Why and When to Go Public : Evidence from Structural Estimation

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Abstract

In this paper we formulate and estimate a dynamic structural model of the going public decision and estimate the hidden costs and benefit parameters using data from Indian IPOs. The model predicts underpricing and hot issues markets as observed as recurrent phenomenon worldwide. The reduced form estimation suggests past performances, age, risk factors listed in the IPO prospectus significantly affects the going public decision. A matching estimation suggests that firms who do not go public probably because of high associated costs loose out in higher profitability and sales. The average treatment effect suggests that firms could have increased their annual profit after tax by about 2.5 times if they went public. We estimate the structural parameters of the costs associated with going public. We also non-parametrically identify and estimate the distribution of the unobserved quality of the firm which showed wide within industry variability.

1 Introduction

Going public is an important milestone for a firm. There are significant benefits and costs associated with the decision of being listed. On one hand the firm can raise the required capital for investment and firm growth through the initial public offering (IPO), make the firm more visible, transfer the risk to shareholders, relax the borrowing constraints and be more competitive in the product market. However on the other hand, going public is associated with significant amount of fixed and variable costs.

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The process and the uncertainty associated with raising equity are further complicated by the adverse selection problem associated with yet to be publicly observed innovations of the firm. The investors may feel that they have inferior information about the future prospects of the firm relative to the management which may lower their propensity to invest. The informational superiority of the firm and its manager leads to the standard lemons problem and the firm has to underprice the issue to give enough incentives to the investors to invest in the IPO. This is an indirect cost and lowers the IPO proceeds and adds to the listing cost. Facing these trade-offs the firm manger would want to time the IPO decision well which makes the decision process inherently dynamic in nature. In this paper we formulate a dynamic structural model of the going public decision and estimate the fundamental costs and benefits parameters associated with being listed as well as the distribution of asymmetric information.

Once these parameters are estimated they can be used for counterfactual experiments. For example, had the cost of raising funds be different in alternative mechanism the potential impact of alternative issuance decisions on the amount of funds raised, information revealed and on market structure etc. can be analyzed. This has important policy implications especially for India which is still undergoing various forms of financial liberalization.

The going public decision is modeled as an optimal stopping time problem of a firm in a dynamic setting. Each period the utility maximizing firm manager of a private firm faces the discrete decision of whether to take the firm public or not. The manager finances his consumption from the net earnings of the firm. The manager privately observes the quality parameter of the firm and the market only knows the distribution of this quality parameter. If the manager decides not to take the firm public then it decides how much to invest for the next period's capital stock which has to be financed from borrowings and retained earnings and how much of his stake he is going to dilute. If it decides to take the firm public then it wants to mitigate the direct and indirect costs and maximize the proceeds from the IPO.

We propose a three step procedure to identify and estimate the parameters based on the equilibrium characterization. The investment and borrowing decision gives rise to the standard Euler equations which is augmented by the unobserved quality parameter and costs associated with going public and adjustment costs of investment. The continuous choices of investment, borrowing and dilution choice in the period of going public leads to Euler equations. These Euler conditions identifies the parameters of the capital stock adjustment cost function and borrowing cost parameters. The identification assumption is that these parameters do not change before and after public. We use a novel identification technique borrowed from the auctions literature to identify the distribution of unobserved quality of a firm non parametrically. We assume that this distribution does not change in a given period of time for a particular industry although the value of the quality of a firm may change. It is like drawing a new value from the same distribution. If the distribution does not change then its moments does not change for a given industry in a given time period. Matching of these moments for different years within the same industry for the same time period helps us generate additional moment conditions which are used to estimate additional parameters. The fixed and variable costs associated with the going public decision as a function of the quality and other parameters are identified from the discrete choice of going public decision.

The estimation procedure closely follows the identification argument described above. We first estimate the distribution of observed state variables like capital stock and market condition non parametrically. Then given initial guess of the adjustment cost parameters we estimate the distribution of the quality of the firm non parametrically. We then do a grid search on these parameters to match the moments of the distribution of the quality of a firm. Given these parameters the likelihood of going public is maximized to estimate the fixed and variable costs of going public.

We apply and estimate our model using data from Indian firms before and after they went public. This data is supplemented with information about firms which never went public and the data about the firm from the prospectuses of while going public. The model and the estimation procedure is applicable for any general IPO process. We take the model to data from the Indian IPOs taken public during the period 1999-2006. We have data for all the IPOs during this period. For each firm we have data three years prior to the firm decides to go public and all the years after it went public. We supplement this data with data on firms which never went public in the entire sample period. The data set is unique in the sense that we can track the firm before it went public as well as after.

The descriptive and reduced form analysis confirms to the basic predictions of our model. For example the structural model equilibrium predicts a monotonic threshold policy of going public decision, monotonic to the underlying state variables. We run standard panel data logistic regression to confirm the predictions. Going public also has significant befits like improvements of the profitability of the firm. Two similar types of firms if they can afford the cost of going public should go public. We match the sample of public firms with that of private firms based on their age, size, industry, capital stock etc. to test this prediction. We employ the matching estimation procedure and estimate the average improvement in sales, EBIT etc. due to the treatment of going public decision. The treatment effect predicts significant improvement in profitability (2.5 times increase in profits if a private firm of similar size and industry goes public) in the matched sample. This means the firm which remained private could not afford the cost of going public. The firm manager only observes the quality of the future profitability of the firm privately. This creates an adverse selection problem as potential investors may need enough premium to invest in the firm. This is an indirect cost of going public. We therefore expect that the firm would like to signal its quality and alleviate the adverse selection cost through its recent past performance before going public and advertise the same in the IPO prospectus. The risk factor chapter in the IPO prospectus is one such place. We use a novel technique to read the IPO prospectuses and its risk factor chapter and classify the risks associated with the future prospect of the firm as outlined in the risk factor chapter. This chapter is written by the firm itself and can be seen as an equilibrium response to mitigate the adverse selection costs. These works as proxies of quality of the firm for the reduced form analysis. We regress the IPO proceeds and the underpricing on different types of risks and find a negative relation to firm specific risks impacting IPO proceeds. Since there is inherent selection and endogeneity bias associated with the going public decision we employ Heckman selection estimation to estimate such regression. The results suggests that these quality proxies are explained significantly by past performances of the firm. The quality proxies also impacts the IPO decision, hidden costs of going public like underpricing, dilution and IPO proceeds. Other notable factors affecting the going public decision is the age of the firm. The average age of going public of Indian firms is about 15 years which is considerably higher than that of the US (7 years) and lower than that of Italian (32 years: as documented in Pagano et al (1998)) firms.

Having confirmed the basic predictions of our model by reduced form we take the model to match the data to estimate the structural parameters. The fundamental parameters in our model are the distribution of the privately observed quality of the firm, the costs of going public and the adjustment costs of new investments. The reduced form analysis cannot estimate these parameters and only confirms the predictions of the impact of these parameters. We use the identification and estimation procedure outlines above to estimate these parameters. The structural estimation brings out the fixed and variable costs associated with the process of going public besides the standard adjustment cost of investments. This fixed cost includes the underwriting fees as well as opportunity cost associated with the going public decision. The high fixed costs partly explains why otherwise similar firms do not go public despite its obvious benefits. Other fundamental parameters include the unobserved quality of the projects in hand. To the best of our knowledge this is the first paper which analyzes going public decision from a structural view point and estimates it.

2 Place in the Literature

Our work builds on to the works of Colley and Quadrini (2001), Hennesy et al (2005,2007) and Moyen (2004). Colley and Quadrini models a firm which has defaultable debt and faces proportional equity costs and presents simulation evidence about the importance of financial frictions in raising equity. Their model greatly influenced the basic dynamic model that we built here. However our focus is on estimation of the financial frictions as structural parameter under asymmetric information about firm quality.

Our work is also closely related to Hennesey and Whited (2007) who generalized Colley and Quadrini by adding corporate and financial taxation and linear quadratic costs of external equity and took the predictions of the model to match the data by simulated method of moments and estimate the parameters by structural estimation. However the nonparametric identification and estimation of the unobserved quality parameter is the first. We also estimate the IPO decision as a discrete choice rather than equity issuance as a continuous choice. The analysis from the perspective of utility maximizing firm manager is crucial for the IPO decision as he has the complete control of the firm. The profit maximization of the firm is embedded in his utility maximization problem. In this way we have indirectly controlled for the indirect moral hazard issues also.

The going public decision has generated considerable theoretical work in recently (see, e.g., Boot, Gopalan, and Thakor (2006), Chemmanur and Fulghieri (1999), and Clementi (2002)). However there is little empirical research except for Lerner (1994), who studies the timing of a sample of venture backed biotechnology firms; and Pagano, Panetta, and Zingales (1998),who study the going public decisions of a sample of Italian firms. Jain and Kini (1994) and Mikkelson, Partch, and Shah (1997) have documented the operating underperformance subsequent to IPO of firms going public relative to seasoned firms. However there has been no research on identification and structural estimation of the critical costs and benefits parameters associated with the going public decision.

