The IPO spread and conflicts of interests

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Abstract

The level of the IPO spread taken by the underwriter is a controversial issue. Some claim that the level is too high and attributes it to collusion between investment banks while others contend to the contrary. The paper examines the spread in the framework of conflicts of interests between the issuer, the underwriter and the informed investor. The argument is developed, based upon incentives for the underwriter. It is shown that the issuer should have the spread large enough for the underwriter to stay faithful to the issuer.

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1 Introduction

There is a controversy regarding the fact that in US initial public offerings(IPOs) there is a strong concentration of the spread around 7 per cent. Chen & Ritter (2000) argue that the level of the spread is above the competitive one as a result of collusion between investment banks. To the contrary, Hansen (2001) contends that the IPO market is unconcentrated and entry into the market is strong and the seven percent contract has persisted despite the Department of Justice investigation arguing strongly against collusion.

This paper examines the spread received by the underwriter in the context where there are conflicts of interests between the issuer, the underwriter and the informed investor and shows that it is against the issuer's interest to seek a low spread. An IPO has many facets, including the issue price, marketing of the issue and analyst coverage. If negotiation on the spread is not advantageous, the issuer tries to get better terms on the other dimensions with the underwriter.

Baron (1982) and Baron & Holmstrom (1980) analysed the issuer's optimal incentive contract in the context where there were an issuer and an underwriter, who had better information than the former. Benveniste & Spindt (1989) and Benveniste & Wilhelm (1990) studied the situation in which there were an issuer, an underwriter, informed investors, and uninformed investors. The underwriter was assumed to behave totally on the issuer's behalf. Biais, Bossaerts & Rochet (2002) investigated the issuer's optimal contract in the context where there were an issuer, uninformed investors and a party which is a coalition of an underwriter and informed investors.

Although the approaches of those studies are different from each other, one common feature is that they considered as separate entities only two of the three parties—the issuer, the underwriter and the informed investor— either neglecting one party for simplicity or uniting it with another as if they pursued common interests by forming a coalition. Baron (1982) and Baron & Holmstrom (1980) only considered the issuer and the underwriter. Benveniste & Spindt (1989) and Benveniste & Wilhelm (1990) assumed that the underwriter was the issuer's faithful delegate. Biais et al. (2002), on the other hand, supposed that the underwriter was allied with the informed investor.

In reality, the issuer, the underwriter and informed investors are separate entities. They each pursue their own profits often conflicting with one other. Indeed, if the IPO is priced too high, the underwriter alienates investors although it pleases the issuer; on the other hand, if the shares are underpriced, the underwriter estranges the issuer. In general, the underwriter is in a delicate position between incongruous interests of the issuer and investors. The present paper attempts to shed light on the effect of the conflicts on the determination of the spread.

In order to introduce the feature of tripartite conflicts into analysis, the present paper takes an approach of contract delegation. The first time issuer has relatively little expertise in financial affairs. It lacks the ability to organise the IPO, which involves information gathering, information offering, advertising, pricing and so forth. The issuing firm delegates the whole IPO procedure to an underwriter and pays the latter a commission of a fixed rate per share price, as done in practice. The underwriter has as a seasoned financial institution ample knowledge of the financial market to collect and analyse information possessed by informed investors and estimate the market valuation of shares to be issued. In full charge of the IPO procedure, the underwriter decides upon the quantity allocation and the price to maximise its own profit.

The question, then, necessarily arises what the underwriter's profit consists of. The underwriter naturally receives a spread as compensation for its services. Were it not for other sources of profit, the underwriter would conduct itself as the issuer's faithful representative. And the situation boils down to that of Benveniste & Spindt (1989) and Benveniste & Wilhelm (1990). However, there is strong reason that it makes other sources of profits, especially through underpricing. Biais et al. (2002), for instance, suppose that the underwriter colludes with informed investors with whom it deals on the regular basis. To put it another way, it benefits from their favourable treatment in the IPO. Indeed, it has been alleged that in return for favourable treatment in allocation and underpricing, institutional investors accept high commissions in regular share trade with the underwriter(Loughran & Ritter (2002)).

Further, the recent deregulation of the financial sector has permitted banks to underwrite IPOs and at the same time acquire an investment house as their affiliate. If allowed to allot IPO shares to its affiliate, then the bank underwriter is able to allocate the shares and set the price in such a way that the affiliate—tantamount to the underwriter itself— can make profits by buying IPO shares and selling them on the aftermarket.

The underwriter faces a trade-off of two opposite interests, those of the issuer and the investors. If attracted by commission earnings, the underwriter sets a high issue price, which benefits the issuer but as much harm to investors. If attracted more by the return from benefiting investors, the issuer underprices IPO shares so that investors are content. There is in general a discrepancy of interests between the underwriter, the issuer and the investors.

In the United States, there are no definite legal restrictions as to how IPO shares are allocated to subscribers by the underwriter. Nor is the underwriter bound to report upon the share allotment afterwards.[1] Besides, as mentioned above, the recent reforms of financial markets provide the underwriter with more and more margin for its strategic share allocation. The IPO procedure, especially the allocation and the pricing of shares, is for the most part left to the discretion of the underwriter.

The present paper examines what role the spread plays in the context of conflicts of interest and the low spread may encourage the underwriter to greater underpricing.

The remainder of the article is organised as follows. In the next section, the parties involved are briefly presented. In section 3, the model is formally presented. Section 4 sets up the problem as the underwriter's mechanism design. Section 5 concludes the paper.

