The Dynamics of Going Public

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Abstract

This paper develops a signaling game in which the decision to raise public equity is a real option of the firm. Firms may use multiple signals to reveal their type: the timing of the IPO, the fraction of shares issued and the underpricing of shares. The model predicts that IPO activity, underpricing, the fraction of shares issued and the pool of issuing firms depend on macroeconomic conditions. In periods where adverse selection is more relevant (*cold markets*), there is low IPO volume, firms with better investment prospects accelerate their IPO, issue a lower fraction of shares and underprice more their shares with respect to worse firms to avoid imitation. In periods where adverse selection is less relevant (*hot markets*), all types of firms issue simultaneously and there is high IPO volume, IPO initial returns are more volatile, and firms on average are younger and issue a lower fraction of shares. The paper provides supporting empirical evidence that firms go public younger during hot markets, and that better ranked firms issue earlier and underprice more than other issuers during cold markets.

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1 Introduction

The market for initial public offerings (IPOs) shows dramatic swings in activity that are often referred to as *hot* and *cold markets*, with hot markets defined as those periods with high IPO activity on average.[1] The existing models on IPO activity provide several reasons for these cycles. Pastor and Veronesi (2003) suggest that IPO waves are caused by declines in expected market return, increases in expected aggregate profitability, or increases in prior uncertainty about the average future profitability of IPOs. Ljungqvist, Nanda and Singh (2006) relate intense IPO activity to periods of high investor optimism. These papers, however, implicitly assume that the pool of issuers does not change with IPO activity.[2] Several pieces of evidence in the IPO literature suggest that the pool of issuers does change with macroeconomic conditions. Helwege and Liang (2004) find that issuers in hot markets have higher market to book ratios, are smaller, and have lower earnings, and that these differences are no longer significant once controlling for macroeconomic conditions.[3] Lowry, Officer and Schwert (2008) find that IPO initial returns are more volatile during hot markets. Loughran and Ritter (2004) and Giudici and Rosemboom (2004) find younger issuers in the hot IPO markets of the late 1990s.[4]

This paper provides an alternative framework that endogeneizes IPO activity to explain hot and cold markets, and explains why the pool of issuers changes with macroeconomic conditions. The model observes that the decision to go public is a real option, and assumes that issuers are better informed than outside investors about their future investment

[1] See Ibbotson and Jaffe (1975) and Ritter (1984). Lowry and Schwert (2002) also relate hot markets to periods of high (short-term) underpricing.

[2] Yung et al (2008) do not model IPO timing, but do observe that adverse selection varies with IPO activity. I comment on this paper later on.

[3] See Table 3 in Helwege and Liang (2004).

[4] The sample in Loughran and Ritter (2004) shows this for US firms, while the paper by Giudici and Rosemboom (2004) focuses on European issuers.

prospects. Because of these informational asymmetries, whenever macroeconomic conditions affect the distribution of investment projects significantly, the number of issuing firms and the pool of issuers that decide to go public also change. The paper reconciles existing empirical facts on hot and cold IPO markets, and provides supporting empirical evidence on additional testable implications. The paper contributes to the financial economics literature in two main dimensions. The first contribution strictly relates to the understanding of hot and cold markets in IPOs. The paper provides a rational approach to understand market timing and underpricing. The second relates more broadly to the impact of asymmetric information on option exercise strategies in real options frameworks.

The model considers two different types of private firms going public, one type having more productive investment opportunities than the other. Firms are subject to uncertainty in their cash flows and are better informed of their future investment prospects than outside investors. Each firm has the real option to go public and raise public equity to finance its growth opportunities. Firms may convey information about the quality of their investment prospects through the timing of the IPO, the fraction of shares issued and the underpricing of shares. The model predicts two mutually exclusive types of equilibria with either intense IPO activity and IPO clustering (*hot markets*), or lower IPO activity and sequential entry (*cold markets*). When firms with good investment prospects are relatively scarce, their cost of revealing firm type to market players is relatively low, and therefore they optimally reveal their type to outside investors, by issuing a lower fraction of shares, underpricing and going public earlier than firms with worse investment prospects. IPO strategies are informative and firms enter the market sequentially. Conversely, when firms with bad investment prospects are relatively scarce, the average market valuation of uninformed investors is closer to the value of those firms with better prospects, there is no signaling, and all firms cluster at the optimal IPO timing of those firms with better prospects. IPO strategies are not informative and there is high IPO activity.

The model therefore incorporates IPO timing as an additional signal to the papers by Welch (1989), Grinblatt and Hwang (1989) and Allen and Faulhaber (1989), which consider underpricing and the fraction of shares issued as the only signals in IPOs. In line with this literature, the model predicts that firms with better investment prospects underprice more and issue a lower fraction of shares to reveal their type. By incorporating IPO timing, however, the real options approach contributes to the IPO literature as it predicts that both IPO activity and the pool of issuing firms are also affected by information asymmetries. When timing is also a signal, firms with better investment prospects reveal their type by going public earlier.

Notably, the framework predicts that it is only in booms when worse issuers are scarce that all types go public simultaneously, resulting in more volatile IPO stock returns and eventually lower quality of stocks on average.[5] This stands as a major difference from static signaling models that cannot explain the empirical evidence that IPO stocks may perform badly during hot markets.[6] Yung et al (2008) also predict the procyclical dispersion in IPO stock return quality with an alternative model of adverse selection. This paper complements Yung et al (2008) as it elaborates on IPO strategies, endogeneizes IPO activity, and characterizes the differences in issuers' characteristics in hot and cold markets.

The alternative real options framework then reconciles the motivational empirical evidence on hot markets. The paper rationalizes the results in Helwege and Liang (2004) as it demonstrates that the pool of issuing firms changes with macroeconomic conditions. In (good) periods where the firms with worse investment prospects are relatively scarce,

[5] In the model, the average quality of stocks during hot markets equals that of the underlying distribution of types. During cold markets, however, this average is higher if bad types are still private.

[6] This is a standard criticism to static IPO models of adverse selection. See Helwege and Liang (2004).

the model predicts simultaneously more IPO activity and more dispersion in the quality of issuers. This explains why Lowry, Officer and Schwert (2008) find more volatile initial IPO returns during hot markets. Furthermore, since hot markets occur precisely when adverse selection is relatively low, the implied benefit of issuing earlier in hot markets for worse firms (i.e. a higher stock price) is larger in magnitude than the corresponding cost of issuing later for better issuers (i.e. a lower stock price). This results in younger firms going public in periods of high IPO activity as in Giudici and Rosemboom (2004) and Loughran and Ritter (2004).[7]

The model provides additional implications which are also documented empirically. The empirical section provides supporting evidence on three main testable implications using a working sample of US non-financial IPOs between 1980 and 2007. The tests follow Helwege and Liang (2004) and define IPO markets conditional on IPO activity. The first implication is that the age of issuing firms is a relevant feature in IPO strategies, and that IPO timing determines the observed sample of issuers in hot and cold markets. As a corollary, the paper also provides a closed form solution for the probability of doing an IPO as a function of adverse selection and firm characteristics.[8] The working sample statistics show that firms in hot markets are significantly younger, and (therefore) have higher market to book ratios, and a larger fraction of capital expenditures and intangibles to fixed assets. Chemmanur, He and Nandy (2007) also show that the probability of going public depends both on asymmetric information and the underlying characteristics of issuers before the IPO.[9]

The paper also predicts significant differences in average issuers' characteristics between cold and hot markets. The model observes that firms go public earlier and issue a lower

[7] See also the evidence in Section 3.

[8] See Appendix.

[9] In their paper, the capital intensity and the cash flow riskiness of private firms significantly their likelihood to go public. Private firms that face less information asymmetries are more likely to go public.

fraction of shares on average during hot markets. There is also a positive probability of buying a *lemon* in hot markets. The paper tests a bivariate model of the probability of issuing in either hot or cold markets as a function of firms' IPO strategies and additional controls. The paper proposes the Standard and Poors' (S&P) common stock rating obtained by issuers in the next two years as a proxy for the underlying quality of their investment projects.[10] Results confirm that issuers in hot markets are younger, issue a lower fraction of shares, and obtain worse common stock rankings in the next two years after the IPO. Results also support Lowry and Schwert (2002) and show that issuers underprice more during hot markets.[11]

Finally, the paper predicts that IPO strategies are mechanically related to the underlying quality of the firms' growth options during cold markets. In periods of low IPO activity, issuers with better investment prospects go public earlier, issue a lower fraction of shares and underprice more to convey information to outside investors. The paper tests the probability of obtaining a high S&P common stock score in the next two years after the IPO as a function of IPO strategies during cold markets. Results show that better ranked firms after the IPO underprice more their shares at the offering. This is supporting empirical evidence to Ibbotson (1975) and the signaling IPO literature on underpricing.[12] Results also show that better ranked firms go public earlier during cold markets. This supports empirically the real options prediction that signaling erodes the option value of waiting to go public during cold markets.

The predictions of the multiple signaling, real options framework of the decision to go public also contribute more broadly to the real options literature on option exercise strategies and asymmetric information. This is the second main contribution of the pa-

[10] See Section 3 for details on the S&P ranking.
[11] This paper does not yield predictions on the relative magnitudes of underpricing in hot and cold markets.
[12] It also complements Michaely and Shaw (1994) who find little support for signaling models of IPOs.

per. Grenadier (1999) notes that firms' optimal timing decisions depend on unobservable firm characteristics, and hence option exercise strategies provide valuable information to uninformed investors. Carlson, Fisher and Giammarino (2006a) predict announcement effects when firms exercise their option to do a seasoned equity offering (SEO) and outside investors update their beliefs. These papers assume, however, that option exercise strategies are always informative to outside investors.[13] This paper shows how option exercise strategies and announcement effects may depend on firms' incentives to reveal their type.

The mechanics of the model can then be restated more generally as a signaling game of investment decisions. When firms have incentives to reveal their type (*separating equilibrium*), firms with better investment prospects invest earlier than their perfect information benchmark to make imitation more costly. Asymmetric information therefore erodes the option value of waiting to invest for firms with better prospects, who accelerate their investments relative to their perfect information strategies. When firms do not have incentives to reveal their type (*pooling equilibrium*), all firms invest simultaneously at the threshold of those firms with better prospects. In pooling equilibria, firms with better prospects optimally invest later than under perfect information, since their gains upon exercise are (now) lower.

