Investment and Financial Constraints: Empirical Evidence for Firms in Brazil and China

Stephen R. Bond
Nuffield College and Department of Economics,
University of Oxford and Institute for Fiscal Studies

Måns Söderbom
Centre for the Study of African Economies,
Department of Economics, University of Oxford,
and Institute for Fiscal Studies

Guiying Wu
Nuffield College and Department of Economics,
University of Oxford and the World Bank

October 2007

Abstract

In this paper we use panel data on firms from Brazil and China to investigate the role of financial constraints for borrowing and investment. We develop a structural investment model, in which borrowing is costly but sometimes necessary to finance investment. Structural parameters are estimated by matching simulated model moments to empirical data, using a simulated minimum distance estimator. The estimated models suggest that the likelihood of being financially constrained is about 0.45 for Brazil and 0.33 for China. Our analysis also shows that a reduction in the cost of external financing would have significant effects on both investment and borrowing.

**JEL Classification:** E22, D92, D81, C15.

**Key words:** Financing, investment, uncertainty, structural estimation.
Acknowledgement: We thank the ESRC for financial support under project RES-156-25-0006. Bond thanks the ESRC Centre for Public Policy at IFS for additional support. Söderbom thanks The Leverhulme Trust for additional support. Wu thanks the World Bank for additional support.
1 Introduction

In this paper we use panel data on firms from Brazil and China to investigate the role of financial constraints for borrowing and investment. We estimate structural investment models in which firms sometimes need to finance investment through borrowing, even though this is more expensive than financing investment by means of internal funds. Structural parameters are estimated by matching simulated model moments to empirical data, using a simulated minimum distance estimator. The estimated models are used to investigate how likely firms in these countries are to be financially constrained, and how these firms’ borrowing behaviour would differ if the marginal instantaneous cost of borrowing were reduced from the estimated level. The results for Brazil suggest the likelihood of being financially constrained is 45%, while for China it is 33%, thus our estimates indicate that being financially constrained is a common problem in these countries. Furthermore, we find that if the marginal instantaneous cost of borrowing were cut by 50%, the proportion of firms incurring debt would approximately double as a result. We also find such a policy experiment would have large effects on the average debt-assets ratio.

The model that we estimate is in many ways similar to that analysed by Bond, Söderbom and Wu (2007a): firms produce output using capital and flexible inputs according to a constant returns to scale Cobb-Douglas production function; output is sold in imperfectly competitive markets; demand is stochastic. A major difference compared to the model in Bond, Söderbom and Wu (2007a), however, is that in the present paper we explicitly model the financial decisions made by the firm, notably regarding debt. In doing so we introduce financial 'imperfections' in the form of transaction costs that have to be paid by the firm whenever it borrows. Under the null hypothesis of no financial imperfections, these costs are equal to zero. Cash-flow fluctuates as a result of stochastic demand, but there is also a serially uncorrelated shock to cash-flow that, under the null of no imperfections in
the financial market, is irrelevant for 'real’ decisions such as investment or employment. Under the alternative, however, the revenue shock may have considerable effects on investment, as we shall see. Indeed, when internal means are insufficient to finance desired investment, the optimal response is to reduce investment, which is financed (at least in part) by a relatively low level of borrowing.

We estimate this model using data for firms in Brazil and China, collected by the World Bank. Since financial markets in these countries are less developed than in high-income countries, firms in Brazil and China plausibly face more severe forms of financial constraints than companies in, say, the UK or the USA. The empirical literature on investment and financing focuses mostly on firms in rich countries. With our data, we can study the effects of financial imperfections in environments where these may matter a lot more than in the UK or the USA, for example. This is one important advantage of our dataset. Indeed, as already alluded to above, we find that the likelihood of being financially constrained is quite high in both countries under study.

The investment models we consider do not have closed-form solutions but can be solved and simulated numerically. We therefore apply a simulated minimum distance procedure to estimate the structural parameters by matching simulated moments, such as the proportion of firms with long-term debt, the correlation between investment and debt, the correlation between investment and cash-flow, etc.

