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Abstract

We examine a dynamic model in which a firm chooses between selling out and going public under asymmetric information. We show that information asymmetry tends to change the firm's policy from selling out to IPO. More precisely, a separating equilibrium can arise in which the good firm goes public while the bad firm follows the first-best sales policy because the good firm signals to market investors by doing an IPO. In order to separate itself from the bad firm, the good firm can choose an IPO timing that is earlier than the first-best IPO timing. This result is consistent with the empirical evidence that less profitable firms tend to sell out to a large firm rather than going public.

JEL Classifications Code: G31; G34; D82.

Keywords: IPO; signaling; real options; asymmetric information; acquisition; earnout.

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1 Introduction

In recent years, the number of initial public offerings (IPOs) has remained small because many firms have chosen selling out to a large firm rather than going public as an independent firm (see Gao, Ritter, and Zhu (2013)). Although there have been numerous studies on IPOs, especially on their relation to asymmetric information (for a review, see Ritter and Welch (2002)), few works focus on the alternative. This paper is the first work to examine a firm's dynamic choice between selling out and going public. In particular, we reveal how asymmetric information regarding a firm's growth opportunity affects the firm's optimal decision.

This paper builds on the dynamic IPO model of Bustamante (2012). An entrepreneur of a private firm has an opportunity to make a growth investment along with an IPO. There are two types of firms with good and bad growth opportunities. The entrepreneur knows the firm's type, while outside investors, who price the IPO, do not observe the type. The firm only signals its type to outside investors thorough the IPO timing. In addition to this setup of Bustamante (2012), we assume that the firm has an option to sell out to a large firm rather than going public. Large firms, which bid for the private firm, do not observe the firm's type. Following the empirical evidence of Gao, Ritter, and Zhu (2013), we suppose that a bidder can expand the business more efficiently because of economies of scope and scale so that the entrepreneur always chooses selling out under symmetric information.

In the model, we show that one of three types of equilibria occurs depending the parameter values: both types of firms sell out at the same time (hereafter, pooling equilibrium of sales), both types of firms go public at the same time (hereafter, pooling equilibrium of IPOs), or the good firm goes public earlier and the bad firm sells out later on (hereafter, separating equilibrium). In particular, we show that the separating equilibrium is likely to occur under stronger asymmetric information and lower volatility.

We add to previous results about IPOs in Bustamante (2012) and Banerjee, Gucbilmez, and Pawlina (2016), by providing implications about the alternative to IPOs. Indeed, the separating equilibrium result predicts that worse firms tend to sell out. This result is consistent with the empirical evidence. Gao, Ritter, and Zhu (2013) showed that less profitable firms tend to sell out rather than going public. Pagano, Panetta, and Zingales (1998) also showed that more profitable firms are more likely to go public.

We also show that contingent payments in acquisitions can decrease inefficiency due to asymmetric information and lead the good firm to sell out in the separating equilibrium. This result can account for empirical findings that contingent contracts are more likely to be used in acquiring private and younger firms with strong asymmetric information (e.g., Kohers and Ang (2000), Datar, Frankel, and Wolfson (2002), Ragozzino and Reuer (2009)).

The remainder of this paper is organized as follows. Section 2 introduces the setup.

After Section 3.1 briefly explains the symmetric information case, Section 3.2 shows the equilibrium results under asymmetric information. Section 4 concludes the paper.

2 Setup

Consider an all-equity and private firm which is run by an entrepreneur who is the single shareholder. The firm receives a continuous stream of cash flows $X(t)$ following a geometric Brownian motion

$$\mathrm{d}X(t) = \mu X(t)\mathrm{d}t + \sigma X(t)\mathrm{d}B(t) \ (t > 0), \quad X(0) = x,$$

where $B(t)$ denotes the standard Brownian motion defined in a probability space $(\Omega, \mathcal{F}, \mathbb{P})$ and $\mu, \sigma(> 0)$ and $x(> 0)$ are constants. For convergence, we assume that $\mu < r$, where a positive constant r is the risk-free interest rate. Assume that x is sufficiently low to exclude a firm's investment at time 0.

