An empirical examination of IPO underpricing between high-technology and non-high-technology firms in Taiwan

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Abstract

This study investigates the determinants of initial public offering (IPO) underpricing by focusing on variables relating to information asymmetry, investor sentiment, and corporate governance and examines whether the determinants of IPO underpricing in high-technology and non-high-technology IPOs differ. With the data from Taiwan from 2009 - 2011, this study finds that overallotment is negatively related to underpricing, whereas market momentum, first day trading volume, and managers' ownership retention rates are positively related to underpricing, particularly for high-technology IPOs. Our results support the signaling hypothesis in high-technology IPOs.

JEL classification: G12; G14; G24; G32

Keywords: High-tech; Information asymmetry; Initial public offering (IPO); Underpricing; Valuation.

1. Introduction

The liberalization of financial markets has directed management attention to using capital markets to raise equity finance for business. Companies increasingly go public through initial public offerings (IPOs) to obtain new sources of finance. Previous studies have reported the existence of IPO underpricing and revealed that stock prices continually increase from the offering date until the listing date (Reilly, 1973; Ibbotson, 1975; Engelen and van Essen, 2010; Khurshed et al., 2014).

IPO underpricing is not limited to the United States and Europe (Yong, 2007; Engelen and van Essen, 2010); it has also been observed in Asian emerging economies (Loughran et al., 1994; Lin and Chuang, 2011; Khurshed et al., 2014). For example, Loughran et al. (1994) find that the average IPO initial return is 17.6% in Hong Kong, 78.1% in South Korea, 80.3% in Malaysia, 45.0% in Taiwan, and 58.1% in Thailand. Engelen and van Essen (2010) observe that the average IPO initial return is 30%–47% in Taiwan and 127%–950% in China. Although previous studies confirm IPO underpricing in Asian emerging markets, such studies are inadequate compared with those conducted in the United States and Europe (Yong, 2007). Indeed, the institutional characteristics and practices of IPOs in Asian emerging economies are unique and considerably different from those of U.S. and European markets (Chan et al., 2011; Chen et al., 2011; Chang et al., 2014). There is a need to identify the determinants of

IPO underpricing in Asian emerging markets.

Moreover, past studies have paid little attention to the differences of IPO underpricing between high-technology (high-tech) and non-high-technology (non-tech) sectors in emerging markets, though the literature has demonstrated differences between high-tech and non-tech IPOs in motivation, issuing strategy, and long-term performance (Carpenter et al., 2003; Kim and Pukthuanthong-Le, 2008). Because high-tech firms tend to have more volatile operating cash flows than do non-tech firms, they often face difficulties in meeting interest and principal repayment obligations should they choose debt financing. IPOs are therefore attractive means for high-tech firms to raise finance. Furthermore, high-tech firms typically have few tangible assets, but they possess substantial intangible assets in the form of patents and other intellectual property; such asset structures result in considerably high financial distress if high-tech firms use debt financing. In addition, high-tech firms that have little or no profitability in their early operating years tend to benefit little from debt tax shields (e.g., from tax savings associated with the tax deductibility of interest payments). These characteristics of high-tech firms are often ignored in prior studies on IPO underpricing, as all IPOs are usually 'thrown into one basket'. Clearly, an investigation of the differences of determinants between high-tech and non-tech IPO underpricing would provide potential contributions to the existing knowledge of IPOs and IPO underpricing.

Therefore, this study attempts to determine whether the determinants of IPO underpricing in high-tech and non-tech IPOs differ with the data from Taiwan, an emerging economy in Asia. In Taiwan, IPOs from high-tech sectors constitute a high proportion of public offerings. This study investigates the determinants of IPO underpricing by distinguishing between high-tech and non-tech sectors and testing three groups of variables, namely information asymmetry, investor sentiment, and corporate governance. First, we use issue size (MKT), underwriter reputation (REPU), initial price range (IPR), research and development (R&D) expenditure, overallotment (OA), and lot-winning rate (LWR) as proxies for information asymmetry. If less information asymmetry exists between underwriters and investors, the IPO underwriting price is generally consistent with market expectations, leading to less underpricing in the market. Second, we investigate first-day trading volume (VOL) and market momentum (MOM) as proxies for investor sentiments on the IPO underpricing problem. Third, we assess corporate governance factors in explaining IPO underpricing. We use managers' ownership retention rate (MAN) and CEO duality (DUAL) as proxies for the rigorousness of a firm's corporate governance.

We contribute to the literature in the following aspects. First, we find that information asymmetry variables such as OA and LWR are negatively related to underpricing, whereas investor sentiment variables such as MOM and VOL are positively related to underpricing. Compared with high-tech IPOs, non-tech IPOs are associated with a higher IPR. For high-tech IPOs, MKT, OA, and R&D reduce IPO underpricing. Second, we observe that there is a negative relationship between R&D intensity and underpricing, indicating that R&D intensity for high-tech IPOs is a signal of intelligent legitimacy and that technology demands reduce IPO underpricing for high-tech firms. Thirdly, we find there is a positive relationship between IPO underpricing by issuers and MAN rates, which supports our signaling hypothesis. We find that high-tech firm managers signal high firm value by owing shares of their firms; however, we do not observe a similar phenomenon for non-tech firms. Finally, we find that the methods of delivering of IPO information in high-tech and non-tech industries differ, which implies that the 'greenshoe option' introduced by the authorities in Taiwan can be used to help stabilize IPO pricing.

The remainder of this paper is organized as follows. Section 2 introduces the institutional setting of Taiwan IPOs. Section 3 presents a literature review. Section 4 describes the data and introduces the empirical methods. Section 5 presents and explains the empirical results, and Section 6 provides the conclusion.

2. Institutional Setting of Taiwanese IPOs

The institutional setting and trading practice of Taiwan's stock market differ from those in developed markets. Taiwan's stock market is principally dominated by individual investors, who constitute the vast majority of the trading volume (Barber et al., 2009; Chen et al., 2011). In 2005, the Taiwan government began introducing a new underwriting system to improve IPO price stability; this system includes an OA agreement between underwriters and an issuing company. Under this system, shareholders and underwriters must sign a stock purchase option (called a greenshoe option). In 2008, the government launched a policy to promote overseas-based Taiwanese companies to list on the Taiwan Stock Exchange (TWSE) and created a funding platform to attract global high-tech companies to list on the TWSE and trade in over-the-counter markets. As part of this promotion, the Taiwanese government opened its stock market to mainland China-based companies, encouraging them to apply Taiwan IPOs.