The rest of the paper is organised as follows. Section 2 outlines the model of investment and financing that we estimate, and illustrates differences in the implied investment behaviour under different forms of financing costs. Section 3 describes the firm-level datasets and the features of these datasets that we use to estimate the structural parameters of our model. Section 4 describes the method we use to estimate the structural parameters of our model and reports the empirical results. Section 5 concludes.
2 Investment and Financing: The Model

Our model is an extension of that presented in Bond, Söderbom and Wu (2007a), where we now allow for potentially costly external financing. We assume the firm chooses investment and debt to maximise the value of its equity $V_t$, given by

$$V_t = E_t \left\{ \sum_{s=0}^{\infty} \beta^s (D_{t+s} - N_{t+s}) \right\}$$  \hspace{1cm} (1)

where $D_t$ denotes dividends paid in period $t$, $N_t$ denotes the value of new shares issued in period $t$, $\beta < 1$ is the one-period discount factor assumed constant for simplicity, and $E_t[.]$ denotes an expected value given information available at time $t$. Dividends are required to be non-negative,

$$D_t \geq 0,$$  \hspace{1cm} (2)

and so all the firm’s decisions regarding investment, borrowing, employment etc. are subject to this constraint. In particular, if desired investment cannot be fully financed by means of internally generated funds, then the firm will have to reduce investment and/or finance investment partly by external funds, so that the dividends are always non-negative. We focus on borrowing as the leading form of obtaining external funds, but we also allow firms to issue new equity as another way of satisfying (2). We write net revenue in period $t$ as

$$\Pi_t = X_t^\gamma (K_t + I_t)^{1-\gamma} - (1 + i) B_{t-1} + B_t - I_t - G(K_t, I_t) - H(K_t, B_t) - \Phi(N_t) + \Lambda(X_t, u_t),$$  \hspace{1cm} (3)

where $X_t$ is a demand shift parameter that follows a random walk with drift process,

$$x_t = \ln X_t = x_{t-1} + \mu + \varepsilon_t$$  \hspace{1cm} (4)

$$\varepsilon_t \sim \text{iid } N(0, \sigma^2_\varepsilon)$$

$$x_0 = 0$$
in discrete time\(^1\); \(K_t\) is the capital stock in the beginning of period \(t\), \(I_t\) is investment; \(\gamma\) is a constant parameter\(^2\); \(B_{t-1}\) is the level of debt inherited from the previous period; \(i\) is the interest rate on debt; \(B_t\) is borrowing in period \(t\); \(G(.)\) is a capital adjustment cost function, \(H(.)\) is a debt cost function, \(\Phi(.)\) is the cost of issuing new equity, and \(\Lambda(X_t, u_t)\) is an additive shock to net revenue, where \(u_t\) is a serially uncorrelated and normally distributed random variable with mean zero and constant variance \(\sigma_u^2\).

The revenue shock \(\Lambda(X_t, u_t)\) plays an important role in our model. Without it, firms can typically finance investment by means of internal funds and so will never, or at least very rarely, be financially constrained in the long run. Given that our main purpose is to investigate if there is any evidence that firms in our data are financially constrained, and if so, what the implications are, a theoretical model predicting that firms never are constrained is clearly not useful. In deciding upon a sensible functional form for \(\Lambda(X_t, u_t)\) (theory gives no guidance here), we thus need to specify this such that, depending on the parameters in the model, a nontrivial proportion of firms may, or may not, be financially constrained. This can be achieved by allowing for high enough variance in \(\Lambda(X_t, u_t)\). In addition, under the null of no financial imperfections, we would like the revenue shock to be irrelevant for real decisions, similar to the idea that Tobin’s Q is a sufficient statistic for investment under the null of no imperfections (e.g. Fazzari, Hubbard and Petersen, 1988). This rules out a functional form such as \(u_t \cdot (K_t + I_t)\), for example. We also want to rule out the possibility that firms can escape the

\(^1\) In contrast to Bond, Söderbom and Wu (2007a) we thus assume demand to be nonstationary. With this assumption estimation of the parameters of interest takes much less time than if demand is stationary, essentially because we can economise on the number of state and control variables (more on this below). Also, whenever we have tried to estimate \(\rho\) (the AR1 coefficient in the demand process when the latter follows an AR1 process) we have obtained results indicating that \(\rho\) is indeed very high, typically around 0.90 or higher. This suggests imposing a random walk process may not be overly restrictive.

\(^2\) Output is produced by means of a Cobb-Douglas production function in which labour, materials and capital are the relevant factor inputs. Labour and materials are assumed freely variable inputs, and so have been ‘optimized out’ in (3) using first order conditions (see Bond, Söderbom and Wu, 2007a, for details).
possibility of being financially constrained simply by becoming large. This rules out writing $\Lambda (X_t, u_t)$ simply as $u_t$. For these reasons we specify $\Lambda (X_t, u_t)$ as $X_t u_t$. This ensures $u_t$ is irrelevant for investment under the null of perfect capital markets, and it also means high growth in demand or capital does not eliminate the possibility that firms may be financially constrained. Notice that a bad draw of $u_t$ combined with a good draw of $X_t$ together make up a large negative revenue shock, which can be interpreted as representing a situation in which the firm has high demand for new capital but low levels of internal funds available to finance the investment.