The firm has a growth opportunity where the entrepreneur expands the cash flows to $\theta_i X(t)$ by issuing a constant fraction of shares, $\alpha \in (0, 1)$, and paying the investment cost $I(> 0)$.[1] The growth option potentially takes on two types: θ_g ($i = g$: good type) and θ_b ($i = b$: bad type), where $\theta_g > \theta_b > 1$. The probability of drawing the good type is $q \in (0, 1)$. The entrepreneur knows the firm's type. Then, the value of the entrepreneur who does an IPO at time T becomes

$$\mathbb{E}_T[\int_T^\infty \mathrm{e}^{-r(t-T)}(1-\alpha)\theta_i X(t)\mathrm{d}t] - I + P_i(T) = \frac{(1-\alpha)\theta_i X(T)}{r-\mu} - I + P_i(T), \qquad (1)$$

where $P_i(T)$ denotes the proceeds from the IPO.

In addition to this basic setup of Bustamante (2012), we assume that the firm has an option to sell out instead of going public. We denote by $Q_i(T)$ the proceeds from sales at time T.[2] In addition to the payments $Q_i(T)$, an acquirer pays the adjustment and investment costs associated with the acquisition and receives a continuous stream of cash flows $\eta\theta_i X(t)$ from the firm's business. For simplicity, we assume that $\eta \geq 1$ and the acquirer's adjustment and investment costs equal I.[3] This means that an acquirer can expand the business more efficiently than the entrepreneur due to economies of scope and scale. We also assume that all agents are risk-neutral and that market investors and bidders are competitive and have the same information and beliefs.[4]

[1] Following the basic setup of Bustamante (2012), we assume that the firm issues an exogenously given α shares in the IPO to finance the growth investment project. Refer to the appendix of Bustamante (2012) to see how α is determined by a financing constraint.

[2] For simplicity, we assume that the entrepreneur sells all shares to the acquirer. Our results remain unchanged even if the entrepreneur keep holdings of a lower fraction of shares than in the IPO case, which means that the effect of asymmetric information is stronger in the sales case than in the IPO case.

[3] Our results remain unchanged as long as an acquirer can expand the business more efficiently than the entrepreneur.

[4] Our model applies a situation of selling out by auction rather than by negotiation. In the negotiated sales,

3 Model Solutions

3.1 Symmetric information

Under symmetric information, investors and bidders observe the firm's real type. Then, we have

$$P_i(T) = \mathbb{E}_T[\int_T^\infty \mathrm{e}^{-r(t-T)}\alpha\theta_i X(t)\mathrm{d}t] = \frac{\alpha\theta_i X(T)}{r-\mu} \tag{2}$$

and

$$Q_i(T) = \mathbb{E}_T[\int_T^\infty \mathrm{e}^{-r(t-T)}\eta\theta_i X(t)\mathrm{d}t] - I = \frac{\eta\theta_i X(T)}{r-\mu} - I \tag{3}$$

By (1)–(3) and $\eta \geq 1$, selling out generates the higher value than doing an IPO. The optimal sales time is the solution to the optimal stopping problem:

$$\begin{aligned} V_i^*(x) &= \sup_T \mathbb{E}[\int_0^T \mathrm{e}^{-rt}X(t)\mathrm{d}t + \mathrm{e}^{-rT}\left(\frac{\eta\theta_i X(T)}{r-\mu} - I\right)] \\ &= \frac{x}{r-\mu} + \sup_T \mathbb{E}[\mathrm{e}^{-rT}\left(\frac{(\eta\theta_i - 1)X(T)}{r-\mu} - I\right)], \end{aligned} \tag{4}$$

where the sales time T is optimized over all stopping times. As in the standard real options literature (e.g., Dixit and Pindyck (1994)), we can easily derive the following solution.