2 The players

There are three players in the model: a firm, an underwriter, an informed investor.[2] The firm wants to sell a fixed amount of shares on the market for the first time. This firm or issuer is assumed to be unable to do this by itself; the initial public offering requires marketing, allotting, and the pricing of shares to be issued, and demands a lot of expertise that the first time issuer does not usually have. Here the underwriter comes in.

The underwriter, which has great experience and expertise as a seasoned financial institution, takes on the task of organising the IPO. It markets, prices and distributes IPO shares to subscribers. In reality, the syndicate of underwriters is often formed by several financial institutions but we assume here that there is only one underwriter.

The informed, often called the "regular", investor is a large investor such as an investment bank, a broker or a securities firm which has great expertise on the financial market. Such an investor may well have some information on the post-offering market valuation of IPO equity. The underwriter gets in touch with this investor to seek information during the registration period.

In fact, the underwriter here is meant to be either a coalition of the underwriter and its affiliated investment bank or an alliance of the underwriter and its "friendly" investors.[3] As explained in the introduction, the underwriter may have institutional

[1] Hanley & Wilhelm (1995) is the pioneering study of how underwriters distribute shares. Of late, Cornelli & Goldreich (2001) and Cornelli & Goldreich (2002) further advance this investigation.

[2] The term "subscriber" is sometimes used interchangeably below with "investor".

[3] Note that the "friendly" investors are completely different entities from the informed investors

customers to which it is in its interest to do a favour in share allocation because it can expect profits later in return. Here we make the simplifying assumption that the underwriter considers their profits from the IPO to be like its own in the same way as it regards the profits of the affiliated investment bank as its own. The underwriter sets the price and allocates shares among the underwriter coalition, the informed investor and maximises the coalition's profits.[4] From now on, we shall refer to the underwriter coalition as simply the "underwriter" . Likewise, strictly speaking, the underwriter allocates shares to the "friendly" investors or the affiliated investment house but in the following we shall merely say by a slight abuse of language, "the underwriter buy shares for itself, allots shares to itself" and so forth.

The following informational structure is assumed. The issuer reveals all its information to the underwriter in respect of the share value.[5] The underwriter reveals to the informed investor all information provided by the issuer and its own information. The informed investor has private information unobservable by the other parties. Consequently, in this model only the informed subscriber possesses private information.

The issuer in this model is rather unsophisticated. It delegates the whole IPO procedure to the underwriter and pays a fixed percentage of the per share price as a spread.[6] Fully designated to organise the whole IPO process, the underwriter decides upon the quantity allocation and the price of the shares while seeking the informed subscriber's private information.

In fact, since the underwriter might obtain the private information possessed by the informed subscriber, the issuer may as well try to make the underwriter reveal the information by the construction of an incentive commission scheme. However, this article does not consider such a sophisticated issuer. Usually, the first time issuer has not acquired so much experience in financial affairs that it can deal with complicated IPO procedures. It will be very difficult for such an issuer to build an optimal commission schedule while dealing with the underwriter which is a longstanding, much practised, financial institution.

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already considered.

[4]It is assumed of course that if the underwriter's "friendly" investors or affiliates possess some information, they reveal the information to the underwriter.

[5]Therefore, the issue is disregarded of signalling by the issuer as in Allen & Faulhaber (1989), Welch (1989).

[6]Although the linear compensation scheme is assumed for the underwriter, in reality it may not be so because of the existence of the overallotment right and the warrant right granted to the underwriter. For warrants, see Barry, Muscarella & Vetsuypens (1991).

In the scenario of the present paper, the underwriter is delegated to organise the IPO and behaves as the principal seeking the informed investor's private information by setting the issue price and making the share allocation. However, in choosing the underwriter, the issuer as a rule gets in touch with several financial institutions and compares conditions on the issuance proposed by them and selects an underwriter from among them. By so doing, the issuer tries to obtain the best deal while getting over the disadvantage of its inferior financial expertise. It is agreed that competition for underwriting is rather fierce. This paper embodies this fact by the setting of the issuer's reservation utility. In choosing the underwriter, the issuer compares, above all, issue prices suggested by potential underwriters. Thus the chosen underwriter has to set a final issue price above a certain level to satisfy the issuer. Even if the former attempts to let its friendly investors make profits by setting a low issue price, it is bounded from below. The more competitive is the underwriting business, the higher will be the issue price. In this sense, if lacking financial experience in the IPO and dependent on the underwriter in the issue process, the issuer keeps some resisting force against the underwriter not to be too much imposed upon.

3 The model

This section presents the model formally. All parties concerned, the issuer, the underwriter, the informed investor are risk neutral. The issuing firm goes public to issue a fixed amount of shares which we normalise to 1. As indicated in the previous section, the informational structure of the paper assumes that only the informed investor has private information, which is unobservable by the other parties.

The underwriter organises the IPO. It sets the per share price p and the quantity allocations between itself and the informed investor, q_0, q_1 such that $q_0 + q_1 = 1$ and $q_i \geq 0$ for $i = 0, 1$. The underwriter receives from the issuer as compensation for its services the commission of a fixed percentage per share price $0 < a < 1$. The issuer, therefore, pays as commission ap in total.

The informed investor has private information on the post-issue value of the shares v unknown to the other agents. v takes a value in the non-empty interval of the positive real number, $[\underline{v}, \overline{v}]$.

The distribution function of v, $F(v)$ is public information and supposed absolutely continuous. The density $f(v)$ is assumed such that $f(v) > 0$ in $[\underline{v}, \overline{v}]$. The post-IPO per share price is realised as v. Therefore, there is no ex post surprise.

The underwriter maximises its own profits by deciding upon the share price and the share allocations. It has two sources of profits: it earns a commission ap for the IPO organisation, and it can make profits by buying and reselling part of the shares $(v-p)q_0$.