There has been considerable theoretical work and empirical documentation of IPO underpricing and dilution choice in a static setting. (e.g. Benvineste and Spindt, Allen and Faulhaber(1989), Chemmanur et al (1993, 1999), Ritter and Welch (2002 etc.). The focus of our paper is not analyze underpricing and allocation problem in detail. We are mostly interested in the costs and benefits parameters of going public decision and the dynamic trade off associated with being listed. We also estimate the adverse selection component of being listed as the unknown quality parameter.

3 A Dynamic Model

In each period the firm has access to the following technology: $F(k, z) = z\theta k^{\gamma}$, where k is the capital stock, z is the aggregate shock to the economy and θ is the own productivity shock privately known only to the firm manager. The preference of the firm manager over his consumption c is represented by the utility function $u(c)$.The firm manager smoothness consumption over two assets: investing in the riskless asset A yielding a constant return R per period or invest in the company's equity which improves the investment in the physical capital stock of the firm one to one and improves profitability. The manager has a claim on this profit. We assume that the entrepreneur cannot short sell the riskless asset, i.e., $A \geq 0$. The entrepreneurs stake in the book value of firm equity is represented by $\alpha \in [0, 1]$. When the firm is private, the entrepreneur has full control and $\alpha = 1$, when the firm is public $\alpha < 1$. The discount factor being represented by $\beta < \frac{1}{1+R}$. The private productivity shock follows a stochastic distribution $F(\theta)$.

Although the entrepreneur cannot borrow to finance his personal consumption, the firm may borrow an amount B' to increase the capital stock beyond the book value of equity k. We impose the restriction $B \leq \phi k$, i.e., the firm can only borrow up to the level which is an increasing function of its book value of equity.

3.1 Timeline of Events

In each period a private firm observes the current productivity shock z, observes his private quality parameter θ and has the following decisions to make:

- whether to default or not on his current debt, default involves a cost Λ.
- If he does not defaults then he decides:
- whether to take the firm public, and if yes how much equity stake α to hold.
- Going public involves a fixed cost of Φ. and a proportional cost h : proportional of the ipo proceeds.
- The following decision is common to both the public and private firm: how much to borrow: B' and how much capital stock k' to choose for the next period and the amount of holdings in riskless assets A'. These choices are continuous.
- The state variables are: capital stock (k_t), borrowing B, aggregate shock to the economy (z), and the level of accumulated wealth A. We shall denote the vector of state variables as x.
- Each period a private firm receives a choice specific productivity shock ϵ in the choice represented by 1. The value function for a firm associated with the decision of whether to go public or not can be given by

$$V(x, z, \epsilon) = \max_{a \in \{0,1\}} \{W^{Pvt}(x, z) + \epsilon_0, W^{Public}(x, z) + \epsilon_1\} \tag{1}$$

- where x is the vector of state variables.

Assumption 1: ϵ follows iid Logistic distribution $(0, \sigma_\epsilon^2)$

For expositional clarity let us first describe the value function after the firm decided to go public:

3.1.1 The post IPO decision problem

A firm which is already public has the following value function:

$$\begin{aligned} S^{Public}(x,z) &= (1-\rho_d) \max_{c,A',k',B'} \{u(c) + \beta \int S^{Public}(x,z') dF(x',z'|x,z)\} \\ &\quad + \rho_d \max_{c,A} \{u(c,0) + \beta S_L(A')\} \end{aligned} \tag{2}$$

where $S^{public}(.)$ is the value function of a firm which is already public. The first term is weighted by the probability that the firm would not default in the current period $(1-\rho_d)$. The second line weighted by default probability represents the value function of the firm manager in case the firm defaults. If the firm does not default then the associated constraints are

Capital accumulation

$$k' = (1-\delta)k + I$$

no short sale

$$A' \geq 0$$

borrowing constraint

$$B' \leq \phi k$$

nonnegative consumption

$$c \leq \alpha d + A(1+R) - A' \tag{3}$$

where d is the dividend stream at time t given by,

$$\begin{aligned} d &= F(k,\theta,z) - T(k,B,z,z') - g(k,I) - R_{B_t}(k,B,z)B + B' - I \\ &= F(k,\theta,z) - T(k,B,z,z') - g(k,I) - R_{B_t}(k,B,z)B + B' - k' + (1-\delta)k \end{aligned}$$

where $T(.)$ is the corporate tax rate which is a function of its borrowing (to account for any interest shield of tax benefits) and capital stock. Thus the entrepreneur finances his consumption c from the stake α it has on the firm's stream of dividends d_t, and his income from riskless asset A minus next period holding A'. $F(.)$ is the operating income of the firm, $g(.)$ is the adjustment cost of new investment,

I_t with the current capital stock k_t. Since the lender can only write a contract based on observable, the stochastic interest rate $R_{B_t}(k, B, z)$ is a function of its current borrowing. Following Whited ('98) we specify the following functional form for the adjustment cost

$$g(k, I) = [\eta_0 + \eta_1 \frac{I}{k} + \eta_2 \left(\frac{I}{k}\right)^2]k$$

Substituting d in c we get the revised budget constraint

$$c \leq \alpha[F(k, \theta, z) - T(k, B, z, z') - g(k, I) - R_{B_t}(k', B, z)B + B' - I] + A(1 + R) - A' \quad (4)$$

The consumption in case of a default is financed only through accumulated wealth

$$c_L = A(1 + R) - A'_L$$

3.1.2 Default and Taxation Decision

Each period given the exogenous shock z the management has a probability ρ_d to default on his debt. This probability is implicitly defined as in Colley and Quadrani and Hennesey & Whited a monotonic function of the exogenous shock $z : \rho_d(z)$. The management defaults when the realized net worth is negative. This would make the interest rate a function of the current state of the firm: $R_B(k, B, z)$. The realized net worth $w(k, z, \theta)$ is defined as the value of the capital stock and current production net of tax and interest payments and given by

$$w(k, z, \theta) = (1 - \delta)k + F(k, \theta, z) - T(k, B, z, z') - R_{B_t}(k', B, z))B \quad (5)$$

We assume that If the management defaults then it cannot take any other company public. Note that we do not explicitly model the interest rate determination here. The interest payments is also affected by potential adverse selection and moral hazard issues. The lender offers an incentive compatible contract to the firm based on the observable state variables only. We explicitly donot model the contract. We assume that the data would be coming from one equilibrium if there are multiple equilibria. The interest rate to be paid is modelled from the perspective of the firm manager.

3.1.3 The pre-ipo decision problem

A private firm has two types of decisions to make: whether to go public or not (discrete choice) and how much to invest for the firm's equity next period irrespective of whether it is going public or not (a continuous choice).

Note the value function given by $V(x, z)$ can be decomposed into the following two discrete decisions: going public or not

$$V(x, z, \epsilon) = \max\{W^{PVT}(x, z) + \epsilon_0, W^{Public}(x, z) + \epsilon_1\} \tag{6}$$

where the value function for a private firm if it decides not to go public be given by $W^{PVT}(x, z)$ and the value function for a private firm if it decides to go public be given by $W^{Public}(x, z)$.

The value function for a private firm if it decides to stay private be given by

$$W^{PVT}(x, z) = (1 - \rho_d) \max_{c, B', A' k'} \{u(c) + \beta \int_{x', z', \epsilon'} V(x', z', \epsilon') dF(x', z'|x, z) dF(\epsilon')\} \tag{7}$$

$$+\rho_d \max_{c, A} u(c_L, 0) + \beta S_L(A') \tag{8}$$

where it faces the choice of the capital stock accumulation (k'), borrowing (B') and riskless investment (A') in the current period if he does not default and it has to decide again whether to go public or not next period with an associated value function $V(x', z')$.

The associated constraints with the choice of not going public remains the same as before, i.e., capital accumulation

$$k' = (1 - \delta)k + I$$

no short sale constraint

$$A' \geq 0$$

borrowing constraint

$$B' \leq \phi k$$

non-negative dividend

$$d \geq 0$$

the firm has to finance its consumption from the dividend (profit) net of investment on the firm which he controls fully i.e., plug $\alpha = 1$ is equation 3

$$c \leq d + A(1 + R) - A' \tag{9}$$

where d is the dividend stream at time t given by,

$$d = F(k, \theta, z) - T(k, B, z, z') - g(k, I) - R_{B_t}(k', B, z))B + B' - I$$

The consumption in case of a default is finance only through accumulated wealth as before

$$c_L = A(1+r) - A'_L$$

If the firm decides to go public it has an associated value function given by

$$W^{Public}(x,z) = \max_{c,B',A'k'} \{\max_{\alpha} u(c) + \beta \int S(x',z')dF(x',z'|x,z)\}\} \tag{10}$$

where it has to decide the amount of stake in the firm he wants to retain (α). He also have to decide the standard investment (k'), borrowing (B') and riskless investment (A'). Next period he is a public firm and has a value function $S(.)$.