Proposition 1 The firm sells out. The sales trigger is

$$x_i^* = \frac{\beta}{\beta-1}\frac{(r-\mu)I}{\eta\theta_i - 1} \quad (i = g, b) \tag{5}$$

and the entrepreneur's value at the initial time (hereafter, called the firm value) is

$$V_i^*(x) = \frac{x}{r-\mu} + \left(\frac{x}{x_i^*}\right)^\beta \frac{I}{\beta-1} \quad (i = g, b), \tag{6}$$

where $\beta = 1/2 - \mu/\sigma^2 + \sqrt{(\mu/\sigma^2 - 1/2)^2 + 2r/\sigma^2} (> 1)$.

For later uses, we denote the IPO trigger and firm value by x_i^{**} and $V_i^{**}(x)$, which equal (5) and (6) with $\eta = 1$.

3.2 Asymmetric Information

Under asymmetric information, investors and bidders do not know the firm's real type. The entrepreneur cannot directly prove the firm's type to them and can signal the type only through the choice between selling out and going public and its timing.[5] Note that the bad firm may have an incentive to imitate the good type and receive $P_g(T)$ and $Q_g(T)$ in (2) and (3). Following Bustamante (2012), we derive the least-cost equilibrium for the

unlike in our setup, through the time-consuming negotiation process with a particular firm, the seller and the acquirer fill gaps in information and prices.

[5]Following the basic model of Bustamante (2012), we omit signaling by underpricing in the IPO. Bustamante (2012) also showed that signaling by the IPO timing tends to be less costly than signaling by underpricing.

good firm that pays all costs due to asymmetric information. We first derive the least-cost separating equilibrium, in which the good firm maximizes the firm value conditional on separating the bad firm. As usual, we restrict our attention to threshold policies expressed as $T_g = \{t \geq 0 \mid X(t) \geq x_g\}$.

When the good firm do an IPO, separates the bad type, and receives $P_g(T)$ defined by (2), the good firm value becomes

$$\begin{aligned}&\mathbb{E}[\int_0^{T_g} \mathrm{e}^{-rt}X(t)\mathrm{d}t + \int_{T_g}^{\infty} \mathrm{e}^{-rt}(1-\alpha)\theta_g X(t)\mathrm{d}t + \mathrm{e}^{-rT_g}\left(\frac{\alpha\theta_g X(T_g)}{r-\mu} - I\right)]\\ =&\frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{(\theta_g-1)x_g}{r-\mu} - I\right),\end{aligned} \tag{7}$$

where T_g and x_g denote the IPO time and trigger, respectively. The good firm maximizes (7) under the incentive compatibility condition (ICC):

$$\begin{aligned}V_g^{ss}(x) = \quad &\max_{x_g \geq x} \quad \frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{(\theta_g-1)x_g}{r-\mu} - I\right)\\ &\text{s.t.} \quad \frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{((1-\alpha)\theta_b + \alpha\theta_g - 1)x_g}{r-\mu} - I\right) \leq V_b^*(x).\end{aligned} \tag{8}$$

In (8), the left-hand side of the ICC corresponds to the value of the bad firm that imitates the good-type IPO timing and receives $P_g(T)$ defined by (2), whereas the right-hand side of the ICC corresponds to the value of the bad firm that follows the policy in Proposition 1. Then, under the ICC, the bad firm has no incentive to imitate the good type.

When the good firm sells out, separates the bad type, and receives $Q_g(T)$ defined by (3), the good firm value becomes

$$\mathbb{E}[\int_0^{T_g} \mathrm{e}^{-rt}X(t)\mathrm{d}t + \mathrm{e}^{-rT_g}\left(\frac{\eta\theta_g X(T_g)}{r-\mu} - I\right)] = \frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{(\eta\theta_g-1)x_g}{r-\mu} - I\right), \tag{9}$$

where T_g and x_g denote the sales time and trigger, respectively. As in the IPO case, the good firm value maximizes (9) under the ICC:

$$\begin{aligned}V_g^{s}(x) = \quad &\max_{x_g \geq x} \quad \frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{(\eta\theta_g-1)x_g}{r-\mu} - I\right)\\ &\text{s.t.} \quad \frac{x}{r-\mu} + \left(\frac{x}{x_g}\right)^{\beta}\left(\frac{(\eta\theta_g-1)x_g}{r-\mu} - I\right) \leq V_b^*(x),\end{aligned} \tag{10}$$

where the left-hand side of the ICC corresponds to the value of the bad firm that imitates the good-type sales timing and receives $Q_g(T)$ defined by (3), whereas the right-hand side of the ICC corresponds to the value of the bad firm that follows the policy in Proposition 1. By taking the higher value of (8) and (10), we have the following solution.[6]