Let us put the upper limit to the amount of shares the underwriter can buy,

$$0 \leq q_0 \leq t$$

where $0 < t < 1$. Even if there is no definite legal restriction to the quantity the underwriter can buy, it may fear that by allotting too few shares to informed institutional investors, it would impair future business relationships with them or attract suspicious attention of the regulatory agency. This observation justifies the imposition of the limit on the underwriter's shares to be alloted.

During the registration period, the underwriter markets IPO shares and collects information about the market acceptance or the price valuation of the shares. In the setting of this paper, it translates into the underwriter's construction of the revelation mechanism. Let us concentrate on the direct mechanism (Myerson (1979)). Formally, the underwriter proposes to the informed subscriber the map

$$(q_1(v), p(v)) : [\underline{v}, \overline{v}] \to [0,1] \times R, \tag{1}$$

where $q_1(v)$ is a quantity alloted to the informed subscriber and $p(v)$ is the per share price.

If the informed subscriber with information v chooses the contract for $\tilde{v}$, its profit is

$$u_1(v, \tilde{v}) := (v - p(\tilde{v}))q_1(\tilde{v}).$$

If the informed subscriber with information v selects the contract for its true information v, its profit is

$$u_1(v) := (v - p(v))q_1(v). \tag{2}$$

Unable to force the informed subscriber to disclose its information, the underwriter has to make a contract which induces it to reveal its information at will. We thus define the implementable contract.

Definition 1. *The contract* $(q_1(v), p(v))$ *is implementable if and only if for any* $v, \tilde{v} \in [\underline{v}, \overline{v}]$,

$$u_1(v) \geq u_1(v, \tilde{v}).$$

As is standard in the mechanism design literature, we turn the implementable contract into the manageable form which permits us to formalise the maximisation problem.

Lemma 1 (incentive compatibility). *If the contract* $(q_1(v), p(v))$ *is implementable, the following two conditions are satisfied;*

$$q_1(v) \text{ is non-decreasing,} \tag{3}$$

$$q_1(v) = \dot{u}_1(v) \qquad a.e.^7 \tag{4}$$

Conversely, given $q_1(v)$ *and* $u_1(v)$ *which satisfy 3 and 4, the implementable contract* $(q_1(v), p(v))$ *can be constructed, by putting*

$$p(v) = v - \frac{u_1(v)}{q_1(v)}. \tag{5}$$

Proof. See Rochet (1985). □

As seen in 5, if $q_1 = 0$, p is not well defined but we will see that this is of no concern. Before proceeding further, we mention a simple fact deduced from the above lemma, which will be made use of in the formulation of a participation constraint.

Lemma 2. *The price of the implementable contract* $(q_1(v), p(v))$ *is non-decreasing.*

Proof. Let us $(q_1(v), p(v))$ be an implementable contract. Posit that $v < v'$ and suppose contrary to the lemma that $p(v) > p(v')$. Then we have

$$u_1(v) = (v - p(v))q_1(v) < (v - p(v'))q_1(v) < (v - p(v'))q_1(v').$$

The second inequality follows from Condition 3 of Lemma 1. It is seen, however, that the left hand and right hand contradict the definition of implementability 1. □

[7] a.e. stands for almost everywhere.

Let us now turn our attention to participation constraints. It is not enough that the underwriter manages to get the informed investor to tell the truth. The informed investor must be ensured of at least a certain level of utility for its participation; otherwise it will not participate in the IPO[8];

$$c \leq u_1(v)$$

where c is a positive constant.
From the incentive compatibility conditions, 3 and 4, this participation condition can be transformed into

$$c \leq u_1(\underline{v}). \tag{6}$$

Unlike in much of literature on asymmetric information, we need yet another participation constraint, that for the issuer. As was explained in Section 2, the issuer has chosen the underwriter by comparing its minimum issue price with those by other financial institutions. Because investment banks compete fiercely on the price for underwriting business,the issuer will simply cancel the IPO if the issue price is too low. Accordingly, the participation constraint for the issuer can be expressed as

$$d \leq p(v).$$

where d is a positive constant. Since only implementable contracts are being considered, this condition is equivalent, by means of Lemma 2, to

$$d \leq p(\underline{v}).$$

Moreover, by Equation 5 in Lemma 1, this can be written as

$$d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})}. \tag{7}$$

This is the form that we shall use as the participation constraint for the issuer.

It is necessary to make some assumptions in order that there may exist implementable contracts which satisfy 6 and 7. When they are satisfied it follows directly that

[8]It might be more convincing to put the participation condition as $r \leq \frac{v-p(v)}{q_1(v)}$ where r is an yield rate of other financial products but, for simplicity, the present article adopts a simpler condition.

$$c \leq u_1(\underline{v}) \leq (\underline{v} - d)q_1(\underline{v}).$$

Owing to the assumption $0 \leq q_0 \leq t$, q_1 takes a value in $[1-t, 1]$. Therefore we make the following assumption so that any value in this interval may satisfy the two participation constraints.

Assumption 1.

$$c < (\underline{v} - d)(1 - t).$$

Were this assumption not met, the two participation constraints might be so stringent that q_1 might not be able to take some values in $[1 - t, 1]$. For instance, if both the issuer and the informed investor ask for unrealistically high reservation utility, the above condition is unmet and the two participation constraints are never satisfied at once.