The competitiveness of Taiwan's capital market has increased in recent years because of the expanded domestic securities market and enhanced market liquidity. Taiwan has become an ideal location for foreign companies, particularly those in Greater China, to raise capital due to its attractive valuations, low listing thresholds, minimal currency transaction requirements, and favorable government policies. Taiwan, commonly regarded as a high-tech island, comprises numerous supply chains of high-tech industries supplying products and services such as semiconductors, optoelectronics, information services, computer and peripheral equipment, and communications and Internet services. High-tech companies constitute the highest proportion of industries listed on the TWSE and the Gre Tai Securities Market (GTSM).

IPO underpricing, or high IPO initial return, is prevalent in the TWSE. Chang et al. (2014) observe that from 2006 to 2010, the average IPO underpricing in Taiwan increased to 50.6%. Several studies examine the factors influencing the considerably high IPO initial returns. Chang (2011) provides evidence that supports the social comparison theory in explaining Taiwan IPO underpricing.[1] Chang et al. (2014) argue that the dual-tranche of bookbuilding in Taiwan imposes considerable regulatory constraints on underwriter discretion. They suggest that the high IPO underpricing in Taiwan may not represent increased information disclosure but rather primary market inefficiency, which is induced by the regulatory constraints of Taiwan's IPO allocations and pricing.

3. Literature Review

This section reviews the literature on IPO underpricing to provide the context for this study. The numerous studies conducted on the determinants of IPO underpricing can be classified into three categories: (a) information asymmetry, (b) investor sentiments, and (c) corporate governance.

3.1 Information asymmetry

[1] 'The social comparison theory in behavioral psychology suggests that when people do not know how to make a decision or are exposed to new information, they refer to the behavioral norm of the public or the behavior of others to frame their decisions. The social comparison theory was developed by Festinger (1954) to explain how individuals evaluate their attitudes towards an issue. The theory proposes that individuals prefer to evaluate self and self-characteristics according to objective standards. When the standards are not available, they compare themselves with society or others around them and look for alternative comparison standards (Chang, 2011, p.368).

Studies related to information asymmetry investigate information imbalance of IPO underpricing among underwriters, IPO firms, and investors from various perspectives and report diverse results (Baron, 1982; Rock, 1986; Allen and Faulhaber, 1989; Aboody and Lev, 2000; Hoque, 2014). Baron (1982) reports that information asymmetry exists between underwriters and IPO firms. When underwriters perceive high uncertainty in the market, they tend to issue IPO stocks at a high discount to reduce their risks. Benveniste and Spindt (1989) indicate that underwriters can use their share allocation rights to gain information from investors and reduce the level of underpricing. Loughran and Ritter (2002) reveal that underwriters do not always act in an issuer's interest and tend to allocate shares to their favorite investors, triggering information asymmetry between underwriters and investors. Previous studies also reveal evidence of the existence of information asymmetry between issuing companies and investors (Allen and Faulhaber, 1989; Welch, 1989; Ritter and Welch, 2002). Allen and Faulhaber (1989) and Welch (1989) suggest that IPO underpricing acts as a signal of firm quality because the owners of high-quality firms have an incentive to underprice with the aim of subsequently selling their retained shares at a high and informed price. The winner's curse hypothesis was posited in relation to this phenomenon, stating that underpricing arises to compensate uninformed investors for the adverse selection problem they face (Rock, 1986). On the basis of information asymmetry, Rock (1986) observes that at a low LWR, uninformed investors participate in IPOs; this suggests that low LWRs attract more investors to participate in IPOs. Thus, IPO underpricing compensates investors who withstand risk. By contrast, a high LWR implies low market demand, which attracts few investors to participate in IPOs; therefore, only informed investors participate in the draw lots. Evidence from numerous studies supports the Rock adverse selection hypothesis (e.g., Amihud et al., 2003; Lin and Fok, 1997). Lin and Fok (1997) find that when investors are optimistic about an IPO firm's prospects, they are more willing to purchase IPO shares, resulting in a lower LWR; thus, LWR is negatively related to IPO underpricing. However, differences exist between institutional investors and retail investors. Aggarwal et al. (2002) analyze the proportion of issues allocated to institutional investors and retail investors and discover that compared with retail investors, institutional investors receive a larger proportion of new issues in IPOs with a larger underpricing and gain more earnings, escaping 'lemons' in the IPO market. Examining a sample of UK IPOs during 1999–2006, Hoque (2014) finds that information asymmetry is a driver of IPO underpricing.[2]

[2] This study also indicates that moral hazards drive lockups in the United Kingdom that is unique for UK institutional settings, which involve highly dispersed and long lockup lengths

Underwriter reputation (REPU) is considered a factor influencing IPO underpricing because it reduces IPO information asymmetry (Carter and Manaster, 1990). However, the empirical results of studies examining the relationships between REPU and IPO underpricing are inconsistent. Neuberger and La Chapelle (1983) find that low IPO underpricing was associated with high REPU, whereas Beatty and Welch (1996) report that high IPO underpricing was associated with high REPU. Su and Bangassa (2011) study Chinese IPOs between 2001 and 2008 and show that REPU has little influence on the level of IPO underpricing; however, they observe a significantly positive relationship between REPU and IPO long-term performance. Because of the inconsistent results, we examine the influence of REPU on IPO underpricing.

Benveniste and Spindt (1989) investigate the relationship between IPR and price uncertainty and claim that underwriters select a wider price range to preserve the elasticity of the changes when they perceive greater uncertainty for the value of the shares of the IPO-issuing company. Hanley (1993) also argues that a wider IPR implies higher uncertainty, increasing the difficulty of evaluating IPO prices.

