Strategic IPOs and product market competition

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ARTICLE INFO

Article history:
Received 23 June 2009
Received in revised form
12 April 2010
Accepted 28 April 2010

JEL classification:
G32
L22

Keywords:
IPO
Risk aversion
Product market competition
Demand uncertainty

ABSTRACT

We examine firms’ incentives to go public in the presence of product market competition. As a result of their greater ability to diversify idiosyncratic risk in the capital market, public firms’ owners tolerate higher profit variability than owners of private firms. Consequently, public firms adopt riskier and more aggressive output market strategies than private firms, which improves the competitive position of the former vis-à-vis the latter. This strategic benefit of being public, and thus, the proportion of public firms in an industry, is shown to be positively related to the degree of competitive interaction among firms in the output market, to demand uncertainty, and to the idiosyncratic portion of this uncertainty. Additional empirical predictions concern the effect of a firm’s initial public offering on its market share and on its rivals’ valuations. We test the model’s predictions and find empirical support for most of them.

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1. Introduction

In this paper we analyze firms’ decisions to go public in the presence of product market competition. In particular, we are interested in the effects of product market competition and demand uncertainty in an industry on the equilibrium proportion of public firms in this industry, as well as the effects of a firm’s initial public offering (IPO) on its industry rivals’ product market strategies, market shares, and valuations.

Issuing public equity has numerous benefits. In addition to facilitating the financing of new investments, an IPO subjects a firm to outside monitoring (e.g., Holmström and Tirole, 1993); improves its liquidity (e.g., Amihud and Mendelson, 1986); reduces valuation uncertainty (e.g., Benveniste and Spindt, 1989; and Dow and Gorton, 1997), which in turn lowers the costs of subsequent seasoned equity offerings (SEOs) (e.g., Derrien and Keczkes, 2007); allows consumers to infer the firm’s product quality from its stock price (e.g., Stoughton, Wong, and Zechner, 2001); and improves the firm’s mergers and acquisitions policy (e.g., Lyandres, Zhdanov, and Hsieh, 2010); increases the firm’s likelihood to become an acquisition target (e.g., Zingales, 1995); increases the dispersion of its ownership (e.g., Chemmanur and Fulghieri, 1999); and loosens financial constraints and provides financial intermediary certification and knowledge capital (e.g., Hsu, Reed, and Rocholl, 2010). In addition,
an underdiversified risk-averse entrepreneur could benefit from an IPO because diversified investors assign higher valuations to a risky asset (firm equity) than the entrepreneur herself (e.g., Bodnaruk, Kandel, Massa, and Simonov, 2008). Furthermore, transferring firm ownership from a risk-averse entrepreneur to diversified investors could improve profitability because risk considerations generally prevent profit maximization (e.g., Rothschild and Stiglitz, 1971).

All of the aforementioned studies examining various reasons for going public abstract from the competitive interaction among firms in output markets. Our model shows that product market competition is an important factor in the decision to go public. The intuition is as follows. Owners of public firms tend to hold more diversified portfolios than owners of private firms. For instance, Moskowitz and Vissing-Jørgensen (2002) find that about three-fourths of all private equity is owned by individuals for whom such investment constitutes at least half of their total net worth. Bodnaruk, Kandel, Massa, and Simonov (2008) show that an IPO substantially increases the degree of diversification of private firms’ controlling shareholders. As a result, public firms tend to be less concerned with idiosyncratic profit variability (e.g., Shah and Thakor, 1988) and, hence, tend to pursue more aggressive product market strategies than otherwise similar private firms.

When firms compete in quantities (à la Cournot), a public firm’s commitment to a more aggressive product market strategy has an important strategic benefit: It reduces the equilibrium aggressiveness of the firm’s rivals. Specifically, a public firm’s commitment to larger output reduces the equilibrium aggressiveness of its rivals. Thus, one of our key results—the positive relation between the degree of competitive interaction and firms’ equilibrium propensity to go public—is parallel to the positive relation between the degree of competitive interaction and optimal financial leverage (e.g., Lyandres, 2006).

While our paper focuses on Cournot competition, a different kind of strategic benefit of going public exists under Bertrand competition. When firms are price-setters, profit variability decreases with product market aggressiveness. As a result, a price-setting public firm pursues less aggressive product market strategy than a similar private firm. However, because under Bertrand-type competition firms’ competitive actions are strategic complements, the less aggressive strategy of a public firm reduces the aggressiveness of its competitors, which increases the residual demand for the firm’s product. In other words, going public has a strategic benefit under both Cournot and Bertrand competition, although the driving forces behind this benefit are different in the two scenarios.

Our model of the strategic benefit of going public that stems from lower risk aversion and resulting greater aggressiveness of public firms in the product market complements the literature that highlights the strategic cost of going public. For example, Maksimovic and Pichler (2001) and Spiegel and Tookes (2009) consider the release of valuable information to product market rivals at the time of IPO and examine the trade-off between this strategic cost of going public and the lower required returns on public issues relative to private ones.

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2 In addition to the underwriting fee (e.g., Chen and Ritter, 2000), the cost of going public includes underpricing (Loughran and Ritter, 2004) as well as the loss of private benefits of control (e.g., Benninga, Helmmantel, and Sarig, 2005).

3 Under price-setting, profit variance is increasing in price and decreasing in output.
We test the empirical implications of our model using a sample of IPOs by firms competing in strategic substitutes. Our empirical analysis confirms that the proportion of public firms in an industry is positively related to the degree of competitive interaction in that industry and to demand uncertainty, and it is negatively related to the systematic component of demand uncertainty. Our tests also support the predictions regarding the effects of an IPO on market shares and valuations of the newly public firm’s product market rivals, as well as regarding the determinants of these effects.

To sum up, our paper contributes to the literature as follows. Ours is the first paper to identify a strategic benefit of going public that stems from the different levels of risk aversion and resulting product market aggressiveness of public and private firms. It complements the existing literature on IPOs and product market competition that highlights the strategic cost of going public. Furthermore, we develop and test a series of predictions regarding the relation between the strategic benefit of going public, on the one hand, and the degree of competitive interaction, demand uncertainty, and its systematic and idiosyncratic components, on the other. In addition to showing that the strategic benefit of going public is economically and statistically significant, the empirical analysis allows us to distinguish the strategic benefit of IPO from the other benefits of going public described in the literature.

The remainder of the paper is organized as follows. In the next section, we develop our model. In Section 3, we present our analytical results and formulate their empirical implications. Section 4 presents empirical tests of the model’s predictions. We conclude in Section 5. In Appendix A, we calibrate our model and illustrate numerically the effect of various model parameters on the equilibrium. Appendix B summarizes the notation used throughout the paper and the comparative statics results. All proofs are provided in Appendix C.

2. Model

In this section, we develop a static model of product market competition among public and private firms in the presence of demand uncertainty. We first derive the values of public firms to diversified investors and the values of private firms to underdiversified entrepreneurs. We then examine how the different valuations of public and private firms by their owners affect the firms’ optimal product market strategies.

2.1. Public and private firm valuations

To derive the values of publicly traded firms, we follow the standard assumptions of the Sharpe-Lintner capital asset pricing model (CAPM). All investors are price takers in the capital market and maximize the expected utility of their terminal wealth. The utility of investor i, as a function of her terminal wealth \( w \), is given by

\[
\mathbb{E} u_i(w) = \mathbb{E} w^{-a_i/2} \frac{a_i}{2} \exp(-a_i/w),
\]

where \( a_i = -u_i''/u_i' \) is the investor’s Arrow-Pratt coefficient of absolute risk aversion, which measures her attitude toward risk. Assuming that returns are normally distributed, investor i’s expected utility simplifies into the mean-variance criterion, i.e.,

\[
\mathbb{E} u_i(w) = \mathbb{E} w^{-a_i/2} / a x(w).
\]

Finally, shares of all publicly traded firms are infinitely divisible, and all investors are able to borrow and lend at the risk-free rate, \( r_f \). Under these assumptions, each investor maximizes expected utility by holding a certain combination of the risk-free asset and the market portfolio, and the expected return of firm i is given by

\[
\mathbb{E} \left( \frac{\pi_i - V_i}{V_i} \right) = r_f + \frac{r_m - r_f}{\sigma_m^2} \text{cov}(\pi_i - V_i, r_m).
\]

where \( \pi_i \) is the firm’s (normally distributed) profit; \( V_i \) is the value of a public firm, i.e., the cash equivalent of the claim to the firm’s uncertain profit, \( \pi_i \), to diversified shareholders; and \( r_m \) is the market portfolio return with mean \( r_m \) and standard deviation \( \sigma_m \). Solving Eq. (3) for \( V_i \), gives the public firm value

\[
V_i = \frac{1}{1 + r_f} \left( \mathbb{E} \pi_i - \frac{r_m - r_f}{\sigma_m^2} \text{cov}(\pi_i, r_m) \right).
\]

We now turn to private firms. Reflecting the empirical observation that owners of private firms hold considerably less diversified portfolios than owners of public firms (e.g., Hansen and Lott, 1996; Moskowitz and Vissing-Jørgensen, 2002; and Bodnaruk, Kandel, Massa, and Simonov, 2008), we assume that unlike public firms, which are owned by fully diversified investors, each private firm is owned by a single entrepreneur.4 Similar to diversified investors, entrepreneurs maximize the expected utility given in Eq. (1) and are able to borrow and lend at the risk-free rate. We also assume that each entrepreneur holds, in addition to her private firm, the optimal combination of the market portfolio and the risk-free asset.5

Suppose that firm i is held privately by a single entrepreneur. Let \( w_0 \) be the entrepreneur’s initial endowment outside the firm, and let \( x \) be the amount of money that the entrepreneur invests in the market portfolio. Finally, let \( V_i \) be the value of private firm i, i.e., the cash equivalent of the claim to the firm’s uncertain profit, \( \pi_i \), to the entrepreneur. The private firm value must satisfy the following equality:

\[
\max x \mathbb{E} u_i((w_0 + x(1 + r_f) + x(1 + r_m) + \pi_i)
\]

\[
= \max x \mathbb{E} u_i((w_0 + V_i + x(1 + r_f) + x(1 + r_m)),
\]

where the left-hand side of Eq. (5) is the firm owner’s expected utility when she keeps her firm private, and the

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4 This is a common assumption in the literature that examines interactions between entrepreneurs and diversified investors (e.g., Gomes, 2000; and Bitler, Moskowitz, and Vissing-Jørgensen, 2005).

5 The assumption that agents exposed to undiversifiable (e.g., labor) income shocks hedge by changing the weights on the market portfolio and the risk-free asset without altering the composition of the risky portfolio is common in the portfolio allocation literature (e.g., Heaton and Lucas, 1997; and Viceira, 2001). This assumption guarantees that the CAPM valuation of public firms given in Eq. (3) remains valid in the presence of private equity.

6 We consider the entrepreneur’s initial endowment \( w_0 \) for expositional purposes only as it impacts neither her decisions nor her firm value.
right-hand side of Eq. (5) is her expected utility when her
closest to the firm’s profit are replaced with cash equivalent
V_i. Solving for the optimal x on each side of Eq. (5) and then
solving for V_i gives the private firm’s value

\[ V_i = \frac{1}{1 + r_f} \left( \left( \pi_i - \frac{T_m - r_f}{\sigma_m^2} \right) \text{cov}(\pi_i, r_m) - \frac{a_i}{2} \sqrt{\text{var}(\pi_i)(1 - \rho^2)} \right). \]  

(6)

where \( \rho \) is the correlation between the firm’s profit \( \pi_i \) and
the market portfolio return \( r_m \).

The intuition for the difference between the value of a
public firm to diversified investors, given in Eq. (4), and the
value of an otherwise equivalent private firm to an under-
diversified entrepreneur, given in Eq. (6), is as follows.
Because a public firm is held by fully diversified share-
holders, its value is affected only by its systematic risk. The
impact of the systematic risk on the public firm value,
\((T_m - r_f)/\sigma_m^2 \text{cov}(\pi_i, r_m)\), is the product of the amount of this
risk, \( \text{cov}(\pi_i, r_m) / \sigma_m \), and the market price of this risk,
\((T_m - r_f) / \sigma_m \).