The paper then elaborates on the interaction between option exercise strategies and announcement effects. The paper defines mispricing as the difference between the actual value of the firm upon option exercise and its prior expected value in the market. In separating equilibria, announcement effects are self-fulfilling and firms underprice their shares such there is no mispricing. In pooling equilibria, option exercise strategies are not informative and there is mispricing. These implications differ from those in Carlson, Fisher and Giammarino (2006a, 2006b), Morellec and Zdhanov (2005) and Hackbarth and Morel-

[13] See also Lambrecht and Perraudin (2003).

lec (2008). This literature assumes that option exercise strategies are always informative, solves for optimal timing as if firms were under perfect information, and defines announcement effects upon exercise as this paper defines mispricing. This paper shows that the informative option strategies under asymmetric information are different from those under perfect information, highlights that timing and announcement effects interact, and predicts mispricing only when firms' strategies are not informative.

The related literature to this paper also includes other models of rational timing of corporate decisions. Lucas and McDonald (1990) and Grenadier and Wang (2005) consider alternative screening models where better firms always have incentives to delay their decisions. The separating equilibrium in this paper predicts the opposite since in signaling games it is better types (and not worse types) who bear the cost of asymmetric information. Alti (2005) develops a model of IPO market timing that explains the clustering of IPOs in hot markets due to information spillovers. This paper predicts IPO clustering only when firms with worse investment projects are relatively scarce. Benninga et al (2005) consider a single firm and explain optimal IPO timing due to the trade-off faced between private benefits of control and diversification. This paper abstracts from agency conflicts and explains how the pool of issuers varies with information asymmetries. The recent works by Morellec and Schurhoff (2009) and Malenko and Grenadier (2009) apply the signaling approach in this paper to explain other corporate decisions.

The paper is organized as follows. Section 2 describes the IPO model and its main results. Section 3 tests the model empirically. Section 4 concludes. All proofs are provided in the Appendix.

2 The IPO model

2.1 Main assumptions

Consider a private firm with both assets in place and a growth option to invest. The firm is all equity financed and it is run by a manager who is the single shareholder. Assets in place generate a continuous stream of cash flows $(X_t)_{t\geq 0}$ governed by the diffusion

$$dX_t = \mu X_t dt + \sigma X_t dZ_t, \quad X_0 > 0 \tag{1}$$

where W_t is a standard Brownian motion under drift μ and volatility σ.

The firm has a growth option to invest which enables the manager to expand firm size and update cash flows by a factor $\theta > 1$. The firm increases capacity at a cost of investment I. There are two different types of firms $j = L, H$ according to the quality of their growth options, such that $\theta_L < \theta_H$. While managers know the true value of their growth options, market players only know that high types occur with probability p and low types occur with probability $(1 - p)$. This implies that there is asymmetric information between managers and market players.

The option to invest can be funded by either private or public capital. Without loss of generality, the decision to raise public equity and the decision to invest are assumed to be made simultaneously at the IPO. The manager of firm j can decide to stay private and fund investment with internal funds. Alternatively, he can decide to go public and fund investment with both internal funds from old shareholders and public capital for new shareholders. If firms decide to invest using public equity, the manager sells a percentage share α_j of firm j at the public offering.[14]

[14] Note that the firm does not have cash holdings by assumption. The firm uses a residual dividend policy whereby all cash flows are distributed to shareholders.

The optimal mechanism to fund investment depends on the relative costs of private and public capital. Private capital is more costly than public capital as long as it pays a prime $\lambda > 0$ per unit invested. Public capital is subject to both underwriting fees and underpricing costs at the time of the public offering. Underwriting fees are composed of a fixed cost f and a variable cost which depends on the value of the shares sold by firm j at the offering. Underwriting fees are given by

$$F_j = [c\alpha_j - f]^\gamma \tag{2}$$

Marginal underwriting fees are an increasing function of α_j so that γ is even and larger than 1. Fixed costs f initially cause scale economies, but as issue size increases diseconomies of scale emerge in the spread due to rising placement costs. The functional for the flotation costs of public equity is therefore in line with the empirical evidence on convex flotation costs by Altinkiliç and Hansen (2000) and Hennessy and Whited (2007).[15]

Underpricing costs at the offering U_j result from the asymmetric information between the manager and market players. Underpricing arises if managers optimally choose to sell their shares at a discount $\epsilon_j \leq 1$ to convey information to market players (Grinblatt and Hwang, 1989). The shares sold by firm j can also be mispriced at the public offering due to the inability of market players to infer firm type out of the signals provided by the manager.

The problem of firm j under perfect or asymmetric information therefore consists of two stages. First, the manager determines the optimal investment strategy conditional on the firm staying private or going public. Second, the manager determines whether the firm should fund the investment privately or publicly by comparing firm value in each

[15] Hennessy and Whited (2007) observe both direct and indirect costs of equity issuance in their structural estimation. In this paper, underwriting fees capture direct costs, while the mechanics of the model capture indirect costs related to asymmetric information.

case. The subsections below derive the optimal strategy to go public both under perfect and asymmetric information. The value of the option to remain private determines the reservation value of firms to go public, and it relates to the individual rationality constraints (IR) of the IPO game described below.

2.2 Benchmark under perfect information

Consider first the manager's problem under perfect information when firms go public. The manager maximizes firm value V_j by choosing the optimal cashflow threshold x_j at which the firm does the IPO, the optimal fraction of shares sold α_j at the offering, and the optimal discount ϵ_j offered on the share price. Using the standard real options approach, the problem of the manager of firm j is given by

$$rV_j = \mu X \frac{\partial V_j}{\partial X} + \frac{\sigma^2}{2} X^2 \frac{\partial^2 V_j}{\partial X^2} + X \tag{3}$$

subject to the boundary conditions

$$V_j|_{X_t=x_j^*} = [1 - \alpha_j + \alpha_j \epsilon_j] \frac{\theta_j}{\delta} x_j - I - F_j \tag{4}$$

$$\left.\frac{\partial V_j}{\partial X}\right|_{X_t=x_j^*} = [1 - \alpha_j + \alpha_j \epsilon_j] \frac{\theta_j}{\delta} \tag{5}$$

where δ stands as the difference between the drift μ of the cashflow process and a constant risk-free interest rate r.

The ordinary differential equation (3) imposes an equality between the required rate of return of the firm and the expected return on the option to go public and the assets in place of the firm. The value matching condition in equation (4) imposes an equality between the value of the firm before going public and the pay-off of the option to do the IPO. Thus, the value of firm on shelf equals, at the time of the public offering, the surplus that the manager extracts from the IPO net of underwriting fees and investment costs. The smooth pasting condition in equation (5) ensures that the option to IPO is exercised along the optimal path by requiring continuity of the slopes at the trigger threshold.

The manager also chooses the percentage amount of shares that maximizes V_j. The optimality condition on α_j at the cash flow threshold x_j^* is given by

$$\left.\frac{\partial V_j}{\partial \alpha_j}\right|_{X_t=x_j^*} = -\left[1-\epsilon_j\right]\frac{\theta_j}{\delta}x_j - c\gamma\left[c\alpha_j - f\right]^{\gamma-1}$$

Finally, managers have no incentives to underprice their shares under perfect information. Underpricing costs are equal to zero and $\epsilon_j^* = 1$.

Proposition 1 *The optimal strategy to perform an IPO under perfect information $S_j^* = \{x_j^*; \alpha_j^*; 1\}$ is such that*

$$x_j^* = \left[\frac{I}{\theta_j - 1}\right]\left(\frac{v\delta}{v-1}\right) \tag{6}$$

$$\alpha_j^* = \frac{f}{c} \tag{7}$$

where $\epsilon_j^* = 1$ and firm value under perfect information is given by

$$V_j^*\left(X_t; S_j^*\right) = \frac{X_t}{\delta} + \left(\frac{\theta_j - 1}{\delta}x_j^* - I\right)\left(\frac{X_t}{x_j^*}\right)^v \tag{8}$$

where $v > 1$ denotes the positive root of the firm's ordinary differential equation (3).

The optimal timing to do the IPO in (6) is a function of firm characteristics: all else equal, firms with better investment projects go public earlier. The threshold x_j^* also increases with investment costs, suggesting that the optimal IPO timing increases with the scale of investment projects. Equation (7) reflects that the fraction of shares of a firm of type j demanded by outside investors does not depend on firm type under perfect information. No firm underprices under perfect information. Panel A in Table 1 illustrates quantitatively the dependence of optimal IPO strategies on firm type.

2.3 Equilibria under asymmetric information

Consider now the case where managers have private information about their type of growth options and fund their investment using public capital. The strategy derived in Proposition 1 under perfect information does not necessarily hold in equilibrium, since low types may find it profitable to mimic the strategy of high types.

The IPO game is thus a signaling game with multiple signals and three players: outside investors (the market) with no private information, and two firms of different types. The decisions of the game are the IPO strategies followed by each firm. The transfers from outside investors to issuers are the proceeds obtained at the IPO. The equilibrium strategy of issuers is to maximize firm value given the strategy of the other issuers and the beliefs by market players.

The necessary requirement such that there is a non-trivial signaling game is that low types have incentives to imitate high types. I therefore assume throughout the paper that the option to go public for low types is always more valuable when imitating good types, namely

$$\left.\widetilde{V}_L\left(X_t; S_H^*\right)\right|_{X_t=x_H^*} > \left.V_L^*\left(X_t; S_L^*\right)\right|_{X_t=x_H^*} \tag{9}$$

where $\widetilde{V}_j$ indicates deviation.

2.3.1 Separating Equilibria

Separating equilibria are such that outside investors infer firm types through IPO strategies and that there is no mispricing in equilibrium. In the current framework, there are multiple separating equilibria since firms have multiple signals to convey information to market players. This section focuses on the least cost separating equilibria of the IPO game in which all firms maximize firm value conditional on revealing their type to outside investors.

A necessary requirement for the existence of a separating equilibrium is that the value function of firms complies with single crossing conditions. The single crossing conditions in the IPO game reflect the impact of signaling on firm value according to firm type. I derive single crossing conditions for the whole IPO strategy $\{x_j; \alpha_j; \epsilon_j\}$ in the Appendix. The derivation applies the work by Cho and Sobel (1990) on single crossing for multiple signals to real options games, and ensures that the marginal effect on firm value of each signal in isolation is either monotone increasing or decreasing in firm type.[16] First, the cost of accelerating the decision to go public is strictly lower for high types. Second, better firms find it more costly to issue public capital; the value of their stake being sold in the market is higher than that of lower types. Since ϵ_j enters linearly in the value function of firm j and does not depend on type explicitly, the single crossing conditions are those on x_j and α_j only. When firms separate in equilibrium, the model predicts that $\epsilon_j < 1$ reflects the shadow cost of signaling for high types.