Some studies use R&D to explain IPO underpricing. This is because R&D is a major source of competitive advantages for firms. For example, Guo et al. (2006) analyze a sample of 2,696 U.S. IPOs issued during 1980–1995 and find that R&D of IPO issuers significantly influences both initial IPO underpricing and the long-term performance of issuers. Chan et al. (1990) report that for high-tech companies, higher R&D expenditure is positively related to stock returns; however, they observe a negative relationship between R&D expenditure and stock returns for non-tech companies. Similar evidence is also reported by Kothari et al. (2002), who argue that investors expect the net value of future earnings to be enhanced when a high-tech firm increases its R&D expenditure. Kim and Pukthuanthong-Le (2008) find that the capital structure of high-tech firms is relevant to IPO underpricing. Debt that serves as a signal of high-tech firm quality influences IPO underpricing. For high-tech firms, higher leverage is associated with increased risks and uncertainty, resulting in a greater underpricing of their IPOs.

Ritter and Welch (2002) argue that asymmetric information can only account for 65% of the explanatory power of average IPO initial stock returns. Asymmetric information is not the primary driver of some IPO underpricing phenomena and there is a need to explore non-rational and agency conflict explanations of IPO underpricing. Following the suggestion of Ritter and Welch (2002), several studies consider investor behavior in determining IPO underpricing. For example, Loughran and Ritter (2002)

find that the managers of issuing firms appear to care less about underpricing when receiving favorable news regarding the increase in their personal wealth. Lowry and Schwert (2004) reveal that IPRs during book-building periods reflect some information about demand. Gao (2010) examines China's IPO market and shows strong evidence supporting behavioral arguments in explaining the subsequent IPO premium.

3.2 Investor sentiment

Previous studies suggest that investor sentiment is related to IPO underpricing. Baker and Stein (2004) report that market liquidity can indicate sentiment in a world with short-sales constraints. An unusually liquid market is a market in which pricing is dominated by irrational investors, who tend to underreact to the information embodied in either order flow or equity matters. Thus, high liquidity indicates the positive sentiments of irrational investors, which lead to abnormally low expected returns. Lowry (2003) observes that IPO volume fluctuations can be explained by the level of investor optimism. When investors are overoptimistic, issuing firms should profit from this period and are incited to offer large IPO volumes because they are highly certain that the large volume of shares will be absorbed by sentimental investors (and vice versa). Oehler et al. (2005) document that IPO initial returns are mainly influenced by investor sentiment. Using grey-market prices of European IPOs as a proxy for the sentiments of retailer investors, Cornelli et al. (2006) observe that this sentiment measure can predict the first-day aftermarket prices of IPOs in favorable situations, but not in unfavorable situations.

3.3 Corporate governance

The third category of studies investigating IPO underpricing is based on corporate governance variables. Corporate governance, which refers to the set of internal and external controls and relationships implemented in an organization to address manager and stockholder conflicts, plays an essential role in ensuring that the interests of public stockholders are protected (Fama, 1980; John and Senbet, 1998). Corporate governance is fundamentally related to the board of directors and ownership of a firm. The board of directors is the central internal-control mechanism in a firm of monitoring managers (Fama, 1980). Firm value depends to a large extent on the quality of the monitoring and decision-making of the board (Shleifer and Vishny, 1997). In general, the monitoring potential of a board is measured using three factors, namely board size, composition, and leadership structure (Jensen, 1993). The ownership of a firm is likely to affect the level of agency problems and ability of stockholders to

control agency problems (Jensen and Meckling, 1976). Ownership is mainly defined by two characteristics: managerial ownership and blockholder ownership.

Previous studies examining the influence of corporate governance on IPO underpricing focus largely on ownership structure. The ownership dispersion hypothesis proposed by Brennan and Franks (1997) suggests that IPO underpricing results in the oversubscription of shares, which induces the issuer to restrict the allocation of shares. Such a dispersed ownership structure improves liquidity and reduces the required rate of return to achieve a higher equilibrium price in the secondary market (Booth and Chua, 1996). Stoughton and Zechner (1998) address the role of IPO underpricing and rationing in determining investor shareholdings with reference to agency theory and find that the value of a firm's IPO is determined by the ownership structure resulting from the offering mechanism. Hartzell et al. (2008) show that firms with stronger governance structures measured by the percentage of shares held by insiders and the proportion of compensation have higher IPO valuations and more effective long-term operating performance compared to their peers. Chahine and Tohmé (2009) reveal that the negative relationship between underpricing and blockholding ownership is greater for foreign blockholding ownership than it is for domestic blockholding ownership. Analyzing the data of 525 IPOs in Taiwan, Lin and Chuang (2011) report that increasing family ownership and institutional ownership increases IPO underpricing, whereas employing independent outside directors mitigates IPO underpricing.

Previous studies have also applied stewardship theory in explaining the determinants of corporate governance. Executives who create an organization and have a strong sense of attachment to and psychological ownership of the organization are more likely to behave as stewards. Some executives are likely to pursue organizational interests even when these interests conflict with their personal interests (Davis et al., 1997; Muth and Donaldson, 1998). Thus, for firms with DUAL (i.e., firms in which the CEO also chairs the board of directors), management has *de facto* control. This implies that the agent and principal interests are correlated, thus reducing the first-day IPO underpricing (Nelson, 2003). Empirical results regarding how DUAL affects IPO underpricing are inconsistent. For example, Hearn (2011) reveals that separating CEO–chairman duality and urging founders to cede CEO positions favorably influences IPO underpricing in West Africa. Lin and Chuang (2011) show introducing DUAL increase IPO underpricing in Taiwan. Using all IPOs of 12 Arab countries from January 2000 until June 2007, Chahine and Tohmé (2009) report an average IPO underpricing of 184.1% and indicate that IPO underpricing is higher in firms with

DUAL than in those without DUAL. They suggest that strategic shareholders (e.g., corporations and other industry-related investors) are likely to play a monitoring role and that IPO underpricing is low in firms with both DUAL and strategic shareholder ownership. However, Mnif (2009) finds that DUAL does not significantly affect IPO underpricing in France. In the current study, we attempt to provide new evidence about how DUAL affects IPO underpricing by separately evaluating high-tech and non-tech IPOs.