In contrast, a private firm’s owner holds her entire firm
and, therefore, her utility is also affected by this firm’s
idiosyncratic risk, \( \sqrt{\text{var}(\pi_i)(1 - \rho^2)} \). The impact of the idio-
syncratic risk on private firm value also depends on the
owner’s coefficient of risk aversion, \( a_i \). The impact of
systematic risk on private firm value is the same as its
impact on public firm value. This is because public and
private firm owners face the same trade-off between
systematic risk and return when choosing their holdings
of the risk-free asset and the market portfolio.

In what follows, we simplify the notation by assuming,
without loss of generality, that the risk-free return \( r_f \) equals
zero. We also assume that no agency conflicts exist
between firms’ managers and shareholders. Equipped
with the valuations of public and private firms, we next
consider their interaction in the product market.

2.2. Product market competition

Consider \( N \) firms competing in quantities in a hetero-
geneous product market. Assuming linear demand curves,
the market-clearing price of firm \( i \)’s product is given by

\[ p_i(q_i, z_i) = z_i - \beta q_i - \gamma \sum_{j \neq i} q_j, \quad i = 1, \ldots, N, \]  

(7)

where \( q_i = (q_1, \ldots, q_N) \) is the output vector of the \( N \) firms and
\( z_i, \beta, \) and \( \gamma \) are the demand curve parameters. 

To reflect demand uncertainty, we assume that demand
curves’ intercepts, \( z_1, \ldots, z_N \), are stochastic and refer to
them as demand shocks. For analytical convenience, we
assume that the vector of demand shocks, \( \mathbf{z} = (z_1, \ldots, z_N) \), is
normally distributed with the mean and variance symme-
trical across firms, i.e., \( E(z_i) = 0 \) and \( \text{var}(z_i) = \sigma_i^2 \) for all \( i \).

To account for the systematic component of demand
uncertainty, we allow each demand shock to be correlated
with the return on the market portfolio. We assume that
the correlation coefficient \( \rho \) between demand shock \( z_i \) and
the market portfolio return \( r_m \) is positive and identical for
all \( i \). Thus, each demand shock can be decomposed into
idiosyncratic and systematic component as

\[ z_i = X_i + Y, \]  

(8)

where \( X_i \) is independent of the return on the market
portfolio and \( Y \) is perfectly positively correlated with the
market portfolio return. We refer to \( \sqrt{\text{var}(z_i)} = \sigma_i \), \( \sqrt{\text{var}(X_i)} = \sigma_i(1 - \rho^2) \), and \( \sqrt{\text{var}(Y)} = \sigma_i \rho^2 \) as the total risk,
the idiosyncratic risk, and the systematic risk, respectively.
We also refer to \( \rho^2 \) as the proportion of systematic risk and
to \( 1 - \rho^2 \) as the proportion of idiosyncratic risk.

The demand curve coefficients \( \beta > 0 \) and \( \gamma \geq 0 \) measure the
sensitivity of the market-clearing price of a firm’s product
to the firm’s own output and to its rivals’ outputs,
respectively. For tractability, these parameters are also
assumed to be symmetrical across firms. Because, in a
heterogeneous product market, the own-price effect has
to be larger than the cross-price effect, we have
\( \beta > \gamma \). Parameter \( \gamma \) is of particular interest because it
measures product substitutability and, thus, the degree
of competitive interaction among firms. When \( \gamma = 0 \), there
are no cross-price effects, i.e., each firm is a monopolist in
its own market. As \( \gamma \) increases, competitive interaction
intensifies.

Before the resolution of demand uncertainty, firm \( i \),
\( i = 1, \ldots, N \), produces \( q_i \) units of output at a constant marginal
cost \( c \). After that, demand shocks are realized and the
product market clears. Thus, firm \( i \) realizes profit

\[ p_i(q_i, z_i) = p_i(q_i, z_i)q_i - cq_i, \]  

(9)

where the market-clearing price \( p_i(q_i, z_i) \) is given in
Eq. (7).

Combining Eqs. (9), (4), and (6), we can write the values
of private and public firms as

\[ V_i(q) = \begin{cases} p_i(q_i) - \beta q_i - \gamma \sum_{j \neq i} q_j - cq_i & \text{if firm } i \text{ is public,} \\ p_i(q_i) - \beta q_i - \gamma \sum_{j \neq i} q_j - cq_i - \frac{a_i}{2} \sigma_i^2 (1 - \rho^2) & \text{if firm } i \text{ is private.} \end{cases} \]  

(10)

where \( \mu = (T_m - r_f) \sigma / \sigma_m \).

We assume, without loss of generality, that firms \( 1, \ldots, n \)
are public and firms \( n + 1, \ldots, N \) are private. Each firm
chooses its output to maximize its value while taking
into account the output decisions of its rivals. Therefore,
the equilibrium output vector \( q(N,n) \) is given by the

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8 Linear demand follows from the second-order approximation of
consumer utility function that is additively separable, linear in money,
and concave in consumption of all other goods.

9 Formally, this inequality follows from the strict concavity of the
utility function.

10 Under extreme demand shock realizations, the linear demand
model can lead to negative prices. As is common in the industrial
organization literature (e.g., Vives, 1984, p. 77), we assume the variance
of demand intercepts to be sufficiently small to make the probability
of negative prices negligible. We also do not allow firms to withhold
any output from the market after observing the demand shock realization.
It can be shown that even if firms were allowed to withhold output from
the market, they would never do so in equilibrium as long as the demand
shock variance is sufficiently small.
firms, we replace the public firm’s index evaluated at the equilibrium output vector, respectively. To simplify the notation, we use $\pi_i(N,n) = \pi_i(q_i(N,n))$ and $V^i(N) = V(q^i(N,n))$ to denote the profit and value of firm $i$ evaluated at the equilibrium output vector, respectively.

The next result characterizes the equilibrium output vector and the corresponding firm values for a given industry structure $(N,n)$. Because the equilibrium outputs, profit distributions, and values do not differ across public firms, we replace the public firm’s index $i$ with $\text{pub}$.

Lemma 1. For any given industry structure $(N,n)$, there exists a unique equilibrium output vector $q^*(N,n)$, which is given by

$$q^\ast_i(N,n) = \frac{\pi - c - \gamma Q^\ast(N,n)}{2\beta - \gamma},$$

and

$$q^\ast_i(N,n) = \frac{\pi - c - \gamma Q^\ast(N,n)}{2\beta - \gamma + a_i\sigma^2(1 - \rho^2)}, \quad i = n + 1, \ldots, N,$$

where

$$Q^\ast(N,n) = \frac{(\pi - c)(\sum_{j=n+1}^{N} \left(2\beta - \gamma + a_j\sigma^2(1 - \rho^2)\right)^{-1} + \frac{n}{2\beta - \gamma})}{1 + \beta(\sum_{j=n+1}^{N} \left(2\beta - \gamma + a_j\sigma^2(1 - \rho^2)\right)^{-1} + \frac{n}{2\beta - \gamma})}.$$ (14)

is the equilibrium total industry output. The resulting equilibrium firm values are

$$V^\ast_{\text{pub}}(N,n) = \beta(q^\ast_{\text{pub}}(N,n))^2,$$

and

$$V^i(N,n) = (\beta + \frac{1}{2}\sigma^2(1 - \rho^2))(q^\ast_i(N,n))^2, \quad i = n + 1, \ldots, N.$$ (16)

In the next section, we examine how the degree of competitive interaction in an industry and the magnitude and type of demand uncertainty affect public and private firms’ product market strategies and values, as well as the equilibrium industry structure.

3. Results

3.1. Product market strategies

Our first proposition presents the comparative statics of equilibrium output levels with respect to demand uncertainty and its composition (systematic versus idiosyncratic), entrepreneurs’ risk aversion, and the degree of competitive interaction in the industry. All of the comparative statics results presented in this section are summarized in Table B2 in Appendix B.

Proposition 1.

(i) The equilibrium output of a public firm is greater than that of any private firm.

(ii) The equilibrium output of private firm $i$ is decreasing, while the equilibrium outputs of all other firms are increasing in this firm owner’s risk aversion $a_i$.

(iii) The equilibrium output of each firm is decreasing, while the combined market share of public firms is increasing in the degree of competitive interaction $\gamma$.

(iv) The combined market share of public firms is increasing in total demand uncertainty $\sigma^2$. 

(v) The combined market share of public firms is decreasing in the proportion of systematic risk $\rho^2$.

The intuition behind Proposition 1 is as follows. Private firms choose lower output levels than public firms to reduce firm-specific risk to which private firms’ owners are exposed. The reduction in a private firm’s output due to idiosyncratic risk considerations is positively related to its owner’s risk aversion and to the idiosyncratic portion of demand uncertainty. In the absence of competitive interaction in the product market, idiosyncratic risk has no effect on public firms whose owners are fully diversified. In the presence of product market competition, however, idiosyncratic demand uncertainty does affect public firms indirectly through its effect on their private competitors. In particular, public firms take advantage of the lower output of their private rivals by increasing their own output. The higher the degree of competitive interaction, the larger the above effect and the larger the difference between the equilibrium outputs of private and public firms. The higher the risk aversion of a given entrepreneur, or the larger the idiosyncratic portion of demand uncertainty, the lower the output of the corresponding private firm and the larger the output of its public rivals. Finally, while the total market share of private firms always decreases in the degree of competitive interaction and in the idiosyncratic portion of demand uncertainty, the market share of private firms whose owners exhibit relatively low risk aversion, and which, therefore, behave similarly to public firms, could be increasing in competitive interaction as well as in idiosyncratic demand uncertainty.

Next, we characterize the effect of a firm going public on its own and its competitors’ equilibrium outputs.

Proposition 2.

(i) When a firm goes public, its equilibrium output increases, while the equilibrium output of each of its rivals decreases.

(ii) The relative increase in the IPO firm’s market share is larger the higher the degree of competitive interaction $\gamma$.

(iii) The relative increase in the IPO firm’s market share is larger the larger the total demand uncertainty $\sigma^2$.

(iv) The relative increase in the IPO firm’s market share is larger the smaller the proportion of systematic risk $\rho^2$.

When a firm goes public, it ceases to be concerned with idiosyncratic risk and becomes more aggressive by increasing its output. Consequently, the equilibrium output of
each of its competitors decreases, and more so when the degree of competitive interaction among firms is high. As a result, the higher the degree of competitive interaction, the larger the relative increase in the newly public firm’s market share. The larger the demand uncertainty or the larger its idiosyncratic proportion, the stronger the effect of going public on the firm’s product market strategy and, therefore, on its market share.

In the next subsection, we examine the effect of going public on firm values and show how this effect depends on competitive interaction and the two components of demand uncertainty.

3.2 Firm values and the strategic benefit of going public

In Section 3.1, we show that going public reduces the total output of the newly public firm’s industry rivals. To isolate this strategic benefit of IPO from the other benefits of going public, we decompose the increase in the newly public firm’s value,

\[ B(N,n) = V_{pub}(N,n+1) - V^*_i(N,n) > 0, \]

into three non-negative components:

\[ B(N,n) = B_{\text{diversification}} + B_{\text{value}} + B_{\text{strategic}} \]

where

\[ B_{\text{diversification}} = \frac{a_i}{2} (1-\rho^2) \sqrt{\alpha x_i \pi_i(q^*(N,n))}, \]

\[ B_{\text{value}} = \max_{q_i} V_{pub}(q_i,q_{-i}^*(N,n)) - V_{pub}(q_i^*,q_{-i}(N,n)), \]

and

\[ B_{\text{strategic}} = \max_{q_i} V_{pub}(q_i,q_{-i}^*(N,n+1)) - \max_{q_i} V_{pub}(q_i,q_{-i}^*(N,n)), \]

where \( V_{pub}(q_i,q_{-i}) = \mathbb{E} \pi_i(q_i,q_{-i}) - \frac{(\pi_i - \pi_i)}{\sigma_i^2} \text{COV}(\pi_i,q_i,q_{-i}). \)

The relative increase in the IPO firm’s value and the relative benefit of being public for any firm \( i \), \( V_{pub}(N,n)/V_i(N,n) \), is increasing in the degree of competitive interaction \( \gamma \).