4 The underwriter's decision making

First recall that $q_0 + q_1 = 1$ and therefore

$$0 \leq 1 - q_1 \leq t.$$

The underwriter maximises its expected profit under the incentive constraints and the participation constraints;

$$\begin{aligned}
&\max_{q_1, p, u_1} \int_{\underline{v}}^{\overline{v}} \Big(ap(v) + \big(v - p(v)\big)\big(1 - q_1(v)\big)\Big) f(v)dv \\
&\text{s. t.} \\
&3,\ 4,\ 6,\ 7, \\
&1 - t \leq q_1(v) \leq 1.
\end{aligned}$$

The objective function consists of the profits from the commission and from share reselling on the aftermarket.[9]

[9] The assumption that the whole IPO profits of the affiliates or friend investors accrue as such to the underwriter might be unrealistic and it is more appropriate to suppose that only part of them do. In the latter case, however, we merely have to rescale a.

We eliminate p from the objective function by virtue of the incentive compatibility lemma and set the problem as that of optimal control. Once the optimal q_1 and u_1 are found, p can be retrieved by Equation 5.

We make q_1 and u_1 state variables and introduce a new control variable.
We can transform $1-t \leq q_1 \leq 1$ by the monotonicity of q_1 (see Lemma 1) into

$$1-t \leq q_1\left(\underline{v}\right), \quad q_1\left(\overline{v}\right) \leq 1.$$

Finally, with regard to Condition 3, we introduce a control variable z

$$z := \dot{q}_1 \quad \text{a.e,} \quad z \geq 0.$$

Now we can formulate the maximisation problem as that of optimal control, which we denote by $\mathcal{P}$.

$$\max_{z,q_1,u_1} \int_{\underline{v}}^{\overline{v}} (av-(a-1)\frac{u_1}{q_1}-u_1)f(v)dv \tag{8}$$

s. t.

$$\dot{u}_1 = q_1 \quad \text{a.e,} \tag{9}$$

$$\dot{q}_1 = z \quad \text{a.e,} \tag{10}$$

$$0 \leq z, \tag{11}$$

$$c \leq u_1(\underline{v}), \tag{12}$$

$$d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})} \tag{13}$$

$$1-t \leq q_1\left(\underline{v}\right), \tag{14}$$

$$q_1\left(\overline{v}\right) \leq 1. \tag{15}$$

Theorem 1. *The solution of the maximisation problem $\mathcal{P}$ is as follows:*
if $a > t$,

$$\begin{aligned} q_1(v) &= 1-t, \\ u_1(v) &= (1-t)(v-\underline{v})+c, \\ p(v) &= \underline{v} - \frac{c}{1-t}; \end{aligned}$$

if $a = t$,

$$
\begin{aligned}
q_1(v) &= 1-t,\\
u_1(v) &= (1-t)\,(v-\underline{v}) + u_1(\underline{v}),\\
p(v) \ &= \underline{v} - \frac{u_1(\underline{v})}{1-t},
\end{aligned}
$$

where $u_1(\underline{v})$ satisfies the end conditions 12 and 13, namely $c \leq u_1(\underline{v})$ and $d \leq \underline{v} - \frac{u_1(\underline{v})}{1-t}$; if $a < t$,

$$
\begin{aligned}
q_1(v) &= 1-t,\\
u_1(v) &= (1-t)(v-d),\\
p(v) \ &= d.
\end{aligned}
$$

Proof. See the appendix. □

Let us look into the features of the theorem.

Result 1. *Whatever the relation between a and t(i.e. $a \geq t$ or $a < t$), the underwriter always buys the largest amount of shares, t.*

In general, the underwriter is attracted by two incongruous incentives. If setting a high price, it gains by way of a commission but must pay more for the shares it purchases for the purpose of reselling them after the IPO. By setting a low price, it makes less commission profits but gains more by reselling later the shares it has bought at the low price. According to intuition, therefore, the underwriter will decide to set a high price to gain by a commission when the rate is high enough and refrain from buying many shares. On the other hand, with a low commission rate, it will choose to make profits by setting a low price although making less commission earnings, and to buy and resell many shares after the IPO.

Contrary to intuition, the result above states that the underwriter buys as many as possible with a high commission rate($a > t$). The reason is the following. The underwriter can use the implementable mechanism to induce the informed subscriber to reveal fully the private information. Simultaneously, the underwriter must assure the subscriber of reservation utility as a participation constraint, by which the subscriber can always make some profits. Therefore, even if the underwriter is willing to set a high price and make profits by the commission, the highest price that it can set is bounded from above. The underwriter, able to get the private information possessed by the subscriber, is also assured of profits from the purchase of shares. Accordingly, the underwriter buys up to the limit even though the commission rate is high and whatever the actual value of the private information is.

Let us see the inflexibility of the quantity allocation from another point of view.

Result 2. *Given a spread, a and a maximum allowable amount of shares for itself, t, the underwriter does not change the allocation pattern of the shares according to the informed subscriber's private information v; namely, whatever the realised value v, the underwriter purchases as many as possible t and distributes the rest to the informed subscriber $1-t$.*

Even if the post-IPO share value v varies, the share allocation remains unchanged. This rigidity of the quantity allocation translates into that of the price.

Result 3. *Given a and t, price is insensitive to the informed subscriber's private information or the share value v.*

Since the price and the quantity are related by Equation 5, it is obvious that the rigid quantity allocation leads to the inflexible price.

Result 4. *Underpricing persists in both cases $a > t$, $a < t$. It is greater in the latter case.*

Proof. By assumption 1, $v - p(v)$ is always positive and thus there is always underpricing. The latter half of Result 4 also follows from Assumption 1. □

Let us first notice the difference of the prices between the two cases $a > t$ and $a < t$. From Assumption 1, the price of $a > t$ is higher than that of $a < t$. As is explained above, when the spread is large enough, the underwriter elects to earn more with the commission by setting a higher price. On the other hand, with a small spread, the underwriter is willing to make profits rather by the purchase and reselling of the shares; therefore it would sooner set a low price. This is the reason why the price is higher in case of $a > t$ than in $a < t$.