4. Data Set and Research Methodology

4.1 Sample selection

We collect Taiwan IPO data from the TWSE and GTSM. All financial and return data are obtained from the Taiwan Economic Journal (TEJ) database. The data comprises the name, industry, offer price, number of shares offered, total asset value, IPO price range, R&D expenditure, net sales, overallotment, LWR, market returns, trading volume, managerial ownership, CEO–chairman DUAL status, underwriters, first-date trading performance, and first-day closing price for all IPOs in the 3 years from January 2009 to December 2011. The focus of this study is on the determinants of IPO underpricing in high-tech and non-tech firms in the post-global financial crisis period. We exclude the IPOs of financial firms, heretofore state-owned enterprises, or firms with incomplete financial or return data. The number of IPOs associated with voting common stocks is 142. Fifty-two of the IPOs are from the TWSE and 90 are from the GTSM, and 94 of the IPOs are from high-tech industries and 48 are from non-tech industries.

4.2 Variable definition

We initiate the IPO pricing behavior analysis by defining the IPO firms' initial returns. Following the similar procedures in Beatty and Ritter (1986), Yong (2007), and Gao (2010), we calculate the initial returns (*IR*) as follows:

$$IR_i = \frac{CP_i - OP_i}{OP_i} \tag{1}$$

where CP_i is the day on which the daily closing price of firm *i* does not reach the daily limit for the first time, OP_i is the offering price, and IR_i is the initial return of firm *i*.

We further investigate the three categories of factors influencing IPO underpricing and then compare influences between high-tech IPOs and non-tech IPOs: (a) information asymmetry proxy, (b) investor sentiment proxy, and (c) corporate governance proxy.

(a) Information asymmetry proxy

Issue size (*MKT*): We measure firm size by evaluating the natural log of total assets (MKT) in the quarter before an IPO. Investors face difficulties in obtaining information about small issuing firms and evaluating their value; therefore, the IPOs of small issuing firms are expected to exhibit more information asymmetry problems than do their large counterparts. Thus, we hypothesize that MKT is negatively related to the IPO initial return.

Initial price range (*IPR*): Hanley (1993) reports that IPOs with final offer prices exceeding the limits of the offer range have greater underpricing than all other IPOs. A wider IPR indicates higher uncertainty and information asymmetry. Therefore, we hypothesize that an IPR is positively associated with IPO underpricing. Following Hanley (1993), IPR is measured by subtracting the lower price limit from the upper price limit and then scaling the difference by the midrange price.

Underwriter reputation (*REPU*): Because of the importance of REPU (Logue et al., 2002; Neupane and Thapa, 2013), underwriters must quote reasonable prices to protect their reputation. REPU is an important indicator for investors in easing their asymmetric information problems (Logue et al., 2002). Neupane and Thapa (2013) report that underwriters with high or low reputations have strong relationships with various sets of investors and such relationships exert critical effects on IPO pricing. Low reputation underwriters demonstrate more aggressive pricing behaviors and set higher offer prices compared to high reputation underwriters. Carter and Manaster (1990) find that underwriters with higher reputation are associated with lower amounts of IPO underpricing. Based on the findings of these studies we hypothesize that REPU negatively influences IPO underpricing. Our research objective is to test whether such a negative relationship holds in Taiwan and whether a difference exists between high-tech and non-tech IPOs. We measure REPU as the ratio of the number of IPOs underwritten by an underwriter to the total number of IPOs in the three years preceding the IPO. Dunbar (1998) applies a similar measure.

Overallotment (*OA*): If a share OA exists in an IPO, investors must wait to determine if other investors might abandon a trade; therefore, waiting investors may

participate in the offering. OA is typically called a greenshoe option. A greenshoe is a clause in an IPO underwriting agreement that enables underwriters to buy up to an additional 15% of issuing shares at the offering price. Underwriters participating in the greenshoe process can exercise this option if public demand for the shares exceeds expectations and the stock trades at a price exceeding its offering price. The greenshoe process is currently the most common method of providing aftermarket price support because it enables underwriters to sell more shares to the public at a limited risk than the actual share size offered. Thus, we hypothesize that an OA moderates IPO underpricing and increases aftermarket stabilization. We measure OA by calculating the OA at the time of the offer.

Research and development intensity (*RD*): Studies indicate that information asymmetries are highly correlated with a firm's R&D expenditure (Guo et al., 2006) and high-tech IPOs are associated with high underpricing (Kim and Pukthuanthong-Le, 2008). Several studies observe that the pre-IPO R&D intensity of issuers is strongly and positively related to the first-day underpricing. This is because R&D-intensive issuers cannot set a high offering price for their IPOs as investors usually undervalue such IPOs. According to the "winner's curse" hypothesis (Rock, 1986; Beaty and Ritter, 1986), informed investors bid only for underpriced securities, whereas less-informed investors end up bidding for overpriced securities. Therefore, IPOs must be sufficiently underpriced to enable uninformed investors to earn a risk-adjusted return. Because of the characteristics of high-tech IPOs, investors are less likely to be informed about the potential effect of R&D activities; therefore, investors are expected to demand high underpricing to compensate for uncertainties. Thus, we hypothesize that RD is positively related to IPO underpricing. We measure RD as the ratio of R&D expenditure to sales in the quarter preceding a firm's IPO.

Lot-winning rate (*LWR*): LWR is directly obtained from the TEJ for the IPOs, and this rate is used to measure investors' expectation and demand for IPO stocks. According to the winner's curse hypothesis, in any bidding situation, uninformed investors overestimate the value of a specific object and tend to place higher bids than do their competitors. Such investors are more likely to win the bids, and thus pay a high price for IPO stocks. A low LWR indicates that investors have an optimal expectation towards an IPO firm. Consequently, when investors' needs are not satisfied, demand in the secondary market increases. This increases the stock price and causes investors to receive abnormal first-day returns. LWR is used to measures information asymmetry in the new stock market and is negatively correlated with IPO initial returns.

(b) Investor sentiment proxy

Market momentum (*MOM*): Loughran and Ritter (2002) report that stocks offered before IPOs positively influence IPO initial returns. Lyn and Zychowicz (2003) and Derrien and Womack (2003) find that MOM in Hungary and France exhibits a positive and significant effect on IPO initial returns. Therefore, we hypothesize that initial returns and MOM are positively correlated. We calculate MOM as follows:

$$MOM = \left[\prod_{t=0}^{T} (1 + r_t) \right] - 1 \qquad (2)$$

where *MOM* is the market momentum, $t = 0$ is the offering day, $t = T$ is the listing day, and r_t is the stock index return at day t. MOM is positive when the stock index demonstrates an upward trend and is negative when the stock index demonstrates a downward trend.