The relative benefit of being public is increasing in the total demand uncertainty \( \sigma^2 \).

The relative benefit of being public is decreasing in the proportion of systematic risk \( \rho^2 \).

A private firm’s value is lower than that of a public firm for the three reasons captured in Eqs. (18)–(21). First, going public enables full diversification of idiosyncratic risk. Second, public firms are more profitable than private firms because their product market strategies are not distorted by idiosyncratic risk considerations. Finally, the greater product market aggressiveness of a public firm reduces the equilibrium aggressiveness of its rivals, further benefiting the public firm.

As the risk aversion of a private firm’s owner increases, her firm’s output and value decrease. As a result of the decreasing output of this firm, the values of all other firms in the industry increase. Stronger competitive interaction results in lower prices and, therefore, in lower firm values. However, public firms suffer less as their strategic commitment to larger outputs (strategic benefit of public incorporation) becomes more valuable. Thus, the relative benefit of being public increases in the degree of competitive interaction.

Because the benefit of going public stems from the ability of public firms’ owners to diversify idiosyncratic risk, the larger this risk, the larger the relative benefit of being public. Unlike idiosyncratic risk, systematic risk has an equally adverse effect on all firms and, therefore, does not impact the relative benefit of being public. As a result, the relative benefit of being public increases in total demand uncertainty and decreases in the systematic proportion of this uncertainty. The next proposition characterizes the effect of a firm’s IPO on the equilibrium values of the firm and its product market rivals.

**Proposition 4.**

(i) When a firm goes public, its equilibrium value increases while the equilibrium value of each of its rivals decreases.

(ii) The relative increase in the IPO firm’s value and the relative decrease in its rivals’ values are larger the higher the degree of competitive interaction \( \gamma \).

(iii) The relative increase in the IPO firm’s value and the relative decrease in its rivals’ values are larger the larger the total demand uncertainty \( \sigma^2 \).

(iv) The relative increase in the IPO firm’s value and the relative decrease in its rivals’ values are larger the smaller the proportion of systematic risk \( \rho^2 \).

**Proposition 3.**

(i) The equilibrium value of a public firm is greater than that of any private firm.

(ii) The equilibrium value of private firm \( i \) is decreasing, while the equilibrium values of all other firms are increasing in this firm owner’s risk aversion \( a_i \).

(iii) The equilibrium value of each firm is decreasing, while the relative benefit of being public for any firm \( i \), \( V_{pub}(N,n)/V_i(N,n) \), is increasing in the degree of competitive interaction \( \gamma \).

(iv) The relative benefit of being public is increasing in the total demand uncertainty \( \sigma^2 \).

(v) The relative benefit of being public is decreasing in the proportion of systematic risk \( \rho^2 \).

The IPO firm’s value increases as the firm starts enjoying the three benefits of being public described above. Its
competitors’ values decrease as a result of the IPO firm’s increased product market aggressiveness. A stronger degree of competitive interaction increases the strategic benefit of going public as well as the adverse effect of the IPO firm’s greater aggressiveness on its industry rivals. Finally, in our model the overall impact of an IPO stems from the ability of the newly public firm’s owners to diversify idiosyncratic risk. Hence, this impact increases with total demand uncertainty and decreases with the proportion of this uncertainty that is systematic.

In the next section, we consider the decision to go public in the context of industry equilibrium. Namely, we characterize the equilibrium number of public firms in an industry and show how it depends on the degree of competitive interaction, demand uncertainty, and its systematic and idiosyncratic components.

3.3. The decision to go public and industry equilibrium

Consider an industry with \( N \) firms, all of which are initially private. While product demand is uncertain, each entrepreneur decides whether to sell her shares to investors through an IPO. Subsequently, public and private firms engage in product market competition. In deciding whether to take her firm public, each entrepreneur weighs the benefit of going public against its cost. A substantial part of the IPO cost is the spread charged by the underwriter, which tends to be a relatively stable percentage of the IPO proceeds (e.g., Chen and Ritter, 2000; and Hansen, 2001). Reflecting this empirical regularity, we assume that the cost of going public is a fixed fraction \( \phi \) of the public firm’s value.\(^{11}\) Therefore, the amount of cash received by the entrepreneur who sells her firm to the public through an IPO is \((1-\phi)V_{\text{pub}}^*\).

When there are \( N \) firms in the industry, \( n \) of which are public, the owner of private firm \( i \) has incentives to take it public if, and only if, the proceeds from taking the firm public exceed her valuation of the private firm, i.e.,

\[
(1-\phi)V_{\text{pub}}^*(N,n+1) > V_i^*(N,n). \tag{22}
\]

We assume that the risk aversion coefficient of each entrepreneur is drawn from a continuous distribution and, without loss of generality, index all entrepreneurs so that \( a_1 \geq a_2 \geq \cdots \geq a_N \). Finally, following a large body of industrial organization literature, we treat the total number of firms \( N \) and the number of public firms \( n \) as continuous variables, so that \( a(i) \) is a decreasing continuous function.\(^{12}\)

Because the benefit of going public increases in the entrepreneur’s risk aversion, in any equilibrium in which both types of firms exist, the first \( n \) entrepreneurs with the highest risk aversion take their firms public while the remaining \( N-n \) entrepreneurs keep their firms private, with the \( n \)th entrepreneur being indifferent between going public and staying private, i.e.,

\[
(1-\phi)V_{\text{pub}}^*(N,n) = V_i^*(N,n). \tag{23}
\]

Eq. (23) implies that there exists a threshold level of risk aversion, \( a^* \), such that entrepreneurs whose risk aversion exceeds this threshold go public, while entrepreneurs with risk aversion below this threshold remain private. We formalize this result in the next proposition.

**Proposition 5.** Let

\[
a^* = \frac{(2\beta-\gamma)}{4\beta(1-\phi)\sigma^2(1-\rho^2)} \left( \sqrt{2(\beta-\gamma)^2 + 8\beta\gamma(1-\phi) - 2(\beta+\gamma)} + 4\beta\phi \right).
\]

There exists a unique equilibrium number of public firms, \( n^* \), which is given as follows.

(i) If \( a(0) > a^* > a(N) \), some firms go public while others remain private, and \( a(n^*) = a^* \).

(ii) If \( a(0) \leq a^* \), all firms remain private, i.e., \( n^* = 0 \).

(iii) If \( a(N) \geq a^* \), all firms go public, i.e., \( n^* = N \).

Case (i) corresponds to the interior equilibrium, in which entrepreneurs whose risk aversion exceeds the IPO threshold, \( a^* \), take their firms public, while the remaining entrepreneurs keep their firms private. Case (ii) corresponds to the boundary equilibrium in which the risk aversion of each entrepreneur is below the IPO threshold and thus no firm goes public. Finally, case (iii) corresponds to the other boundary equilibrium in which the risk aversion of each entrepreneur exceeds the IPO threshold, and, therefore, all firms go public.

The degree of competitive interaction and idiosyncratic demand uncertainty affect the equilibrium proportion of public firms in the industry by altering the threshold risk aversion, \( a^* \), which determines the number of firms that choose to go public. These effects are characterized in the next proposition.

**Proposition 6.**

(i) The equilibrium proportion of public firms in the industry is increasing in the degree of competitive interaction \( \gamma \).

(ii) The equilibrium proportion of public firms in the industry is increasing in total demand uncertainty \( \sigma^2 \).

(iii) The equilibrium proportion of public firms in the industry is decreasing in the proportion of systematic risk \( \rho^2 \).

As the degree of competitive interaction increases, so does the strategic benefit of going public, which leads to more firms going public in equilibrium. As total demand uncertainty or its idiosyncratic proportion increase, the
benefit of shareholder diversification enabled by going public increases, and so does the equilibrium number of public firms. Because the threshold risk aversion, \( a' \), is independent of the number of firms in the industry \( N \), Proposition 6 holds when the total number of firms in the industry is determined endogenously and the distribution of risk aversion across entrepreneurs is independent of the industry size.\(^{13}\)

In Appendix A, we calibrate our model to US data and show that an interior equilibrium, in which both public and private firms exist, is likely to arise. In this Appendix, we also numerically illustrate the comparative statics of the equilibrium with respect to various model parameters to show their economic significance. In the next subsection we outline the main empirical predictions following from the model.

### 3.4. Empirical implications

Proposition 2, which characterizes the effects of an IPO on firms’ equilibrium market shares, leads to the following empirical prediction.

**Empirical prediction 1.** Under competition in strategic substitutes (e.g., quantities),

(i) going public increases the firm’s market share;
(ii) the relative increase in the IPO firm’s market share is positively related to the degree of competitive interaction in its industry;
(iii) the relative increase in the IPO firm’s market share is positively related to demand uncertainty in its industry; and
(iv) the relative increase in the IPO firm’s market share is negatively related to the proportion of demand uncertainty that is systematic.

The empirical evidence in recent papers by Chemmanur and He (2008) and Hsu, Reed, and Rocholl (2010) is consistent with Empirical prediction 1(i).\(^{14}\) There are reasons that an IPO is likely to have a positive impact on the firm’s market share other than the one captured by our model. In particular, a firm could be able to use the capital raised through its IPO to expand its production capacity.\(^{15}\) Thus, to test our explanation of the increase in the IPO firm’s market share, it would be useful to test parts (ii)–(iv) of the prediction, i.e., the relations between the effect of an IPO on the firm’s market share, on the one hand, and competitive interaction, demand uncertainty, and the systematic portion of this uncertainty, on the other hand.

Proposition 4, which characterizes the effects of an IPO on the values of the firm’s product market rivals, leads to our second empirical prediction.

**Empirical prediction 2.** Under competition in strategic substitutes (e.g., quantities),

(i) going public has an adverse effect on the values of the IPO firm’s product market rivals;
(ii) the magnitude of this effect is positively related to the degree of competitive interaction in the industry;
(iii) the magnitude of this effect is positively related to demand uncertainty in the industry; and
(iv) the magnitude of this effect is negatively related to the proportion of demand uncertainty that is systematic.

The first part of Prediction 2 is consistent with Slovin, Sushka, and Ferraro (1995) and Hsu, Reed, and Rocholl (2010), who report that a firm’s IPO results in abnormally negative returns to the firm’s competitors, and with Slovin, Sushka, and Bendek (1991), who find positive valuation effects on the industry rivals of firms going private. However, none of these papers tests whether our explanation, i.e., the change in the IPO firm’s product market aggressiveness due to shareholder diversification, contributes to this effect. Testing parts (ii)–(iv) of Prediction 2 allows us to empirically distinguish our explanation from other potential theories such as the deep pockets argument.

Proposition 6, characterizing the equilibrium structure of an industry, leads to the following empirical prediction.

**Empirical prediction 3.** (i) The proportion of public firms in an industry is positively related to the degree of competitive interaction in this industry;
(ii) the proportion of public firms in an industry is positively related to demand uncertainty in this industry; and
(iii) the proportion of public firms in an industry is negatively related to the proportion of demand uncertainty that is systematic.

Empirical prediction 3 is a key implication of our model, which reflects the strategic benefit of diversification associated with going public in the presence of product market competition. Examining empirically the relation between the proportion of public firms in an industry and the degree of competitive interaction in it is of particular interest because an argument opposite to Prediction 3(i) can be made based on the information disclosure theory. Namely, because more intense competitive interaction exacerbates the cost of releasing valuable information at the time of IPO, it could lead to fewer public firms in the industry. As we show in Section 4, the data support Prediction 3, suggesting that the strategic benefit of going public dominates the cost of disclosure associated with the release of public incorporation to product market competitors.

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\(^{13}\) Models in which industry size does not affect the distribution of firms’ characteristics are common in the industrial organization literature (e.g., Melitz, 2003; and Ghironi and Melitz, 2005).

\(^{14}\) There also exists some anecdotal evidence supporting Empirical prediction 1(i). Killian, Smith, and Smith (2001) cite a number of examples in which firms that went public ahead of their competitors gained a considerable market share (e.g., Handspring, Affymetrix, Petsmart).