Since the impact of the decision to go public is not realized until the end of the period, the firm still faces the same budget constraint with only change that it has to incur the IPO related fixed and variable cost and would have the IPO proceeds at its disposal for reinvestment:

$$c \leq \alpha[F(k,\theta,z) - T(k,B,z,z') - g(k,I) - R_{B_t}(k',B,z)B + B' - I] + A(1+R) - A' + (1-h)(1-\alpha)P(.) - \Phi \tag{11}$$

where P is the price of the issue, α is the amount of stake retained by the firm. Thus $(1-\alpha)*P$ is the IPO proceeds. The firm incurs a fixed cost Φ and a proportional cost h of IPO proceeds connected with the decision to go public. Thus it has an amount $(1-h)(1-\alpha)P(.)$ at its disposal net of IPO related variable cost. Note α and P are determined as a static choice associated with the decision to go public. Their impact is felt in the years to come by determining how much stake the firm has on its future stream of profits.

We shall parametrize the ipo proceeds as a function of its quality θ and observed aggregate shock z and firm's current state variables x.

$$P(.) = a + b_1 \times \alpha + b_2 \times \alpha \times \theta + b_3 \times \theta \times \alpha \times Q \times z \tag{12}$$

where Q is a vector of observable firm characteristics like past sales, risk factors etc. The proportional cost of the IPO: h is modelled as a reduced form as a proportion of this proceeds $P(.)$.

When the firm has more information than average investors about the future value of the firm. This asymmetric information leads to the typical lemons problem leading to underinvestment. The choice of dilution would be taken in the pre IPO stage and would affect the decision outlined above. Nonparametric estimation and inversion of these choices using the respective first order conditions would give us estimates of the future value and variability of the firm.

Let the conditional choice probability of whether to go public or not be given by

$$\Pr(a = j|X, z) = \Pr(W^j(x, z) + \epsilon_j > W^k(x, z) + \epsilon_k))$$

where $j = \{Public, Pvt\}$

Hence the optimal decision rule of whether to go public can be characterized as

$$a(x, z_{jt}, \epsilon_{jt}) = \begin{Bmatrix} 1 \text{ if } W^{Public}(x, z) + \epsilon_1 > W^{PVT}(x, z) + \epsilon_0 \\ 0 \text{ otherwise} \end{Bmatrix} \tag{13}$$

which can equivalently be represented as

$$a(x, z_{jt}, \epsilon_{jt}) = \begin{Bmatrix} 1 \text{ if } \epsilon = \epsilon_0 - \epsilon_1 \leq W^{Public}(x, z) - W^{PVT}(x, z) \\ 0 \text{ otherwise} \end{Bmatrix} \tag{14}$$

Let us define the smoothed value function as

$$\begin{aligned} \overline{V}(x, z) &= \int_\epsilon V(x, z, \epsilon) dF(\epsilon) \\ &= \int_\epsilon \max\{W^{PVT}(x, z) + \epsilon_0, W^{Public}(x, z) + \epsilon_1\} dF(\epsilon) \end{aligned}$$

3.2 Equilibrium

Proposition 1 *There exists only one value function V which solves the function equation given by 1.*

Proof. Follows using standard arguments of contraction mapping. ■

The post IPO choices

Lemma 2 *The associated equilibrium conditions corresponding to the choices of future capital stock, risk free asset and amount of borrowing can be represented by the following equation:*

$$(1 + R + \frac{\lambda_A}{\beta})[\{g_I(.) + 1\}] - \{F_k - [g_k + g_I(1 - \delta)] - \frac{\partial R(k', z', B')}{\partial k'} - \frac{\partial T()}{\partial k'} - (1 - \delta)\} = 0 \tag{15}$$

the unobserved quality parameter can be written as

$$\theta = \frac{M_1 + M_2}{z \gamma k^{\gamma - 1}} \tag{16}$$

where $M_1 = (1 + R + \frac{\lambda_A}{\beta})[\{\eta_1 + 2 \times \eta_2 \times I + 1\}]$, $M_2 = [\eta_0 + (\eta_1 + 2 \times \eta_2 \times I)(1 - \delta) - \frac{\partial R(k',z',B')}{\partial k'} - \frac{\partial T(k',B')}{\partial k'} - (1 - \delta)$

Proof. In the appendix

The above equation would be used for identification and structural estimation later. ■

The pre IPO choices

Choice of investment if the firm decides not to go public

Lemma 3 *The pre ipo period investment choices would be higher than had the firm was not facing the potential decision of whether to go public or not.*

Proof. (technical details in the appendix, here is an intuitive explanation) A private firm after deciding that he does not want to go public this period, knows that it has a chance of going public next period. If it goes decides to go public then to mitigate the adverse selection problem he has to signal by underpricing the issue and making appropriate dilution choices as a function of its current operating profits. These are indirect costs of going public affects the IPO proceeds. If the firm can show better operating profits then it may have to underprice less and lower these costs, all of these are weighted by the positive equilibrium probability of whether he is going public next period. Higher investment in the current period would increase the operating profits next period. Thus his current investment can be decomposed into two components: one what he would otherwise be making had he not facing the choice of going public next period and the other which reduces his cost of going public next period via better operating performance. Given the equilibrium probability of going public is strictly positive the second component would also be strictly positive. ■

Choice of Dilution (α)

Lemma 4 *(Dilution) The dilution choice of the firm is characterized by the following equation*

$$(1+R)[(1-h)*P(.)+(1-h)(1-\alpha)\frac{\partial P}{\partial \alpha}] = \beta h[F(k,\theta,z)-T(k,B,z,z')-g(k,I)-(1+R_{B_t}(k',B,z))B'-I] \tag{17}$$

Proof. In the appendix ■

The IPO decision

Theorem 5 *Given the distributional assumption on ϵ, the smoothed value function in matrix form can be written as*

$$\overline{V}(x,z) = \sigma_\epsilon \ln(\exp\{\frac{W^{PVT}(x,z)}{\sigma_\epsilon}\} + \exp\{\frac{W^{Public}(x,z)}{\sigma_\epsilon}\})$$

moreover the smoothed value function is a contraction and has a unique fixed point with the decision rule is monotonic in the state variables.

Proof. (In the Appendix) ■

Given the above theorem, note that we can decompose the vector of state variables x as aggregate state variable and the firm specific state variables. Conditional on the firm specific variables if the state of the economy is high given the monotonicity of the decision rule it is more likely that more firms would choose to become public. This would lead to cluster of IPOs during good times and cold issue period during bad times.

Corollary 6 *(The Hot Issue Market) The IPO events would be characterized by hot issue market. i.e.,there would be significantly more IPOs in some periods than others.*

4 Identification and Estimation

The primitives of the model are the transition distribution of the observed state variables, the distribution of the quality parameter θ, the adjustment cost parameters associated with investment function $g(.)$, the fixed and variable cost parameters associated with the IPO decision and the parameters associated with the per period profit function. There are seven parameters $\eta = (\eta_0, \eta_1, \eta_2, \gamma, h, b_1, b_2)$ besides the distribution of θ associated with the continuous choices and the fixed cost of going public Φ associated with the discrete choice of going public. Given η the conditional choice probability associated with the discrete choice of going public in equation 14would identify and estimate Φ. To identify the seven parameter in η we have three moment conditions associated with the continuous choices of investment in the pre and post ipo decisions respectively and the dilution choice. We therefore need at least four other moment conditions to identify the parameters mentioned above given θ. Note that given these parameters the distribution of θ can be estimated nonparametrically using equation 16. Given this observation we make the identifying assumption that the distribution of θ is industry invariant. This means the distribution of qualities within a specific industry does not change in a given time period. Specifically we are making the assumption that the distribution of quality of different firms within a given industry (say cement) does not change in a given period (say in 1998-2000). Note we are not saying that the quality parameter remains unchanged. The actual value of θ taken by different firms may change though even within this period. If the distribution does not change in a given time period then its moments should be invariant within that time period. Then we use the moments of the distribution of θ for each industry in a given time period as additional moment restrictions to identify the remaining parameters. The estimation would follow this argument. Given initial values of η we shall first nonparametrically estimate θ using 16. Then we shall run grid search over these parameters η to match the moments from the first order conditions and that of the distribution of θ via GMM.

Specifically, the estimation follows the following steps:

Step 1: Estimate $\frac{\partial R(k,z,B)}{\partial k}$ and $\frac{\partial T(k,B)}{\partial k}$ semi-parametrically. We estimate these by local linear regression.

Step 2: Given initial values of $\eta = (\eta_0, \eta_1, \eta_2, \gamma, h, b_1, b_2)$ chosen from a grid, estimate the distribution of θ for each industry in a given period, where $\theta = \frac{M_1+M_2}{z\gamma k^{\gamma-1}}$ and $M_1 = (1+R+\frac{\lambda_A}{\beta})[\{\eta_1 + 2\times\eta_2\times I+1\}]$, $M_2 = [\eta_0 + (\eta_1 + 2\times\eta_2\times I)(1-\delta) - \frac{\partial R(k',z',B')}{\partial k'} - \frac{\partial T(k',B')}{\partial k'} - (1-\delta)$

Step 3: Form the moments of θ for each industry for each period within that given time period[1], Given these additional moments[2] search over the grid of η via GMM to get estimated η.