However, how are the two prices different although the quantity allocations are identical in both cases? It comes, as seen in the theorem, from which participation condition is binding of $u_1(\underline{v}) \geq c$ and $d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})}$.

When $a > t$, the underwriter sets the higher price and makes profits by commission, which benefits the issuer at the expense of the investor. The price is indeed set at such a high level that the informed subscriber's participation constraint $u_1(\underline{v}) \geq c$ is binding. In this case, the underwriter can be viewed as taking sides with the issuer.

Contrariwise, if $a < t$, the underwriter sets the lower price, intending to make earnings by reselling shares on the aftermarket and the resulting low price benefits the informed investor. The price is set so low as to make binding the issuer's participation constraint $d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})}$. In this case, the underwriter can be regarded as taking sides with the informed investor at the expense of the issuer.

This result translates into the following in a general context.[10] When the underwriter finds it profitable to let institutional investors (or just its affiliates) make money in the IPO for future business, it does not benefit the issuer to negotiate hard on the spread, which on the contrary harms it by pushing the former towards the investors. It is in the issuer's interest to bargain for other terms than the spread among many dimensions of the IPO contract.

It can be safely thought that when the underwriter has more discretion in allocation, there is more room for it to make future profit with investors by giving favourable treatment in the IPO. It is consistent with our result that in the US where the underwriter is allowed considerable discretion, a much higher spread is observed than in other countries(Chen & Ritter (2000)).

Let us summarise the previous result upon the participation constraints in the following.

Result 5. *When the spread is relatively large($a > t$), the informed subscriber's participation constraint is binding. When the spread is relatively small($a < t$), the binding participation constraint is the issuer's.*

5 Concluding remarks

Among financial institutions, underwriting business is competed for on various fronts: the minimum issue price, the spread, business advising, analyst coverage, post-issue price support and so forth. The present paper has considered the first two. We have seen that the issuer cannot make the underwriter lower the spread excessively. By so doing, the former might push the latter towards investors and make it take side with them. Chen & Ritter (2000) argues that the actual spread observed in the American

[10]Recall that the underwriter is a coalition with friendly investors or affiliates in our context.

IPO is too high on account of anticompetitiveness between financial institutions while Hansen (2001) contends to the contrary. The present paper adds another argument on this issue, which is based on incentives for the underwriter: the spread must be large enough for the underwriter to stay faithful to the issuer.

The underwriter needs to attract the issuer and investors. If it underprices shares too much, the issuer will never resort to the underwriter in the future. On the other hand, if it prices shares too high, investors will not use the underwriter. The underwriter must carry out a difficult task of satisfying mutually conflicting interests. This paper has tried to model this aspect of tri-partite conflicts of interest. In so doing, it could not help leaving out an interesting factor analysed by Benveniste & Spindt (1989) and Benveniste & Wilhelm (1990): the underwriter's information extracting schemes faced to several informed investors. Consequently, the result obtained here is quite a rigid allocation-price scheme. In the context of multiple informed investors, it will presumably be modified.

A difficulty for empirical work is that it is very hard to know exactly how shares are allocated among subscribers by the underwriter: the paper assumed a coalition of the underwriter and "friendly" investors or the affiliate. In many countries, there is no requirement to report on the details of share allocation, not to mention the identities of subscribers to whom shares have been distributed. Even with an underwriter's internal report on share distribution, it might be somewhat difficult to distinguish friendly investors from other investors. In contrast, an underwriter's affiliated investor is relatively easy to identify.

In either case, it requires the underwriter's internal report to investigate its behaviour on the lines of this paper. Hanley & Wilhelm (1995) is the first work to look into the internal report of underwriters to investigate how they distribute shares among investors. Their work concerns a long-standing argument concerning American IPOs that institutional investors are favoured by underwriters in share distribution and come by a lion's share of the profits of underpriced issues. They showed that institutional investors were allocated a large part of shares, not merely in underpriced but also overpriced issues. Hanley & Wilhelm (1995), however, fell short of investigating how shares are distributed between institutional investors.

Cornelli & Goldreich (2001), by obtaining underwriters' actual books, develop further the line of Hanley & Wilhelm (1995) and looks into identities of each subscriber. They report that investors frequently participating in the underwriter's IPOs receives favourable treatment in share allocation. Further work needs to be done to integrate the conflicts of interests in this paper and interactions between several informed investors.

Along with regulatory reforms of financial sectors throughout the world, there are fewer and fewer fire walls between underwriters and institutional investors. This allows underwriters to allot shares to their affiliated investors. In particular, the reforms of the banking industry has, by degrees, sanctioned the expansion of banks' activity to underwriting.[11] At the same time, they have authorised the bank to have an investment bank as its affiliate. The bank underwriter is now entitled to allocate a part of IPO shares to its affiliate. This amounts to enabling the bank to buy shares for itself. For the time being, there does not seem to have appeared work for the US IPO on this issue but Ber, Yafeh & Yosha (2001) have used Israeli data, obtaining results that are not in accordance with the implication of this article.[12] It seems, however, still premature to say whether or not the banking deregulation has such an effect as predicted here upon the underwriter's behaviour.