\(^{15}\) In addition, Chemmanur and He (2008) argue that going public could increase the firm’s market share because of the enhanced credibility of a public firm with customers, its greater ability to acquire other firms, or its ability to hire quality employees and motivate them using stock options.
4. Empirical evidence

In this section we empirically test our predictions regarding the effects of competitive interaction, demand uncertainty, and its systematic component on the post-IPO change in the newly public firm’s market share (Empirical prediction 1), on the values of the newly public firm’s product market competitors (Empirical prediction 2), and on the proportion of public and private firms in an industry (Empirical prediction 3).

4.1. Empirical proxies

4.1.1. The degree of competitive interaction

In constructing a proxy for the degree of competitive interaction among firms in an industry, we follow Sundaram, John, and John (1996), who were the first to develop an empirical measure of the responsiveness of firms’ profits to changes in their competitors’ actions. Assuming that sales proxy for firms’ actions, Sundaram, John, and John (1996) define the Competitive Strategy Measure (CSM) as the correlation between the ratio of the change in a firm’s profit to the change in its sales and the change in the combined sales of the firm’s product market rivals. For firm $i$, it is

$$\text{CSM}_i = \text{corr} \left( \frac{\Delta \pi_i}{\Delta S_i}, \frac{\Delta S_{-i}}{\Delta S_i} \right). \quad (25)$$

where $\Delta \pi_i$ is the change in firm $i$’s profit between two consecutive periods, $\Delta S_i$ is the change in its sales, and $\Delta S_{-i}$ is the change in its product market rivals’ combined sales. As pointed out by Sundaram, John, and John (1996), this measure is a direct proxy for the cross-partial derivative of a firm’s value with respect to its own and its rivals’ competitive actions.

Following the definition of Bulow, Geanakoplos, and Klemperer (1985), a positive cross-partial derivative of a firm’s value with respect to its own and its rivals’ competitive actions corresponds to competition in strategic complements, whereas a negative cross-partial derivative corresponds to competition in strategic substitutes. Thus, we classify industries with a positive (negative) mean CSM as those in which firms compete in strategic complements (substitutes). Because our model assumes competition in quantities, which are strategic substitutes, we restrict the sample used in the empirical analysis to firms belonging to industries with negative mean CSMs.$^{16}$

Whereas the sign of mean industry CSM indicates the type of competitive interaction among firms in the industry, its magnitude measures the intensity of this interaction. Because we restrict our attention to industries with negative mean CSMs, we use the absolute value of mean industry CSM as a direct proxy for the degree of competitive interaction in the industry in the empirical tests below.

Similar to Sundaram, John, and John (1996), we use quarterly Compustat data and define a firm’s profit as its quarterly operating profit and rivals’ sales as combined quarterly sales of all other firms operating in the same industry. We first calculate the correlation given in Eq. (25) for each firm for 20-quarter rolling windows. We then compute the mean industry CSM using all firms with at least ten non-missing observations for changes in sales and profits. We assign the mean industry CSM to all firms operating in that industry during the quarter following the estimation period. This procedure reduces the noise involved in estimating each firm’s CSM and also enables time-varying CSM for each industry.$^{17}$

We use the Standard Industrial Classification (SIC) system as well as the North American Industry Classification System (NAICS), which was introduced in 1999 and which improves SIC’s outdated categorizations of emerging industries. A deficiency of the NAICS is that industry assignments are made on a retroactive basis before 1999. Using both four-digit SIC and six-digit NAICS industry classifications to determine newly public firms’ product market rivals results in a more robust depiction of the strategic effects of IPOs.

The summary statistics of the CSM are presented in Panel A of Table 1. Overall, slightly more than half of industry-years have negative estimates of the CSM, consistent with Sundaram, John, and John (1996) and Lyandres (2006). Among industries with competition in strategic substitutes, the mean absolute value of the CSM is 0.061 (0.049) according to the NAICS (SIC) classification, and the median is 0.037 (0.034). While there is considerable variation in CSMs across industries as evident from Table 1, mean industry CSMs are rather stable over time.$^{18}$ In addition, while there is sizable within-industry variation of firm CSMs (the average within-industry standard deviation of firm-specific CSM equals 0.26), 76% of firms in industries with negative mean CSMs have negative firm-specific CSMs.

4.1.2. Demand uncertainty and its systematic component

We follow the empirical industrial organization literature and use overall sales by firms belonging to an industry as a proxy for industry demand (e.g., Ghosal, 1991; and Guiso and Parigi, 1999). Our measure of demand uncertainty is the standard deviation of seasonally adjusted quarterly industry sales growth. We employ the following estimation procedure. For 20-quarter rolling windows we first regress industry sales growth, computed as the sum of sales of all firms that report quarterly sales throughout all 20 quarters of the estimation period, on four indicator variables equaling one if the observation belongs to the first, second, third, or fourth quarter and equaling zero otherwise. We refer to the residuals from this regression as seasonally adjusted sales growth. We compute the standard deviation of seasonally adjusted sales growth for each industry and assign it to the industry-quarter following the estimation period. Restricting the estimation sample to

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$^{17}$ This procedure is different from that of Sundaram, John, and John (1996), who calculate the CSM for only one firm in an industry (in their case, the firm announcing a change in research and development expenditures) and assign this CSM to all firms in the industry.

$^{18}$ If an estimated mean industry CSM is negative in a given quarter, it is negative in about 86% of the other quarters.
firms reporting sales throughout the estimation period circumvents potential problems related to firm additions (e.g., due to IPOs) and deletions from the database (e.g., due to mergers or restructuring).

To measure the systematic component of industry demand uncertainty we estimate rolling-window regressions of seasonally adjusted quarterly industry sales growth on seasonally adjusted overall sales growth, defined as the relative change in sales of all firms available in quarterly Compustat files throughout the estimation period. We call the ratio of the variance of the residuals from this regression to the overall variance of seasonally adjusted industry sales growth the idiosyncratic component of sales growth, and we refer to the ratio of the variance of the predicted values of industry sales growth to the overall variance of industry sales growth as the systematic component of sales growth.\(^\text{19}\) As follows from Panel A of Table 1, for industries with competition in strategic substitutes, the mean value of our proxy for demand uncertainty is 0.15–0.16. On average, 5% of demand uncertainty is systematic.

19 Similarly, in the specification in which we proxy for demand uncertainty using return volatility, we estimate the proportion of systematic demand uncertainty by regressing firm daily returns on value-weighted market returns and computing the mean industry ratio of the variance of the explained portion of returns to the overall variance of returns.

Table 1: Summary statistics.
This table presents the summary statistics of the variables used in the empirical tests. Panel A contains statistics for measures of competitive interaction, demand uncertainty, and the systematic component of this uncertainty. CSM is a measure of the degree of competitive interaction. Absolute CSM is the absolute value of the CSM. Standard deviation of sales growth is the measure of demand uncertainty. Systematic proportion of sales growth is the measure of the systematic proportion of demand uncertainty. The construction of these measures is discussed in Subsection 4.1. Full sample refers to all initial public offerings (IPOs) with non-missing Compustat variables. Strategic substitutes sample refers to all IPOs in industries with negative estimated CSM. NAICS classification refers to six-digit North American Industry Classification System. SIC classification refers to four-digit Standard Industrial Classification. Panel B contains statistics for the dependent variables in the regression analysis. One-year (three-year) market share growth is the logarithm of the ratio of the IPO firm’s market share one year (three years) after the year of the IPO to its market share in the year of the IPO. Market share is the ratio of a firm’s sales to the sum of sales of all firms in the industry. Three-day rivals’ raw (abnormal) return is the weighted average return during days \([-1,1]\), where day 0 is the IPO filing day, of all firms operating in the IPO firm’s industry. Abnormal returns are based on the market model. Proportion of public firms is the ratio of the number of public firms in a NAICS industry to the number of all firms in that industry with more than one hundred (five hundred) employees. Panel C contains statistics for control variables in the regression analysis. Age is the difference between the year of observation and the earlier of the founding year and incorporation year. Assets is the book value of assets at the end of the year preceding the year of the observation. Market-to-book (M/B) is the ratio of the sum of market value of equity and book value of debt to book assets at the end of the year preceding the year of the observation. Median age (assets, M/B) refers to median age (assets, M/B) in the firm’s industry. Issue rate is the ratio of the number of primary shares issued during the IPO to the number of shares outstanding pre-IPO.

<table>
<thead>
<tr>
<th>NAICS classification</th>
<th>SIC classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>CSM</td>
<td>-0.006</td>
</tr>
<tr>
<td>Strategic substitutes</td>
<td>0.061</td>
</tr>
<tr>
<td>Absolute CSM</td>
<td>0.161</td>
</tr>
<tr>
<td>Standard deviation of sales growth</td>
<td>5.13%</td>
</tr>
<tr>
<td>Systematic proportion of sales growth</td>
<td>0.159</td>
</tr>
<tr>
<td>One-year market share growth</td>
<td>0.491</td>
</tr>
<tr>
<td>Three-year market share growth</td>
<td>-0.46%</td>
</tr>
<tr>
<td>Three-day rivals’ raw return</td>
<td>-0.52%</td>
</tr>
<tr>
<td>Three-day rivals’ abnormal return</td>
<td>0.08%</td>
</tr>
<tr>
<td>Proportion of public firms</td>
<td>0.43%</td>
</tr>
<tr>
<td>Age</td>
<td>14.338</td>
</tr>
<tr>
<td>Median industry age</td>
<td>17.755</td>
</tr>
<tr>
<td>Assets</td>
<td>692.34</td>
</tr>
<tr>
<td>Median industry assets</td>
<td>252.75</td>
</tr>
<tr>
<td>M/B</td>
<td>3.137</td>
</tr>
<tr>
<td>Median industry M/B</td>
<td>2.070</td>
</tr>
<tr>
<td>Issue rate</td>
<td>0.252</td>
</tr>
<tr>
<td>Market share</td>
<td>5.93%</td>
</tr>
</tbody>
</table>

Please cite this article as: Chod, J., Lyandres, E., Strategic IPOs and product market competition. Journal of Financial Economics (2010), doi:10.1016/j.jfineco.2010.10.010
4.2. Test of empirical prediction 1: changes in IPO firms’ market shares

In this subsection we test Prediction 1 according to which the post-IPO growth in a newly public firm’s market share is positively related to the degree of competitive interaction and to demand uncertainty, and it is negatively related to the systematic proportion of this uncertainty.

Because full coverage of quarterly Compustat database begins in 1985 and we require 20 prior quarters of accounting data to estimate the degree of competitive interaction and demand uncertainty, our sample of IPOs starts in 1990. We obtain IPO data from the New Issues database of Thomson Financial’s Securities Data Company (SDC). To be included in the IPO sample, a firm must perform an IPO on one of the three major exchanges and have IPO filing date available in the SDC database. We exclude rights issues, unit issues, reverse leveraged buyouts, real estate investment trusts (REITs), closed-end funds, and American Depositary Receipts (ADRs). In addition, we exclude firms with offer prices below $1. Finally, we require that IPO firms have accounting data available in the quarterly and annual Compustat databases. Our sample contains 3,871 IPOs, out of which 1,993 IPOs are by firms belonging to industries with competition in strategic substitutes (negative estimated CSms).

We follow Chemmanur and He (2008) and measure changes in IPO firms’ market shares over one-year and three-year post-IPO periods. A firm’s market share in a given year is defined as the ratio of the firm’s annual sales to the overall industry sales. We define one-year (three-year) post-IPO market share growth as the natural logarithm of the ratio of a newly public firm’s market share in the first (third) post-IPO year to its market share in the IPO year. Panel B of Table 1 shows that the mean (median) growth in the IPO firm’s market share is 16% (14%) in the first year and 33–49% (17–20%) in the first three post-IPO years depending on industry classification. This increase in market share is consistent with Prediction 1(i) and with Hsu, Reed, and Rocholl (2010), who show that firms going public exhibit sizable post-IPO sales growth.