Step 4: Given η and the distribution of θ, form the predicted choice probabilities of going public and match it with the observed choice of going public to estimate Φ.

The identification and estimation arguments presented here is borrowed from the auction literature where the distribution of valuation is assumed to remain unchanged across different auctions to estimate the distribution of unobserved valuations from bids data (see Guerre, Perrigne and Vuoung (2000)).

Note that since we potentially have many moments for each industry in a given time period we have an overidentified system.

5 Data

5.1 Data Sources

Our data is drawn from three main sources. The balance sheet and income statements were drawn from the CMIE Prowess[3] database. Center for Monitoring Indian Economy (CMIE) collates data from the annual reports of both public and private the companies filed at the Registrar of Companies. The information on offer price, risk factors etc. for the companies that went public are drawn from the IPO prospectuses from the Securities and Exchange Board of India (SEBI) website. The total number of companies that went public in the sample is currently 176. When we augment the dataset with firms that did not go public we have approximately 27,000 firm-year observations between 1999 − 2006. The majority of the firms went public via book-building method. SEBI abolished the discriminatory

[1] For example, if the time period is 1996-1999, then form moments of θ for each year in the period 1996-1999.

[2] For example, one moment could be $m_1(\theta)$ in year 1996. Form another estimate of the same moment of θ for 1997 and the squared distance between the two $[m_{1,1996}(\theta) - m_{1,1997}(\theta)]^{2} = 0$ is a moment condition.

[3] Center for Monitoring Indian Economy (CMIE) collates data from the annual reports of the comanies filed at the Registrar of Companies.

allocation rule of the book building in Nov. 2005. This makes the entire process effectively a proportional allocation rule. The underwriter still has the flexibility of setting the offer price from a band after the roadshow. For details about the regime change and its impact on underpricing and allocation please see Bubna and Prabhala (2010).

5.2 Descriptive Statistics

The total number of companies that went public in the sample is currently 176. When we augment the dataset with firms that did not go public we have approximately $27,000$ firm-year observations between $1999-2006$.

Descriptive Statistics of 176 companies are given below with respect to different variables. The average age of going public is about 14 years of Indian firms compared to about 33 years in Itally (Pagano et al (1998)) and about 7 in the US. Current liabilities drop significantly for public firms, which may also motivate the decision to go public. As reported in table 2 the amount of underpricing is also wide and prevalent across different industries. As shown in the figure (in the appendix) the sales and investment of firms go up significantly after being listed. The unsecured borrowing also go up which may signify the improvement in bargaining power of listed firms.

Table 1

Panel A : Firms Going Public Year

Industry	Mean	Median	Standard Deviation
Sales	1.00	.856	.750
Age till IPO	14.82	12	11.13
Investments	.077	0.030	0.12
Working Capital	0.51	0.50	0.25
Current Liabilities	0.09	0	0.13
Secured Borrowing	0.24	0.24	0.16
UnSecured Borrowing	0.06	0.015	0.12
Interest Payments	0.021	0.017	0.02
Dilution	0.30	0.27	0.1
EBIT	0.09	0.08	0.11
Total Risk Factors [4]	33.43	34	11.16
Internal to Total Risk	0.75	0.75	0.08

Table1

Panel B : Firms That were Private

Industry	Mean	Median	Standard Deviation
Sales	1.06	.781	2.19
Investments	.107	.011	.19
Working Capital	.0056	.15	1.93
Current Liabilities	.597	.38	2.2
Secured Borrowing	.31	.153	2.00
UnSecured Borrowing	.266	.045	2.07
Interest Payments	.0554	.027	.29
EBIT	.071	.072	.72
Internal to Total Risk	.75	.752	.07

Table1

Panel C: Firms That were already Public

[4] Total risk factors listed in the prospectus.

Industry	Mean	Median	Standard Deviation
Sales	0.84	0.75	0.63
Investments	0.11	0.06	0.14
Working Capital	0.61	0.63	0.2
Current Liabilities	0.002	0	0.018
Secured Borrowing	0.17	0.16	0.15
UnSecured Borrowing	0.059	0.002	0.11
Interest Payments	0.014	0.012	0.013
EBIT	0.098	0.097	0.087

Table 2 : *Industry wise Underpricing*

Industry	Underpricing Average	No. of Companies that Underpriced
Manufacturing Sector	−0.41	38(79.17%)
Banking and Financial Sector	−0.31	14(66.67%)
Computer and IT	−2.09	46(79.31%)
Drugs and Pharmaceuticals	−0.99	8(72.73%)
Media and Entertainment	−0.80	16(69.57%)
Trading	−0.77	4(50%)
Others	−0.50	6(85.71%

Underpricing is highest for companies belonging to other industries (services) other than the classification. However, Computer and IT have the highest average underpricing followed by Drugs and Pharmaceuticals.

6 Reduced form Evidence and Hypothesis

In this section we form the reduced form hypotheses based on existing theory and the dynamic model of going public decision as presented in earlier section. The potential investors face an adverse selection problem about the quality of the future prospect of the firm. This would affect the expected proceeds from the IPO. The management tries to mitigate this problem in various ways. One way of signaling its quality is through past performances, in terms of its sales, profitability (EBIT) and investment. The firm carefully delineates these in the IPO prospectus through a audited report of its past performances. Since the past performances may not be enough signal about the future quality; the firm decide to explains the risk factors as listed in the prospect associated with the firm (internal risk factors) and the industry (external risk factors). Since by regulation these disclosures has to be upheld in the court of law, the firm takes special care in delineating them. It does take special care in explaining and corroborating its position through other evidences like its past performances or giving a managerial explanations wherever possible. We use these risk factors as a proxy for the quality of the future prospect of the firm. The firm has to incur indirect costs like underpricing its share to attract investors. Dilution of the firm is another cost as it reduces management's claim on future profitability. In the following subsections we first evaluate the management's decision to go public as a function of the observed past performances, quality (risk factors in the prospectus). We then evaluate the evolution of the risk factors and the determinants of the indirect costs of going public. The benefits of going public is evaluated using a matching regression where we match public and private firms based on their size (sales), age and industry. We then compare the performance of key financial variables like EBIT, profits, sales of a matched public and private firm.

6.1 The Going Public Decision

In the following tables we analyze the factors affecting the going public decision. The following factors affect the firm's performance in the going public decision: the firm's size, it's recent performance and borrowing and working capital. The coefficients of all these variables in table 3 and 4 are significant and have the same sign across different specifications. For example last year's current liabilities have a significant negative impact of going public decision. This may be rationalized as current liability being a signal of the firm's past performances and quality which worsens the adverse selection problem to the investors and increases the costs of going public. The firm then decides accordingly not to go public if the liability is too high.

Table 3 : Going Public Decision

The following table represents a logistic regression of the going public decision. The dependent variable is a dummy variable which takes value one if the firm went public in a given year and zero otherwise. EBIT is the earnings before interest and taxes. The numbers in parentheses are the t-statistics.

Logistic Regression of Decision to IPO		
Lag Log Sales	0.89 (6.66)	.92 (6.73)
Log Age	−1.09 (−8.23)	−1.04 (−7.71)
Lag Interest payments	−1.26 (−1.86)	−1.18 (−1.83)
Secured Loans	.03 (0.93)	.05 (2.71)
Unsecured Loans	.06 (2.38)	.06 (2.55)
Lag Current Liabilities	−.17 (−3.66)	−0.18 (−3.81)
Lag Working Capital	.003 (1.43)	
Lag EBIT	.19 (1.43)	0.17 (1.52)
Tech Dummy	No	Yes
No of Observations	21128	21128
R^2	0.25	0.26

$Table$ 4 : Going Public Decision

The following table examines the going public decision. The dependent variable is a dummy variable which takes value one if the firm went public in a given year and zero otherwise. Logistic and probit regression with and without random effects are reported. The numbers in parentheses are the t-statistics.

Logistic Regression of Decision to IPO	Logit	Probit	Random Effects Logit	Random Effects Probit
Lag Log Sales	1.01 (9.94)	0.4 (9.71)	1.13 (6.21)	0.4 (9.62)
Log Age	−1.28 (−8.37)	−0.57 (−8.48)	−1.51 (−4.95)	−0.55 (−8.28)
Lag Current Liabilities	−0.0005 (−2.4)	−0.002 (−2.32)	−0.006 (−2.34)	−0.02 (−2.35)
UnSecured Loans	−0.16 (−2.13)	−0.74 (−2.35)	−0.19 (−2.08)	−0.8 (−2.39)
secured Loans	0.012 (0.87)	0.009 (1.5)	0.02 (1.11)	0.009 (1.5)
Lag Working Capital	0.0034 (2.22)	0.001 (2.66)	0.004 (2.19)	0.002 (2.66)
Year Fixed Effects	Yes	Yes	Yes	Yes
No of Observation	21128	21128	21128	21128
R^2	0.38	0.38	$\Pr ob > \chi^2 = 0.00$	$\Pr ob > \chi^2 = 0.00$

In the following table we evaluate the decision of going public as based on the need for funds for future investment. The dependent variable is 1 if the firm goes public and zero otherwise. We then run a logistic regression on a set of control and the log of future (one period ahead) investments. A positive significant coefficient of log future investment implies going public decision is motivated by the future need of investment.