Lemma 1 Separating equilibrium:

Case (I): $\eta \geq \theta_g/\theta_b$. The good firm sells out. The good firm's sales trigger and value are x_g^s and $V_g^s(x) = V_b^*(x)$, where $x_g^s \in (0, x_g^*)$ is the solution to $\eta\theta_g x_g^s/(r-\mu) - I = V_b^*(x_g^s)$.

[6] We can easily show that the solution satisfies the ICC for the good firm, i.e., the good firm has no incentive to imitate the bad type.

Case (II): $\eta < \theta_g/\theta_b$. The good firm goes public. The good firm's IPO trigger and value are x_g^{ss} and $V_g^{ss}(x)$ as follows. If $((1-\alpha)\theta_b + \alpha\theta_g)x_g^{**}/(r-\mu) - I > V_b^*(x_g^{**})$ holds, $x_g^{ss} \in (x, x_g^{**})$ is the solution to

$$\frac{((1-\alpha)\theta_b + \alpha\theta_g)x_g^{ss}}{r-\mu} - I = V_b^*(x_g^{ss}), \tag{11}$$

and

$$V_g^{ss}(x) = \frac{x}{r-\mu} + \left(\frac{x}{x_g^{ss}}\right)^\beta \left(\frac{(\theta_g - 1)x_g^{ss}}{r-\mu} - I\right) = V_b^*(x) + \left(\frac{x}{x_g^{ss}}\right)^\beta \frac{(1-\alpha)(\theta_g - \theta_b)}{r-\mu}$$

Otherwise, $x_g^{ss} = x_g^{**}$ and $V_g^{ss}(x) = V_g^{**}(x)$. In each case, the bad firm sells out, and its sales trigger and value are $x_b^*(x)$ and $V_b^*(x)$.

Proof. In Case (I), problem (10) dominates (8). We can easily derive the trivial solution x_g^s to problem (10). In Case (II), problem (8) dominates (10). Note that x_g^{**} is the solution to problem (8) without the ICC. If x_g^{**} does not satisfy the ICC, we obtain the solution x_g^{ss} defined by (11) because the objective function in (8) monotonically increases with $x_g \in (x, x_g^{**}]$. From the triggers, we can easily calculate the firm values. □

The belief of investors and bidders is as follows: For sales at a trigger in $(x, x_g^s]$ and an IPO at a trigger in $(x, x_g^{ss}]$, the firm is good at probability one; otherwise, the firm is bad at probability one. For $\eta \geq \theta_g/\theta_b$, the result is trivial. For $\eta < \theta_g/\theta_b$, both the policy and the value depend on the firm's type. The good firm signals to outsiders by doing an IPO although the firm is better off selling out under symmetric information. In the binding case, as in Bustamante (2012), the good firm accelerates the IPO timing to avoid imitation, while in the non-binding case the choice of an IPO is enough to separate the bad firm.

Next, we derive the least-cost pooling equilibrium for the good firm. Consider the sales case, in which a bidder pays $\eta\bar{\theta}X(T)/(r-\mu) - I$, where $\bar{\theta} = q\theta_g + (1-q)\theta_b$. The sales time is the solution to the optimal stopping problem:

$$V^p(x) = \sup_T \mathbb{E}[\int_0^T \mathrm{e}^{-rt}X(t)\mathrm{d}t + \mathrm{e}^{-rT}\left(\frac{\eta\bar{\theta}X(T)}{r-\mu} - I\right)].$$

In a standard manner, we can easily derive the following solution.