First-day trading volume (*VOL*): The trading volume is measured by dividing the VOL by the total outstanding shares. The trading volume is an important indicator of the behavior of individual investors (Gao, 2010). Cornelli et al. (2006) reveal that the IPO trading volume is positively related to the behavior of individual investors and leads to high first-day IPO returns. Therefore, we hypothesize that initial returns and VOL are positively correlated.

(c) Corporate governance proxy

Managers' ownership retention rate (*MAN*): According to agency theory, managers with high ownership retention have modest incentives to undertake non-value maximizing projects (Jensen and Meckling, 1976). Because of the reduction of agency costs, agency theory predicts that firm value increases with management ownership. Both Beatty and Zajac (1994) and Mikkelson and Partch (1997) suggest that executives and outside shareholders have a higher conflict of interest when executives' stakes decrease, which diminishes performance. By contrast, when executives retain equity, they signal to outside investors that their firms have high value. Leland and Pyle (1977) observe that a manager owning shares in a company is unintentionally signaling that the firm has a high value (signaling hypothesis). Share retention serves as a signal of firm optimal quality because founders know more about their firms' future cash flows. Morck et al. (1988) examine how the bonding of management affects agency costs by retaining an ownership stake of an IPO firm. They determine that retained ownership increases the IPO firm value because it provides a guarantee that managers can

internalize the value effects of their decisions about firms through retained ownership, and thus will make decisions in the interests of the firms rather than for their own benefit. Because of reductions in agency costs, the price investors are willing to pay for IPO shares is expected to increase. Retained ownership is a positive indicator of IPO firm value. Thus, we hypothesize that MAN and the initial underpricing are positively correlated. We measure the MAN as managerial ownership shares scaled by the total number of outstanding shares.

CEO duality (*DUAL*): The results of previous studies on the effects of DUAL on a firm's performance are inconsistent (e.g., Krause et al., 2014; Rechner and Dalton, 1991). According to general perceptions of corporate leadership structures, splitting the titles of CEO and chairman produces superior results than does combining them. Fama and Jensen (1983) argue that agency costs in large organizations are reduced by institutional arrangements that separate decision management from decision control. However, several researchers argue that information costs, the costs of changing the succession process, and splitting titles may dilute CEO and chairman of the board power to provide effective leadership; therefore, combining the titles of CEO and chairman is indeed efficient and generally consistent with shareholders' interests because management has total control (Brickley et al., 1997). Dalton et al. (1998) apply meta-analysis to 31 studies comprising 69 samples and observe no overall correlation between DUAL and firm performance. Krause and Semadeni (2014) report that splitting the CEO and board chairman positions leads to positive effects after weak firm performance, but negative effects after strong firm performance. In the current study, we consider DUAL as a determinant. The dummy variable is equal to 1 if an IPO firm has DUAL; otherwise, it is equal to zero.

4.3 Descriptive statistics

Table 1 details several characteristics of the sample data, indicating that the mean and median of the initial returns are 30% and 17% respectively. The average size of the IPO firms is NT$ 3.5 billion (approximately US$110 million). The average REPU is 0.65% and the average IPR is 15%. The greenshoe option is approximately 11%, with a standard deviation of 5%. The average lot-wining rate is 4% and ranges from 0.001 to 0.48. The R&D intensity ranges from 1% to 240%. The average MOM is 1% and ranges from −15% to 20%. The average first-day trading volume is 5% with a range from 1% to 18%.

<Insert Table 1 Here>

Table 2 shows the correlations among the information asymmetry, investor sentiment, and corporate governance measures. Initial return (IR) demonstrates positive and significant correlations with MOM and VOL, and negative and significant correlations with MKT, LWR and DUAL. In general, the correlations between the information asymmetry, investor sentiment, and corporate governance variables are small and insignificant. Only 12 of the correlations reach a significance level of at least 10%.

<Insert Table 2 Here>

5 Empirical Results

5.1 Descriptive statistics for the high-tech industry, RD expenditure, MAN, and DUAL

Panel A of Table 3 shows the full sample and subsample descriptive statistics for the high-tech industry, RD expenditure, MAN, and DUAL. Panel B shows the statistics for the double classification between the high-tech industry, MAN, and DUAL. Panel A reveals that the initial return for the entire sample is 30.26%, indicating that Taiwan's IPOs are underpriced. In addition, the average underpricing level of the high-tech IPOs is 31.7%, which is higher than that of the non-tech IPOs, implying that the high-tech IPOs have greater information asymmetry. The results also reveal that the initial return for IPOs of firms without DUAL is 32.98%, which is higher than the stock of IPOs of firms with DUAL (i.e., 12.64%); this finding is consistent with that of Brickley et al. (1997). Moreover, a positive MOM is observed before IPO filing, implying that firms tend to go public during bull markets. The average log market size is 14.36, and the difference in the log market size between the high-intensity R&D and low-intensity R&D IPOs is −0.589, indicating that high-intensity R&D IPOs tend to be associated with smaller firms compared with low-intensity R&D IPOs. We also find that the high-intensity R&D IPOs have less uncertainty than do the low-intensity R&D IPOs. In addition, the stocks of the high-intensity R&D IPOs tend to have higher momentum and trading volume compared with those of the low-intensity R&D IPOs.

Panel B indicates that DUAL and high-tech IPOs are less underpriced than the non-DUAL, high-tech IPOs (16.6% vs. 33.9%); the mean difference between these two groups is −17.2% (t = −2.32), implying that DUAL reduces the uncertainty of high-tech IPOs and thus reduces their underpricing. DUAL exerts a stronger influence on non-tech IPOs compared with high-tech IPOs, and the difference in underpricing for non-tech IPO between with DUAL and those without DUAL is −25.3% (t = −2.91). Therefore, when the chairman of a board of directors also acts as CEO, management

has total control; consequently, firms with DUAL tend to quote offering prices close to the first-day closing price. However, the stocks of IPOs without DUAL have higher underpricing. This implies that adopting effective corporate governance practices is an indicator of positive firm value. Moreover, the stocks of high-tech IPOs generate 31.72% returns (t = 6.31), whereas those of non-tech IPOs generate 27.40% returns (t = 4.17). This signifies that high-tech IPOs exhibit higher growth potential compared with non-tech IPOs. We double-sort stocks according to high-tech or non-tech status and MAN (Table 3) and observe that high-tech IPO stocks with high MAN produce higher first-day returns (32.3%) compared with the other three groups. As expected, non-tech IPOs with low MAN produce the lowest first-day return (2.26%). We also conduct multivariate analyses to examine the effects of interactions among technology, R&D spending, MAN, and DUAL on IPO underpricing.