The separating equilibrium strategies also comply both with individual rationality (IR) and incentive compatibility constraints (ICC). Individual rationality (IR) constraints ensure that agents participate in the principal's mechanism, and reflect the reservation value of the agent if he does not participate in the game. The reservation value of firms in the IPO

[16] This implies, for instance, that a more restricted game of IPO timing only would also predict that better firms go public earlier to reveal their type.

game is given by the option to stay private and fund investment with internal funds. The IR constraints of the IPO game are given by

$$V_j^a\left(X_t; S_j^a\right)\big|_{X_t=x_H} \leq V_j\left(X_t; S_j\right)\big|_{X_t=x_H} \tag{10}$$

where V_j^a is the value of firm j if private, S_j^a is the strategy of private firms and S_j is the strategy of firm j when it goes public and reveals its type in equilibrium. I show in the Appendix that condition (10) for low types provides a lower bound on the prime on private capital $\underline{\lambda}$ such that all firms have incentives to raise public equity if $\lambda > \underline{\lambda}$.[17] I assume throughout the paper that the prime on private capital λ is large enough (i.e. $\lambda > \underline{\lambda}$) such that all firms have incentives to go public.

Incentive compatibility constraints (ICC) require that the manager of firm j has no incentives to imitate other types. The ICCs of the IPO game are then given by

$$\widetilde{V}_j\left(X_t; S_{-j}\right)\Big|_{X_t=x_H} \leq V_j^*\left(X_t; S_j^*\right)\big|_{X_t=x_H}$$

such that the value of firm j under its perfect information strategy is lower or equal to the value of firm j when following the other type's strategy. The relevant ICC for the signaling game is that of low types due to single crossing.[18]

As it is standard in signaling games, the low type performs its optimal equilibrium strategy under perfect information. Meanwhile, the high type deviates from its strategy under perfect information to prevent low types from imitating. This paper extends the concept of signaling to a real options framework such that adverse selection also affects the

[17] The lower bound implied by (10) for $j = 2$ is also a sufficient condition such that pooling equilibria exist. See Appendix for derivation.

[18] See Appendix for derivation.

timing of corporate decisions.

Under asymmetric information, the manager of firm H maximizes firm value subject to two additional constraints. First, high types are constrained by the ICC of low types such that

$$\chi_H \left[\widetilde{V}_L \left(X_t; S_H \right) - V_L^* \left(X_t; S_L^* \right) \right] \Big|_{X_t = x_H} = 0 \tag{11}$$

where χ_H is the Lagrange multiplier of high types on the ICC of low types. The complementary slackness condition in (11) is such that either the constraint is binding and multiplier is positive $\chi_H > 0$, or the constraint is slack and $\chi_H = 0$. The Lagrange multiplier $\chi_H > 0$ reflects the marginal cost for higher types of signaling its true type to investors.

Furthermore, the firm also ensures that the underpricing determined by managers equals the underpricing by market players, namely

$$U_H|_{X_t = x_H} = (1 - \epsilon_H) \frac{\theta_H}{\delta} x_j \tag{12}$$

Since there is no mispricing in separating equilibria, condition (12) guarantees that beliefs by market players are self-fulfilling.

Given conditions in (11)-(12), the problem of firm H is then given by

$$rV_H = (r - \delta) X \frac{\partial V_H}{\partial X} + \frac{\sigma^2}{2} X^2 \frac{\partial^2 V_H}{\partial X_t^2} + X$$

subject to the boundary conditions

$$\begin{aligned} V_H|_{X_t = x_H} &= [1 - \alpha_H + \alpha_H \epsilon_H] \frac{\theta_H}{\delta} x_H - I - F_H - \chi_H \left[\widetilde{V}_L - V_L^* \right] && (13) \\ \left. \frac{\partial V_H}{\partial X_t} \right|_{X_t = x_H} &= [1 - \alpha_H + \alpha_H \epsilon_H] \frac{\theta_H}{\delta} - \chi_H \left[\frac{\partial \widetilde{V}_L}{\partial X_t} - \frac{\partial V_L^*}{\partial X_t} \right] && (14) \end{aligned}$$

where the smooth pasting and value matching conditions (13)-(14) are constrained by (11). The interpretation of conditions (13)-(14) is similar to the value matching and smooth pasting conditions in (4)-(5). The boundary conditions (13)-(14) further incorporate condition (11) on the right hand side. This paper therefore proposes an alternative approach to that of Grenadier and Wang (2005) to solve for incentive compatibility in real options set-ups by incorporating the incentive compatibility constraints directly in the boundary conditions of the ODE.[19] The manager of firm H also chooses the optimal fraction of shares such that

$$\left.\frac{\partial V_H}{\partial \alpha_H}\right|_{X_t=x_H} = -\left[1-\epsilon_H\right]\frac{\theta_H}{\delta}x_H - c\gamma\left[c\alpha_H - f\right]^{\gamma-1} - \chi_H\frac{\partial \widetilde{V}_L}{\partial \alpha_H} \tag{15}$$

The last term in (15) shows that the optimal amount of shares issued is affected by the shadow cost of signaling.

Proposition 2 *The least cost optimal separating equilibria of the IPO game are such that:*

- *Low types perform the optimal IPO strategy under perfect information S_L^*, and attain $V_L^*\left(X_t; S_L^*\right)$;*
- *High types follow the strategy $S_H = \{x_H; \alpha_H; \epsilon_H\}$ given by*

$$\begin{aligned}
x_H &= \frac{\left(1-\chi_H\right)\left(I+F_H\right)\left(\frac{\delta v}{v-1}\right)}{\left[1-\alpha_H+\alpha_H\epsilon_H\right]\theta_H - 1 - \chi_H\left[\left(1-\alpha_H\right)\theta_L + \alpha_H\epsilon_H\theta_H - 1\right]} \\
\alpha_H &= \frac{f}{c} - \frac{1}{c}\left[\frac{\chi_H\left(\epsilon_H\theta_H - \theta_L\right)}{c\gamma\left(1-\chi_H\right)}\frac{x_H}{\delta} + \frac{\left(1-\epsilon_H\right)\theta_H}{c\gamma\left(1-\chi_H\right)}\frac{x_H^s}{\delta}\right]^{\frac{1}{\gamma-1}} \\
\epsilon_H &= \frac{I+F_H+\left[\frac{I+F_L}{v-1}\left(\frac{x_H}{x_L^s}\right)^v\right]}{\alpha_H\frac{\theta_H x_H}{\delta}} - \frac{\left(\left(1-\alpha_H\right)\theta_L - 1\right)}{\alpha_H\theta_H}
\end{aligned}$$

where $\chi_H > 0$ is the shadow cost of incentive compatibility constraints. The firm

[19] It is possible to show that both approaches yield the same result.

value of high types is such that

$$V_H\left(X_t;S_H\right)=\frac{X_t}{\delta}+\left(\frac{\left(1-\alpha_H+\alpha_H\epsilon_H\right)\theta_H-1}{\delta}x_H-I-F_H\right)\left(\frac{X_t}{x_H}\right)^v \tag{16}$$

where $v>1$ *denotes the positive root of the firm's ordinary differential equation (3).*

Proposition 2 summarizes the optimal strategy to do an IPO when firms reveal their private information in equilibrium. The strategies of higher types in Proposition 2 differ from those of Proposition 1 as long as the ICCs are binding for high types and thus $\chi_H>0$. When $\chi_H=0$ and $\epsilon_H=1$, all strategies converge to the case of perfect information stated in Proposition 1.

Proposition 2 shows that there are multiple least cost separating equilibria that are incentive compatible, depending on the combination between χ_H and all the signals issued by the firm. Two special cases are relevant. First, the manager of the firm can reveal private information to market players solely through the timing of the IPO and the fraction of shares issued; in this case, the complementary slackness condition in (11) is attained with $\chi_H>0$ and $\epsilon_H=1$. This equilibrium is in line with the literature motivated by Grenadier (1999) where the timing of the exercise of growth options conveys information to market players. Better firms optimally accelerate the time to go public and issue a lower fraction of shares to convey information to outside investors.

Second, the manager can also attain the same firm value and reveal firm type using underpricing, such that $\chi_H=0$ and $\epsilon_H<1$. In this case, underpricing reflects the shadow cost of signaling in equilibrium. Firms with good investment projects substitute deviations in IPO timing and the fraction of shares issued for positive underpricing at the IPO. This alternative equilibrium is in line with Ibbotson's (1975) conjecture that new issues can be underpriced in order to "leave a good taste in investors' mouth". The difference between proceeds under perfect information and proceeds under asymmetric information is mainly driven by underpricing. Low types do not have incentives to imitate high types since the complementary slackness condition (11) is binding.

Table 1 provides the calibrated version of the basic IPO model; it illustrates the difference between the strategies of firms under perfect information and those under asymmetric information. In all separating equilibria, higher types choose to go public earlier than under perfect information to make imitation more costly. Panel B considers the case where $\chi_H > 0$ and $\epsilon_H = 1$; high types reveal their type only through the timing to go public and the fraction of shares issued. Panel C illustrates the case where $\epsilon_H < 1$ is the lowest; the timing to go public for higher types is the closest to their perfect information threshold, and instead managers heavily underprice their shares to signal their type. The equilibrium strategies for the timing to go public in Panel C are the closest to those of Panel A; signaling costs in Panel C are mainly re-allocated to outside investors by means of underpricing.

The multiplicity of least cost separating equilibria provides a functional relation between all signals in the least cost separating equilibrium. The model suggests that the static signals commonly reviewed in the IPO literature optimally depend on the time to raise public equity. Figure 3 illustrates the comparative statics implied by Proposition 2. All else equal, firms that wait longer to issue (and thus time their issue closer to perfect information) must provide higher underpricing to ensure incentive compatibility. This provides a rational explanation for the link between underpricing and market timing when firms reveal their type. Also, older (and larger) firms issue a lower fraction of equity in equilibrium. Finally, the multiplier χ_H for firm H is increasing in ϵ_H; this illustrates the duality between underpricing and the shadow cost of signaling in the model.