To distinguish our explanation of the increase in newly public firms’ market shares from alternative explanations, we also test parts (ii)–(iv) of Prediction 1. Namely, we estimate pulled regressions of post-IPO market share growth on proxies for the extent of competitive interaction, demand uncertainty, and its systematic component:

$$\Delta MS_{ij} = \alpha + \beta_1 \overline{\tau}_j + \beta_2 \overline{\sigma}_j + \beta_3 \overline{\sigma}_j^2 + \beta Z_i + \varepsilon_{ij},$$

(26)

where $\Delta MS_{ij}$ is the post-IPO market share growth of firm $i$ operating in industry $j$; $\overline{\tau}_j$ is the absolute value of the CSM proxying for the degree of competitive interaction in industry $j$; $\overline{\sigma}_j$ is the estimate of the volatility of seasonally adjusted industry sales growth proxying for demand uncertainty; $\overline{\sigma}_j^2$ is the proportion of systematic variance of sales growth; and $Z_i$ is the vector of control variables that are expected to be related to the IPO firm’s market share growth. Because of industry and time clustering of IPOs (e.g., Ritter, 1984; Lowry and Schwert, 2002; and Lowry, 2003), we use standard errors clustered by industry and month (e.g., Petersen, 2009).

In choosing the control variables, we generally follow Chemmanur and He (2008) and Hsu, Reed, and Rocholl (2010). Because younger, smaller firms with relatively more investment opportunities and higher growth potential are expected to benefit more from going public, our control variables include the IPO firm’s relative age, size, and market-to-book ratio. Relative age (size, market-to-book ratio) is defined as the natural logarithm of the ratio of the firm’s age (book assets, market-to-book ratio) to median age (book assets, market-to-book ratio) of all public firms operating in the firm’s industry. We define a firm’s age as the difference between the current year and the founding year or incorporation year in that order of availability. Motivated by the cash infusion hypothesis, our control variables also include the IPO issue rate, defined as the ratio of the number of newly issued shares to the number of the firm’s pre-IPO outstanding shares.

Table 2 presents the results of estimating Eq. (26) using one-year and three-year growth in the IPO firms’ market shares in six-digit NAICS and four-digit SIC industries. The coefficients on the absolute value of CSM are positive for both measures of market share growth and for both industry classifications, and they are significant at 10% level in all four specifications. This is consistent with Prediction 1(ii) and with the intuition that the increased aggressiveness of a newly public firm has a larger effect on market shares in industries with higher degrees of competitive interaction. The economic significance of the effect of the mean industry CSM on market share growth is substantial. Increasing the absolute value of the CSM by one standard deviation (0.065 for NAICS-based industries and 0.051 for SIC-based industries; see Panel A of Table 1) is associated with 10–14 percentage points increase in one-year market share growth and with 11–22 percentage points increase in three-year market share growth. For comparison, the mean (median) IPO firm’s one-year market share growth is 16% (14%).

The coefficients on the standard deviation of industry sales growth, proxying for demand uncertainty, are positive and highly significant in three out of the four specifications, supporting Prediction 1(iii) and consistent with the intuition that the increase in the IPO firm’s aggressiveness is partially due to reduced risk aversion. In addition, consistent with Prediction 1(iv), the systematic proportion of the volatility of sales growth is negatively and significantly related to the post-IPO market share changes. The economic effects of demand uncertainty and its systematic component on sales growth are also substantial. An increase of one standard deviation in the volatility of industry sales growth (0.139 and 0.128 for NAICS and SIC classifications, respectively) is associated with an increase of 11–12 percentage points in one-year post-IPO market share growth and with a 17–19 percentage points

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20 In particular, the inflow of cash generated by the IPO can be used to increase production and sales of the newly public firm.

21 We obtain firms’ founding and incorporation years from Boyan Jovanovic’s website at http://www.nyu.edu/econ/user/jovanovic/.
increase in three-year market share growth. Increasing the systematic proportion of demand uncertainty by one standard deviation (4.86% and 4.39% for the two classifications) reduces market share growth by 12–14 percentage points.

In addition, smaller firms and firms with higher market-to-book ratios relative to those of their product market rivals gain more market share post-IPO than larger firms and firms with lower market-to-book ratios. The coefficients on relative age are negative in all four specifications, but age is significant only for one-year growth in NAICS-
classifications. Surprisingly, the coefficients on the issue rate variable in market share growth regressions are insignificant.²²

<table>
<thead>
<tr>
<th></th>
<th>One-year market share growth</th>
<th>Three-year market share growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAICS</td>
<td>SIC</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.151</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>(0.72)</td>
<td>(0.52)</td>
</tr>
<tr>
<td>Issue rate</td>
<td>-0.071</td>
<td>-0.340</td>
</tr>
<tr>
<td></td>
<td>(-0.20)</td>
<td>(-1.02)</td>
</tr>
<tr>
<td>Relative age</td>
<td>-0.124</td>
<td>-0.037</td>
</tr>
<tr>
<td></td>
<td>(-2.24)</td>
<td>(-0.68)</td>
</tr>
<tr>
<td>Relative size</td>
<td>-0.209</td>
<td>-0.107</td>
</tr>
<tr>
<td></td>
<td>(-3.87)</td>
<td>(-2.12)</td>
</tr>
<tr>
<td>Relative M/B</td>
<td>0.191</td>
<td>0.357</td>
</tr>
<tr>
<td></td>
<td>(1.78)</td>
<td>(2.84)</td>
</tr>
<tr>
<td>Absolute CSM</td>
<td>2.101</td>
<td>1.973</td>
</tr>
<tr>
<td></td>
<td>(2.04)</td>
<td>(1.68)</td>
</tr>
<tr>
<td>Standard deviation of sales growth</td>
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<td></td>
<td>(1.87)</td>
<td>(2.43)</td>
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<td></td>
<td>(-2.02)</td>
<td>(-2.39)</td>
</tr>
<tr>
<td>R-squared</td>
<td>4.57%</td>
<td>5.30%</td>
</tr>
<tr>
<td>Number of observations</td>
<td>1,777</td>
<td>1,799</td>
</tr>
</tbody>
</table>

4.3. Test of empirical prediction 2: product market rivals’ returns on IPO announcements

Next, we examine the effect of IPO announcements on the values of IPO firms’ product market rivals. According to Prediction 2, this effect is negative and its magnitude is positively related to the degree of competitive interaction and demand uncertainty, and it is negatively related to the systematic component of this uncertainty.

We obtain firms’ daily returns from the Center for Research in Security Prices (CRSP). To estimate competitors’ abnormal returns around IPO announcements, we use their betas from 60-month rolling-window firm-level market model regressions and subtract the product of estimated betas and daily market returns from firms’ daily returns.²³ We then calculate cumulative abnormal returns for the window [−1, 1], where day 0 is the IPO filing date.²⁴ Finally, we compute the weighted average return of all public firms in the newly public firm’s industry.²⁵

22 Because of industry and time clustering of IPOs, post-IPO change in a newly public firm’s market share could be affected by the contemporaneous IPOs of the firm’s product market rivals. To examine the robustness of the results in Table 2, we reestimate Eq. (26) using a subsample of IPOs that did not occur in hot IPO markets. We follow Helwege and Liang (2004) and Pástor and Veronesi (2005) and define hot IPO periods as months in which three-month moving average volume of IPOs belongs to the top quartile of IPO volume throughout our sample period. The coefficient estimates for the subsample of IPOs that occurred outside of hot markets are similar to those reported, albeit somewhat less statistically significant due to a smaller sample size.

23 Using the Fama and French (1993) three-factor model in defining abnormal returns leads to results that are similar to those reported below.

24 Using IPO announcement rivals’ returns over one-day or seven-day windows produces results similar to those reported below.

25 As is standard in the empirical literature (e.g., Hertzel, 1991; Song and Walkling, 2000; Fee and Thomas, 2004; and Shahru, 2005 among
This table presents panel regressions of raw and abnormal value-weighted three-day returns of firms operating in the IPO firm’s industry on the measures of competitive interaction, demand uncertainty, and its systematic component using a sample of 1,993 IPOs in years 1990–2008 in industries with competition in strategic substitutes. Three-day rivals’ raw (abnormal) return is the weighted average return during days $[-1,1]$, where day 0 is the IPO filing day, of all firms operating in the IPO firm’s industry. Abnormal returns are based on the market model. Issue rate is the ratio of the number of primary shares issued during the IPO to the number of shares outstanding pre-IPO. Market share is the ratio of the IPO firm’s sales in the year of the IPO to the sum of sales of all firms in its industry. We use both the North American Industry Classification System (NAICS) six-digit classification and the Standard Industrial Classification (SIC) four-digit classification to define industries. Absolute CSM is the measure of the degree of competitive interaction. Standard deviation of sales growth is the measure of demand uncertainty. Systematic proportion of sales growth is the measure of the systematic proportion of demand uncertainty. The construction of these measures is discussed in Subsection 4.1. The regressions are estimated using ordinary least squares. t-statistics, computed using standard errors clustered by industry and month, are presented in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>Three-day return</th>
<th>Three-day abnormal return</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAICS</td>
<td>SIC</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.161</td>
<td>0.298</td>
</tr>
<tr>
<td></td>
<td>(1.01)</td>
<td>(2.16)</td>
</tr>
<tr>
<td>Issue rate</td>
<td>0.069</td>
<td>−0.368</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(−1.34)</td>
</tr>
<tr>
<td>Market share</td>
<td>−1.088</td>
<td>−1.176</td>
</tr>
<tr>
<td></td>
<td>(−3.17)</td>
<td>(−3.22)</td>
</tr>
<tr>
<td>Absolute CSM</td>
<td>−0.728</td>
<td>−1.387</td>
</tr>
<tr>
<td></td>
<td>(−0.43)</td>
<td>(−0.91)</td>
</tr>
<tr>
<td>Standard deviation of sales growth</td>
<td>−1.216</td>
<td>−1.685</td>
</tr>
<tr>
<td></td>
<td>(−2.49)</td>
<td>(−3.32)</td>
</tr>
<tr>
<td>Systematic proportion of sales growth</td>
<td>0.697</td>
<td>1.376</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(1.99)</td>
</tr>
<tr>
<td>R-squared</td>
<td>1.39%</td>
<td>1.86%</td>
</tr>
<tr>
<td>Number of observations</td>
<td>1,472</td>
<td>1,538</td>
</tr>
</tbody>
</table>

The results of estimating Eq. (27) for raw and abnormal returns of rivals belonging to the IPO firms’ NAICS-based and SIC-based industries are presented in Table 3. Consistent with Prediction 2(iii), the coefficients on the measure of demand uncertainty are negative in all four specifications and are significant at 1% level in three specifications. An increase of one standard deviation in the demand uncertainty measure reduces the average rivals’ announcement return by 13–33 basis points. Consistent with Prediction 2(iv), the coefficients on the systematic proportion of demand uncertainty are positive in all four specifications and are significant in three of them. An increase of one standard deviation in the systematic proportion of demand uncertainty is associated with a 3–9 basis points increase in rivals’ announcement returns.

The data do not provide support for Prediction 2(ii) of a negative relation between the degree of competitive interaction and rivals’ announcement returns. The coefficients on the absolute value of the CSM are statistically insignificant in all four specifications. The IPO firm’s market share is significantly negatively related to rivals’ returns, consistent with IPOs by larger firms having more pronounced effects on product market rivals’ values. Finally, issue rates are not significantly related to rivals’ IPO announcement returns.

4.4. Test of empirical prediction 3: Proportion of public firms in an industry

To examine how the proportion of public firms in an industry is related to the degree of competitive interaction,
demand uncertainty, and its systematic component, we use the data on the number of firms in each six-digit NAICS industry in year 2006 provided by the US Census Bureau. We compute the number of public firms in each NAICS industry by counting all firms in the daily CRSP file having at least one non-missing return observation in 2006. As before, we restrict our attention to industries characterized by competition in strategic substitutes, i.e., those with a negative mean CSM.

Measuring the proportion of public firms in each industry is not straightforward. It follows from annual Compustat data that the mean (median) number of employees in a public firm was 1,141 (505) in 2006. At the same time, it follows from the Census data that the median number of employees in a private firm ranges between one and four for the vast majority of NAICS industries. Going public is a costly endeavor, preventing smaller firms from doing so. Therefore, in computing the proportion of public firms in each industry we concentrate on relatively large firms using two specifications. Namely, for each industry we compute the proportion of public firms among all firms with more than five hundred employees and the proportion of public firms among all firms with more than one hundred employees. Panel A of Table 2 shows that in an average (median) industry, public firms constitute 28% (21%) of all firms with more than five hundred employees and 13% (8%) of all firms with more than one hundred employees.