A The proof of Theorem 1

Let us set λ_0, λ_1, λ_2 as adjoint variables and we have the Hamiltonian,

$$H\left(u_1, q_1, z, \lambda\right) = \lambda_0\Big(av - (a-1)\,\frac{u_1}{q_1} - u_1\Big)f + \lambda_1 q_1 + \lambda_2 z$$
$$\text{where}\ \lambda := \left(\lambda_0, \lambda_1, \lambda_2\right).$$

u_1 and q_1 are absolutely continuous state variables and z is a measurable control variable.

The necessary conditions for optimality can be written as follows. First there are $\lambda_0 = 0$ or 1 and non-negative real numbers α_i for $i = 1, \ldots, 4$ such that $(\lambda_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4) \neq 0$. In addition, there are absolutely continuous adjoint variables λ_1 and λ_2 and the following conditions hold:

[11] Gande, Puri & Saunders (1999) is empirical work of the effects.

[12] A great deal of caution seems to be needed for the interpretation of the result of Ber et al. (2001). They report that there is no short or long term underpricing observed for any type of underwriter but that with a bank underwriter there is significantly better post issue accounting performance.

$$\dot{\lambda}_1 = -\frac{\partial H}{\partial u_1} = \lambda_0((a-1)\frac{1}{q_1} + 1)f \qquad \text{a.e,} \tag{16}$$

$$\dot{\lambda}_2 = -\frac{\partial H}{\partial q_1} = \lambda_0 \frac{(1-a)u_1 f}{q_1^2} - \lambda_1 \qquad \text{a.e;} \tag{17}$$

As the transversality conditions, we have

$$\lambda_1(\underline{v}) = -\alpha_1 + \alpha_2, \qquad \lambda_1(\overline{v}) = 0, \tag{18}$$

$$\lambda_2(\underline{v}) = -\alpha_2(\underline{v} - d) - \alpha_3, \qquad \lambda_2(\overline{v}) = -\alpha_4, \tag{19}$$

and also

$$\alpha_1(u_1(\underline{v}) - c) = 0, \tag{20}$$

$$\alpha_2(q_1(\underline{v})(\underline{v} - d) - u_1(\underline{v})) = 0, \tag{21}$$

$$\alpha_3(q_1(\underline{v}) - (1-t)) = 0, \tag{22}$$

$$\alpha_4(1 - q_1(\overline{v})) = 0; \tag{23}$$

In addition, z has to maximise $H(u_1, q_1, z, \lambda)$ a.e. with optimal u_1 and q_1. Hence $\lambda_2 \leq 0$.

Lemma 3. $\lambda_0 = 1$

Proof. Suppose that $\lambda_0 = 0$. Then $\lambda_1 = 0$ and $\alpha_1 = \alpha_2$ from 16 and 18. It follows that $\alpha_1 = \alpha_2 = 0$; for if $\alpha_1 = \alpha_2 \neq 0$, it must be that $u_1(\underline{v}) - c = 0$ and $q_1(\underline{v})(\underline{v} - d) - u_1(\underline{v})) = 0$. This is impossible from Assumption 1. Now we know that λ_2 is a non-positive constant from 17. In fact it must be that $\lambda_2 = 0$. Suppose to the contrary. Then the Hamiltonian maximising z is zero and accordingly q_1 is a constant. On the other hand, since we have $\lambda_2(\underline{v}) = -\alpha_3$ and $\lambda_2(\overline{v}) = -\alpha_4$ from the transversality conditions, it must hold that $q_1(\underline{v}) = 1 - t$ and $q_1(\overline{v}) = 1$. This is contradictory to q_1 being constant. Now that we have found that $\lambda_2 = 0$, it follows from the terminal conditions that $\alpha_3 = \alpha_4 = 0$. Accordingly, we have $(\lambda_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4) = 0$, which is a contradiction.

□

We split the analysis into three cases (1) $a > t$, (2) $a = t$, (3) $a < t$.

(1) *The case of* $a > t$.

From 16, we see that $\dot{\lambda}_1$ is strictly increasing with respect to q_1. Recall $1-t \leq q_1 \leq 1$ and substitute $q_1 = 1-t$ into 16. Then we have $\left(\frac{a-1}{1-t}+1\right)f > 0$ a.e.
Accordingly, we have

$$\dot{\lambda}_1 > 0 \quad \text{a.e.}$$

From this and the transversality conditions, it follows that

$$\lambda_1 \begin{cases} < 0 & \text{in } [\underline{v}, \overline{v}), \\ = 0 & \text{at } \overline{v}. \end{cases} \tag{24}$$

From the first inequality and the transversality condition 18, we have $\alpha_2 < \alpha_1$. If $0 < \alpha_2$, then it must follow that $u_1(\underline{v}) - c = 0$ and $q_1(\underline{v})(\underline{v} - d) - u_1(\underline{v}) = 0$. This is impossible from Assumption 1. Therefore we have

$$0 = \alpha_2 < \alpha_1.$$

This leads from 20 to

$$u_1(\underline{v}) = c.$$

From λ_1 and 17, it follows that $\dot{\lambda}_2 > 0$ a.e. and thus

$$\lambda_2 \begin{cases} < 0 & \text{in } [\underline{v}, \overline{v}), \\ \leq 0 & \text{at } \overline{v}. \end{cases} \tag{25}$$

It follows that the Hamiltonian maximising z is almost everywhere zero and thus q_1 is constant. From the transversality condition, we have $\lambda_2(\underline{v}) = -\alpha_3$, which is negative. We conclude from 22 that $q_1(\underline{v}) = 1-t$ and thus

$$q_1 = 1-t.$$

Now we find u_1 from 9 and p from 5:

$$u_1 = (1-t)(v-\underline{v}) + c, p = v - \frac{(1-t)(v-\underline{v})+c}{1-t} = \underline{v} - \frac{c}{1-t}.$$

(2) *The case of $a = t$.*

As we have $\dot{\lambda}_1 \geq 0$ a.e. in the previous case, we have

$$\lambda_1 \leq 0.$$

Then $\dot{\lambda}_2 > 0$ a.e. follows from 17 and we have 25.
We deduce that $z = 0$ a.e. and thus q_1 is a constant.