Now consider the role of financing in this model. Firms can borrow any amount they wish in period $t$ at a fixed interest rate $i$. Loans incurred in period $t$ are to be paid back, with interest, in period $t + 1$. The debt cost function $H (K_t, B_t)$ represents additional costs imposed by borrowing, to be paid in period $t$. Formally we treat $H (K_t, B_t)$ as a transaction fee that must be paid whenever the firm has outstanding debt. Less formally we can also think of these costs as reflecting agency costs, or losses imposed on existing shareholders when the firm becomes exposed to high levels of debt, perhaps because a perceived high risk of bankruptcy (though note that, formally, bankruptcy does not feature in our model). We assume a simple quadratic functional form for the debt cost function:

$$H (K_t, B_t) = \frac{h}{2} \left( \frac{B_t}{K_t} \right)^2 K_t,$$

where $h$ is a constant parameter. In Section 5 we estimate $h$, as well as the interest rate on borrowing, $i$. Notice that, in the special case where $h = 0$, we require $i \geq r$ in order to rule out infinite borrowing. With $h > 0$, however, $i < r$ is not economically uninteresting. In fact, one might argue $i < r$ is quite realistic, given that tax advantages often are associated with borrowing.

In our model, firms are allowed to issue new equity as a way of satisfying the nonnegativity constraint on dividends, in addition to borrowing. We assume a simple linear relationship between the cost and the amount of new equity issued,
\[ \Phi(N_t) = \phi N_t, \]

where \( \phi \) is the marginal cost. In practice, issuing new equity is likely to be extremely unusual for the (typically fairly small) firms in our datasets, however we do not have data on this. We therefore do not attempt to estimate \( \phi \); instead, we set it to a value high enough for it to be a very unusual for firms to issue new equity. We thus treat new equity primarily as a last resort solution to a liquidity problem that if dealt with by increased borrowing might lead to ever increasing debt and negative firm value.

Finally, we assume the capital adjustment cost function to be quadratic,

\[ G(K_t, I_t) = \frac{g}{2} \left( \frac{I_t}{K_t} \right)^2 K_t, \]

so as to make large investments very costly.\(^3\)

Given all of the above, the (stochastic) Bellman equation can be written

\[
V(K_t, B_{t-1}, X_t, u_t X_t) = \max_{I_t, N_t, B_t} \Pi(K_t, B_{t-1}, X_t, u_t X_t; I_t, B_t, N_t) \\
+ \beta E_t V(K_{t+1}, B_t, X_{t+1}, u_{t+1} X_{t+1}),
\]

subject to the following constraints:

\[
K_{t+1} = (1 - \delta) (I_t + K_t), \\
B_t \geq 0, \\
N_t \geq 0, \\
D_t = \Pi_t + N_t \geq 0.
\]

That is, capital is assumed to depreciate at a constant rate \( \delta \), and neither borrowing, nor new equity, nor dividends can be negative. Whenever the nonnegativity constraint on dividend binds, the associated Lagrange multiplier, denoted \( \lambda^D_t \), is strictly positive. If this constraint does not bind, then \( \lambda^D_t = 0 \). Accordingly, whenever \( \lambda^D_t > 0 \) we classify the firm as being financially constrained, in the sense that

\(^3\)We will generalize the adjustment cost function to allow for nonconvexities in future work.
relaxing the nonnegativity constraint on dividends in period $t$ would increase the value of the firm. Conversely, whenever $X_t^D = 0$, we classify the firm as financially unconstrained.

The model above has four state variables, namely $K_t, X_t, B_{t-1}, u_t$, and three control variables, $I_t, B_t, N_t$. In order to speed up the procedure by which we solve numerically for the optimal policies, we exploit the fact that the value function is homogenous in $X_t, K_t, B_{t-1}$ and rewrite the Bellman equation as

$$v \left( \frac{B_{t-1}}{K_t}, \frac{X_t}{K_t}, \frac{X_t}{K_t}, \frac{u_t}{K_t} \right) = \max_{\frac{B_t}{K_t}, \frac{u_t}{K_t}, \frac{N_t}{K_t}} \left( \frac{B_{t-1}}{K_t}, \frac{X_t}{K_t}, \frac{X_t}{K_t}, \frac{I_t}{K_t}, \frac{B_t}{K_t}, \frac{N_t}{K_t} \right)$$

$$+ \beta E_t v \left( \frac{B_t}{K_{t+1}}, \frac{X_{t+1}}{K_{t+1}}, \frac{X_{t+1}}{K_{t+1}}, \frac{u_{t+1}}{K_{t+1}} \right) \frac{K_{t+1}}{K_t},$$

where $V_t \equiv K_t \times v \left( \frac{B_{t-1}}{K_t}, \frac{X_t}{K_t}, \frac{u_t}{K_t} \right)$, subject to

$$\frac{K_{t+1}}{K_t} = (1 - \delta) \left( \frac{I_t}{K_t} + 1 \right),$$

$$\frac{B_t}{K_t} \geq 0,$$

$$\frac{N_t}{K_t} \geq 0,$$

$$\frac{D_t}{K_t} = \frac{\Pi_t + N_t}{K_t} \geq 0.$$

We have thus reduced the size of the problem such that there are only three state variables (i.e. the inherited debt-to-capital ratio, the ratio of demand to initial capital, and the shock to net revenue). This reduction in dimensionality facilitates estimation significantly.