2.3.2 Pooling equilibria

Pooling equilibria are such that IPO strategies do not convey information to outside investors about firm type. Firms with bad investment prospects always have incentives to imitate high types and obtain a higher market stock price due to (9). Firms with good investments prospects, in turn, may find it profitable to obtain the average market price of stocks and still avoid the signaling costs of revealing its type to outside investors.[20] In this case, both firms have incentives to cluster and there is mispricing of stocks in equilibrium.

The optimal IPO strategy for all firms in pooling equilibria is that of firms with good investment opportunities that obtain the average market price for their stocks. High types are undervalued and low types are overvalued with respect to the expected market value $E\left[V_j\left(X_t; S_p\right)\right]$. Since all firms issue simultaneously, there is a higher supply of shares in the market and higher IPO activity.

Proposition 3 *The pooling strategy of all firms $S_p = \{x_p; \alpha_p; \epsilon_p\}$ is such that*

$$\begin{aligned} x_p &= \left(\frac{I + F_p}{\left(1-\alpha_p\right)\theta_H + \alpha_p \epsilon_p \overline{\theta} - 1}\right)\left(\frac{v\delta}{v-1}\right) \\ \alpha_p &= \frac{f}{c} - \frac{1}{c}\left[\frac{\left(1-\frac{\overline{\theta}}{\theta_H}\right)}{\gamma c}\frac{\theta_H}{\delta}x_p\right]^{\frac{1}{\gamma-1}} \end{aligned}$$

where $\epsilon_p = 1$ and the value of firm j under pooling is then given by

$$V_j\left(X_t; S_p\right) = \frac{X_t}{\delta} + \left[\frac{\left(1-\alpha_p\right)\theta_j + \epsilon_p \alpha_p \overline{\theta} - 1}{\delta}x_p - I - F_p\right]\left(\frac{X_t}{x_p}\right)^v$$

while market players consider $E\left[V_j\left(X_t; S_p\right)\right] = pV_H\left(X_t; S_p\right) + (1-p)V_L\left(X_t; S_p\right)$.

Propositions $2-3$ characterize the role of asymmetric information on IPO strategies.

[20] A formal derivation of this statement is provided in the next section.

Consider first the implications for timing. When firms separate, the time to go public is a signal and better firms go public earlier to make imitation more costly. When firms pool, the timing to go public is not informative and worse firms to go public earlier to enhance the value of their shares. Consider now the fraction of shares issued. When firms reveal their type, high firms issue a lower fraction of shares due to higher underpricing costs. In pooling equilibria, all types issue a fraction α_p which reflects that high types are sold at a lower market value. Finally, consider underpricing. High types underprice in separating equilibria and are undervalued (i.e. mispriced) when firms pool. Low types are fairly priced when there is revelation in equilibrium, but they are overvalued in pooling equilibria. Table 1 illustrates numerically the differences between separating and pooling strategies.

2.3.3 Implications for Hot and Cold IPO Markets

A general criticism posed by Tirole (2007) on signaling games is that they are plagued by multiplicity of equilibria. This section considers two refinements to obtain clear-cut testable implications about IPO strategies in hot and cold IPO markets.

The first refinement selects one least cost separating equilibrium out the least cost separating equilibria in Proposition 2. While Proposition 2 derives optimal strategies from the managers' perspective, the equilibrium allocation of the fraction of shares issued and the corresponding share prices should also depend on the willingness of outside investors to buy new shares. Results in Figure 1 suggest that the equilibria in Proposition 2 imply a positive supply-type relation between the fraction of shares issued and the offer price of shares at the IPO. Notice, however, that outside investors may benefit from underpricing in equilibrium; underpricing re-allocates signaling costs of issuers as abnormal returns to outside investors. The equilibrium allocation of the IPO game when firms reveal their type therefore depends on the relative bargaining power of issuers and outside investors. For simplicity, I consider the least cost separating equilibrium with $\chi_H = 0$ in Proposition 2 to be the allocation preferred both by issuers and outside investors. This corresponds to a situation where issuers have little bargaining power and outside investors benefit from high underpricing. The empirical evidence on IPO underpricing suggests that firms effectively underprice their shares in equilibrium.[21]

The second refinement predicts when separating equilibria are the only possible outcome under asymmetric information. Notice that firms with better investment prospects have the option to either separate from low types or to pool with them in equilibrium. When low types are relatively scarce in the market, the average market value of issuers is closer the actual firm value of high types; the mispricing of high types in pooling is therefore lower than the corresponding cost of signaling in separating equilibria. Conversely, when high types are relatively scarce in the market, the cost of revealing firm type to market players is lower than the corresponding mispricing in pooling equilibria. Maskin and Tirole (1992) provide a formal derivation of this intuition to determine an upper bound $\overline{p}$ on the probability of being of a high type such that firms optimally reveal their type when $p \leqslant \overline{p}$.[22]

The optimal strategy of high types under asymmetric information is thus a function of p. In scenarios where there is high share of low types in the market ($p \leqslant \overline{p}$), asymmetric information erodes the option value of waiting to issue. Conversely, when there is a high share of high types in the market ($p > \overline{p}$), high types may allow low types to cluster and the optimal IPO strategies of both types are the same.[23] In particular, the threshold $\overline{p}$ such that high types are indifferent between revealing their type or pooling in equilibrium

[21] See Ritter (2003) for a survey and Table 2 for the corresponding working sample statistics.

[22] See Maskin and Tirole (1992) and Tirole (2007). Hennessy, Livdan and Miranda (2007) apply this equilibrium refinement in a dynamic signalling game of capital structure decisions.

[23] The refinement by Maskin and Tirole does not ensure pooling equilibria for $p > \overline{p}$. This is because pooling equilibria also require a set of beliefs such that the equilibrium allocation is Nash.

is given by

$$V_H\left(X_t; S_H\right)|_{X_t=x_H} = V_H\left(X_t; S_p\right)|_{X_t=x_H}$$

Figure 2 illustrates the optimal strategy for high types under asymmetric information as a function of p. When firms with good investment opportunities are relatively more scarce, high types optimally separate and follow the strategy in Proposition 2. Otherwise, firms pool in equilibrium and the optimal strategy of high types depends on p. When p equals unity, the optimal strategy under pooling converges to the optimal strategy under perfect information in Proposition 1.

Figure 3 further illustrates that $\overline{p}$ increases when signaling is relatively less costly in equilibrium. Assuming a uniform distribution of types such that $p = 0.5$ and cash flow mark-ups are given by $\{\theta\left(1-\sigma_\theta\right); \theta\left(1+\sigma_\theta\right)\}$, the dispersion on cash-flow mark-ups σ_θ affects the upper bound $\overline{p}$ such that high types optimally reveal their type when signaling is less costly. When σ_θ increases, the relative advantage of high types with respect to bad types also increases, reducing the costs of revealing firm type in equilibrium. The range of separating equilibria $(0, \overline{p}]$ is increasing in the dispersion of cashflows σ_θ.

The main results of the signaling game can then be easily extended to explain the evidence on hot and cold IPO markets. Denote *hot markets* are those states of nature where adverse selection is less relevant such that $p > \overline{p}$ (Tirole, 2007).[24] The definition of hot and cold markets is related to the *lemons problem*. Whenever $p < \overline{p}$, adverse selection is more likely; firms optimally reveal their type to market players and enter the market sequentially. Conversely, when $p > \overline{p}$, both good types and bad types issue simultaneously, there is increased IPO activity and a positive probability of buying a *lemon* in equilibrium.

[24] Note that hot markets need not be perfectly correlated with booms. Hot markets occur whenever there is an increase in the overall perception of p by market players.

Ljungqvist, Nanda and Singh (2006) relate IPO waves to higher investor optimism. The relative scarcity of good issuers that drives IPO activity in this paper may relate to higher investor optimism.

Hot markets occur whenever there is an increase in the overall perception of p by market players. Hot markets may therefore relate to booms of high average investment productivity (as in Pastor and Veronesi, 2003) or to periods of high investor optimism about future investment opportunities (as in Ljungqvist, Nanda and Singh, 2006).

The model then characterizes the behavior of firms according to the degree of adverse selection in the market. During periods of relatively high adverse selection (*cold markets*), IPOs are distributed in time according to firm type, trading volume of issuing stocks decreases, there is a higher average expected age of issuers and good types efficiently underprice their shares to signal their type to outside investors. During periods of relatively low adverse selection (*hot markets*), there is clustering of IPOs, a higher trading volume, a lower average expected age of issuers, and a positive probability of buying a *lemon*.

Finally, notice that results on underpricing relate to abnormal returns. When firms reveal their type in equilibrium, abnormal returns to market players translate into announcement effects that are equal to the percentage underpricing provided by firms. When firms do not reveal their type in equilibrium, there exists mispricing of stocks by market players. The optimal timing and the corresponding announcement effects of corporate decisions are intrinsically related under asymmetric information. Announcement effects vary according to firms' incentives to reveal their type under asymmetric information. During cold markets, firms with more productive investment opportunities go public earlier, underprice their shares and there is fair pricing. During hot markets, instead, all firms issue simultaneously, IPO activity increases and there is overpricing of stocks. During hot markets, the average mispricing is zero; however, IPO initial returns are more volatile.

Proposition 4 *When $p \leqslant \overline{p}$, firms reveal their type in equilibrium and abnormal returns at the IPO of firm j are given by $1 - \epsilon_j$. When $p > \overline{p}$, there may be either undervaluation* *of high types or overvaluation of low types. During hot markets, issuers are younger on average, firms issue a lower fraction of shares on average, bad stocks are overpriced and IPO returns are more volatile.*

3 Testable implications and empirical evidence

The IPO model has three main testable implications. The first implication is that the age of issuing firms is a relevant feature in IPO strategies, and that IPO timing determines the observed sample of issuers in hot and cold markets. The second related implication is that firms behave differently during hot and cold period: issuing firms enter progressively in cold markets, and optimally cluster in hot markets. The model predicts that IPO stocks are more volatile and may perform worse on average during hot markets; firms are also younger and issue a lower fraction of shares when IPO activity is high.[25] Lowry, Schwert and Officer (2008) already document the implication on volatilities. The third prediction is that firms' IPO strategies are mechanically related to the underlying quality of the firms' growth options in cold markets. Better firms go public earlier, issue a lower fraction of shares and underprice more during cold markets.