To examine the effects of the degree of competitive interaction, demand uncertainty, and its systematic component on the proportion of public firms in an industry, PROP_PUB, we estimate the regression

$$PROP_{PUB} = \alpha + \beta_1 CSM + \beta_2 g + \beta_3 s + \beta_4 r + \varepsilon_{ij}, \quad (28)$$

using a sample of 335 NAICS industries with negative CSM estimates. We generally follow Chemmanur, He, and Nandy (2010) in choosing the control variables in Eq. (28). Older industries with larger firms are expected to have higher proportions of public firms, and thus, we control for median age and median size of the firms in the industry. In addition, firms are more likely to choose public incorporation in industries with relatively abundant investment opportunities, particularly in high-tech industries. We proxy for the availability of investment opportunities by the median industry market-to-book ratio, and we follow Loughran and Ritter (2004) and Chemmanur, He, and Nandy (2010) and define a high-tech industry indicator equaling one for the following industries: computer hardware, communications equipment, electronics, navigation equipment, measuring and control devices, medical instruments, telephone equipment, communications services, and software.

The results of estimating Eq. (28) are presented in Table 4. Consistent with Prediction 3(i), the proportion of public firms in an industry is positively and very significantly related to the degree of competitive interaction in that industry, as follows from the coefficients on the absolute value of CSM in both specifications. The effect of the extent of competitive interaction on the proportion of public firms is also economically significant. Increasing the absolute value of CSM by one standard deviation raises the proportion of public firms among those with at least one hundred (five hundred) employees by 4 (2) percentage points. These numbers are substantial in comparison to the mean and median proportions of public firms reported in Panel A of Table 1.

Consistent with Predictions 3(ii) and 3(iii), the coefficients on the proxy for demand uncertainty are positive and significant at 10% level in both regression

<table>
<thead>
<tr>
<th></th>
<th>More than one hundred employees</th>
<th>More than five hundred employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.170</td>
<td>22.032</td>
</tr>
<tr>
<td></td>
<td>(1.88)</td>
<td>(2.71)</td>
</tr>
<tr>
<td>log (median age)</td>
<td>0.002</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.76)</td>
</tr>
<tr>
<td>log (median assets)</td>
<td>1.084</td>
<td>1.888</td>
</tr>
<tr>
<td></td>
<td>(2.05)</td>
<td>(2.92)</td>
</tr>
<tr>
<td>log (median M/B)</td>
<td>0.256</td>
<td>1.245</td>
</tr>
<tr>
<td></td>
<td>(1.87)</td>
<td>(2.43)</td>
</tr>
<tr>
<td>High-tech indicator</td>
<td>11.511</td>
<td>19.690</td>
</tr>
<tr>
<td></td>
<td>(3.47)</td>
<td>(3.18)</td>
</tr>
<tr>
<td>Absolute CSM</td>
<td>31.756</td>
<td>56.280</td>
</tr>
<tr>
<td></td>
<td>(3.33)</td>
<td>(3.64)</td>
</tr>
<tr>
<td>Standard deviation of sales growth</td>
<td>7.770</td>
<td>12.171</td>
</tr>
<tr>
<td></td>
<td>(1.71)</td>
<td>(1.85)</td>
</tr>
<tr>
<td>Systematic proportion of sales growth</td>
<td>-3.838</td>
<td>-6.452</td>
</tr>
<tr>
<td></td>
<td>(-3.15)</td>
<td>(-2.84)</td>
</tr>
<tr>
<td>R-squared</td>
<td>10.02%</td>
<td>9.04%</td>
</tr>
<tr>
<td>Number of observations</td>
<td>335</td>
<td>335</td>
</tr>
</tbody>
</table>

26 The Census data, which are available at http://www2.census.gov/econ/susb/data/2006/6digitnaics_2006.txt, contain six-digits NAICS industry-specific information on the total number of firms belonging to various brackets in terms of the number of employees. Annual snapshots of this kind are available for years 1998–2006. We report results only for the latest available data (from 2006). The results for all other years are similar and available upon request. We do not use the whole panel in the analysis because the total number of firms in an industry and the number of public firms in it exhibit very high autocorrelations.
specifications, whereas the coefficients on the proportion of systematic demand uncertainty are negative and highly significant in both specifications. A one standard deviation increase in demand uncertainty raises the proportion of public firms by 1.1–1.7 percentage points. Increasing the proportion of systematic demand uncertainty by one standard deviation is associated with a reduction of 0.2–0.3 percentage points in the proportion of public firms. The coefficients on control variables, with the exception of median age, are all significant and consistent with the underlying intuition. Industries with larger firms are more likely to have larger proportions of public firms, as do industries with abundant growth opportunities and, in particular, high-tech industries.

To sum up, the empirical evidence presented in Tables 2–4 is generally consistent with the implications of our model and allows us to distinguish it from existing theories of the going public decision. The degree of competitive interaction, demand uncertainty, and its systematic component have statistically significant and economically sizable effects on the evolution of newly public firms’ market shares, on their product market rivals’ reactions to IPO announcements, and on the proportions of public firms operating in various industries. The only exception is that our proxy for the extent of competitive interaction does not seem to have power in explaining product market rivals’ returns to IPO announcements.

5. Conclusions

This paper presents a model of the decision to go public in the presence of product market competition. Because going public facilitates shareholder diversification, public firms are less concerned with idiosyncratic profit variability than otherwise similar private firms. Under Cournot competition, this leads to greater product market aggressiveness of public firms, which, in turn, reduces the equilibrium aggressiveness of their competitors. This strategic benefit of IPO and, thus, firms’ incentives to go public and the equilibrium proportion of public firms in an industry increase in the degree of competitive interaction among firms in the product market.

Our model generates several testable empirical predictions. First, going public is expected to increase an IPO firm’s market share, and more so within industries characterized by stronger competitive interaction, larger demand uncertainty, and a smaller proportion of this uncertainty that is systematic. Second, going public is expected to adversely affect the values of an IPO firm’s product market rivals, and more so within industries characterized by stronger competitive interaction, larger demand uncertainty, and a smaller systematic proportion of this uncertainty. Finally, the proportion of public firms is expected to be higher in industries characterized by stronger competitive interaction, larger demand uncertainty, and a smaller systematic proportion of this uncertainty.

Most of these predictions are supported by the data. The degree of competitive interaction, demand uncertainty, and its systematic component generally have economically and statistically significant effects on newly public firms’ market shares and their product market rivals’ returns on IPO announcements, as well as on the proportion of firms choosing the public mode of incorporation.

Appendix A. Model calibration

In this Appendix, we examine whether an interior equilibrium, in which both public and private firms exist in the same industry, is likely to arise under reasonable parameter values. In principle, one could compute the threshold absolute risk aversion, $a_r$, for a given combination of model parameters and examine whether it lies within the range of coefficients of absolute risk aversion typical of entrepreneurs. There are two difficulties with this approach. First, determining the range of typical coefficients of absolute risk aversion requires estimating the distribution of wealth among entrepreneurs within each industry. Second, the value of $a_r$ depends on absolute (dollar) values of firms’ characteristics (e.g., variance of sales), which vary considerably across firms, making its estimation impractical.

We circumvent these difficulties by computing the coefficient of relative risk aversion $R^*$ that corresponds to the threshold coefficient of absolute risk aversion $a_r$, and we compare $R^*$ with the coefficients of relative risk aversion typical of entrepreneurs. The advantage of this approach is that there is less ambiguity regarding typical levels of relative risk aversion. In addition, the calibration of $R^*$ requires estimating only ratios, which exhibit considerably lower variation than do dollar variables.

Consider entrepreneur $n$, whose absolute risk aversion is $a_r$ and who is therefore indifferent between going public and staying private, i.e., $V_{pub}(N', n') = V_n(N', n')$. Let $R^*$ be the coefficient of this entrepreneur’s relative risk aversion, i.e.,

$$R^* = (V_{pub}(N', n') - w_0) a_r^{*},$$

where $w_0$ is the entrepreneur’s wealth outside the firm. To calibrate $R^*$, we rewrite Eq. (29) using parameters that can be estimated empirically.

Proposition 7. The coefficient of relative risk aversion given in Eq. (29) can be written as

$$R^* = \frac{m(2 - \gamma)/(\beta P/E)}{4\eta \delta (1 - \phi)(1 - \phi^2) CV_{sales}^2} \times \left( \sqrt{2 - \gamma} / \beta^2 + 8(1 - \phi) \gamma / \beta - 2 - \gamma / \beta + 4 \phi \right).$$

Whereas our stylized model assumes constant absolute risk aversion, in reality absolute risk aversion depends strongly on the individual’s wealth level. See Rabin (2000) for a detailed discussion. Friend and Blume (1975) estimate the relative risk aversion of investors to be between 2.21 and 2.39. The empirical estimates of relative risk aversion reported in the survey by Meyer and Meyer (2005) range between 1 and 7.03. Heaton and Lucas (2001) calibrate their model with the relative risk aversion of entrepreneurs ranging between 0.5 to 5.

For example, while the absolute risk aversion $a_r$ depends on the variance of sales, the corresponding relative risk aversion $R^*$ depends on the coefficient of variation of sales, which exhibits smaller variation across firms.
where

\[
\eta = \frac{\mathbb{E}[q_i, p_i]}{\mathbb{E}[p_i, q_i]} = \frac{1}{\beta} \frac{p_{pub}}{q_{pub}}
\]  
(31)

is the expected price elasticity of demand,

\[
CV_{sales} = \sqrt{\mathbb{V}[ar(p_{pub}q_{pub})]} \]

(32)

is the coefficient of variation of sales,

\[
m = \frac{\mathbb{E}[p_{pub}]}{\mathbb{E}[p_{pub}, q_{pub}]}
\]

(33)

is the ratio of expected profit to expected sales,

\[
P/E = \frac{V_{pub}}{\mathbb{E}[p_{pub}]}
\]

(34)

is the price-to-earnings ratio, and

\[
\delta = \frac{V_{ar}}{V_{ar} + w_0} = \frac{V_{pub}}{V_{pub} + w_0}
\]

(35)

is the value of firm n as a fraction of the total net worth of entrepreneur n, where all variables are evaluated at Nn and qn.

When written as in Eq. (30), the relative risk aversion of the “threshold entrepreneur” can be calibrated using publicly available data. The base-case values of \(m, P/E, CV_{sales},\) and \(\rho\) are based on the US economy-wide averages computed from Compustat data. In particular, mean profit margin, defined as the ratio of operating profit to sales, is used as a proxy for \(m\). It equals 0.35 during our sample period. Mean price-to-earnings ratio, defined as end-of-year share price divided by annual earnings per share, is close to 10.\(^{30}\) We compute the coefficient of variation of detrended annual sales for each firm in the sample with at least ten annual sales observations during our sample period and average these coefficients of variation across firms. This results in the average \(CV_{sales}\) of 0.45.\(^{31}\) We use the estimated mean systematic proportion of the variance of quarterly sales growth of 0.05 as a proxy for \(\rho^2\), as discussed in Section 4.

The value of \(\delta\) is based on Moskowitz and Vissing-Jørgensen (2002), who estimate the mean percentage of net worth invested in private equity for households with positive private equity and net worth to be 41.1%, out of which 82% on average is invested in one actively managed firm. This corresponds to \(\delta = 0.34\). Because the entrepreneur might not own the entire firm, the actual \(\delta\) could be somewhat higher. The price elasticity of demand \(\eta\) varies widely among industries. For example, Taylor and Weerapana (2009) report that typical values of \(\eta\) range from 0.1 for phone services to 2.6 for jewelry. Finally, we set the cost of going public \(\phi\) at 0.07, reflecting the typical underwriting spread (e.g., Chen and Ritter, 2000).