<Insert Table 3 Here>

5.2. Initial return determinants

Regression (3) is used to examine the information asymmetry control variables related to IPO underpricing, including MKT, REPU, IPR, RD, OA, and LWR.

$$IR = \beta_0 + \beta_1 Ln(TA) + \beta_2 REP + \beta_3 IPR + \beta_4 OA + \beta_5 LWR + \beta_6 RD + \mu \quad (3)$$

Column 1 of Table 4 shows that OA is negatively related to IPO underpricing (t = −2.05), signifying that OA enhances aftermarket stabilization. LWR is negatively related to IPO underpricing (t = −2.12), supporting the winner's curse hypothesis.

Regression (4) shows the independent and moderating variables of investor sentiment, including MOM and first day trading volume ratio.

$$IR = \beta_0 + \beta_1 Ln(TA) + \beta_2 REP + \beta_3 IPR + \beta_4 OA + \beta_5 LWR + \beta_6 RD + \beta_7 MOM + \beta_8 VOL + \mu \quad (4)$$

Column 2 of Table 4 reveals that both MOM and VOL are positively related to IPO underpricing (t = 4.32 and t = 6.77 respectively), indicating that market conditions and market liquidity are partly reflected by IPO pricing.

Regression (5) shows the independent and moderating variables of corporate governance, including MAN, DUAL, and a high-tech industry dummy (*TECH*).

$$IR = \beta_0 + \beta_1 Ln(TA) + \beta_2 REP + \beta_3 IPR + \beta_4 OA + \beta_5 LWR + \beta_6 RD + \beta_7 MOM + \beta_8 VOL + \beta_9 MAN + \beta_{10} DUALITY + \beta_{11} TECH + \mu \quad (5)$$

Column 3 of Table 4 reveals that MAN is positively related to IPO underpricing (t = 2.14). This result is consistent with the signaling hypothesis (i.e., a manager owning shares in a company is unintentionally signaling that the firm has a high value, leading to higher initial returns). DUAL is negatively related to IPO underpricing (t = −1.65), signifying that combining the CEO and chairman positions reduces the uncertainty of high-tech firms in pricing their IPOs, thereby reducing underpricing. Column 3 also shows that TECH and IPO underpricing are positively related, though the relationship is insignificant.

We combine regression (6) with a MAN rate and high-tech IPO (*MAN* × *TECH*) interaction term to determine whether ownership retention increases the value of IPO firms. Column 4 of Table 4 reveals that the interaction term (*MAN* × *TECH*) is significantly positive (t = 1.73), indicating that IPO underpricing is greater at higher levels of MAN rate for the high-tech industry. Regression (6) includes two additional interaction terms, namely DUAL and high-tech IPO (*DUAL* × *TECH*) and R&D expenditure and high-tech IPO (*TECH* × *RD*). The interaction term (*DUAL* × *TECH*) and DUAL (*DUAL*) are insignificant (t = 0.44 for both terms), indicating that DUAL does not directly moderate the form of the relationship between technology and IPO underpricing. The interaction term (*TECH* × *RD*) is significantly negative (t = −1.77), signifying that R&D expenditure can reduce the influence of uncertainty on IPO underpricing because of the high demand for technology.

$$IR = \beta_0 + \beta_1 Ln(TA) + \beta_2 REP + \beta_3 IPR + \beta_4 OA + \beta_5 LWR + \beta_6 RD + \beta_7 MOM + \beta_8 VOL + \beta_9 MAN + \beta_{10} DUALITY + \beta_{11} TECH + \beta_{12} MAN \times TECH + \beta_{13} DUAL \times TECH + \beta_{14} TECH \times RD + \mu \quad (6)$$

< Insert Table 4 Here>

The results in Column 4 of Table 4 suggest that technology does not directly influence IPO underpricing. Thus, we further investigate whether technology indirectly moderates IPO underpricing. Column 1 of Table 5 shows that for high-tech IPOs, RD and MAN are significant (t = −2.29 and 2.15, respectively), while for non-tech IPOs, RD and MAN are insignificant (t = 0.14 and 0.48 respectively). Our results suggest that investor perceptions about firm value significantly influence underpricing phenomena across various industries. For non-tech IPOs, we observe that the IPR positively and significantly influence IPO underpricing, and LWRs negatively affect

IPO underpricing. The results are consistent with our expectations. Typically market news about high-tech IPOs attracts investors' attention more easily compared with that about non-tech IPOs. Therefore, the methods of delivering IPO information in high-tech and non-tech industries differ. We find that non-tech IPOs are associated with a higher IPR, implying high market price uncertainties leading to considerable underpricing effect for the first trading day. One reason for this may be that in Taiwan's stock market, less timely and high-quality market-ready information is available for non-tech firms compared with high-tech firms; thus, investors may have difficulty in interpreting the IPO pricing information of such firms in the pre-IPO market. For high-tech IPOs, the MKT and OA reduce IPO underpricing. These results are consistent with those of previous studies. Notably, we observe a negative relationship exists between R&D intensity and underpricing in the case of high-tech IPOs. This result is different from the findings of some prior studies that show investors typically undervalue R&D-intensive firms. However, underpricing is extremely costly for issuers because it reduces a firm's capital. RD is considerably vital for high-tech industries as it enables them to develop technologies and establish a strong intellectual property portfolio. Evidence shows that R&D intensity for high-tech IPOs is a signal of intelligent legitimacy and that technology demand reduces IPO underpricing for high-tech firms. Moreover, we find that the MAN rate is positively related to first-day trading returns for high-tech IPOs. This result is consistent with the signaling hypothesis and supports the argument that the ownership retention rate is a signal of a company's quality. However, this relationship does not reach significance for non-tech IPOs. This may be because more high-tech firms in Taiwan adopt executive share bonus schemes compared with non-tech firms. Furthermore, the Chow test demonstrates that a significant difference exists in the explanatory power of the regressions between the two subsamples (F-value = 12.14) as shown in Table 5.