The section tests these predictions in a working sample of non-financial US IPOs between 1980 and 2007. I discuss on database construction in the Appendix.[26] I consider two different probit models to test the main testable implications. First, I assess whether firms' IPO strategies are related to the probability that firms issue in either cold or hot markets. Second, I study the probability of firms attain a high common stock rating by Standard

[25] The average quality of stocks during hot markets equals that of the underlying distribution of types. During cold markets, however, this average is higher if bad types are still private.

[26] The source for identifying IPOs is the Securities Data Company's (SDC) Deals Database. I use the merged CRSP-Compustat database to obtain information on the issuing firms' financials. I use CRSP to compute the short-term underpricing of stocks.

and Poors (S&P) once public. The S&P common stock ranking is an appraisal of the past performance of a stock's earnings and dividends, and of the stock's relative standing at its company's current fiscal year-end.[27]

The working assumption is that the unobserved quality of firms' investment projects relates to a higher rating on stock performance by S&P. While this index relates to more common measures of stock performance in the literature that use buy and hold returns on IPO portfolios, the S&P ratings are firm-specific and more closely related to firms' earnings.[28] The long run performance literature also relates stock performance to underlying firm quality.[29] The index SPRAN and the dummy TYPEH relate to the first common stock rating attained by the issuing firm during its next two years after the IPO.[30] The index SPRAN restates the actual scores given by S&P into numbers, where a higher number of SPRAN relates to a higher score by S&P. The dummy TYPEH is equal to one if the firm receives a common stock ranking in the top quartile of the distribution of scores in the data; a firm has a high type in the sample if it has at least an index of 4 or a rating of B by S&P.

The model characterizes hot and cold markets conditional on the underlying distribution of firm types; however, the observable implication of this mechanism is that IPO volume is larger during hot markets. I thus follow the standard procedures in the IPO literature and

[27] The index is available since 1985 up to date. The highest score in the S&P ranking is A+ and the lowest is D. See COMPUSTAT User's Guide, Chapter 5, pp. 228-229.

[28] Note that buy and hold IPO portfolios may be subject to stock market trends not related to firms' fundamentals. Carlson, Fisher and Giammarino (2006a, 2006b) further observe that the long run underperfomance of equity issues is due to firms' growth options becoming assets in place, and suggest that firm-specific time to build schemes also affect the pace of underperformance. Both effects are not related to firm quality and still apply for buy and hold returns on IPO portfolios.

[29] See Loughran and Ritter (1995) and Helwege and Liang (2004).

[30] Since S&P constructs the ranking based on a minimum amount of information for each firm, I consider the horizon of 2 years to obtain sufficient observations within the working sample. The index is available from 1985 up to date. For further details, see COMPUSTAT User's Guide, Chapter 5, pp. 228-229. The highest score in the S&P ranking is A+ and the lowest is D.

define hot and cold period based on volume.[31] I define those years in the thirty percent of the distribution of IPOs (i.e. 245 IPOs per year) as the hot periods; conversely, I define those years in the bottom thirty percent (i.e. 95 IPOs per year) as the cold periods. Table 2 provides the distribution of IPOs in the sample.

The working sample statistics in Table 3 show that the average firm characteristics differ significantly between hot and cold IPO markets. On average, firms go public earlier and issue a lower fraction of shares during hot markets. Since firms issuing in hot markets are younger on average, they also have higher market to book ratios, a larger fraction of capital expenditures to fixed assets, a larger fraction of intangible to fixed assets, and lower book leverage. Firms going public in hot markets also have significantly lower earnings per share and pay a higher fraction of dividends relative to their asset base. A larger share of ventured backed firms goes public during hot markets. The average S&P common stock rating and the share of better ranked firms is also lower during hot markets. In line with Lowry and Schwert (2002), firms also underprice more during hot markets.[32]

Table 4 tests the probability that a firm enters the stock market in either a hot or a cold period conditional on their IPO strategy and additional controls. The IPO strategy includes the firm's age AGEIF, the fraction of shares issued ALPHA and the short-term underpricing UNDPR. I consider a bivariate probit model in which the dependent dummy variables are COLIP and HOTIP, respectively. COLIP is equal to one if the firm issues during a cold period, and is equal to zero otherwise. HOTIP is equal to one if the firm is goes public during a hot period, is equal to zero otherwise. The bivariate approach incorporates all firms that issue during periods of average IPO activity in which neither dummy variable is equal to one. The explanatory variables include the firm characteristics related to the IPO strategy,

[31] See Loughran and Ritter (1995) and Helwege and Liang (2004).

[32] Note that this paper does not yield predictions on the relative magnitudes of underpricing in hot and cold markets.

the dummy variable TYPEH, and controls for IPO size LNPRO, market to book ratios VALUE, capital expenditures CAPXK, book leverage LEVER, intangible assets INTAK and venture capital VCDUM.[33] The variable INTAK complements VALUE to assess firms' growth option value. The dummy VCDUM equals one if the IPO is ventured backed, and controls for the potential use of IPOs as an exit mechanism for venture capitalists, since this might affect IPO strategies. I cluster for stock exchange listing to control for the differences in listing requirements across exchanges described by Corwin and Harris (2001).

Table 4 shows that the probability of issuing in cold markets is significantly and negatively related to the probability of issuing in hot markets. The probability of issuing in cold markets is significantly and positively related to firm age and negatively related to underpricing. Conversely, the probability of issuing in hot markets is significantly and negatively related to firm age, positively related to underpricing and negatively related to the fraction of shares issued. These results are in line with the predictions of the model on IPO timing and the fraction of shares issued. Firms also underprice more during hot markets in line with Lowry and Schwert (2002). Notably, the significant coefficients for cold markets always have the opposite sign than those of hot markets for the same regressor, while their magnitudes are similar. Younger firms issuing during hot markets also have higher market to book ratios, are less levered and have a larger fraction of intangibles. Finally, firms issuing in hot markets are more likely to attain a lower S&P score in the future. This prediction is in line with the model and yet differs from the standard predictions of the IPO signaling literature.[34]

Table 5 provides the empirical evidence on signaling during cold markets. The model predicts that firms with better investment prospects go public earlier, issue a lower of shares

[33] LNPRO controls for both IPO size and firm size at the IPO. Results in Tables $4-5$ are similar using log of the total market value of the firm instead of LNPRO.

[34] See Helwege and Liang (2004) for a discussion.

and underprice more than firms with worse investment prospects during cold markets. I test these predictions in the working sample using the S&P common stock rankings as a measure of firm quality. I consider a two-stage procedure to see if IPO strategies relate to the probability that a firm obtains a high common stock ranking. First, I estimate the probability that a firm is actually given an S&P ranking in the next two years after its IPO: the working sample is censored to those firms getting their score in a short term horizon after the IPO. Second, I estimate the probability that a firm obtains a higher score as a function of its former IPO strategy. I include the inverse Mills' ratio from the first stage and add further controls. Table 5 considers two alternative versions of the second stage. Panel B considers a probit model on TYPEH and tests the probability that a firm obtains a score above average during cold markets. Panel C considers an ordered probit model on SPRAN; this test is more demanding as it requires that the explanatory variables also explain the marginal probabilities of attaining a different score in the ranking. I cluster for stock exchange listing in all stages.

Results in Table 5 support the signaling implications of the model for cold markets. The estimates for the first stage correct for selection bias and show that the probability of getting an S&P ranking is positively related firms' age and earnings per share. The ranking is constructed once there is sufficient information about the issuing firm, and relates to firms providing higher earnings per share to stockholders. The estimates for the second stage support all the signaling predictions in the model. First, better ranked firms go public earlier during cold markets. The result supports the main real options implication that signaling erodes the option to go public during cold markets. Second, an increase in IPO underpricing induces a marginal increase in the probability of having an S&P above average in the two years after the offering. This result supports the statement by Ibbotson

(1975) that better firms underprice more to "leave a good taste in investors' mouths". It also complements the literature that finds no empirical support for signaling explanations of IPO underpricing.[35] Better ranked firms also issue a lower fraction of shares. This supports the predictions of the model for cold markets.

Finally, this paper emphasizes that the optimal IPO timing is a function of both firms' characteristics and asymmetric information. Firms decide endogenously when to go public when subject to a stochastic variation in their cashflows. Since IPO timing is not deterministic, the model shows that optimal IPO timing relates mechanically to the probability of raising public equity and provides a closed-form solution for such probability.[36] The corresponding empirical prediction is that the probability of doing an IPO also depends on firms' characteristics and asymmetric information. The empirical evidence Chemmanur, He and Nandy (2007) supports this alternative prediction as they show empirically that the probability of going public depend on firms' underlying characteristics and the information asymmetries between firms and outside investors before the IPO.

4 Conclusions

This model addresses the option to raise public equity in a signaling, real options framework. The model predicts that the number of IPOs and the pool of issuers change endogenously with changes in adverse selection, and provides a rational approach to analyze IPO underpricing and market timing.

From the theoretical standpoint, the paper provides new insights to the current literature of real options and IPOs. The model provides a tractable approach to solve for signaling

[35] See Ritter (2003) and Helwege and Liang (2004) for a description of the main studies assessing the empirical evidence on alternative theories on IPO underpricing.

[36] See Appendix for derivation.

games in real options, and relates both option exercise strategies and announcement effects to the decision to go public. In hot markets, all types of issuers go public simultaneously, there is mispricing of stocks and the timing to go public is uninformative. In cold markets, issuers reveal their type through signaling, and issuers with better investment prospects go public earlier, issue a lower fraction of shares and underprice more. The framework endogeneizes IPO activity, and predicts both more disperse IPO initial returns and a potential decrease in average stock quality during hot markets.

From the empirical standpoint, the model reconciles the findings that the average firm characteristics of issuers change with macroeconomic conditions (Helwege and Liang, 2004) and that initial IPO returns are more volatile during hot markets (Lowry, Schwert and Officer, 2008). The paper then provides supporting empirical evidence on the main implications of the model. Using a sample of US non-financial IPOs between 1980 and 2007, results show that the average age of issuers, the average fraction of shares issued and the average quality of stocks are lower during hot markets. Furthermore, during cold markets, results shows that better ranked firms by S&P underprice more their shares, issue a lower fraction of shares and go public earlier.

The framework developed in this paper can be extended in many ways. Direct extensions of the model include the implications for seasonal public offerings (SEOs), and the effect on informational spillovers on IPO signaling. The real options signaling game can be applied to alternative case studies in economics and corporate finance in which there is both strategic timing and asymmetric information. Finally, this paper demonstrates that real options frameworks can endogeneize sample selection biases as a function of changes in market conditions. This more broader implication may also apply under perfect information.