Lemma 2 Pooling equilibrium of sales:
The firm sells out. The sales trigger is

$$x^p = \frac{\beta}{\beta-1}\frac{(r-\mu)I}{\eta\bar{\theta} - 1}$$

and the firm value is

$$V^p(x) = \frac{x}{r-\mu} + \left(\frac{x}{x^p}\right)^\beta \frac{I}{\beta-1},$$

regardless of its type.

The belief of outsiders is as follows: For selling out at the trigger x^p, the firm is good at probability q and bad at probability $1-q$; otherwise (off the equilibrium path), the firm is bad type at probability one. It is easy to see $x_g^* < x^p < x_b^*$ and $V_b^*(x) < V^p(x) < V_g^*(x)$.

We now consider the IPO case, in which investors pay $\alpha\bar{\theta}X(T)/(r-\mu)$. The IPO time is the solution to the optimal stopping problem:

$$V_g^{pp}(x) = \sup_T \mathbb{E}[\int_0^T \mathrm{e}^{-rt}X(t)\mathrm{d}t + \int_T^\infty \mathrm{e}^{-rt}(1-\alpha)\theta_g X(t)\mathrm{d}t + \mathrm{e}^{-rT}\left(\frac{\alpha\bar{\theta}X(T)}{r-\mu} - I\right)]$$

In a standard manner, we can easily derive the following solution.

Lemma 3 Pooling equilibrium of IPOs:
The firm goes public. The IPO trigger is

$$x^{pp} = \frac{\beta}{\beta-1}\frac{(r-\mu)I}{(1-\alpha)\theta_g + \alpha\bar{\theta} - 1},$$

regardless of its type. The good firm value is

$$V_g^{pp}(x) = \frac{x}{r-\mu} + \left(\frac{x}{x^{pp}}\right)^\beta \frac{I}{\beta-1}$$

and the bad firm value is[7]

$$V_b^{pp}(x) = \frac{x}{r-\mu} + \left(\frac{x}{x^{pp}}\right)^\beta \left(\frac{((1-\alpha)\theta_b + \alpha\bar{\theta} - 1)x^{pp}}{r-\mu} - I\right).$$

The belief of outsiders is as follows: For an IPO at the trigger x^{pp}, the firm is good at probability q and bad at probability $1-q$; otherwise (off the equilibrium path), the firm is bad type at probability one. We have $x_g^{**} < x^{pp} < x_b^{**}$ and $V_b^{**}(x) < V_g^{pp}(x) < V_g^{**}(x)$.

By comparing $V_g^s(x)$, $V_g^{ss}(x)$, $V^p(x)$, and $V_g^{pp}(x)$ in Lemmas 1–3, we obtain the least-cost equilibrium for the good type.[8]

Proposition 2 The least-cost equilibrium:
Case (I): $\eta \geq \theta_g/\theta_b$. The pooling equilibrium of sales is chosen.
Case (II-i): $(1-\alpha)\theta_g/\bar{\theta}+\alpha \leq \eta < \theta_g/\theta_b$. If $V^p(x) \geq V_g^{ss}(x)$ holds, the pooling equilibrium of sales is chosen. Otherwise, the separating equilibrium is chosen.
Case (II-ii): $1 \leq \eta < (1-\alpha)\theta_g/\bar{\theta} + \alpha$. If $V_g^{pp}(x) \geq V_g^{ss}(x)$ holds, the pooling equilibrium of IPOs is chosen. Otherwise, the separating equilibrium is chosen.

[7] $V_b^{pp}(x)$ could be lower than $V_b^*(x)$ for some parameter values. However, when the pooling equilibrium of IPOs is chosen (see Proposition 2), $V_b^{pp}(x)$ is higher than $V_b^*(x)$, which means that the bad firm has no incentive to deviate from the pooling equilibrium of IPOs.

[8] As shown in Bustamante (2012), the least-cost equilibrium for the good firm is chosen by the intuitive criterion and the Pareto-dominant criterion of alternative equilibrium refinements in the Bayes-Nash equilibrium in which both types of firms jointly have incentives to reveal their type or cluster.