< Insert Table 5 Here>

6. Conclusions

In this study, we investigate the first-day underpricing of IPOs in Taiwan during the post-financial crisis period of 2009–2011. We examine 142 IPOs in Taiwan, and the results show substantial IPO underpricing of approximately 30.26%. We hypothesize that three categories of factors influence IPO underpricing, namely information asymmetry, investor sentiment, and corporate governance. Our results support the existence of all three categories determining IPO underpricing. In particular, we find that information asymmetry variables such as OA and LWR are negatively related to

underpricing, whereas investor sentiment variables such as MOM and first-day trading volume are positively related to underpricing.

We divide IPO stocks into high-tech IPOs and non-tech IPOs. We find that for high-tech IPOs MKT, OA, and RD are negatively related to underpricing. The MKT, OA, and RD reduce high-tech IPO underpricing, whereas high MAN rates increase high-tech IPOs' first-day trading returns. This result is consistent with the signaling hypothesis and supports the argument that ownership retention rate is a signal of a company's quality. For non-tech IPOs the IPR positively and significantly affects IPO underpricing, and LWRs and DUAL negatively affect IPO underpricing. Overall, the findings of this study suggest that IPO prices can be stabilized by introducing greenshoe options, and IPO underpricing is strong in hot markets, particularly when investor demand is high. Furthermore, our results show that high manager ownership retention rates in high-tech IPOs are associated with high IPO underpricing, which supports the signaling hypothesis.

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Table 1 Descriptive statistics

Variables						*Percentiles*		
	Mean	*Median*	*Std. Deviation*	*Minimum*	*Maximum*	*25*	*50*	*75*
IR	0.30	0.17	0.48	-0.20	3.49	0.00	0.17	0.41
MKT (millions)	3,553	1,410	11,181	209	130,495	892	1,410	3,137
REPU	0.065	0.066	0.047	0.00	0.19	0.024	0.0662	0.0960
IRP	0.15	0.13	0.11	0.00	1.02	0.10	0.13	0.18
OA	0.11	0.14	0.05	0.00	0.15	0.05	0.14	0.15
LWR	0.04	0.02	0.06	0.00	0.48	0.01	0.02	0.05
RD	0.19	0.13	0.25	0.01	2.40	0.08	0.13	0.23
MOM	0.01	0.02	0.07	-0.15	0.20	-0.05	0.02	0.05
VOL	0.05	0.05	0.03	0.01	0.18	0.03	0.05	0.06
MAN	0.36	0.31	0.19	0.01	0.94	0.21	0.31	0.45
DUAL	0.13	0.00	0.34	0.00	1.00	0.00	0.00	0.00

Table 2 Correlation analysis

	IR	*MKT*	*REPU*	*IRP*	*OA*	*LWR*	*MOM*	*VOL*	*MAN*	*DUAL*	*TECH*
MKT	-0.23***										
REPU	0.04	0.05									
IRP	0.08	-0.16**	-0.08								
OA	-0.09	-0.09	-0.05	-0.02							
LWR	-0.28***	0.43***	-0.16*	0.08	-0.12						
MOM	0.42***	0.01	0.15*	0.001	0.12	-0.26***					
VOL	0.60***	-0.26***	0.07	-0.004	-0.07	-0.34***	0.27***				
MAN	0.10	-0.09	0.11	-0.01	-0.02	0.006	-0.02	-0.002			
DUAL	-0.14*	-0.02	-0.11	0.01	0.005	-0.04	0.01	-0.07	0.04**		
TECH	0.04	0.06	-0.01	0.003	0.003	0.10	0.05	0.07	0.20	-0.02	
RD	-0.08	-0.22**	0.05	0.01	-0.18*	-0.05	-0.12	0.00	-0.05	0.02	-0.16*

Table 3 Descriptive statistics by high-tech industry, RD expenditure, ownership retention by managers, and CEO duality

Panel A

	Full	TECH	Non-TECH	High R&D	Low R&D	High MAN	Low MAN	Dual	Non Dual								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(2)-(3)	*t-stat*	(4)-(5)	*t-stat*	(6)-(7)	*t-stat*	(8)-(9)	*t-stat*
IR	0.302	0.317	0.274	0.287	0.317	0.330	0.274	0.126	0.329	0.043	(0.52)	-0.030	(-0.37)	0.056	(0.70)	-0.203	(-3.53)
MKT	14.366	14.408	14.283	2.558	3.148	14.212	14.519	14.306	14.375	0.124	(0.68)	-0.589	(-3.76)	-0.307	(-1.89)	-0.068	(-0.28)
REPU	0.064	0.064	0.065	0.064	0.065	0.068	0.060	0.051	0.066	-0.001	(-0.15)	-0.001	(-0.17)	0.008	(1.00)	-0.015	(-1.36)
IRP	0.154	0.155	0.154	0.169	0.140	0.165	0.144	0.158	0.154	0.0003	(0.03)	0.029	(1.63)	0.021	(1.20)	0.004	(0.25)
OA	0.106	0.106	0.105	0.103	0.109	0.105	0.107	0.107	0.106	0.001	(0.03)	-0.006	(-0.70)	-0.002	(-0.22)	0.001	(0.05)
LWR	0.040	0.044	0.030	0.029	0.050	0.037	0.042	0.033	0.041	0.013	(1.60)	-0.020	(-1.92)	-0.005	(-0.54)	-0.007	(-0.77)
MOM	0.009	0.011	0.004	0.009	0.008	0.008	0.010	0.011	0.008	0.007	(0.59)	0.001	(0.14)	-0.002	(-0.17)	0.003	(0.20)
VOL	0.052	0.053	0.049	0.056	0.048	0.053	0.051	0.046	0.053	0.004	(0.89)	0.007	(1.54)	0.002	(0.35)	-0.006	(-1.27)
MAN	0.030	0.035	0.019	0.030	0.030	0.053	0.007	0.034	0.029	0.016	(3.02)	-0.000	(-0.02)	0.046	(9.80)	0.005	(0.61)
DUAL	0.13	0.13	0.15	0.13	0.14	0.17	0.10	-	-	-0.02	(-0.29)	-0.01	(-0.24)	0.07	(1.23)	-	
TECH	0.662	-	-	0.619	0.704	0.746	0.577	0.631	0.666	-		-0.084	(-1.06)	0.169	(2.14)	-0.035	(-0.28)
RD	0.195	0.211	0.155	0.308	0.080	0.175	0.213	0.208	0.192	0.055	(1.71)	0.227	(6.01)	-0.038	(-0.90)	0.015	(0.25)
N	142	94	48	71	71	71	71	19	123								