5 Appendix

5.1 Individual Rationality Constraints

The individual rationality (IR) constraints of the IPO game reflect that firms have incentives to go public and participate in the IPO game only if the option value of staying private is lower. Condition (10) for $j = 1, 2$ provides the IR constraints when firms separate in equilibrium. Conditional on firms staying private, the manager maximizes private firm value V_j^a by choosing the optimal cashflow threshold x_j^a at which the firm triggers its investment option. Using the standard real options approach, such threshold is given by

$$x_j^a = \left[\frac{I}{\theta_j - 1}\right]\left[\frac{u(\delta + \lambda)}{u - 1}\right]$$

and the value of the private firm equals

$$V_j^a\left(X_t; S_j^*\right) = \frac{X_t}{\delta + \lambda} + \left(\frac{\theta_j - 1}{\delta + \lambda} x_j^a - I\right)\left(\frac{X_t}{x_j^a}\right)^u$$

where $u > v > 1$ denotes the positive root of the private firm's ordinary differential equation. The relevant IR constraints for both types $j = 1, 2$ in all equilibria are then given by

$$\begin{aligned} V_j\left(X_t; S_j\right) &\geqslant V_j^a\left(X_t; S_j^a\right) \qquad (17) \\ V_j^p\left(X_t; S^p\right) &\geqslant V_j^a\left(X_t; S_j^a\right) \end{aligned}$$

The value of the low type under pooling is always higher than its value under separating equilibria due to (9). The lower bound for participation for low types is therefore given by the participation constraint under separation. Since the growth option of low types is always less valuable than that of high types, and all firms are subject to the same prime on private capital λ, all firms have incentives participate in the IPO game if low types have incentives to go public. The participation constraint (17) for $j = 2$ therefore implies that all firms go public if $\lambda > \underline{\lambda}$. The lower bound on the prime of private capital $\underline{\lambda}$ is given by

$$\underline{\lambda} = \frac{\left[\frac{1}{u-1}\left(\frac{x_L^*}{x_L^a}\right)^u - \frac{1}{v-1}\right]}{I\delta - \left[\frac{1}{u-1}\left(\frac{x_L^*}{x_L^a}\right)^u - \frac{1}{v-1}\right]}$$

5.2 Single Crossing Conditions

The proof that the IPO game complies with single crossing conditions consists of two steps. The first step is to show that since the value functions of both issuers and investors comply with the conditions stated by Cho and Sobel (1990), the single crossing condition of the set of signals $S_j = \{\alpha_j, x_j\}$ corresponds to the sorting conditions of each signal in isolation. The second step is to derive the sorting conditions for each signal in isolation.

The mechanism of the IPO game consists of a decision for each firm j and a vector of transfers from investors to firms. In the current set-up, the decisions are given by the strategy S_j and the transfers T_j are the value of the firm as seen by market players. Denote then $V_j(S_j, T_j)$ as the value function of firm type θ_j given set of signals S_j and the price paid by investors T_j. Then $V_j(S_j, T_j)$ is given by

$$V_j(X_t; S_j) = \frac{X_t}{\delta} + \left[\frac{(1-\alpha_j)\,\theta_j - 1}{\delta} x_j + \alpha_j T_j - I - F_j\right]\left[\frac{X_t}{x_j}\right]^v$$

where the x_j and α_j may take *any* value given $x_j > 0$ and $0 < \alpha_j < 1$. Then the IPO game complies with the following conditions in Cho and Sobel (1990):

1. The value function $V_j(S_j, T_j)$ of the issuer is continuous in S_j and P_j for any type θ_j.

2. The value function $V_j(S_j, T_j)$ of the issuer is increasing in T_j for any type θ_j.

3. The pay-off function of investors is continuous in S_j and P_j for any type θ_j.and is also strictly quasiconcave differentiable in T_j for $X_t \leq x_j$.

4. The pay-off function of investors is a strictly increasing function of θ_j.

5. If $\theta_L < \theta_H$, $S_L > S_H$ then $V_L(S_L, T_L) \leq V_L(S_H, T_H)$ implies $V_H(S_L, T_L) < V_H(S_H, T_H)$.

Conditions $1-4$ are standard regularity assumptions. The pay-off function of investors is proportional to $V_j(S_j, T_j)$ so it complies with Condition 3. Condition 5 states that if two signal-action pairs yield the same utility to some type of issuer and one signal is lower (componentwise) than the other, then all types prefer to send the lower signal. This is to ensure that the higher types has no incentives to deviate when the lower type does. Consider first the condition $V_L(S_L, T_L) \leq V_L(S_H, T_H)$. Reorganizing terms, the expression can be restated such that $\theta_L \geqslant \Omega$ where Ω is given by

$$\Omega = \frac{\left[x_H - x_L\left(\frac{x_H}{x_L}\right)^v\right] + \delta\left[(\alpha_L T_L - I - F_L)\left(\frac{x_H}{x_L}\right)^v - (\alpha_H T_H - I - F_H)\right]}{(1-\alpha_H) - (1-\alpha_L)\left(\frac{x_H}{x_L}\right)^v}$$

Consider now the inequality $V_H(S_L, T_L) < V_H(S_H, T_H)$. Reorganizing terms, the inequality equals $\theta_H > \Omega$. Therefore given $\theta_L < \theta_H$, if $\theta_L \geqslant \Omega$ then $\theta_H > \Omega$ such that Condition 5 holds for any parameter value.

Given conditions $1-5$ and the results in Cho and Sobel (1990), the IPO game has a separating equilibrium as long as each signal x_j and α_j complies with *single crossing.* Consider first the timing to do the IPO x_j. The single crossing condition for x_j reflect that, all else equal, good types find it less costly to issue earlier, namely

$$\frac{\partial}{\partial\theta_j}\left[\frac{\frac{\partial V_j}{\partial x_j}}{\frac{\partial V_j}{\partial T_j}}\right] = \frac{(1-v)(1-\alpha_j)\frac{1}{\delta}}{\alpha_j} < 0 \tag{18}$$

Consider now the fraction of shares issued α_j. The derivative of firm value with respect to α_{1j} at the threshold is such that, all else equal, better firms find it more costly to issue public capital, namely

$$\frac{\partial}{\partial \theta_j}\left[\frac{\frac{\partial V_j}{\partial \alpha_j}}{\frac{\partial V_j}{\partial T_j}}\right] = \frac{-\frac{x_j}{\delta}}{\alpha_j} < 0 \tag{19}$$

The single crossing conditions (18)-(19) ensure that there exists a separating equilibrium of the IPO game, and that incentive compatibility constraint (11) is binding with $\chi_H > 0$. The ultimate value of T_j is then determined in equilibrium such that $T_j = \epsilon_j \alpha_j \theta_j \frac{x_j}{\delta}$.

5.3 Implications for Hot and Cold Markets

Consider probability of being of the high type when firms separate and the probability of being of the high type when firms pool around $\overline{p}$ such that firms optimally separate at $\overline{p} - \varepsilon$ and pool at $\overline{p} + \varepsilon$. The argument that the average age of issuers decreases during hot markets then implies

$$\begin{aligned} \ln(x_p) &\leq \overline{p}\ln(x_H) + (1-\overline{p})\ln(x_L) \\ &\Rightarrow \overline{p} > 0 > -\frac{\ln(x_H) - \ln(x_L)}{\ln(x_L) - \ln(x_p)} \end{aligned}$$

which holds for any parameter values given $x_H < x_p < x_L$. Using the same approach, the statement on that the fraction of shares issued decreases during hot markets implies

$$\begin{aligned} \alpha_p &< \overline{p}\alpha_H + (1-\overline{p})\,\alpha_L \\ &\Rightarrow \overline{p} < 1 < \frac{\theta_H - \theta_L}{(\theta_H - \theta_L) + (1-\epsilon_H)\,\theta_H} \end{aligned}$$

which holds for any parameter values given $\epsilon_H < 1$.

5.4 The probability of going public

The underlying parameters explaining the probability that a firm goes public are the same of those determining the expected age at which the firm does its IPO. In the model, the expected age of firms raising public equity at time T_j is given by

$$E\left[T_j\right] = \frac{\ln\left(\frac{x_j}{X_0}\right)}{\mu - \frac{\sigma^2}{2}}$$

Meanwhile, the probability $\Pr_{(0,T_j]}$ that firm j goes public at time T_j is given by

$$\Pr{}_{(0,T_j]} = \Phi\left(\frac{-\ln\left(\frac{x_j}{X_0}\right) + \eta T_j}{\sigma\sqrt{T_j}}\right) + e^{\frac{2\eta}{\sigma^2}}\frac{x_j}{X_0}\Phi\left(\frac{-\ln\left(\frac{x_j}{X_0}\right) - \eta T_j}{\sigma\sqrt{T_j}}\right)$$

where Φ is the is the standard normal cumulative probability distribution. The closed-form solution for this probability can be computed from the hitting time distribution of the Brownian motion (Harrison, 1985). The prediction on $\Pr_{(0,T_{ij}]}$ is conditional on p such that the probability of going public for bad types is higher during hot markets ($p < \overline{p}$).

5.5 Database construction

The source for identifying IPOs is the Securities Data Company's (SDC) Deals Database. The sample considers common equity issues between January 1, 1980 and December 31, 2007 for all US firms excluding financial firms (SICs 6000-6999) and regulated industries (SICs 4900-4999). I then match the data obtained from this source to the merged CRSP-Compustat database, to obtain information on firms' financials and their stock prices after the first day of trading.

The variable describing firm age AGEIF comes from two sources. First, for the firms no missing info on dates, AGEIF is the difference between the date of the issue and the date when the firm was founded as reported by SDC. For firms whose date of foundation is not reported at SDC, I use the information on years of foundation available online on the websites of Professors Boyan Jovanovic and Jay Ritter.[37] ALPHA is the ratio of the principal amount traded (SDC) over the market value of equity after the offer (the offer price in SDC times item25 from COMPUSTAT). UNDPR is the percentage difference between the offer price in SDC and the prices at the end of the first trading day reported in CRSP.. LNPRO is the log of the proceeds obtained by the firm at the main exchange of listing (SDC). VALUE is the market value of the equity at the IPO (the closing price in CRSP times item25 from COMPUSTAT) divided by the book value of equity reported in COMPUSTAT. The variables CAPXK, LEVER, DIVIK, EARPS and INTAK are computed using COMPUSTAT data for the fiscal year of the IPO. VCDUM is obtained from SDC. SPRAN is obtained from COMPUSTAT and is the first SP rating given to the firm in the next two years after the firm goes public. The correspondence between actual scores and numbering is the following: A+ 8, A 7, A- 6, B+ 5, B 4, B- 3, C 2 and D 1.