### 2.1 The Firm’s decisions: Investment and debt

Given the specification of the model outlined above, there is no analytical solution that describes the optimal levels of investment and borrowing as a function of the state variables $\frac{B_{t-1}}{K_t}, \frac{X_t}{K_t}, \frac{X_t}{K_t}, \frac{u_t}{K_t}$. However we can use numerical stochastic dynamic programming methods to simulate these decisions. We use a method known as modified policy function iteration, which has proved much faster than
value iteration in our applications. Modified policy iteration works in much the same way as value iteration but economizes on steps that are computationally expensive in value iteration (in particular the value maximization step). The key to policy iteration is to make explicit use of the computed policy function in calculating the value of the firm. Specifically, each time a new policy function is computed, policy function iteration calculates the value function which would occur if the current policy were used for \( k \) periods (where \( k \) is some suitable number, typically between 5 and 20). Each iteration is more costly than under value iteration, but convergence typically requires far fewer iterations. To give an example, obtaining the solution for the model shown in Figure 1 below takes nearly three times longer using value iteration compared to modified policy iteration.\(^4\) For details on policy function iteration, see e.g. Judd (1999).

Figures 1-2 illustrate the policy functions for investment that relate the investment rate \( I_t/K_t \) to the demand variable \( X_t/K_t \), evaluated at three levels of revenue shocks (high, average, low).\(^5\) In Figure 1 there are no financial imperfections, consequently the revenue shock \( u_t \) is irrelevant - it affects net revenue, of course, but nonnegative dividends can always be achieved by borrowing (or issuing new equity). The graph shows that investment is an increasing function of demand, a relationship driven by higher marginal productivity of capital at higher levels of demand, everything else equal.

Figure 2 shows the policy function for investment for a case where it is costly to issue new equity and borrow. The graph shows that the policy function for investment is quite different in the presence of financial imperfections. Optimal investment varies with demand, however the revenue shock \( u_t \) now plays an important role. A bad draw of the revenue shock translates into low investment and a low response of investment to changes in demand. These results reflect the effects

\(^4\) Using Matlab version 7.1.0 with an Intel Pentium M processor 1700MHz.

\(^5\) For Figure 1, we set \( h = 0 \), for Figure 2 \( h = 0.2 \). Remaining parameter values as follows: \( \delta = 0.05, r = 0.20, b_q = 0.5, \mu = 0.04, \sigma_x = 0.2, i = 0.2, \sigma_u = 1.0, \gamma = 0.6. \)
of the financing costs. Figure 3 shows the associated levels of borrowing. A bad
draw of the revenue shock forces the firm to borrow, which is costly. It therefore
combines modest borrowing with low investment, in order to meet the nonnegativ-
ity constraint on dividends. For a good or an average draw of the revenue shock,
no borrowing is needed and so the firm can undertake its desired investment.\textsuperscript{6}

3 Data and empirical moments

This section describes the datasets used in our empirical analysis, and the features
of these datasets that we use to estimate the structural parameters of our model.

3.1 Samples

Our data on firms in China and Brazil come from the World Bank’s Investment
Climate Surveys. The survey for China was conducted in 2002, asking for recorded
annual data from 1998 to 2000, for 1,548 firms, with approximately 300 firms
in each of 5 main cities: Beijing, Chengdu, Guangzhou, Shanghai and Tianjin.
The survey covered both manufacturing and service sector firms, and covered
state-owned as well as private sector enterprises. We focus on a sub-sample of
manufacturing firms with majority private ownership. The survey for Brazil was
conducted in 2003, asking for recorded annual data from 2000 to 2002, for 1,642
private-owned firms, randomly sampled from 13 cities and 9 manufacturing sectors.
From each of these samples we obtain measures of annual investment expenditure
(net of asset sales) on machinery, equipment, vehicles land and buildings; end of
period net book values of machinery, equipment, vehicles, land, and buildings;
total sales; cash-flow; and long-term debt. These financial variables, measured
in current prices in local currencies, are deflated by the annual inflation rates for

\textsuperscript{6}Note that desired capital stocks are actually higher under financial imperfections than under
no imperfections, given an average or a good draw of the revenue shock. This is because the firm
uses physical capital as a way of protecting itself against being financially constrained in the
future. This, arguably, is not a very realistic feature of our model. A richer model, allowing for
the accumulation of financial assets, would probably change this result. Work on such a model
is currently underway.
corresponding countries and years. We focus on firms with between 76 and 1,000 employees within each country. The construction of other variables used in the analysis, additional criteria for excluding observations from our samples, and some basic descriptive statistics are provided in the Data Appendix.