Panel B

	High-MAN/ TECH	Low-MAN/ TECH	High-MAN/ Non-TECH	Low-MAN/ Non-TECH	Dual/ TECH	Non-Dual/ TECH	Dual / Non-TECH	Non-Dual/ Non-TECH	(1)-(2)	*t-stat*	(3)-(4)	*t-stat*	(5)-(6)	*t-stat*	(7)-(8)	*t-stat*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)								
IR	0.323	0.309	0.353	0.226	0.166	0.339	0.057	0.311	0.013	(0.13)	0.126	(0.93)	-0.172	(-2.32)	-0.253	(-2.91)
MKT	14.245	14.618	14.113	14.385	14.328	14.419	14.269	14.286	-0.372	(-1.99)	-0.272	(-0.92)	-0.091	(-0.31)	-0.016	(-0.04)
REPU	0.067	0.060	0.073	0.060	0.040	0.067	0.069	0.065	0.006	(0.62)	0.013	(0.90)	-0.027	(-2.15)	0.004	(0.20)
IRP	0.170	0.135	0.152	0.155	0.158	0.154	0.159	0.153	0.034	(1.59)	-0.002	(-0.10)	0.003	(0.15)	0.006	(0.21)
OA	0.107	0.105	0.099	0.109	0.104	0.106	0.111	0.105	0.002	(0.15)	-0.010	(-0.63)	-0.002	(-0.14)	0.006	(0.31)
LWR	0.041	0.048	0.024	0.034	0.040	0.045	0.021	0.032	-0.007	(-0.48)	-0.010	(-1.35)	-0.004	(-0.21)	-0.010	(-1.52)
MOM	0.006	0.018	0.013	-0.002	0.010	0.011	0.013	0.002	-0.012	(-0.89)	0.015	(0.71)	-0.002	(-0.10)	0.011	(0.43)
VOL	0.053	0.055	0.054	0.046	0.050	0.054	0.041	0.051	-0.002	(-0.33)	0.007	(0.99)	-0.004	(-0.57)	-0.010	(-1.81)
MAN	0.056	0.008	0.042	0.006	0.044	0.034	0.017	0.020	0.049	(8.14)	0.036	(7.60)	0.010	(0.87)	-0.002	(-0.30)
DUAL	0.19	0.05	0.11	0.17	1.0	0.0	1.0	0.00	0.14	(2.18)	-0.05	(-0.51)	-	-	-	-
TECH	1.000	1.000	0.000	0.000	1.000	1.000	0.000	0.000	-	-	-	-	-	-	-	-
RD	0.184	0.242	0.148	0.160	0.240	0.206	0.139	0.158	-0.058	(-0.99)	-0.012	(0.44)	0.034	(0.38)	-0.019	(-0.49)
N	53	41	18	30	12	82	7	41								

Table 4 Results of the moderated regression analyses between the independent variables and underpricing

Variables				
Intercept	1.7415***	0.8705	0.7978	0.8585
	(2.54)	(1.51)	(1.39)	(1.51)
MKT	-0.0837*	-0.0589	-0.0610*	-0.0667*
	(-1.79)	(-1.56)	(-1.64)	(-1.78)
REPU	0.0015	-0.0114	-0.0066	-0.0057
	(0.79)	(-0.73)	(-0.43)	(-0.37)
IRP	0.3514	0.2939	0.2743	0.3120
	(0.95)	(1.01)	(0.96)	(1.11)
OA	-0.0152**	-0.0109*	-0.0124**	-0.0127**
	(-2.05)	(-1.83)	(-2.11)	(-2.19)
LWR	-0.0185***	-0.0005	-0.0006	-0.0014
	(-2.72)	(-0.09)	(-0.11)	(-0.26)
RD	-0.3174**	-0.1869	-0.1582	-0.0534
	(-2.01)	(-1.48)	(-1.25)	(-0.38)
MOM		0.0211***	0.0226***	0.0233***
		(4.32)	(4.68)	(4.87)
VOL		8.0659***	0.0792***	0.0794***
		(6.77)	(6.69)	(6.79)
MAN			0.0033**	0.0032**
			(2.14)	(2.09)
DUAL			-0.1450*	-0.1978
			(-1.65)	(-1.37)
TECH			0.0016	0.0295
			(0.03)	(0.32)
*MAN*TECH*				0.0154*
				(1.73)
*DUAL*TECH*				0.0790
				(0.44)
*TECH*RD*				-0.5037*

				(-1.77)
Adj-R^2	0.1088	0.4441	0.4634	0.4765
Prob > F	0.001	0.000	0.000	0.000
N	142	142	142	142

Table 5 Subgroup analysis for examination of the effect of MAN on DUAL

	High-TECH	Non-TECH
Variables		
Intercept	1.8043**	-0.5562
	(2.39)	(-0.55)
MKT	-0.1299***	0.0444
	(-2.66)	(0.63)
REPU	-0.0123	0.0047
	(-0.76)	(0.11)
IRP	-0.0086	0.2723**
	(-0.03)	(2.12)
OA	-0.0117*	-0.0130
	(-1.71)	(-1.03)
LWR	0.0064	-0.0638***
	(1.09)	(-2.51)
R&D	-0.5841**	0.0232
	(-2.29)	(0.14)
MOM	0.0241***	0.0184**
	(4.06)	(2.04)
VOL	0.0899***	0.0555**
	(6.69)	(2.26)
MAN	0.0040**	0.0014
	(2.15)	(0.48)
DUAL	0.0226	-0.3826
	(0.14)	(-1.54)
Adj-R^2	0.5522	0.3523
Prob > F	0.000	0.003
N	94	48
Difference in R^2	Chow test F-value = 12.14	(p-value = 0.000)