5.6 Parameter choice in Figures 1-2 and Table 1

The choice of parameters in the numerical example is determined in one of three ways using the basic IPO model for $i = 1$. The first group of parameters is determined by direct or indirect measurements conducted in other studies. Direct measurements include the annual risk free rate $r = 5\%$, the convenience yield on cash flows $\delta = 2,5\%$ and cash flow volatility $\sigma = 25\%$. The annual risk free rate r, the convenience yield on cash flows δ and cash flow volatility σ are in line with the baseline parametrization of a SEO model by Carlson et al (2006a). The second subset of parameters is based on assumptions. Marginal

[37] See http://www.nyu.edu/econ/user/jovanovi/ and http://bear.cba.ufl.edu/ritter/ipodata.htm.

underwriting fees are linear (i.e. $\gamma = 2$) as in Altinkiliç and Hansen (2000). I assume a uniform distribution of types such that $p = 0.5$. The third set of parameters consists is intended to obtain realistic IPO moments with respect to the empirical evidence. I consider $I = 18$ based on the mean capital expenditures in the database. I set $X_0 = 0.8$ such that the expected age of high types is 8 years at the IPO. I set $\overline{\theta} = 2$ and $\sigma_\theta = 0.2$ such that $\theta_H = \overline{\theta}\,(1 + \sigma_\theta)$ and $\theta_L = \overline{\theta}\,(1 - \sigma_\theta)$. I consider $f = 6$ and $c = I$ such that the average expected underpricing is 8% and the fraction of shares issued under perfect information is close to 25%.

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Figure 1: Comparative Statics for High Types in the basic IPO model

This figure illustrates the comparative statics between the different signals when firms fully reveal their private information at the IPO. Denote underpricing as $(1 - \epsilon_j)$. The cash flow threshold x_j is increasing in underpricing; the timing to raise public equity is closer to that of perfect information when firms provide higher levels of underpricing to outside investors. The fraction of shares issued α_j is decreasing in underpricing costs; firms optimally issue less when the issuance costs are higher. The Lagrange multiplier χ_j is increasing in ϵ_j; this reflects the duality between signaling costs and underpricing in the model. Finally, the cash flow threshold to raise public equity is decreasing in α_j; older (and larger) firms issue lower percentages of equity in equilibrium.

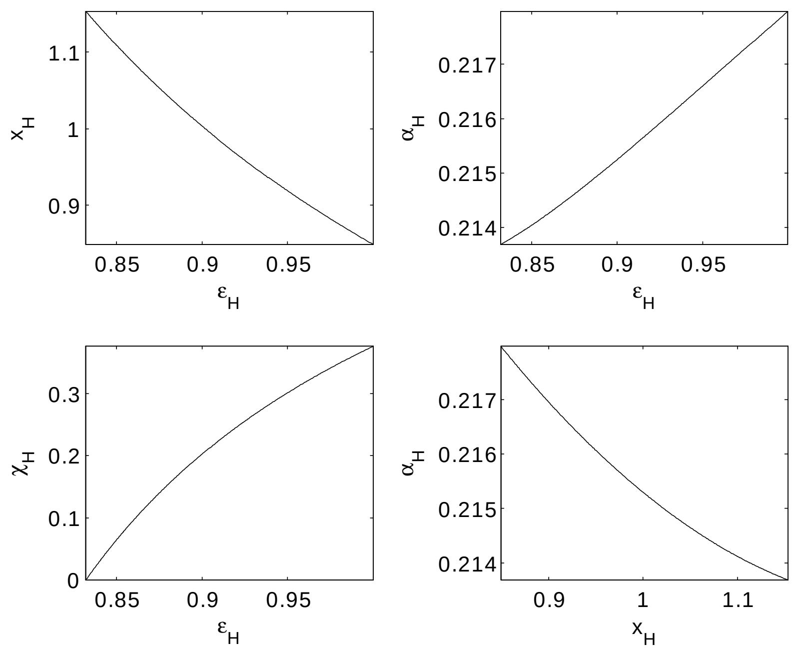

Figure 2: The Optimal Strategy for High Types under Asymmetric Information

This figure illustrates the optimal IPO strategies for high types depending on the level of adverse selection in the market. The solid black line in all charts illustrates the optimal IPO strategy under asymmetric information. When p is relatively low and high types are relatively scarce, high types optimally separate in equilibrium. This is illustrated on the left-hand side of all charts when the probability of being of a high type is lower than 0.5. For high levels of p, firms optimally pool and IPO strategies are then a function of p. The optimal strategy of firms under pooling converges to the optimal strategy of high types under perfect information (dashed line in black) when p converges to 1.

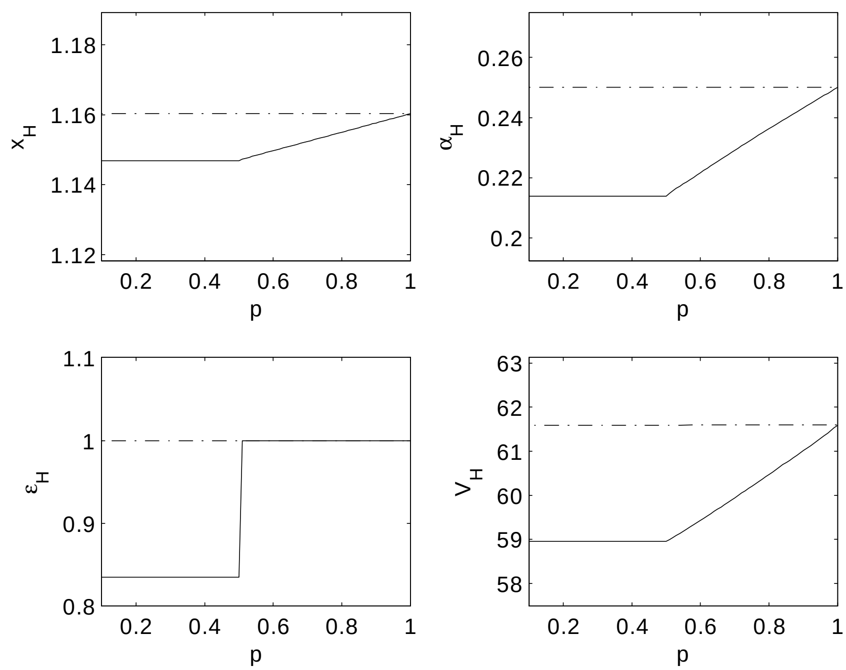

Figure 3: Signaling costs for High Types in the basic IPO model

This figure illustrates that it is more costly for higher types to separate when the two types are more similar. Consider a uniform distribution of types such that σ_θ reflects the dispersion of the quality of growth options in the market. As σ_θ increases, the high types try to make the issue unappealing to low types by going public earlier earlier, issuing a lower percentage amount of equity and underpricing more their shares. The the upper bound on the probability of high types is increasing in σ_θ; this suggests that separating equilibria are more likely when signaling is less costly.

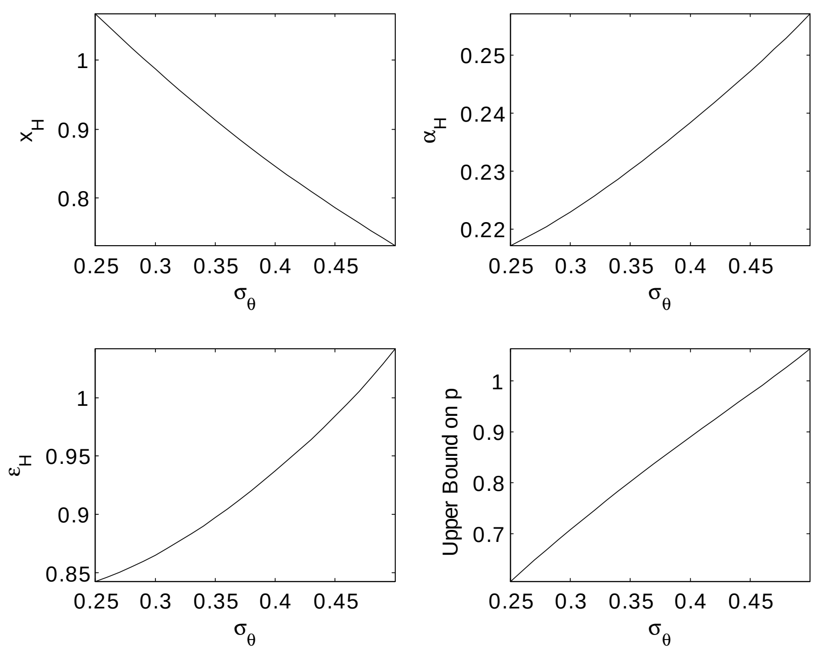

Table 1: A numerical example of the IPO Model

This table illustrates the main predictions of the model for IPOs. Panel A reports the case of perfect information. Panel B reports the optimal separating equilibrium. Panel C shows the optimal strategies in pooling for p=0.5. In separating equilibria, high types issue earlier, issue a lower fraction of shares and provide more underpricing to reveal their type. In pooling equilibria, all firms issue simultaneously. The average age of issuing firms and the corresponding average fraction of shares issued is lower during hot markets. This is because the low types accelerate their IPOs in hot markets much more than what high types delay their IPOs during hot markets. Similarly, low types reduce the fraction of shares issued relatively more during hot markets, and therefore the average fraction of shares issued decreases.