3.2 Moments

Table 1 reports the moments that we use in our estimation procedure, separately for the two countries. About 73% of the Brazilian firms have outstanding long-term debt, which can be compared to 43% of the Chinese firms. Furthermore, the ratio of debt to fixed assets is more than twice as high in Brazil as in China (0.35 and 0.16, respectively). It thus appears clear that firms in Brazil tend to rely more on long-term debt than firms in China. As one would expect given that we are focussing on long term debt, there is very high persistence in the debt-assets ratio in both countries: in Brazil the serial correlation between $B_t/K_t$ and $B_{t-1}/K_{t-1}$ is 0.80, in China it is 0.88.

In both countries, investment is positively correlated with cash-flow (denoted $C_t/K_t$). A positive correlation between investment and cash-flow is often interpreted as a sign of financial imperfections, at least if economic ‘fundamentals’ (costs, productivity, demand etc.) are conditioned on in the analysis. The basic idea is that, under no imperfections in the financial markets, the availability of internal funds should not affect investment because if the firm runs out of cash temporarily it can always borrow money at the going rate to finance its desired investment. Under financial imperfections, however, an increase in internal funds may well relax the financial constraint and so impact on investment. As discussed in the Introduction, credit markets in developing countries are indeed likely to exhibit considerable imperfections, which may be part of the reason investment and cash-flow are correlated in the data. Of course, the correlation between investment and cash-flow documented in Table 1 is unconditional and so may be may be driven by economic fundamentals and have nothing to do with financial
constraints. The estimated structural parameters reported below will be informative as to whether firms in our data appear to be financially constrained or not. There is also some evidence that highly indebted firms invest less than firms with little debt, which is consistent with our theoretical model: a highly indebted firm will find additional borrowing very expensive and so may choose to decrease investment as the leading way of addressing a cash-flow problem.

Investment rates exhibit positive serial correlation in both samples, suggesting a potentially important role for quadratic adjustment costs. The correlation between investment rates and current real sales growth is positive, as is the correlation between investment rates and the lagged ratio of real sales to capital. Both results are consistent with the theoretical prediction that investment responds to demand shocks (see e.g. Figure 1 above).

The average investment rate is about 0.13 in both countries. This is quite high, suggesting considerable growth in the capital stock. There is also evidence of rapid growth in sales in both countries. The standard deviation of investment rate is high across the countries, whereas the standard deviation in the growth rates of sales is much higher in China than in Brazil. This could reflect higher uncertainty in China than Brazil, but it is also consistent with cross-country differences in the severity of measurement errors. This is another issue that our structural estimates will shed some light on.

4 Estimation and results

This section outlines the simulated method of moments procedure that we use to estimate the structural parameters of our investment model, and presents the estimated parameters that we obtain for each of the samples described in the previous section.
4.1 Empirical specification

We use a simulated method of moments estimator to estimate the key structural parameters in the model described in Section 2. The estimation procedure basically consists of two main parts. The first is to solve the firm’s dynamic optimisation problem, subject to the relevant constraints, given a particular vector of parameter values. The second part is to use this solution to generate artificial data and match simulated moments to real ones. The firm’s optimisation problem is solved using modified policy function iteration, as discussed in Section 2. To generate simulated data on investment and borrowing, we draw different histories of the demand shocks ($\varepsilon_t$) and the revenue shocks ($u_t$) from the distributions specified in Section 2, and track each firm’s optimal decisions in response to these shocks.

Estimation of the structural parameters of the model exploits the fact that different values of these parameters generate different simulated moments. For example, a lower interest rate on debt will generate higher debt-assets ratios, on average, whilst a higher quadratic adjustment cost parameter will generate more positive serial correlation in investment rates. The basic idea of simulated method of moments estimation is to find the parameter values which provide the best match between these features of the simulated datasets and the corresponding moments in our empirical datasets. More precisely, we find the parameter vector that minimises the discrepancy between the vector of empirical moments and the vector of simulated moments, in a weighted quadratic distance sense. Our implementation uses an estimate of the optimal weight matrix based on the covariance matrix of the empirical moments (estimated by means of cluster bootstrapping), and a robust simulated annealing algorithm to find the global minimum of this criterion function. Further details are given in Appendix B in Bond, Söderbom and Wu (2007a).