In Fig. A1, we plot \(R^*\) as a function of the degree of competitive interaction \(\gamma \in (0, \beta)\), or equivalently as a function of \(\gamma / \beta \in (0, 1)\) for the following base-case parameter values: \(m = 0.35\), \(P/E = 10\), \(\eta = 1.5\), \(\delta = 0.5\), \(CV_{sales} = 0.45\), \(\rho^2 = 0.05\), and \(\phi = 0.07\). In each graph, we indicate the base-case by the thick line and vary the various model parameters as follows: \(m \in (0.2, 0.5)\), \(P/E \in (7, 13)\), \(\eta \in (0.6, 2.4)\), \(\delta \in (0.2, 0.8)\), \(CV_{sales} \in (0.3, 0.6)\), and \(\rho^2 \in (0.0, 5)\).

For the base-case parameter values, the degree of relative risk aversion of the entrepreneur who is indifferent between taking her firm public and keeping it private, \(R^*\), varies between 1.2 and 3.65 as the degree of competitive interaction \(\gamma\) varies between 0 and \(\beta\). While there is no complete agreement on the degree of risk aversion for the typical entrepreneur, these values of \(R^*\) are of the same magnitude as the empirical estimates of relative risk aversion reported in the literature (See footnote 27). Therefore, given the heterogeneity of risk aversion among individuals, there are likely to be entrepreneurs with relative risk aversions below as well as above \(R^*\), resulting in an interior equilibrium in which both public and private firms exist.

Appendix B. Summary of notation and comparative statics

Appendix C. Proofs

To simplify notation, we let \(\sigma_X^2 = \mathbb{V}[ar(X)] = \sigma^2(1 - \rho^2)\) and \(\sigma_X^2 = \mathbb{V}[ar(Y)] = \sigma^2 \rho^2\).

Proof of Lemma 1. First we prove, by contradiction, that among pure-strategy equilibria, only symmetric ones, in which all public firms produce the same quantity, can exist. Suppose there are two public firms, \(i\) and \(j\), which produce different equilibrium quantities, \(q_i \neq q_j\). Because \(q_i\) maximizes firm \(i\)’s objective function given in Eq. (10), it must satisfy the first-order condition

\[
\pi - 2\beta q_i - \gamma q_i - \gamma \sum_{k \neq i, k \neq j} q_k - c = 0.
\]

(36)

The fact that \(q_i \neq q_j\) together with Eq. (36) gives

\[
\pi - 2\beta q_i - \gamma q_i - \gamma \sum_{k \neq i, k \neq j} q_k - c \neq 0.
\]

(37)

Hence, \(q_i\) does not satisfy the first-order condition for maximizing firm \(j\)’s objective function and thus cannot be firm \(j\)’s equilibrium output. Therefore, our premise that \(q_i \neq q_j\) is false, and the outputs of all public firms in any equilibrium, if it exists, must be equal.

The equilibrium output vector \(q(N, n)\) defined in Eq. (11) is given by the first-order conditions

\[
\frac{\mathbb{E}[V_i(q)]}{\mathbb{E}[q_i]} = 0 \quad \Leftrightarrow \quad \pi - 2\beta q_i - \gamma \sum_{j \neq i} q_j - c = 0 \quad \text{for } i = 1, \ldots, n,
\]

(38)

and

\[
\frac{\mathbb{E}[V_i(q)]}{\mathbb{E}[q_i]} = 0 \quad \Leftrightarrow \quad \pi - (2\beta + a_i \sigma_i^2) q_i - \gamma \sum_{j \neq i} q_j - c = 0 \quad \text{for } i = n + 1, \ldots, N.
\]

(39)

Please cite this article as: Chod, J., Lyandres, E., Strategic IPOs and product market competition. Journal of Financial Economics (2010), doi:10.1016/j.jfineco.2010.10.010
Because each firm's objective is strictly concave in its output, the first-order conditions are sufficient, i.e., any \( q \) that satisfies Eqs. (38) and (39) is an equilibrium. Taking advantage of the equilibrium symmetry, we denote the equilibrium output of each public firm as \( q_{\text{pub}}^* \). Because the equilibrium output of each private firm depends on its owner's risk aversion, we continue to denote the equilibrium output of private firm \( i \) as \( q_i^* \). Thus, the equilibrium conditions given in Eqs. (38) and (39) can be written as

\[
\frac{m}{c_0} - \frac{2}{b_0} g_0 q_{\text{pub}} \frac{Q}{c_0} = 0, \tag{40}
\]

and

\[
\frac{m}{c_0} - \frac{2}{b_0} g_0 + a_i \frac{Q}{c_0} = 0 \quad \text{for} \quad i = n+1, \ldots, N, \tag{41}
\]

where \( Q = nq_{\text{pub}} + \sum_{i=n+1}^N q_i \) is the total industry output. It is straightforward to show that the system of Eqs. (40) and (41) has a unique solution, which is given in Eqs. (12) and (13). Plugging Eqs. (12) and (13) into Eq. (10) produces Eqs. (15) and (16).

**Proof of Proposition 1.** (i) The result follows directly from Lemma 1.

(ii) Differentiating \( q_i^* \) given in Eq. (12) with respect to \( a_i \) gives

\[
\frac{\partial q_i^*}{\partial a_i} = \left( \frac{m}{c_0} - \frac{2}{b_0} g_0 \right) \gamma - \left( 1 + \gamma \left( \sum_{j=n+1}^N (2\beta - \gamma + a_j \sigma_j^2)^{-1} \right) \right) (2\beta - \gamma + a_i \sigma_i^2) < 0.
\]

Differentiating \( Q^* \) given in Eq. (14) with respect to \( a_i \) gives

\[
\frac{\partial Q^*}{\partial a_i} = -\frac{\gamma - \left( 1 + \gamma \left( \sum_{j=n+1}^N (2\beta - \gamma + a_j \sigma_j^2)^{-1} \right) \right) (2\beta - \gamma + a_i \sigma_i^2)}{1 + \gamma \left( \sum_{j=n+1}^N (2\beta - \gamma + a_j \sigma_j^2)^{-1} \right)} < 0,
\]

and, therefore, \( \frac{\partial q_{\text{pub}}}{\partial a_i} > 0 \) and \( \frac{\partial q_i^*}{\partial a_i} > 0 \) for any \( j \neq i \).

---

**Fig. A1.** The threshold relative risk aversion \( R^* \) as a function of the ratio of the degree of competitive interaction, \( \gamma \), and slope of demand function, \( \beta \), for different levels of model parameters. See Table B1 for parameter definitions. The thick lines indicate the base-case.
\[
\left(\frac{\partial q_{\text{pub}}}{\partial \gamma}\right) = (\Pi - c) \left(1 - \frac{n^2}{2(\beta - \gamma + a_i \sigma_k^2)} - \frac{N - n + 1}{2(\beta - \gamma + a_i \sigma_k^2)} \frac{\gamma n a_i \sigma_k^2}{(2\beta - \gamma)} \frac{n}{2(\beta - \gamma)} < 0 \right.
\]

Because \((2\beta - \gamma)/(2\beta - \gamma + a_i \sigma_k^2(1 - \rho^2))\) decreases in \(\gamma\) for any \(j\), the combined market share of public firms given in Eq. (46) increases in \(\gamma\). (iii) Differentiating \(q_{\text{pub}}^*\) and \(q_j^*\) with respect to \(\gamma\) gives

\[
\frac{\partial q_{\text{pub}}^*}{\partial \gamma} = \frac{2(\beta - \gamma) - a_i \sigma_k^2}{2(\beta - \gamma + a_i \sigma_k^2)} - \frac{1}{2(\beta - \gamma + a_i \sigma_k^2)} \left(\sum_{i=1}^{N} \gamma n a_i \sigma_k^2 \frac{n}{2(\beta - \gamma)}\right)
\]

The combined market share of public firms is

\[
\frac{n q_{\text{pub}}^*}{Q^*} = \frac{n}{\sum_{i=n+1}^{N} \frac{g_i^* + 1}{2(\beta - \gamma + a_i \sigma_k^2(1 - \rho^2))}} + n
\]

Proof of Proposition 2. Suppose, without loss of generality, that it is firm \(n + 1\) that goes public.

(i) To show that when firm \(n + 1\) goes public, its output increases, we need to show that \(q_{\text{pub}}^*(N,n+1) > q_{\text{pub}}^*(N,n)\), which is the case if, and only if,

\[
\frac{\partial q_{\text{pub}}^*}{\partial \gamma} = (\Pi - c) \left(1 - \frac{n^2}{2(\beta - \gamma + a_i \sigma_k^2)} - \frac{N - n + 1}{2(\beta - \gamma + a_i \sigma_k^2)} \frac{\gamma n a_i \sigma_k^2}{(2\beta - \gamma)} \frac{n}{2(\beta - \gamma)} < 0 \right.
\]

which clearly holds.

To prove that the output of all other firms decreases, we need to show that \(q_{\text{pub}}^*(N,n+1) < q_{\text{pub}}^*(N,n)\) and \(q_j^*(N,n+1) < q_j^*(N,n)\) for all \(i \neq n + 1\), both of which follow directly from Lemma 1.

(ii) The market share of the IPO firm before going public is

\[
M_{n+1}(N,n) = \frac{q_{n+1}^*(N,n)}{Q^*(N,n)} = \frac{1}{(2\beta - \gamma + a_i \sigma_k^2(1 - \rho^2))} \left(\sum_{i=n+1}^{N} (2\beta - \gamma + a_i \sigma_k^2) - 1 + \frac{n}{2(\beta - \gamma)}\right)
\]

The market share of the IPO firm after going public is

\[
M_{\text{pub}}(N,n+1) = \frac{q_{\text{pub}}^*(N,n+1)}{Q^*(N,n+1)} = \frac{1}{(2\beta - \gamma + a_i \sigma_k^2(1 - \rho^2))} \left(\sum_{j=n+1}^{N} (2\beta - \gamma + a_i \sigma_k^2) - 1 + \frac{n-1}{2(\beta - \gamma)}\right)
\]
Table 8.2
Summary of comparative statics.
A plus (minus) sign denotes a positive (negative) effect of the parameter on the variable.

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Output of private firm</th>
<th>Output of any firm other than i</th>
<th>Total market share of public firms</th>
<th>Value of private firm</th>
<th>Value of any firm other than i</th>
<th>Ratio of public firm value to private firm value</th>
<th>Relative decrease in the value of the IPO firm's competitors</th>
<th>Proportion of public firms in industry</th>
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<td>Proposition 2</td>
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<tr>
<td>Proposition 6</td>
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</tr>
</tbody>
</table>

\[ \frac{\partial V_i^V}{\partial \gamma} = \frac{q_i \sigma_i^2 (\pi - c)}{2} \]

Proof of Proposition 3. (i) The result follows directly from Lemma 1.

(ii) We have

\[ \frac{\partial V_i^V}{\partial \gamma} = \frac{q_i \sigma_i^2 (\pi - c)}{2} \]

Thus, the relative increase of the IPO firm’s market share equals

\[ M_{\text{pub}}(N,n+1) - M_{\text{pub}}(N,n) \]

\[ = \frac{(2\beta - \gamma + a_{n+1} \sigma_i^2) \left( \sum_{j=n+2}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n+1}{2\beta - \gamma} \right)}{(2\beta - \gamma) \left( \sum_{j=n+2}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n+1}{2\beta - \gamma} \right)} \]

\[ = \frac{\left( \sum_{j=n+2}^{N} 2\beta - \gamma + a_j \sigma_j^2 \right) + \frac{n+1}{2\beta - \gamma}}{\left( \sum_{j=n+2}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n+1}{2\beta - \gamma} \right)} > 0. \]

(iii) Differentiating Eq. (51) with respect to \( \sigma^2 \) gives

\[ \frac{\partial}{\partial \sigma^2} M_{\text{pub}}(N,n+1) - \frac{\partial}{\partial \sigma^2} M_{\text{pub}}(N,n) = (1 - \rho^2) a_{n+1} \frac{n+1}{2\beta - \gamma} \left( \sum_{j=n+2}^{N} 2\beta - \gamma + a_j \sigma_j^2 \right) + (1 - \rho^2) a_{n+1} \frac{n+1}{2\beta - \gamma} \left( \sum_{j=n+2}^{N} 2\beta - \gamma + a_j \sigma_j^2 \right) \]

\[ > 0. \]

Proof of Proposition 3. (i) The result follows directly from Lemma 1.