Indeed, we can obtain that

$$q_1 = 1 - t.$$

Proof. Suppose to the contrary. Then, it follows that

$$\lambda_1 \begin{cases} < 0 & \text{in } [\underline{v}, \overline{v}), \\ = 0 & \text{at } \overline{v}. \end{cases} \tag{26}$$

From the transversality condition, we have $\lambda_1(\underline{v}) = -\alpha_1 + \alpha_2 < 0$. It can be deduced that $0 = \alpha_2 < \alpha_1$; for we know by Assumption 1 that $u_1(\underline{v}) - c = 0$ and $q_1(\underline{v})(\underline{v}-d) - u_1(\underline{v}) = 0$ cannot hold simultaneously.

Now we obtain from the transversality condition and 26, $\lambda_2(\underline{v}) = -\alpha_3 < 0$. Then it follows from 22 that $q_1(\underline{v}) = 1-t$ and with the fact that q_1 is a constant, $q_1 = 1-t$. This is a contradiction.

□

Now we know $\dot{\lambda}_1 = 0$ a.e. and

$$\lambda_1 = 0.$$

It follows from 18 that $\lambda_1(\underline{v}) = -\alpha_1 + \alpha_2 = 0$. By Assumption 1, $u_1(\underline{v}) - c = 0$ and $q_1(\underline{v})(\underline{v} - d) - u_1(\underline{v})) = 0$ do not hold simultaneously, which leads to

$$\alpha_1 = \alpha_2 = 0.$$

To find u_1, we have only to find $u_1(\underline{v})$. It cannot be determined by 20 and 21 because of the value of α_1 and α_2. Indeed if we substitute $q_1 = 1-t$ and $(1-t)(v-\underline{v})+u_1(\underline{v})$ into the objective function of Problem $\mathcal{P}$, it is seen that $u_1(\underline{v})$ is irrelevant to the maximisation of the objective function. Therefore the optimal u_1 is written as

$$u_1 = (1-t)(v-\underline{v}) + u_1(\underline{v})$$

such that $u_1(\underline{v})$ satisfies Condition 12, $c \leq u_1(\underline{v})$ and Condition 13, $d \leq \underline{v} - \frac{u_1(\underline{v})}{1-t}$.

(3) *The case of* $a < t$. First, we will prove that

$$q_1 \leq 1 - a.$$

Proof. Let us prove that it is impossible to have $q_1 > 1 - a$ on the whole interval. Suppose so and then we obtain 24 from 16 and 18
Therefore from 18, we have $\lambda_1(\underline{v}) = -\alpha_1 + \alpha_2 < 0$ and thus it follows from Assumption 1, 20 and 21 that

$$0 = \alpha_2 < \alpha_1.$$

From 17, we now have $\dot{\lambda}_2 > 0$ and 25.
Consequently q_1 is constant and $\alpha_3 = 0$ from 22. It leads to $\lambda_2(\underline{v}) = 0$ by 19. This contradicts 25. We have demonstrated that $q_1 > 1 - a$ is impossible.

Now that we have found that there is a point v at which $q_1(v) \leq 1 - a$, let us prove that $q_1 \leq 1 - a$ on the whole interval $[\underline{v}, \overline{v}]$. Suppose that there is a point where $q_1(x) > 1 - a$. Then since q_1 is continuous and non-decreasing, there is a point y such that $q_1(y) = 1 - a$ and $y < x$. Moreover, it holds that $\dot{\lambda}_1 \geq 0$ a.e. on $[y, \overline{v}]$ and thus $\lambda_1 \leq 0$ on the same interval and in turn $\dot{\lambda}_2 > 0$ a.e. on this interval from 17. Accordingly we have

$$\lambda_2 < 0 \quad \text{in} \, [y, \overline{v}).$$

Therefore, on this interval, $z = 0$ and q_1 is constant. It follows that $q_1 = 1 - a$, which is contradictory.

$\square$

We obtain from 16 that

$$\lambda_1 \geq 0.$$

This leads from 18 to $\lambda_1(\underline{v}) = -\alpha_1 + \alpha_2 \geq 0$. Again, by Assumption 1, 20 and 21, it is deduced that $\alpha_2 \geq \alpha_1 = 0$.
Indeed we can establish

$$\alpha_2 > \alpha_1 = 0.$$

If $0 = \alpha_2$, considering that $\dot{\lambda}_1 \leq 0$ from 16, we have $\lambda_1 = 0$ and $\dot{\lambda}_1 = 0$ a.e. Again from 16, $q_1 = 1 - a$ a.e. and thus everywhere by absolute continuity. Then from 22 and 23, $\alpha_3 = \alpha_4 = 0$. However, with $\lambda_1 = 0$, we have $\dot{\lambda}_2 > 0$ a.e. This is a contradiction.

Now we can conclude from 21 that $q_1(\underline{v})(\underline{v} - d) - u_1(\underline{v}) = 0$. and from 5, $p(\underline{v}) = \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})} = d$.
It has been proved that if $a < t$,

$$q_1(v) \leq 1 - a, \qquad p(\underline{v}) = d.$$

We further improve on this result. We proceed to solve the maximisation problem $\mathcal{P}$ with condition 13 replaced by the following condition

$$d \leq p(\overline{p}) = \overline{v} - \frac{u_1(\overline{v})}{q_1(\overline{v})}. \tag{27}$$

and at the end verify that the original participation constraint 13, $d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})}$ is satisfied.

