable with financial constraints is significant and negative. The coefficient for bribes alone is positive and insignificant from zero under random effect estimation, and positive and significant under fixed effects. This suggests there may be support for the idea that bribes may not significantly affect the growth of firms who are not liquidity constrained, or if there was an effect, higher bribes are associated with higher growth. In the context of the debate over whether bribes retard growth or whether it functions as an allocative mechanism, the results from interacting bribes and financial constraints suggest that: a) the effect of bribes do differ significantly between financially constrained firms and non-financially constrained firms and b) that the two sides of the debates on the effect of bribes on growth could possibly both be valid with the effects delineated between financially constrained and unconstrained firms.

The estimated coefficient for the effect of bribes interacted with financial constraints takes on values of about-0.074 for random effects estimate and -0.024 for fixed effects. This suggests that a one-percent point increase in bribe payments will reduce the growth of financially constrained firm growth by 0.0007 percent, or 0.0002 percent in semi-annual growth.

There should be some caution in interpreting the magnitude of the coefficients. It is

[13]Previous studies, such as Fisman and Svensson (2007), were concerned with issues of endogeneity of bribes with growth due to the possible positive association of bribes with growth. Such studies show that estimation without instruments result in weak estimates of the effect of bribes. However, as can been seen in the benchmark estimates, not controlling for the difference between financially constrained versus non-financially constrained firms can also yield a weak estimate. It remains an empirical question as to whether better performers get extorted more than worse performing firms.

possible that the amount of bribes is endogenous to the growth of the firm along financially constrained categories, although the use of lagged bribe amount could possibly address this if the amount is not correlated with previous amounts. One potential avenue for future research is to look at changes in the amount at the firm level. Another reason for caution is that there may exist a relationship between unreported bribe amounts and the growth of the firm. For example, those reported may tend to be those most impacted by these bribes and thus overstating the effect. However, at the firm level, there were only 2 firms that consistently did not report the amount (out of around 240 firms). Also, 46 out of the 59 missing amount observations were in the first semester of 2004 and this could be related to the fact that this was the first time the survey instrument was introduced.

4.5 Conclusion

The working capital model applied to bribe payments suggests that the effects of bribes on firm growth may be delineated according to whether firms are financially constrained. Bribe payments for obtaining licenses, as a fixed cost, affect optimal production choices only when firms are liquidity constrained. Under no financial constraints, bribes do not enter into the marginal decisions for optimal production. Using firm level panel data from Bangladesh, I find that the effect of bribes on the short-run growth rates of Bangladeshi firms differs significantly between financially constrained and non-financially constrained firms. Furthermore, for financially constrained firms, there is a significant negative relationship between bribes while for unconstrained firms, there may exist a positive association between bribes and growth.

To my knowledge, this is the first micro-level support for the interactive effects of financial constraints and corruption and provides support for the working capital model of the firm. More work is still required in the area of corruption, as well as access to finance and while the results need to be interpreted with care given the nature of the data, the results presented in this paper, as well as complementary observations and qualitative reports from firm managers, all suggest that corruption is a serious constraint and one that may further exasperate access to finance issues that are also widespread in developing countries.

The results of the paper also have significant policy implications. The donor community and international organizations have focused attention on looking for ways to combat corruption in developing countries, and simultaneously, also look for ways to improve access to finance. My results suggest that the two issues are linked fundamentally. Corruption may not have a strong negative effect on firm growth if firms do not have liquidity problems. Likewise, firms would have more liquidity if they do not have to pay bribes. Together, corruption and financial constraints pose a serious barrier to growth - and particularly for those firms that have the highest potential for growth. Results suggest that policies to stimulate growth need to examine at the firm level both the supply of finance, such as financial institutions, as well as the demands on liquidity, such as bribes.

Table 4.2: The Interactive Effect of Bribes and Financial Constraints on Firm Growth

Dependent Variable: Growth	RE				FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FC0	-0.0461	-0.0250	-0.00197	0.0202	-0.0842	-0.0542	0.0190	0.0548
	(0.0583)	(0.0612)	(0.0632)	(0.0659)	(0.0800)	(0.0826)	(0.0857)	(0.0883)
FC0_lnBribesDCC			-0.261*	-0.264*			-0.680***	-0.695***
			(0.145)	(0.144)			(0.211)	(0.211)
lnBribesDCC	-0.0245	-0.0197	0.187	0.194	0.0522	0.0502	0.658***	0.671***
	(0.0569)	(0.0592)	(0.130)	(0.131)	(0.0880)	(0.0897)	(0.207)	(0.208)
Llnsize	-0.0533**	-0.0579**	-0.0492**	-0.0539**	-0.933***	-0.932***	-0.911***	-0.911***
	(0.0243)	(0.0270)	(0.0244)	(0.0271)	(0.145)	(0.145)	(0.144)	(0.144)
lnage	0.0390	0.0390	0.0429	0.0423	-0.572	-0.703*	-0.557	-0.715*
	(0.0379)	(0.0427)	(0.0379)	(0.0427)	(0.360)	(0.393)	(0.358)	(0.390)
export	0.132**	0.102	0.130**	0.100	0.541***	0.527***	0.554***	0.541***
	(0.0589)	(0.0691)	(0.0589)	(0.0691)	(0.166)	(0.166)	(0.165)	(0.165)
lnP1	0.00695	0.0386	0.00885	0.0376	-0.0999	0.0470	-0.129	0.0323
	(0.104)	(0.116)	(0.104)	(0.116)	(0.377)	(0.386)	(0.374)	(0.383)
lnPut	-0.0866	-0.143	-0.0884	-0.145	0.341	-0.0629	0.325	-0.111
	(0.0920)	(0.0971)	(0.0919)	(0.0970)	(0.273)	(0.342)	(0.271)	(0.340)
Controls for city, industry and time		yes		yes		yes		yes
Constant	0.345	0.438	0.286	0.385	5.481***	6.190***	5.342***	6.143***
	(0.330)	(0.349)	(0.331)	(0.350)	(1.505)	(1.597)	(1.494)	(1.585)
Observations	869	869	869	869	869	869	869	869
Number of id2	241	241	241	241	241	241	241	241
R-Square					0.081	0.089	0.096	0.104

Source: Bangladesh Panel Survey 2004:1-2005:2

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix

4.5.1 Data Description

Growth	Semi-annual sales growth, defined as $log(Sales_t) - log(Sales_{t-1})$
lnBribesDCC	Informal payment for license $log(1 + bribe\ DCC)$
FC0	Financially Constrained indicator of last period: 100% internal finance and reported access to finance as some sort of problem.
FC0_lnBribesDCC	Interactive term: $FC0 * lnBribesDCC$
Llnsize	Lagged log of the number of workers
lnage	Log of age of the firm
export	Indicator for whether firms exports any of it's output.
lnP1	Top Output Price
lnPut	Top Raw Material Price

4.5.2 Response Rates to License and Bribe Survey Questions

Table 4.3: Response Rates to License Bribe Questions

Bangladesh Enterprise Survey 2003-2005 (Semi-annual)					
LICENSES:	CCIE	RJSC	DCC	EVRN	BFS
Number of respondents to whether license was required	995	995	994	994	995
Proportion that answered yes	0.824	0.561	0.963	0.541	0.859
Number of respondents to whether an informal payment was expected	820	558	955	538	855
Proportion that answered yes	.751	.711	.353	.818	.827
Number of respondents to reporting amount of informal payment expected	710	498	896	480	761
Number of observations in estimation	699	491	869	466	738
Number of firms in estimation	213	161	241	165	224

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