(ii) We have

\[ \frac{\partial V_i^V}{\partial \gamma} = \frac{q_i \sigma_i^2 (\pi - c)}{2} \]

\[ = \frac{(2\beta + \gamma + a_i \sigma_i^2) \left( \sum_{j=n+1}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n}{2\beta - \gamma} \right)}{(2\beta - \gamma + a_i \sigma_i^2)^2 \left( \sum_{j=n+1}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n}{2\beta - \gamma} \right)^2} > 0. \]

We know from Proposition 1(ii) that the output of any firm \( j \neq i \) increases in \( a_i \). Hence, it follows from Eqs. (15) and (16) that the value of any firm \( j \neq i \) increases in \( a_i \) as well.

(iii) We know from Proposition 1(iii) that the output of any firm decreases in \( \gamma \). Hence, it follows from Eqs. (15) and (16) that the value of any firm decreases in \( \gamma \) as well. The relative benefit of being public,

\[ \frac{V_i^V}{V_i^V} = \frac{2\beta + a_i \sigma_i^2 (1 - \rho^2)}{2\beta + \rho^2 (1 - \rho^2)} \frac{1}{2\beta - \gamma} \]

clearly increases in \( \gamma \).

Proof of Proposition 3. (i) The result follows directly from Lemma 1.

(ii) We have

\[ \frac{\partial V_i^V}{\partial \gamma} = \frac{q_i \sigma_i^2 (\pi - c)}{2} \]

\[ = \frac{(2\beta + \gamma + a_i \sigma_i^2) \left( \sum_{j=n+1}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n}{2\beta - \gamma} \right)}{(2\beta - \gamma + a_i \sigma_i^2)^2 \left( \sum_{j=n+1}^{N} (2\beta - \gamma + a_j \sigma_j^2)^{-1} + \frac{n}{2\beta - \gamma} \right)^2} > 0. \]

We know from Proposition 1(ii) that the output of any firm \( j \neq i \) increases in \( a_i \). Hence, it follows from Eqs. (15) and (16) that the value of any firm \( j \neq i \) increases in \( a_i \) as well.

(iii) We know from Proposition 1(iii) that the output of any firm decreases in \( \gamma \). Hence, it follows from Eqs. (15) and (16) that the value of any firm decreases in \( \gamma \) as well. The relative benefit of being public,

\[ \frac{V_i^V}{V_i^V} = \frac{2\beta + a_i \sigma_i^2 (1 - \rho^2)}{2\beta + \rho^2 (1 - \rho^2)} \frac{1}{2\beta - \gamma} \]

clearly increases in \( \gamma \).
Proof of Proposition 4. Suppose, without loss of generality, that it is firm \( n+1 \) that goes public.

(i) We first show that the value of the IPO firm increases, i.e., \( V^*_{n+1} (N, n+1) > V^*_{n+1} (N, n) \). Using Lemma 1, this inequality can be written as

\[
\frac{\partial}{\partial \rho^2} \frac{V^*_{n+1}}{V^*_{n+1}} < 0. \tag{58}
\]

(ii) The relative increase in the IPO firm value equals the fact that the values of public and private rivals of the IPO firm increase in the value of public rival of the IPO firm is decreasing in \( g \)

\[
\frac{q^*_n (N, n+1)}{q^*_n (N, n)} = 1 - \left( \frac{q^*_n (N, n+1)}{q^*_n (N, n)} \right)^2, \tag{67}
\]

and

\[
\frac{V^*_n (N, n) - V^*_n (N, n+1)}{V^*_n (N, n)} = 1 - \left( \frac{q^*_n (N, n+1)}{q^*_n (N, n)} \right)^2, \tag{68}
\]

respectively. Thus, to show that the expressions given in Eqs. (67) and (68) are increasing in \( g \), it is enough to show that \( q^*_n (N, n+1) / q^*_n (N, n) \) is decreasing in \( g \). Given that

\[
\frac{q^*_n (N, n+1)}{q^*_n (N, n)} = \frac{2 + a \frac{\gamma}{2 \beta - \gamma}}{2 + a \frac{\gamma}{2 \beta - \gamma}} 
\]

we have

\[
\frac{\partial}{\partial \gamma} \left( \frac{q^*_n (N, n+1)}{q^*_n (N, n)} \right) = \frac{\partial}{\partial \gamma} \left( \frac{2 + a \frac{\gamma}{2 \beta - \gamma}}{2 + a \frac{\gamma}{2 \beta - \gamma}} \right), \tag{69}
\]

where

\[
A = \sum_{j=n+2}^{N} \frac{1}{(2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma})^2}, \tag{64}
\]

\[
B = \sum_{j=n+2}^{N} \frac{1}{(2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma})^2}, \tag{65}
\]

and

\[
C = \sum_{j=n+2}^{N} \frac{q^*_j (N, n+1)}{(2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma})^2}, \tag{66}
\]

Clearly, \( (\partial / \partial \gamma) q^*_n (N, n+1) / q^*_n (N, n) > 0 \), which implies that \( (\partial / \partial \gamma) q^*_n (N, n+1) / q^*_n (N, n) > 0 \) as well.

The relative decrease in the value of a public and a private rival of the IPO firm is

\[
\frac{V^*_n (N, n) - V^*_n (N, n+1)}{V^*_n (N, n)} = 1 - \left( \frac{q^*_n (N, n+1)}{q^*_n (N, n)} \right)^2, \tag{67}
\]

and

\[
\frac{V^*_n (N, n) - V^*_n (N, n+1)}{V^*_n (N, n)} = 1 - \left( \frac{q^*_n (N, n+1)}{q^*_n (N, n)} \right)^2, \tag{68}
\]

respectively. Thus, to show that the expressions given in Eqs. (67) and (68) are increasing in \( g \), it is enough to show that \( q^*_n (N, n+1) / q^*_n (N, n) \) is decreasing in \( g \). Given that

\[
\frac{q^*_n (N, n+1)}{q^*_n (N, n)} = \frac{1 + \sum_{j=n+2}^{N} \frac{\gamma}{2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma}} + \sum_{j=n+2}^{N} \frac{\gamma}{2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma}} + \frac{3 \gamma}{2 \beta - \gamma}}{1 + \sum_{j=n+2}^{N} \frac{\gamma}{2 \beta - \gamma + a \frac{\gamma}{2 \beta - \gamma}} + \sum_{j=n+2}^{N} \frac{\gamma}{2 \beta - \gamma}}. \tag{69}
\]

Please cite this article as: Chod, J., Lyandres, E. Strategic IPOs and product market competition. Journal of Financial Economics (2010), doi:10.1016/j.jfineco.2010.10.010
we have
which is clearly negative.

(iii) Differentiating the relative increase in the IPO firm’s value given in Eq. (61) with respect to \( \sigma^2 \) gives

\[
\frac{\partial}{\partial \sigma^2} \left( \frac{V^*_\text{pub}(N,n+1)-V^*_n(N,n)}{V^*_n(N,n)} \right)
= \frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
= \left(1-\rho^2\right)^2 \frac{a_{n+1}}{2\beta\left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2}
\]

\[
\left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 \frac{\partial q^*_\text{pub}(N,n+1)}{\partial \sigma^2} + \frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
\]

\[
\left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 \frac{\partial q^*_\text{pub}(N,n+1)}{\partial \sigma^2} + \frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
\]

\[
= 0.
\]

Using Eq. (62), we have

\[
\frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
\]

which is clearly negative.

(iv) The relative increase in the IPO firm’s value given in Eq. (61), and the relative decrease in the values of public and private rivals of the IPO firm given in Eqs. (67) and (68) are all decreasing in \( \rho^2 \) because they are increasing in \( \sigma^2 \) [as shown in part (iii)] and because \( \sigma^2 \equiv \sigma^2(1-\rho^2) \).

Proof of Proposition 5. We first show, by contradiction, that in any equilibrium where firm \( i \) is public and firm \( j \) is private, we must have \( i<j \). Suppose that firm \( i \) is public, firm \( j \) is private, and \( i>j \). Because firm \( i \) is public, we have \( (1-\phi)\mu^*_\text{pub} > \mu^*_j \). The fact that \( i>j \) implies \( \mu^*_i < \mu^*_j \), which in turn implies \( \mu^*_i > \mu^*_j \). Thus, \( (1-\phi)\mu^*_\text{pub} > \mu^*_j \) and firm \( j \) has an incentive to go public, which is a contradiction with the industry being in equilibrium. Therefore, in any equilibrium, firm \( i \) is public if \( i<n^* \), and it is private if \( i>n^* \).

Before we address each of the three cases (i)-(iii), it is useful to establish several facts. We define \( f(n) \equiv (1-\phi)\mu^*_\text{pub}(N,n)-\mu^*_n(N,n) \) so that the equilibrium condition given in Eq. (23) can be written as \( f(n)=0 \). Because

\[
f(n) = \frac{(\pi(\pi-c)^2}{(1+n)\sum_{i=1}^{n} \frac{\partial q^*_\text{pub}(N,n+1)}{\partial \sigma^2}} + \frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
\]

\[
= 0.
\]

Using Eqs. (62) and (73), the desired inequality given in Eq. (72) becomes

\[
a_{n+1} \left(2\beta+\gamma+\gamma_2\right) + \gamma_2(n) \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 + \gamma_2(n) \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 + \gamma_2(n) \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2
\]

\[
+b_{n+1} \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 + \gamma_2(n) \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2 + \gamma_2(n) \left(2\beta+\alpha_2 \gamma+\gamma_2\right)^2
\]

which is clearly satisfied. Therefore, \( (\partial/\partial \sigma^2)(\mu^*_\text{pub}(N,n+1)-\mu^*_n(N,n)) > 0 \).

To prove that the relative decreases in the values of a public and a private rivals of the IPO firm given in Eqs. (67) and (68) are increasing in \( \sigma^2 \), we need to show that \( q^*_\text{pub}(N,n+1)/q^*_n(N,n) \) is decreasing in \( \sigma^2 \). Differentiating Eq. (69) with respect to \( \sigma^2 \) gives

\[
\frac{\partial}{\partial \sigma^2} \left( \frac{q^*_\text{pub}(N,n+1)}{q^*_n(N,n)} \right)
\]

which is clearly negative.
Proof of Proposition 6. The result follows from the facts that $\partial \alpha / \partial \gamma < 0$, $\partial \gamma / \partial \sigma > 0$, and $n$ decreases in $\alpha$. \hfill $\square$

Proof of Proposition 7. In what follows, we suppress the equilibrium notation while recognizing that all variables are evaluated at $N^*$, $n^*$ and $q^*$. Using Eq. (24), the relative risk aversion of entrepreneur $n$ given in Eq. (29) can be written as

$$R^* = \frac{q_{pub}^2(2-\gamma/\beta)}{4\eta(1-\phi)^2(1-\phi)^2} \left( \sqrt{(2-\gamma/\beta)^2 + 8(1-\phi)/\beta - 2-\gamma/\beta + 4\phi} \right).$$

(77)

where $\delta$ is given by Eq. (35). Realizing that $q_{pub}^2 = \text{Var}(q_{pub}p_{pub})$, this can be further rewritten as

$$R^* = \frac{q_{pub}^2/V_{pub}(2-\gamma/\beta)}{4\eta(1-\phi)^2(1-\phi)^2} \left( \sqrt{(2-\gamma/\beta)^2 + 8(1-\phi)/\beta - 2-\gamma/\beta + 4\phi} \right).$$

(78)

where $\eta$ is given by Eq. (31), $CV_{sales}$ is given by Eq. (32), $m$ is given by Eq. (33), and $P/E$ is given by Eq. (34) as stipulated in Proposition 7. \hfill $\square$

References


Please cite this article as: Chod, J., Lyandres, E., Strategic IPOs and product market competition. Journal of Financial Economics (2010), doi:10.1016/j.jfineco.2010.10.010