Why this replacement can be done is intuitively explained in the following way. Setting a high price, the underwriter gains more commission but pays more for the shares it purchases. Setting a low price, it makes less commission but gains more by reselling. Therefore, the underwriter will set a high price when the spread is large and refrain from buying shares. On the other hand, with a small spread, it will make profits by underpricing. The result of case $a > t$ shows that even in that case, the underwriter buys the maximum. It is then natural to think that in the case of $a < t$ the underwriter should also buy the largest amount t. Then q_1 is constant by monotonicity and so is p and we can replace the original participation constraint by the new one.

All of the necessary conditions of Problem $\mathcal{P}$ are carried over here except those from

18 to 23, which we replace by

$$
\begin{aligned}
\lambda_1(\underline{v}) &= -\alpha_1, & \alpha_1(u_1(\underline{v}) - c) &= 0,\\
\lambda_1(\overline{v}) &= -\alpha_2, & \alpha_2(q_1(\overline{v})(\overline{v} - d) - u_1(\overline{v})) &= 0,\\
\lambda_2(\underline{v}) &= -\alpha_3, & \alpha_3(q_1(\underline{v}) - (1 - t)) &= 0,\\
\lambda_2(\overline{v}) &= \alpha_2(\overline{v} - d) - \alpha_4, & \alpha_4(1 - q_1(\overline{v})) &= 0,
\end{aligned}
$$

Lemma 4. $\lambda_0 = 1$.

Proof. Suppose that $\lambda_0 = 0$ and then we obtain that λ_1 is a non-positive constant.

Actually, λ_1 is a negative constant. To see this, let us suppose $\lambda_1 = 0$. Then we obtain that $\lambda_2 < 0$ and thus $z = 0$ from the maximisation of the Hamiltonian. We see that q_1 is constant from 10. On the other hand, $\lambda_2 < 0$ leads to $q_1(\underline{v}) = 1 - t$ and $q_1(\overline{v}) = 1$ by the terminal conditions. This is a contradiction to q_1 being constant.

Now, since $\dot{\lambda}_2 = -\lambda_1 > 0$, we have $\lambda_2 < 0$ in $[\underline{v}, \overline{v})$, which leads from the terminal condition to $q_1(\underline{v}) = 1 - t$. In addition, $z = 0$ in $[\underline{v}, \overline{v})$.
Thus from 10, we obtain

$$q_1 = 1 - t \quad \text{in} \, [\underline{v}, \overline{v}] \, .$$

Since λ_1 is a negative constant, we have $u_1(\underline{v}) = c$ and $u_1(\overline{v}) = q_1(\overline{v})(\overline{v} - d)$. We also obtain by 9 that

$$u_1(v) = (1 - t)(v - \underline{v}) + u_1(\underline{v}) = (1 - t)(v - \underline{v}) + c.$$

At the same time, u_1 must satisfy $u_1(\overline{v}) = (1 - t)(\overline{v} - d)$. As a result, it must be satisfied that

$$(1 - t)(\overline{v} - d) = (1 - t)(\overline{v} - \underline{v}) + c.$$

This is impossible due to Assumption 1.

□

Lemma 5.

$$\lambda_1 \leq 0.$$

Proof. We will prove $\lambda_1 \leq 0$ by contradiction. Let us suppose there exists v_1' such that $\lambda_1(v_1') > 0$. Then there is in the neighbourhood of v_1' such v that $v \neq \underline{v}$ and $\lambda_1(v) > 0$

and that there exists $\dot{\lambda}_1$ at v, because λ_1 is absolutely continuous. Now we can suppose $\lambda_1(v) > 0$. Then there is in $[\underline{v}, v]$ a non-negligible set S at which point $\dot{\lambda}_1$ exists by absolute continuity and $\dot{\lambda}_1 > 0$. For if there is not, $\dot{\lambda}_1 \leq 0$ a.e. in $[\underline{v}, v]$ and

$$\lambda_1(v) = \int_{\underline{v}}^{v} \dot{\lambda}_1(s)ds + \lambda_1(\underline{v}) \leq 0.$$

Thus if we take $y \in S$, $\dot{\lambda}_1(y) = \left(\frac{a-1}{q_1(y)} + 1\right)f(y) > 0$. It follows that $q_1(y) > 1 - a$, which leads to $q_1(y) > 1 - a$ due to the monotonicity of q_1. Therefore,

$$\dot{\lambda}_1(v) = \left(\frac{a-1}{q_1(v)} + 1\right)f(v) > 0.$$

Again, by the monotonicity of q_1, it is true that $\dot{\lambda}_1 > 0$ a.e. in $[y, \overline{v}]$. Then we have, for $x \geq v$,

$$\lambda_1(x) = \int_{v}^{x} \dot{\lambda}_1(s)ds + \lambda_1(v) > 0.$$

Therefore,

$$\lambda_1(\overline{v}) = \int_{v}^{\overline{v}} \dot{\lambda}_1(s)ds + \lambda_1(v) > 0.$$

This is a contradiction to $\lambda_1(\overline{v}) \leq 0$.

□

Now we obtain, as in the other two cases, 25 and thus $q_1 = 1 - t$.
The rest is similar to the other cases and we actually obtain the results of the theorem.

It only remains to verify that the original participation constraint 13, $d \leq \underline{v} - \frac{u_1(\underline{v})}{q_1(\underline{v})}$ is indeed satisfied. Immediately we can see that it is.

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