We do not attempt to estimate the complete set of structural parameters. We
impose a depreciation rate of 5% per annum, and discount rates of 20% per annum, across the two countries. We draw on our earlier work (Söderbom, Bond and Wu, 2007a) and set the capital coefficient in the revenue function to 0.40. This leaves six structural parameters to be estimated: the adjustment cost parameter \( b_q \), the trend growth rate of demand \( \mu \), the standard deviation of the demand shocks \( \sigma_x \), the debt cost parameter \( h \), the interest rate on borrowing \( i \), and the standard deviation of the serially uncorrelated revenue shocks \( \sigma_u \). Finally, we allow for measurement errors in sales of the following form:

\[
\ln Y_{it} = \ln Y^*_it + m^Y_{it},
\]

where \( Y_{it} \) denotes the observed level of real sales, \( Y^*_it \) denotes the true underlying level of real sales which is not measured accurately in the data, and the measurement error \( m^Y_{it} \) is transitory with mean zero and constant standard deviation \( \sigma_{YT} \).

Thus, in addition to the structural parameters, we also estimate the parameter \( \sigma_{YT} \).

4.2 Results

Table 2 presents our simulated method of moments estimates of the parameters of our model, and the standard deviation of the output measurement error introduced in our empirical specification. Table 3 shows the associated simulated moments.

Overall, there is a lot of evidence here that firms in China and Brazil often face financial constraints. To determine formally if a firm is financially constrained we use the Lagrange multiplier method discussed in Section 2. Table 3 shows that 45% of the firms in the Brazilian sample, and 33% of the firms in the Chinese sample, are financially constrained according to our results. This is the result of a fairly high estimate of the debt cost parameter \( h \), as shown in Table 2. Interpreting this parameter, estimated at 0.10 for both samples, is not as straightforward as

---

7Allowing for more general forms of measurement errors (see e.g. Bond, Söderbom and Wu, 2007a) is desirable. Work on this issue is ongoing.
it may seem, however. The point estimate of 0.10 implies that the marginal instantaneous cost of incurring debt is 0.03, evaluated at \((B_t/K_t) = 0.3\) (the average simulated debt-assets ratio across the two countries). At first glance, this appears rather low, especially given that the estimated interest rates on debt are rather much lower than the (imposed) discount rate. The marginal instantaneous cost of borrowing, however, is not the full economic cost associated with debt. Importantly, by incurring debt the firm increases significantly the risk of being financially constrained in the future, since loans taken today have to be repaid in the future. Such repayments might necessitate further borrowing and future financial costs. As a result, the expected value of the firm in \(t + 1\) may fall quite rapidly with the debt-assets ratio. It is precisely for this reason firms are reluctant to borrow, even though the estimated interest rates on debt, and the marginal instantaneous cost of borrowing, are rather low.

To illustrate the economic significance of the debt cost parameter, we investigate the effect of reducing \(h\) from 0.10 to 0.05, on borrowing behaviour. Based on our results for China, such a reduction in the cost of debt would lead to a doubling of both the proportion of firms having debt, and the debt-assets ratio. For Brazil, reducing \(h\) to 0.05 would lead to virtually all firms borrowing (99.8%) and a doubling in the mean debt-assets ratio.

Other parameter estimates shown in Table 2 are of interest too. It is noteworthy that the interest rate on debt is higher for the Chinese sample than for Brazil, which is consistent with the pattern observed in the data that firms in Brazil tend to borrow more than firms in China. The demand shift parameter has an underlying growth of about 3 percent, and the standard deviation of demand shocks is slightly lower than 0.20, in both countries. Furthermore, the standard deviation of the serially uncorrelated revenue shock is considerably higher for Brazil than for China, which is consistent with the result that Brazilian firms are more likely to be financially constrained. The capital adjustment costs are somewhat higher in the Brazilian sample than for China. Finally, the standard deviation of the
measurement error in sales is much higher for China than for Brazil, suggesting
that the high variance in sales growth observed for China to a large extent can be
explained by measurement errors.

Table 3 reports the simulated moments generated by our model at these sets
of estimated parameters. Compared to the empirical moments reported in Table
1, it seems clear that the model does relatively well in matching the proportion
of firms incurring debt, the average debt-assets ratio, and the serial correlation
in debt-assets ratios; and less well in matching the average growth in sales, and
the correlations between investment on the one hand and current sales growth,
lagged ratio of real sales to capital, and cash-flow, on the other. Since we use
13 moments to estimate 7 parameters, the minimised values of the simulated
method of moments criterion functions used to obtain these estimated parameters
provide a test of the overall fit of the models, based on the six over-identifying
restrictions. These tests are reported together with the parameter estimates and
sample sizes in Table 2. Not surprisingly, the validity of these over-identifying
restrictions is formally rejected. This result is commonly found in the related
literature. Implications are discussed in Bond, Söderbom and Wu (2007a).