Table 5 : The Need for Going Public **:** Future Investment

The dependent variable is 1 if the firm goes public in a given period t and zero otherwise. Log future investment at time (t+1) is used as a proxy for need for future funds.

Decision to IPO	Coefficients	t-stat
Log future Investment (at t+1)	.504	4.67
Lag log sales	.029	0.21
Log Age	.397	0.94
Tech Dummy	.867	1.52
Litigation Dummy	−.112	−0.17
Ratio of Internal to total risk	−1.66	−0.52
Total risk	−.046	−1.75
Lag Secured Loans	−.001	−0.01
Lag Unsecured Loans	−.031	−2.01
Lag Current Liabilities	.19	2.07
Lag Share capital	−.29	−2.77
Lag Working Capital	−.005	−0.98
Const	1.38	0.49
R^2	0.21	

6.2 Quality Proxy: Evolution of the Risk Factors

The firm is required by law to delineate potential risk factors in the IPO prospectus. Given this requirement the firm and conditional on its decision to go public the firm may want to signal its quality through this risk factors. These can be seen as a proxy of firm quality. There are two sections of the risk factor chapter in the IPO prospectus: internal risk factor and external risk factor. The internal risk factor is about the firm, the external risk factor is about the industry and the economy as a whole. After delineating the risk factors the firm goes on explaining them in a paragraph or two. We first count the number of internal risk factors in each category and define the variable ratio of internal to total risk factors as a proxy of the relative riskiness of the firm. In the following regression we regress this variable on the past performances of the firm and it size. In table below we report results from a ordinary least square regression where the dependent variable is the ratio of the number of internal risk factors to the number of total risk factors. Internal risk factor is influenced by firm's past performances (like sales). Bad past performance would lead to more risk.

Table 6

The following table describes the determinants of internal risks as a percentage of total risk factors in the IPO prospectus chapter. The dependent variable is the ratio of the number of internal risk factors to the number of total risk factors. Sales is deflated value of the total revenue. Age is measured in number of years since inception. Total risk is the number of risk factors in the IPO prospectus. Number of Companies that were public in the same industry was used to proxy for any information revealed and riskiness of the type of the business.

Evolution of Firm Specific Risks (Internal Risk)	Co-eff	t-stat
Lag Sales	−.0004	−3.25
Log Age	−.0087	−1.39
Total Risk	.0024	6.38
Tech Dummy	−.0083	−0.60
No. of Companies that were public	.00003	0.42
Constant	.699	35.69
N (firm year)	354	
R^2	0.12	

In the following table we analyze when does the management come forward to explain the risk. Management would explain if his past performance (EBIT) cannot explain the internal risk. Management only explains if they go for IPO. Thus the explanation is only observed if the firm decides to go public. This makes the sample a self selected one. We therefore run a bivariate probit of the decision to go public as well as the decision of managerial explanation. By explaining the risk factors convincingly the management may try to signal the quality of the project. This has to be consistent with the firm's other past performances. Conditional on the fact that the firm is going IPO the management perceptions is significantly affected by the log of the ratio of internal to total risk. If there is too much risk associated with the firm the management decides not to explain its position.

Table : 7 *Bivariate Probit of Management Perception conditioning the fact that the firm is going public*

The following table describes results from a bivariate probit regression where the dependent variables are whether to go public and whether the management provides an explanation to any risk factors. EBIT is earnings before interest and tax, tach dummy takes value 1 if it is a technology company, otherwise it is zero. Litigation dummy takes value 1 if a pending litigation against the company.

Probit Decision to IPO			Probit whether there is a Management explanation		
Variables	Coeff	t-stat	Variables	Coeff	t-stat
Lag log EBIT	.0164	3.32	Litigation Dummy	$-.78$	-1.80
Age	$-.021$	-5.56	Log ratio of Internal to Totalrisk$\times$*Lagged* log EBIT	.88	2.16
Tech Dummy	.47	3.43	Age	$-.0007$	-0.03
Constant	-2.28	-30.53	Constant	$-.16$	-0.06

6.3 Costs of Going Public: Underpricing

Even after the management explains the future prospects of the firm, it still has to underprice the issue for the remaining uncertainties. Below we regress the underpricing on the proxy of for risk factors and its past performances. underpricing is thus seen as a cost associated with adverse selection. However if the management can convincingly signal firm quality via past performances and well delineated risk factors then it need not underprice much. We test this hypothesis below. The firm only underprice only when it goes public. We therefore observe a selected set of firm who chose to go public. We therefore run a Heckman selection regression (selected on the basis of going public decision) to evaluate the impact of risk factors on underpricing. As shown below management explanation reduces IPO underpricing by about 25%.

$Table:$ 10 $Heckman\ Selection\ Model: Impactof\ risk\ factors\ and\ management\ perceptionon\ underpricing$

The dependent variable is the amount of underpricing that the firms experience based on the first day closing price relative to the offer price. Management perception dummy takes value one if the management decides to explain the risk factors in the IPO prospectus. Litigation dummy takes value one if there is a litigation pending against the firm. Ratio of internal to total risk is the no of internal risk factors reported in the IPO prospectus relative to the total risk factors.

Underpricing			IPO Decision		
Variables	Coeff	t-stat	Variable	Coeff	t-stat
Management Perception Dummy	−.25	−2.04	Lag log Profit	.25	11.35
Litigation Dummy	−.36	−2.45	Log Age	−.406	−7.28
Lag log profit	.22	3.77	Tech Dummy	.408	3.13
Ratio of Internal to Total Risk	.12	0.15	Constant	−.67	−3.84
Log Age	−.45	−3.54			
Constant	−.51	−0.74			
No of Observations			15206 Firm Year		

6.4 Post IPO: The Benefits of Going Public

6.4.1 Matching Estimation

In this section we evaluate the benefits of going public on key performance variables like profitability, sales, and earnings before interest and taxes (EBIT) using propensity score matching. The matching is based on the criterion of size (log sales), age and industry classifications of the firm. Each public firm is matched with a private firm based on these criterion via propensity scores. We then evaluate the impact (benefits) of going public by comparing their key performance indicators like log earnings before interest and taxes (EBIT), sales, profitability etc. In table 9 we find that the treatment effect of going public would lead to higher EBIT on average (positive ATT). A positive difference in average treatment effect (ATT) (third column in panels B through D) measures the improve in performance of the treated group (public firms). Thus the difference between the log profits of a public and a matched private firm would be about 0.93 (as reported in table 9C). Therefore a public firm would earn about 2.5 times more profit than a private firm of similar size, age and industry. Similar impact of IPO on EBIT and log sales are 13 and 6.5 times respectively.

Table 11

The impact of IPO on performance variable earnings before interest and taxes (EBIT). Private firms are matched based on the criterion of size (log sales), age and industry classifications of the firm with a similar public firm. The matching regression is reported in panel A. The impact of IPO on Log Sales, log profit and log EBIT are reported in Panels B through D. A positive difference in average treatment effect

(ATT) (third column in panels B through D) measures the improve in performance of the treated group (public firms).

Table 11: Panel A: Propensity Score Matching of Public and Private Firms

	Coefficients	t-stat
Lag Sales	.005	5.96
Age	−.022	−6.08
Industry Dummy	.031	1.74
Constant	−2.28	−26.55

Table 11 Panel B: IPO Effect on log Sales

	Treated	Controls	Difference	t-stat
Unmatched	1.65	−1.85	3.51	12.98
ATT	1.65	−.224	1.88	6.41

Table 11 Panel C: IPO Effect on log Profit

	Treated	Controls	Difference	t-stat
Unmatched	1.65	−1.85	3.51	12.98
ATT	−.224	1.88	.293	6.42

Table 11: Panel D: IPO Effect on log EBIT

	Treated	Controls	Difference	t-stat
Unmatched	−.0192	−3.61426	3.594	12.47
ATT	−.019264	−2.6256	2.60	7.2

6.5 Structural Testing for Financing Constraints for Private and Public Firms

In this section we employ a structural testing procedure to test whether the firms were financially constrained before going public. We follow Bond Meghir ('94) in testing procedure to

- Firm manager's problem:

$$\max imize\ V_t = E\sum_{t=0}^{\infty}\beta^t D_t \tag{18}$$

subject to

- dividend paid

$$D_t = \pi_t(k_t, \xi_t) - C(I_t, k_t) - I_t$$

- depreciation of capital stock

$$k_t = (1-\delta)k_{t-1} + I_t$$

- Nonnegative dividend

$$D_t \geq 0 \tag{19}$$

where $\pi_t(k_t, \xi_t)$ is the profit function and ξ_t is the productivity shock, $C(I_t, k_t)$ is the adjustment cost of investment. The financial friction is represented by a non-negativity constraint on dividends and its associate multiplier λ_t. The constraint is associated with costly external financing due to information asymmetry.