Case (II-ii) with $\eta = 1$ corresponds to the basic result of Bustamante (2012). The separating equilibrium in Cases (II-i) and (II-ii) is consistent with the empirical evidence about IPOs. For instance, Bustamante (2012) and Banerjee, Gucbilmez, and Pawlina (2016) showed that firms with better growth opportunities go public earlier, while Pagano, Panetta, and Zingales (1998) showed that more profitable firms are more likely to go public. Most notably, the separating equilibrium results can also account for an empirical finding about selling out. Indeed, Gao, Ritter, and Zhu (2013) showed that less profitable firms tend to avoid IPOs and choose selling out.

In Cases (II-i) and (II-ii), a higher q leads to a higher $\bar{\theta}$, which causes the pooling equilibrium rather than the separating equilibrium. This is consistent with the result of Bustamante (2012). Further, we explore the effects of asymmetric information and volatility on the equilibrium in numerical examples. We set the base parameter values as $r = 0.07, \mu = 0.03, \sigma = 0.25, \alpha = 0.5, q = 0.5, x = 0.01, \theta_g = 2.3$ and $\theta_b = 1.7$. In Figure 1 we change levels of $\theta_g - \theta_b$ with $\bar{\theta} = 2$ fixed, while in Figure 2 we change levels of σ. In the figures, the regions S, PS, and PI stand for the separating equilibrium, the pooling equilibrium of sales, and the pooling equilibrium of IPOs, respectively. We can see from the figures that the separating equilibrium tends to occur under stronger asymmetric information and lower volatility.

Our model is also related to a contingent contract, in which an acquirer first pays a fraction of the total consideration and later pays the remaining value contingent on the performance (e.g., see earnouts in Lukas, Reuer, and Welling (2012)). Consider a contingent contract in which a bidder pays a fraction of the firm value, denoted by $\tilde{\alpha}$, at the acquisition timing and pays the remaining fraction $1 - \tilde{\alpha}$ contingent on the realized cash flows. For instance, suppose that $\tilde{\alpha}$ is low enough to satisfy $\eta((1 - \tilde{\alpha})\theta_b + \tilde{\alpha}\theta_g) \leq (1-\alpha)\theta_b+\alpha\theta_g$. In such a case, the ICC in (10) is looser than the ICC in (8); hence, the good firm sells out in the separating equilibrium. As $\tilde{\alpha} \to 0$, the good firm value approaches the first-best value $V_g^*(x)$ in (6). In other words, the good firm can benefit from such a contingent contract because it reduces loss due to asymmetric information. This result is consistent with the empirical findings in Kohers and Ang (2000), Datar, Frankel, and Wolfson (2002), and Ragozzino and Reuer (2009). They show that contingent payments are more likely to be used in the acquisition of private firms, especially new ventures (i.e., in higher asymmetric information cases) than public and established firms (i.e., in lower asymmetric information cases).

4 Conclusion

We examined a real options signaling game in which a firm chooses between selling out and going public. We derive three types of equilibria; one separating and two pooling equilibria. Most interestingly, in the separating equilibrium, the good firm goes public while the bad firm sells out. This is because the good firm signals to outsiders by choosing an IPO. In addition, the good firm can choose an IPO timing that is earlier than the first-best IPO timing to avoid imitation. This result is consistent with empirical findings that less profitable firms tend to choose selling out rather than going public. We can also account for empirical findings that contingent payments are likely to be used in M&A under stronger asymmetric information.

References

Banerjee, S., U. Gucbilmez, and G. Pawlina, 2016, Leaders and followers in hot IPO markets, *Journal of Corporate Finance* 37, 309–334.

Bustamante, M., 2012, The dynamics of going public, *Review of Finance* 16, 577–618.

Datar, S., R. Frankel, and M. Wolfson, 2002, Earnouts: The effects of adverse selection and agency costs on acquisition techniques, *Journal of Law, Economics, and Organization* 17, 201–238.

Dixit, A., and R. Pindyck, 1994, *Investment Under Uncertainty* (Princeton University Press: Princeton).

Gao, X., J. Ritter, and Z. Zhu, 2013, Where have all the IPOs gone?, *Journal of Financial and Quantitative Analysis* 48, 1663–1692.