5 Conclusions

The estimated models in this paper highlight the importance of financing costs
for firms in Brazil and China. Our analysis of the theoretical model shows that
costly external financing leads to low investment in periods in which the firm
experiences negative cash flow shocks. Firms are reluctant to borrow to deal with
such problems, partly because of high current costs to doing so, but also because of
dynamic considerations. High levels of debt for long periods of time would be very
costly for the firm, and so firms opt for a strategy of using modest levels of debt
and low investment as a way of addressing liquidity problems. Our results indicate
that the proportion of financially constrained firms is high in both countries, and
that a reduction in the cost of borrowing would have large effects on the way in
which firms finance investment.

Future work will involve generalising the model to allow for financial assets as
an alternative way of guarding against future financial problems, and to further
probe the implications of the estimated financing costs for short run and long run
capital accumulation.
References


Data Appendix

(1) Sampling
The original datasets are downloadable from http://www.enterprisesurveys.org/Portal after registration for Brazil and China.

- Brazil
  The survey for Brazil was conducted in 2003, asking for recorded annual data from 2000 to 2002, for 1,642 private-owned firms, randomly sampled from 13 cities and 9 manufacturing sectors.

- China
  The survey for China was conducted in 2002, asking for recorded annual data from 1998 to 2000, for 1,548 firms, with approximately 300 firms in each of 5 main cities: Beijing, Chengdu, Guangzhou, Shanghai and Tianjin. The survey covered both manufacturing and service sector firms, and covered state-owned as well as private sector enterprises.

(2) Definition of Variables

- Define I = investment-disinvestment in machinery, equipment, vehicles, land and buildings.
- Define Y = total sales.
- Define L = number of (permanent) employees.
- Define wage = total wage bill or manpower cost.
- Define rawmat = value of raw materials used.
- Define totic = value of total indirect costs, i.e. consumption of energy + other costs.
- Define vad = value-added, i.e. Y - rawmat - totic.
- Define C = cash flow, i.e., Y - wage - rawmat - totic.
- Define B = long-term liabilities.

(3) Cleaning Rules

- Deflate financial variables by annual inflation rates for corresponding countries and years.
- Drop non-manufacturing firms.
- Drop state-owned firms--government ownership more than 50%.
- Drop firms with negative value-added.
- Drop firms with employment less than 10 or larger than 1000.
- Drop firms with less than two consecutive observations for I/K.
- Rule out Investment Rate less than -1 or larger than 1.
- Rule out top and bottom 5% observations for Y/K and ΔlnY.
- Rule out top and bottom 5% observations for C/K and B/K.
- Divide each sample into small firms (L <= 75) and large firms (L > 75).
- We focus on large firms only in this paper.

(4) Sample Structure

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td># of firms</td>
<td>473</td>
<td>455</td>
</tr>
<tr>
<td>median L</td>
<td>152</td>
<td>281</td>
</tr>
</tbody>
</table>
## (5) Macro and Micro Comparison

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th></th>
<th>Brazil</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Macro</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP annual growth rate (%)</td>
<td>8.0</td>
<td>sales growth rate (%)</td>
<td>12.2</td>
<td>10.2</td>
</tr>
<tr>
<td>GDP per capita (USD)</td>
<td>886</td>
<td>value-added per employer (USD)</td>
<td>9435</td>
<td>3232</td>
</tr>
<tr>
<td>Gross fixed capital formation (%)</td>
<td>10.3</td>
<td>net investment rate (%)</td>
<td>13.2</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Micro</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP annual growth rate (%)</td>
<td></td>
<td>sales growth rate (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per capita (USD)</td>
<td></td>
<td>value-added per employer (USD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross fixed capital formation (%)</td>
<td></td>
<td>net investment rate (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mean</td>
<td></td>
<td>median</td>
<td></td>
</tr>
<tr>
<td>GDP annual growth rate (%)</td>
<td></td>
<td>sales growth rate (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per capita (USD)</td>
<td></td>
<td>value-added per employer (USD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross fixed capital formation (%)</td>
<td></td>
<td>net investment rate (%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: macro data comes from World Development Indicator Database, the World Bank.
Figure 1: Investment and Demand. Costless Financing.
Figure 2: Investment and Demand. Costly Financing.
Figure 3: Borrowing and Demand. Costly Financing.
Table 1: Sample Moments