First order condition with respect to k_t, we get the Euler equation

$$1 + \left[\frac{\partial C}{\partial I}\right]_t = \beta_t E_t[\Theta_t\{\left[\frac{\partial \pi}{\partial k}\right]_{t+1} + (1-\delta)(1 + \left[\frac{\partial C}{\partial I}\right]_{t+1})\}]$$

where $\frac{\partial C}{\partial I}$ is the marginal cost of investment, $\frac{\partial \pi}{\partial k}$ is the marginal profit of capital and $\Theta_t = \frac{1+\lambda_{t+1}}{1+\lambda_t}$ is the relative shadow price of external finance in periods t and $t+1$. The above equation characterizes the optimal choice of investment where the left hand side is the marginal cost of investment at time t and the right hand side is the marginal benefit of an extra unit of capital plus the adjustment cost of investment tomorrow. If a firm is not constrained then $\Theta_t = 1$.We parametrize $\Theta_t = a_{0i} + aCash_{it-1}$ with a_{0i} as the firm specific fixed effect[5]. If going public lowers the cost of raising external capital, then Θ_t can be represented as

$$\Theta_t = a_{0i} + (a_1 + a_2 \times IPOdum)Cash_{it-1} \tag{20}$$

[5] As in Love (03, *RFS*)

where $IPOdum$ is a dummy variable taking value 1 if the firm is private and 2 if the firm is public. Thus going public should have an decreased impact on internal funds on the stochastic discount factor Θ_t.

Following Gilchrist & Himmerberg ('98) we represent marginal product of capital $\frac{\partial \pi}{\partial k}$ as the ratio between sales (Y) and capital stock (k).

$$\frac{\partial \pi}{\partial k} = \theta_i \frac{Y}{k_{it}} \tag{21}$$

The marginal cost of investment can be represented as

$$\frac{\partial C}{\partial I_{it}} = m \left(\frac{I}{k_{it}} - g \frac{I}{k_{it-1}} \right) \tag{22}$$

Substituting the above specifications in the first order conditions, we get the empirical model,

$$\left[\frac{I}{k}\right]_{it} = \beta_1 \left[\frac{I}{k}\right]_{it+1} + \beta_2 \left[\frac{I}{k}\right]_{it-1} + \beta_3 \left[\frac{Y}{k}\right]_{it} + \beta_4 \left[\frac{CF}{k}\right]_{it-1} + \beta_5 \left[\frac{CF}{k}\right]_{it-1} \times IPOdummy + d_t + f_i + \nu_t \tag{23}$$

Under the null hypothesis that financial frictions are non zero for some companies and they decrease after the firm goes public, $\beta_4 \geq 0$ and $\beta_5 < 0$.

Testing for Financial Constraints

Variables	Coeff	t-stat
$\left(\frac{I}{k}\right)_{t+1}$	-0.031	-1.2
$\left(\frac{I}{k}\right)_{t-1}$	0.685	34.88
$\left[\frac{Y}{k}\right]_{it}$	0.057	6.21
$\left[\frac{CF}{k}\right]_{it-1}$	0.099	1.31
$\left[\frac{CF}{k}\right]_{it-1} \times ipodummy$	-0.167	-2.92
Constant	-0.003	-0.16
Sargan's Test $p-$values		0.12
No of Observations		11724
No of Firms		3097

Thus we cannot reject the hypothesis that Indian firms are financially more constrained before they went public. By going public firm do somehow reduce their financing constraints. However going public itself is costly. There are two types of costs of going public: exogenous cost associated with going through the process of going public and endogenous cost associated with trying to sell part of the company to asymmetrically informed investors. The firm has to leave some money on the table to make sure the firm is sold. This endogenous cost thus depends on the stake the entrepreneur has to hold in the public firm to signal the quality of the firm. It may also have to underprice the issue depending on what else he is trying to signal. These costs are endogenous as it depends on the past and present information that he could credibly commit to the market. The entrepreneur thus would like to time his decision to go public to balance the trade off between going public and remaining private.

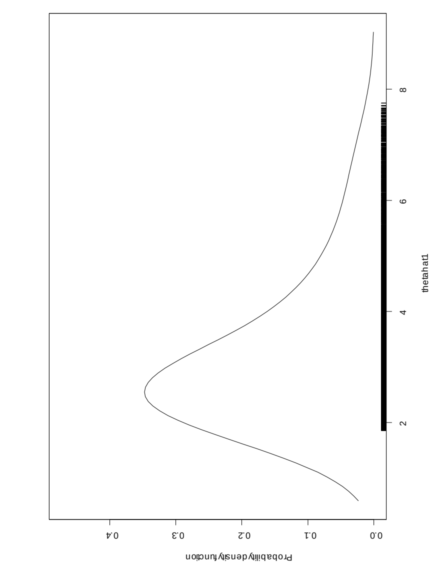
7 Structural Estimation Results

We present here the initial estimates of the structural parameters. The continuous value functions are estimated via the standard Euler equations and the discrete choice parameters are estimated using the one step Hotz Miller estimation procedures.The variable cost of going public is estimated at about 8% of the gross proceeds of the IPO, and the fixed cost of going public is about 1.25 million Indian rupees.

Table : 13 : *Structural Parameters*

Decision to IPO: Structural Parameters	Coefficients
Investment: Adjustment Cost Parameter: η_0	2.85
Investment: Adjustment Cost Parameter: η_1	4.85
Investment: Adjustment Cost Parameter: η_2	0.002
Returns To Scale: γ	0.93
Going Public : Variable Cost: h	0.08
Going Public : Fixed Cost: Φ	12.5

The distribution of the quality parameter is given below. As can be seen from the second graph that the distribution is positively skewed and different from a normal distribution. The red line is the distribution of theta and the dotted line is the corresponding normal density with the same mean and variance. The shaded region is the bootstrap confidence interval.


Probability density function
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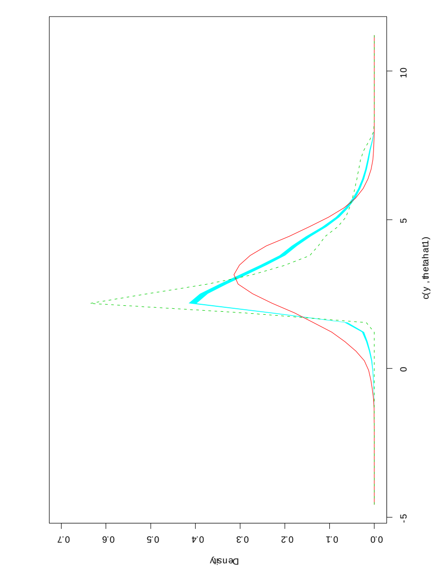
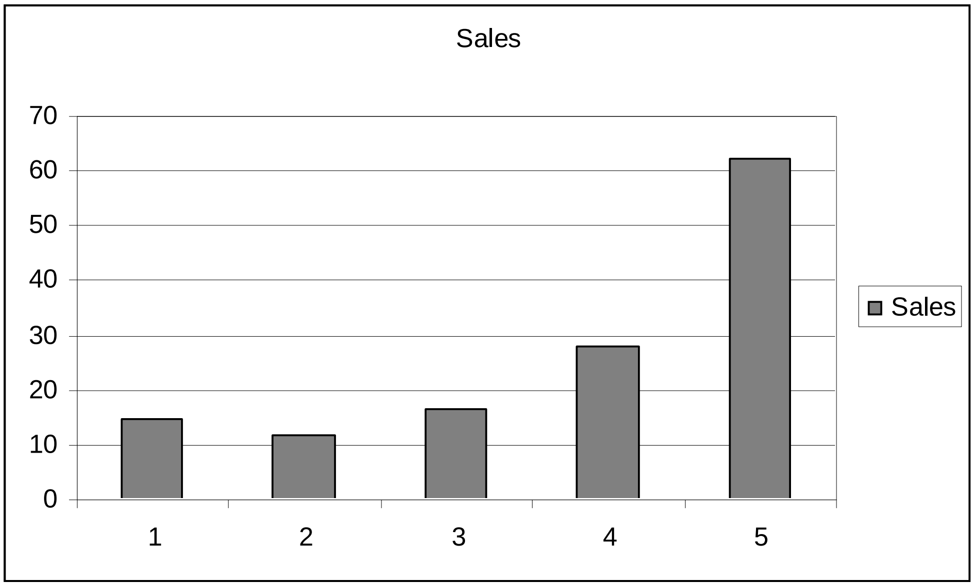
0.1
0.2
0.3
0.4
2
4
6
8


Density
c(y, thetahat1)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
-5
0
5
10

Distribution of θ	
Minimum	1.96
First Quantile	2.25
Mean	3.19
Median	2.74
3rd Quantile	3.64
Max	7.67