Kohers, N., and J. Ang, 2000, Earnouts in mergers: Agreeing to disagree and agreeing to stay, *Journal of Business* 73, 445–476.

Lukas, E., J. Reuer, and A. Welling, 2012, Earnouts in mergers and acquisitions: A game-theoretic option pricing approach, *European Journal of Operational Research* 223, 256–263.

Pagano, M., F. Panetta, and L. Zingales, 1998, Why do companies go public? An empirical analysis, *Journal of Finance* 53, 27–64.

Ragozzino, R., and J. Reuer, 2009, Contingent earnouts in acquisitions of privately held targets, *Journal of Management* 35, 857–879.

Ritter, J., and I. Welch, 2002, A review of IPO activity, pricing, and allocations, *Journal of Finance* 57, 1795–1828.

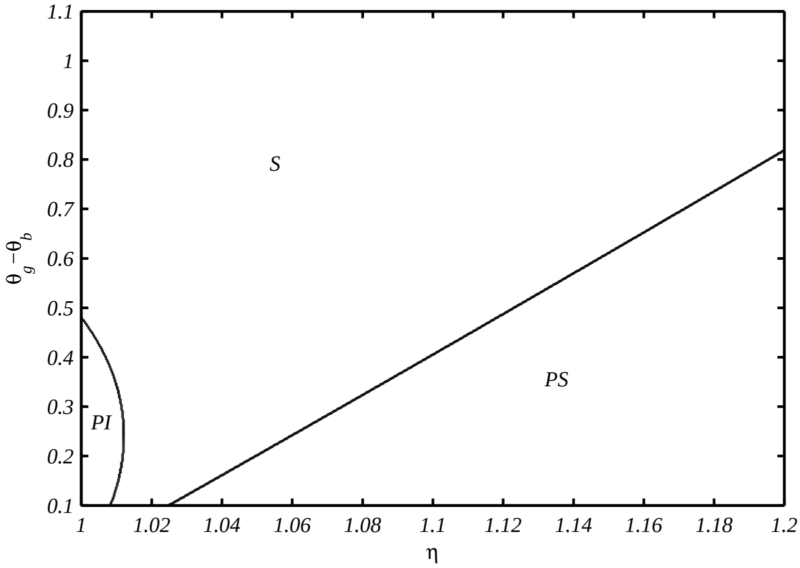

Figure 1: The effects of asymmetric information on the equilibrium.

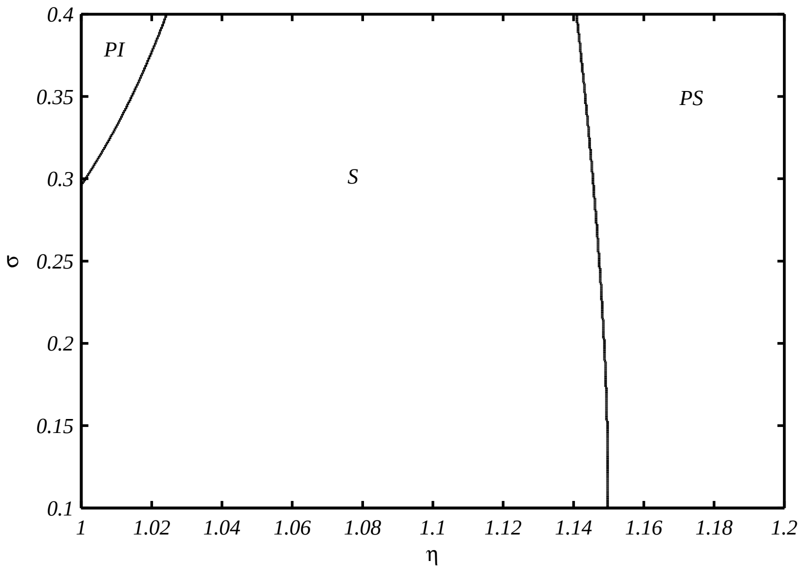

Figure 2: The effects of volatility on the equilibrium.