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{corr}(I_t/K_t, \ln(Y_{t-1}/K_{t-1}))$</td>
<td>0.189</td>
<td>0.376</td>
</tr>
<tr>
<td>$\text{corr}(I_t/K_t, \Delta \ln Y_t)$</td>
<td>0.217</td>
<td>0.214</td>
</tr>
<tr>
<td>$\text{corr}(I_t/K_t, I_{t-1}/K_{t-1})$</td>
<td>0.497</td>
<td>0.475</td>
</tr>
<tr>
<td>$\text{Pr}(B_t &gt; 0)$</td>
<td>0.731</td>
<td>0.427</td>
</tr>
<tr>
<td>$\text{mean}(B_t/K_t)$</td>
<td>0.350</td>
<td>0.160</td>
</tr>
<tr>
<td>$\text{corr}(B_t/K_t, B_{t-1}/K_{t-1})$</td>
<td>0.800</td>
<td>0.879</td>
</tr>
<tr>
<td>$\text{corr}(I_t/K_t, B_t/K_t)$</td>
<td>-0.033</td>
<td>-0.054</td>
</tr>
<tr>
<td>$\text{corr}(I_t/K_t, \Delta B_t/K_t)$</td>
<td>0.035</td>
<td>-0.013</td>
</tr>
<tr>
<td>$\text{corr}(I_t/K_t, C_t/K_t)$</td>
<td>0.076</td>
<td>0.117</td>
</tr>
<tr>
<td>$\text{mean}(I_t/K_t)$</td>
<td>0.126</td>
<td>0.132</td>
</tr>
<tr>
<td>$\text{sdev}(I_t/K_t)$</td>
<td>0.206</td>
<td>0.223</td>
</tr>
<tr>
<td>$\text{mean}(\Delta \ln Y_t)$</td>
<td>0.124</td>
<td>0.122</td>
</tr>
<tr>
<td>$\text{sdev}(\Delta \ln Y_t)$</td>
<td>0.182</td>
<td>0.298</td>
</tr>
</tbody>
</table>
Table 2: SMM Estimates of Structural Parameters

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjustment cost function:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$b_q$</td>
<td>0.578</td>
<td>0.447</td>
</tr>
<tr>
<td><strong>Demand process:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.028</td>
<td>0.027</td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>0.194</td>
<td>0.180</td>
</tr>
<tr>
<td><strong>Revenue shock:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_u$</td>
<td>2.269</td>
<td>1.600</td>
</tr>
<tr>
<td><strong>Debt cost function:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$h$</td>
<td>0.101</td>
<td>0.101</td>
</tr>
<tr>
<td><strong>Interest rate on debt:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i$</td>
<td>0.100</td>
<td>0.155</td>
</tr>
<tr>
<td><strong>Measurement error in output:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{YT}$</td>
<td>0.041</td>
<td>0.147</td>
</tr>
<tr>
<td><strong>Criterion value</strong></td>
<td>609</td>
<td>506</td>
</tr>
<tr>
<td><strong>Over-ID restrictions</strong></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Firms</strong></td>
<td>473</td>
<td>455</td>
</tr>
<tr>
<td><strong>Time periods</strong></td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>China</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>$corr(I_t/K_t, \ln(Y_{t-1}/K_{t-1})$</td>
<td>0.446</td>
<td>0.495</td>
</tr>
<tr>
<td>$corr(I_t/K_t, \Delta \ln Y_t$</td>
<td>0.686</td>
<td>0.558</td>
</tr>
<tr>
<td>$corr(I_t/K_t, I_{t-1}/K_{t-1})$</td>
<td>0.323</td>
<td>0.391</td>
</tr>
<tr>
<td>Pr($B_t &gt; 0$)</td>
<td>0.743</td>
<td>0.460</td>
</tr>
<tr>
<td>mean($B_t/K_t$)</td>
<td>0.411</td>
<td>0.205</td>
</tr>
<tr>
<td>$corr(I_t/K_t, B_{t-1}/K_{t-1})$</td>
<td>0.766</td>
<td>0.753</td>
</tr>
<tr>
<td>$corr(I_t/K_t, B_t/K_t$)</td>
<td>-0.147</td>
<td>-0.080</td>
</tr>
<tr>
<td>$corr(I_t/K_t, \Delta B_t/K_t$</td>
<td>-0.070</td>
<td>-0.078</td>
</tr>
<tr>
<td>$corr(I_t/K_t, C_t/K_t$)</td>
<td>0.270</td>
<td>0.306</td>
</tr>
<tr>
<td>mean($I_t/K_t$)</td>
<td>0.088</td>
<td>0.071</td>
</tr>
<tr>
<td>sdev($I_t/K_t$)</td>
<td>0.099</td>
<td>0.117</td>
</tr>
<tr>
<td>mean($\Delta \ln Y_t$)</td>
<td>0.028</td>
<td>0.010</td>
</tr>
<tr>
<td>sdev($\Delta \ln Y_t$)</td>
<td>0.208</td>
<td>0.311</td>
</tr>
<tr>
<td>Pr(financially constrained)</td>
<td>0.45</td>
<td>0.33</td>
</tr>
</tbody>
</table>