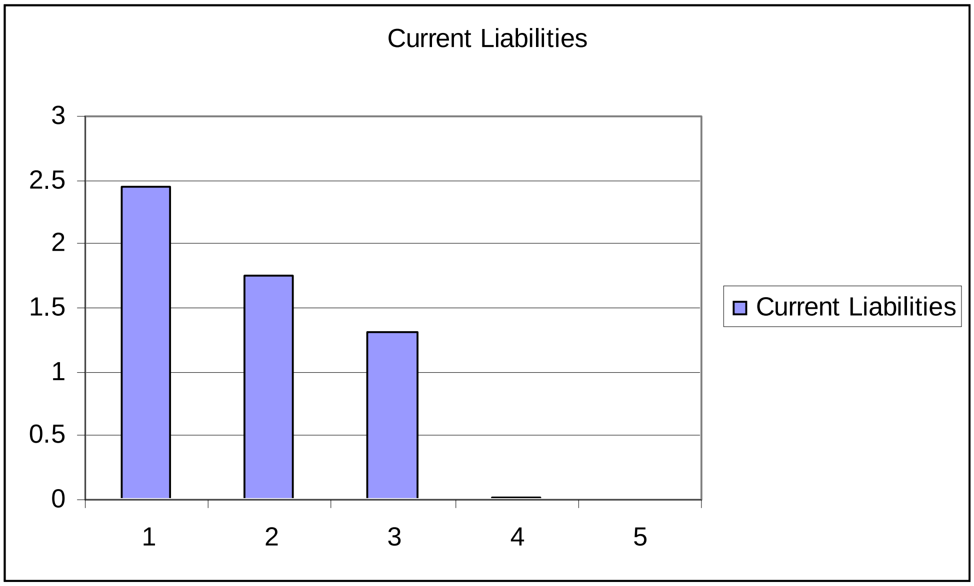
8 Conclusion

In this paper we have formulated and estimated a dynamic structural model of going public decision. Going public is an important milestone in a firm's decision with significant costs and benefits. The model and estimation methodology developed in this paper has wider applicability. In this paper we have estimated the hidden structural parameters using data from Indian IPOs. The variable cost of going public is estimated at about 8% of the gross proceeds of the IPO, and the fixed cost of going public is about 1.25 million Indian rupees. We also nonparametrically identify and estimate the distribution of the privately observed quality of the firm. Reduced form evidence also supports the structural model. The risk factors as outlined in the IPO prospectuses are significant determinants of IPO underpricing, dilution and the decision to go public. The average treatment effect of going public on profitability, sales etc. controlling for the selection bias of going public is significantly positive, thus it may be the significant going public costs which deters many firms to go public. The reduced form evidence is also significant controlling for various other robustness checks like selection bias of going public decision, endogeneity of dilution and underpricing choice etc. The paper is being extended in various directions from its present preliminary form. For example right now the IPO decision is modelled as an optimal stopping time problem where going public is an absorbing state, i.e, once a firm becomes public it remains public forever. We are extending it towards defining the IPO decision as part of a broad discrete decision where a firm changes its status. The potential change of status could be going private, merge, reverse IPO etc.



9 Appendix

9.0.1 Impact of IPO: average sales, investment other relevant variables around IPO year (=3 in the graphs)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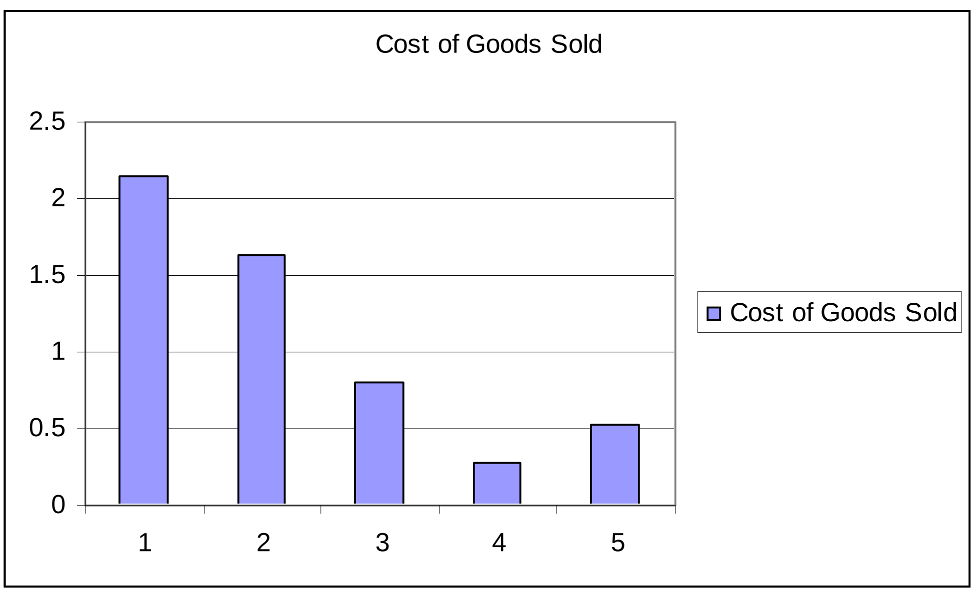
2
1.5
1
0.5
0
1
2
3
4
5
Current Liabilities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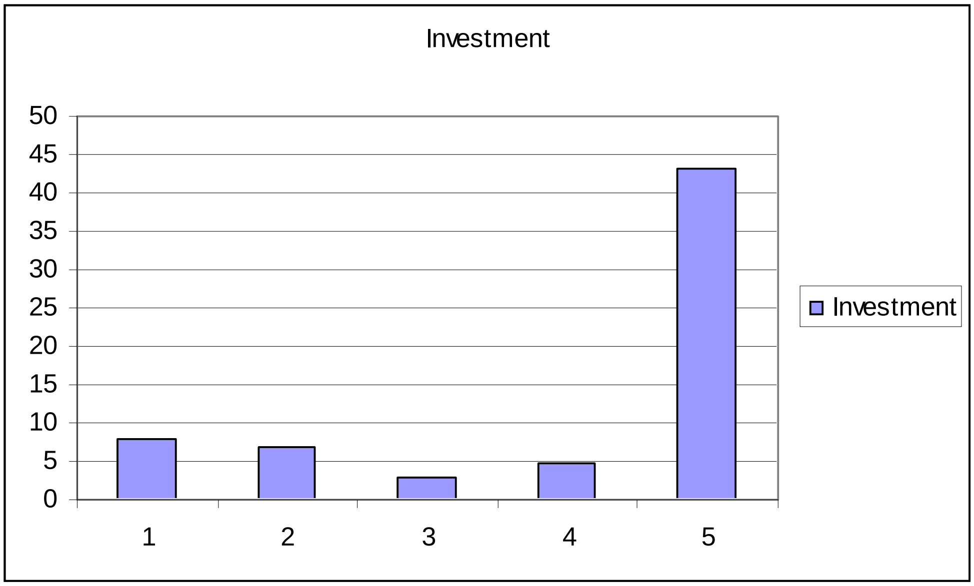
0.5
0
1
2
3
4
5
Cost of Goods Sold


Investment
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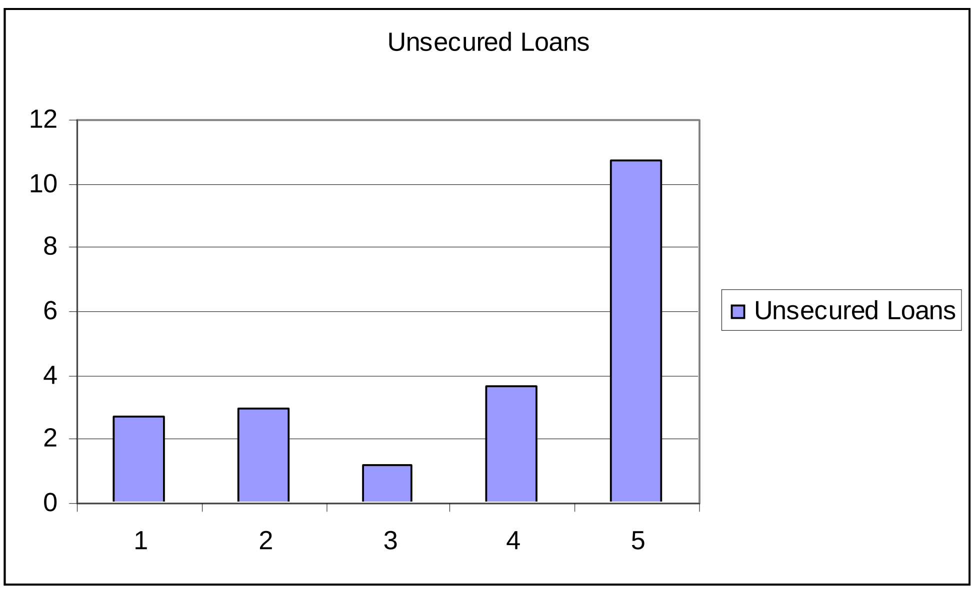
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Investment


Unsecured Loans
12
10
8
6
4
2
0
1
2
3
4
5
Unsecured Loans

Proof. Proof of Lemma 1:Let the Kuhn Tucker multiplier associated with the non-negative A' be given by λ_A ■