	Perfect Info		**Least Cost Sep. Eq.**				**Pooling Eq.**	
	Panel A		$\chi_H > 0$; $\epsilon_H = 1$		$\chi_H = 0$; $\epsilon_H < 1$			
	L	**H**	**L**	**H**	**L**	**H**	**L**	**H**
Going Public Strategy								
x_{ipo}	2.474	1.160	2.474	0.849	2.474	1.147	1.153	1.153
α_1	25.00%	25.00%	25.00%	21.80%	25.00%	21.37%	21.40%	21.40%
ϵ_1	1.000	1.000	1.000	1.000	1.000	0.835	1.000	1.000
χ_1	0.000	0.000	0.000	0.376	0.000	0.000	0.000	0.000
IPO Statistics								
Underpricing	0.00%	0.00%	0.00%	0.00%	0.00%	16.53%	0.00%	0.00%
Underwriting cost	2.25	2.25	2.25	4.31	2.25	4.63	4.62	4.62
Gross Spread	5.68%	12.12%	5.68%	36.40%	5.68%	35.39%	29.24%	29.24%
Announcement Effect	0.00%	0.00%	0.00%	0.00%	0.00%	16.53%	0.00%	0.00%
Proceeds								
Current value	39.58	18.56	39.58	11.84	39.58	13.10	15.79	15.79
At X_0	8.56	11.31	8.56	11.07	8.56	8.11	9.71	9.71
Actual Firm Value								
At IPO	160.13	96.51	144.23	65.33	144.23	96.57	76.94	110.53
At X_0	46.40	69.19	43.01	69.26	43.01	69.39	43.95	68.89
Expected Firm Value								
At IPO	160.13	96.51	144.23	65.33	144.23	96.57	93.74	93.74
At X_0	45.55	62.86	42.11	61.66	42.11	63.71	61.61	61.61
Ages and Probabilities								
$P^i po_{[0,5]}$	0.00%	67.66%	0.00%	0.00%	0.00%	70.14%	69.05%	69.05%
Age at x_{ipo}	25.57	8.27	25.57	1.12	25.57	8.00	8.12	8.12

Table 2: Distribution of IPOs in Hot and Cold Markets in the Working Sample

This table reports the distribution of IPOs in cold and hot markets from a working sample of 4,888 US non-financial public equity issues between 1980 to 2007. The procedure for determining periods of relatively high or low IPO activity follows Helwege and Liang (2004). Hot markets are defined as those years in the top thirty percent of the distribution of IPOs with more than 245 IPOs per year. Cold periods are those in the bottom thirty percent with less than 95 IPOs per year.

Year	Cold Markets COLIP=1	Hot Markets HOTIP=1	Neutral Markets	Total
1980	30	0	0	30
1981	73	0	0	73
1982	32	0	0	32
1983	0	0	199	199
1984	81	0	0	81
1985	0	0	97	97
1986	0	0	213	213
1987	0	0	165	165
1988	70	0	0	70
1989	69	0	0	69
1990	0	0	73	73
1991	0	0	170	170
1992	0	258	0	258
1993	0	370	0	370
1994	0	287	0	287
1995	0	304	0	304
1996	0	456	0	456
1997	0	340	0	340
1998	0	0	215	215
1999	0	350	0	350
2000	0	277	0	277
2001	59	0	0	59
2002	43	0	0	43
2003	55	0	0	55
2004	0	0	182	182
2005	0	0	142	142
2006	0	0	142	142
2007	0	0	136	136
Total	512	2,642	1,734	4,888

Table 3: Working sample statistics for hot and cold IPO markets

This table reports the summary statistics for cold and hot IPO markets from a working sample of 4,888 US non-financial public equity issues between 1980 to 2007. AGEIF is the age of the issuing firm at the IPO. UNDPR short-term underpricing. ALPHA fraction of shares issued. LNPRO the log of proceeds at the IPO. VALUE market to book equity ratio. CAPXK capital expenditures to fixed assets. LEVER book leverage once public. INTAK intangible assets over fixed assets. VCDUM equals 1 if the IPO is venture backed. SPRAN is the SP common stock equity score. TYPEH equals one if SPRAN is above 4 or B. EARPS are the earnings per share of the firm once public. DIVIK dividends to fixed assets. The data suggests that Firms go public earlier and issue a lower fraction of shares during hot markets. Average underpricing and the size of the IPO in terms of proceeds are also larger. Firms in hot markets are younger, and therefore have higher market to book ratios, a larger fraction of capital expenditures to fixed assets, a larger fraction of intangibles to fixed assets, and lower book leverage. A larger share of ventured backed firms goes public in hot markets. The share of firms with a high SP score is lower during hot markets. Firms in hot markets have significantly lower earnings per share and pay a higher fraction of dividends to fixed assets.

	Cold Markets COLIP=1			Hot Markets HOTIP=1			Tests for H_0 $\Delta = \mu_{cold}$-μ_{hot}		
	N	Mean	SD	N	Mean	SD	$H_a<0$	$H_a\neq0$	$H_a>0$
AGEIF	517	16.064	20.436	2655	13.317	17.856	0.998	0.005	0.002
UNDPR	663	0.082	0.320	2925	0.228	0.520	0.000	0.000	1.000
ALPHA	686	0.403	0.289	2945	0.334	0.228	1.000	0.000	0.000
LNPRO	686	3.299	1.611	2945	3.699	1.080	0.000	0.000	1.000
VALUE	518	18.254	34.517	2577	38.996	66.909	0.000	0.000	1.000
CAPXK	531	0.478	0.261	2576	0.505	0.282	0.016	0.033	0.984
LEVER	574	0.136	0.181	2791	0.115	0.182	0.994	0.011	0.006
INTAK	686	0.317	1.322	2945	0.537	1.685	0.000	0.000	1.000
VCDUM	686	0.318	0.466	2945	0.395	0.489	1.000	0.000	0.000
SPRAN	138	3.449	1.571	946	3.027	1.326	0.000	0.000	1.000
TYPEH	138	0.435	0.498	946	0.301	0.459	0.999	0.000	0.001
EARPS	552	0.347	1.490	2765	-0.089	1.528	1.000	0.000	0.000
DIVIK	686	0.086	0.438	2945	0.169	0.653	0.000	0.000	1.000

Table 4: IPO strategies and the probability of issuing in hot and cold IPO markets

This tables reports the results of a bivariate probit estimation of the probabilities of issuing either in cold (COLIP=1) or hot (HOTIP=1) markets as a function of IPO strategies and firm characteristics. The signs of the coefficients in each probit regression support the predictions of the model on IPO timing and those of the literature on underpricing. The signs of the coefficients for cold markets are always opposite of those of hot markets, while the magnitudes are similar. The coefficient ρ confirms that the probability of issuing in a cold market is negatively related to that of issuing in a hot market. Panel A reports the baseline model. Panel B shows that the probability of issuing in a hot market is negatively related to obtaining a high SP score in the next two years after the IPO. Panel C adds further controls for firm characteristics to the baseline model in A. Panel D considers both TYPEH and other firm controls obtaining similar results.

Variable	(A)		(B)		(C)		(D)	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
AGEIF	0.003***	-0.005***	0.004**	-0.005***	0.002***	-0.002	0.006***	-0.001
	(0.000)	(0.001)	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)
UNDPR	-0.301**	0.390***	-0.607***	0.312***	-0.196	0.341***	-0.461***	0.194
	(0.127)	(0.097)	(0.041)	(0.078)	(0.121)	(0.078)	(0.103)	(0.143)
ALPHA	-0.020	-0.255*	-0.089	0.001	-0.469	-0.007	-0.211	0.193
	(0.103)	(0.136)	(0.208)	(0.350)	(0.308)	(0.107)	(0.332)	(0.150)
LNPRO	-0.147**	0.076	-0.280***	0.281***	-0.149**	0.068	-0.286**	0.272***
	(0.062)	(0.061)	(0.083)	(0.066)	(0.074)	(0.058)	(0.123)	(0.087)
TYPEH			0.188	-0.339***			0.270*	-0.358***
			(0.147)	(0.080)			(0.139)	(0.082)
VALUE					-0.003***	0.001***	-0.005**	0.003***
					(0.000)	(0.000)	(0.002)	(0.001)
CAPXK					-0.042	0.045	0.461	-0.141
					(0.086)	(0.065)	(0.324)	(0.165)
LEVER					0.373*	-0.388***	0.400***	-0.546
					(0.191)	(0.039)	(0.127)	(0.385)
INTAK					-0.015	-0.010	-0.164**	0.109**
					(0.022)	(0.018)	(0.080)	(0.046)
VCDUM					0.106	0.081	0.237	0.047
					(0.150)	(0.069)	(0.164)	(0.097)
α_0	-0.751***	-0.084	-0.448***	-0.394***	-0.617***	-0.189	-0.687***	-0.471***
	(0.154)	(0.136)	(0.156)	(0.081)	(0.132)	(0.162)	(0.097)	(0.139)
ρ		-0.977***		-0.989***		-0.982***		-0.976***
		0.007		0.002		0.015		0.010
χ		227.00		1199.00		40.51		102.41
χ pval		0.000		0.000		0.000		0.000
N		4888		1364		4422		1247

** p<0.1; ** p<0.05; *** p<0.01*

Table 5: IPO strategies and S&P common stock rankings during cold IPO markets

This table reports the results of a two-stage procedure to test whether the probabillity of attaining a high SP score in the next two years after the IPO is related to IPO strategies in cold markets. The first stage is show in Panel A, and controls for selection as the sample is censored to those firms obtaining a score in two years. The probability of getting score by SP is positively related to firm age and positively related for the reported earnings per share; this relates to the information requirements and appraisal by SP when providing the score. Panels B and C report the second stage results for cold markets using two alternative estimation procedures. The first computes a probit on TYPEH and confirms that better ranked firms go public earlier, issue less and underprice more during cold markets. The second computes an ordered probit on SPRAN obtaining similar results. The constants of all regressions are significant and are omitted for brevity.

	SPRHAS	TYPEH	SPRAN
AGEIF	0.003***	-0.021***	-0.015*
	(0.001)	(0.002)	(0.008)
UNDPR		0.576**	0.344*
		(0.278)	(0.181)
ALPHA		-1.041**	-0.873***
		(0.515)	(0.249)
LNPRO	-0.036**	0.180***	0.129
	(0.016)	(0.068)	(0.097)
VALUE	0.001**	-0.009***	-0.006**
	(0.000)	(0.003)	(0.003)
CAPXK		-0.146	-0.183
		(0.432)	(0.249)
LEVER		0.129	-0.167
		(0.173)	(0.125)
INTAK		0.065	0.016
		(0.139)	(0.146)
VCDUM		-0.252*	-0.192***
		(0.141)	(0.054)
IMILL		-9.263***	-6.959**
		(1.957)	(2.996)
EARPS	0.052***		
	(0.015)		
DIVIK	-0.050		
	(0.034)		
HOTIP	0.427***		
	(0.042)		
Pseudo R^2		0.1921	0.1340
N	4423	418	418

** p<0.1; ** p<0.05; *** p<0.01*