The first order conditions associated with A' be

$$\frac{u'(c)}{u'(c')} = \beta(1+R) + \lambda_A \tag{24}$$

The first order conditions associated with k' be

$$u'(.)[\alpha\{-g_I(.) - 1_i\} + \beta ES_{k'}] = 0$$

Equivalently

$$u'(.)\alpha\{g_I(.) + \frac{\partial R_B}{\partial k'} + 1\} = \beta ES_{k'}$$

By Envelop condition

$$ES_{k'} = u'(c')\alpha\{F_k - [g_k + g_I(1-\delta)] - \frac{\partial R()}{\partial k'} - \frac{\partial T()}{\partial k} - (1-\delta)\}$$

Hence the first order conditions associated with k' leads to the following Euler condition

$$u'(c)[\alpha\{-g_I(.) - 1\}] = \beta u'(c')\alpha\{F_k - [g_k + g_I(1-\delta)] - \frac{\partial R()}{\partial k'} - \frac{\partial T()}{\partial k} - (1-\delta)\} \tag{25}$$

Using 24 above we can write

$$\{\beta(1+R) + \lambda_A\}[\alpha\{g_I(.) + \frac{\partial R_B}{\partial k'} + 1\}] = \beta\alpha\{F_k - [g_k + g_I(1-\delta)] - \frac{\partial R()}{\partial k'} - \frac{\partial T()}{\partial k} - (1-\delta)\}$$

$$(1 + R + \frac{\lambda_A}{\beta})[g_I(.) + 1] = \{F_k - [g_k + g_I(1-\delta)] - \frac{\partial R()}{\partial k'} - \frac{\partial T()}{\partial k} - (1-\delta)\} \tag{26}$$

$$(1+R+\frac{\lambda_A}{\beta})[\eta_1+2\times\eta_2\times I+1] = \{\theta z\gamma k'^{\gamma-1} - [\eta_0+(\eta_1+2\times\eta_2\times I)(1-\delta)] - \frac{\partial R(k',z',B')}{\partial k'} - \frac{\partial T(k',B')}{\partial k'} - (1-\delta)\} \tag{27}$$

Hence Proof.

Lemma 7 *(dilution choice) The dilution choice of the firm is characterized by the following equation*

$$(1+R)[(1-h)*P(.) + (1-h)(1-\alpha)\frac{\partial P}{\partial \alpha}] = \beta h[F(k,.) - g(k,k') - R_B B + B' - I] \tag{28}$$

Proof. Let us consider the problem of the firm when it uses the amount of dilution as a signal for firm quality only. The value of the firm after public is given by $S(x)$. The choice problem for the dilution looks like

$$\max_{\alpha}\{u(c)+\beta\int S(x';\alpha)dF(x'|x)\}$$

■

subject to

$$c \leq [F(k,\theta,z)-T(k,B,z,z')-g(k,I)-(1+R_{B_t}(k',B,z))B'-I]+A(1+R)-A'+(1-h)(1-\alpha)P(.)-\Phi \tag{29}$$

where the ipo proceeds $P(.)$ can be modelled as a reduced form

$$P(.)=a+b_1\times\alpha+b_2\times\alpha\times\theta+b_3\times\alpha\times\theta\times Z \tag{30}$$

where Z is a vector of observable firm characteristics like past sales, risk factors etc.

Hence

$$\frac{\partial P(.)}{\partial\alpha}=b_1+b_2\times\theta+b_3\times\theta\times Z$$

substituting the constraint into the problem we get

$$\max_{\alpha}\{u([F(k,\theta,z)-T(k,B,z,z')-g(k,I)-(1+R_{B_t}(k',B,z))B'-I]+A(1+R)-A'+(1-h)(1-\alpha)P(.)-\Phi)+\beta\int S(x';\alpha)dF($$

Differentiating w.r.t. α we get,

$$u'(c)\frac{\partial u(.)}{\partial\alpha}+\beta\int S_{\alpha}(x';\alpha)dF(x'|x)\}=0$$

Equivalently,

$$u'(c)[-(1-h)\times P(.)+(1-h)(1-\alpha)\frac{\partial P}{\partial\alpha}]+\beta\int S_{\alpha}(x';\alpha)dF(x'|x)\}=0$$

where $\frac{\partial u(.)}{\partial\alpha}=-(1-h)*P(.)$ and $ES_{\alpha}=\int\frac{\partial S(.)}{\partial\alpha}dF(x'|x)=\beta dEu'(c_{t+1}|x)$ by Envelop theorem

Equivalently,

$$u'(c_t)[-(1-h)*P(.)+(1-h)(1-\alpha)\frac{\partial P}{\partial\alpha}]+\beta hEu'(c_{t+1}|x)=0$$

which gives the following condition

$$u'(c_t|x)[(1-h)*P(.)+(1-h)(1-\alpha)\frac{\partial P}{\partial \alpha}] = \beta h[F(k,\theta,z)-T(k,B,z,z')-g(k,I)-(1+R_{B_t}(k',B,z))B'-I]Eu'(c_{t+1}|x) \quad (31)$$

Equivalently,

$$(1+R)[(1-h)*P(.)+(1-h)(1-\alpha)\frac{\partial P}{\partial \alpha}] = \beta h[F(k,\theta,z)-T(k,B,z,z')-g(k,I)-(1+R_{B_t}(k',B,z))B'-I] \quad (32)$$

Hence Proof.

9.1 Estimation Details

The estimation proceeds in the following steps:

Step 1: Estimate the conditional distribution of $R(k,B,z)$ semi parametrically. We estimate $\widehat{R}(k,B,z)$ semiparametrically using the local linear regression.

Step 2: Given initial guess of $\eta = (\eta_0, \eta_1, \eta_2, \gamma, h, b_1, b_2)$, estimate the distribution of θ using

$$\theta = \frac{M_1 + \alpha \times M_2}{\alpha z \gamma k^{\gamma-1}}$$

where $M_1 = (1+R)[\alpha\{\eta_1 + 2 \times \eta_2 \times \frac{I}{k} + 1\}]$, $M_2 = [\eta_0 - \eta_2 \times \left(\frac{I}{k}\right)^2] + \left(\eta_1 + 2 \times \eta_2 \times \frac{I}{k}\right)(1-\delta) - \frac{\partial T()}{\partial k} - (1-\delta)$

Step 3: Solve for the parameters $\eta = (\eta_0, \eta_1, \eta_2, \gamma, h, b_1, b_2)$ using GMM $\eta = \arg\min_\eta g_n(\eta)'Wg(\eta)$ where $g(\eta) = \frac{1}{n}\sum g(z, \widehat{R}, ; \eta)$

Step 4: Given these parameters estimate the fixed cost of going public by forming the likelihood of going public and matching this with the observed decision to go public.

Plug in the estimated continuation values in 1 to estimate the associated parameters with the discrete choice. Note that the assumption of logistic distribution would lead to a closed form solution of the choice probabilities of whether to go public or not which would be matched with the nonparametric estimates of observed choices probabilities to estimate the discrete choice parameters mainly the parameters associated with the costs of going public. To be specific note that given the assumption of logistic distribution of ϵ_a, we have

$$P_a(x,z) = \Pr(a|x,z,\theta) = \frac{\exp(\widetilde{z}_a(x,z,P)\frac{\theta}{\sigma_\epsilon} + \widetilde{e_a}(x,z,a,P)}{\sum_{j=0}^{1}\exp(\widetilde{z_j}(x,z,P)\frac{\theta}{\sigma_\epsilon} + \widetilde{e_j}(x,z,a,P)} \quad (33)$$

where

$$\widetilde{z}_a(x,z,P) = z_a(x,z) + \beta \sum_{x',z'} f(x',z'|x,z) W_z(x',z';P) \tag{34}$$

and

$$\widetilde{e}(x,z,a) = \beta \sum_{x',z'} f(x',z'|x,z) W_e(x',z';P) \tag{35}$$

and

$$W_z(x',z';P) = [I - \beta \sum_{j=0}^{1} P_a \times F_a]^{-1} \times [\sum_{j=0}^{1} P_a \times Z_a] \tag{36}$$

and

$$W_e(x',z';P) = [I - \beta \sum_{j=0}^{1} P_a \times F_a]^{-1} \times [\sum_{j=0}^{1} P_a \times \{\lambda - \ln(P(a=j|x,z)\}] \tag{37}$$

and Z_a is a matrix of dimension $(M \times N)$ with $\mathrm{z}_a(x, z^m)$ at the m^{th} row.

Note that W_z and W_e can be consistently estimated from the data without going through iterating the value function. Hence the right hand side of the conditional choice probability 33 can be estimated. The Hotz Miller estimation procedure would involve a GMM procedure to minimize the observed choice and the estimated choice probability given by the above conditional choice probabilities in equation 33 with a suitable set of instruments $H(.)$.

$$\sum_{i=1}^{n} \sum_{t=1}^{T} H(x, z_{it}) \begin{bmatrix} I\{a_{it} = 0\} - \frac{\exp(v(x,z;a=0))}{\sum_{j=0}^{1} v(x,z;a_j)} \\ I\{a_{it} = 1\} - \frac{\exp(v(x,z;a=1))}{\sum_{j=0}^{1} v(x,z;a_j)} \end{bmatrix} = 0 \tag{38}$$

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