Pricing Taiwan's Initial Public Offerings

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Abstract

This paper has employed the nonparametric minimum convex input requirement set (MCIRS) approach to measure the premarket underpricing and aftermarket inefficiency in Taiwan's initial public offerings (IPOs). The empirical results show that first, the average level of underpricing in Taiwan's IPO premarket is 15.66%, and underpricings in the hot- and nonhot-market periods are not different. Second, underpricing in the electronic IPOs (purchased by both (informed) institutional investors and (uninformed) individual investors) is not different from that in the non-electronic IPOs (purchased by (uninformed) individual investors). This result may not be consistent with Rock's (1986) winner's curse explanation for IPO underpricing. Third, in the nonhot-market period, premarket underpricing disappears one week after trading (i.e. there is no aftermarket inefficiency), and in the hot-market period, new issues are overpriced one week after trading (i.e. there is an aftermarket inefficiency). The paper also finds that the commonly used method of valuing IPOs with price-earnings (*P/E*), market-to-book and price-to-sales multiples of comparable firms performs poorly in Taiwan's IPOs. The predictability of the comparable firms method improves when the market values-to-sales and enterprise value-to-sales multiples are used.

JEL classification: G11, G14, and G32

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1. Introduction

It is well known that initial public offerings (IPOs) generate abnormally high returns during a short period following their issuance (Logue, 1973; Ibbotson, 1975; Ibbotson, Sindelar and Ritter, 1988; Ritter, 1991; Aggarwal and Rivoli, 1990; Koh and Walter, 1989; Loughran, Ritter and Rydqvist, 1994; Liaw, Liu and Wei, 2001; Ritter 2003; among

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others). Ibbotson and Jaffe (1975) and Ibbotson, Sindelar and Ritter (1988) show that issuers obtain a higher offer price in hot-issue than in nonhot-issue markets. Rock (1986) suggests that IPO underpricing compensates uninformed investors for the risk of trading against superior information. Rock's winner's curse explanation for underpricing is consistent with the empirical findings of Carter and Manaster (1990), Lee, Taylor and Walter (1999) and Aggarwal, Prabhala and Puri (2002) that institutional investors are better informed and tend to earn greater profits on their IPO investments. Baron (1982) argues that the investment bank (underwriter) is better informed, and the demand for investment banking advice and distribution services provides an explanation for underpricing. Beatty and Ritter (1986) shows that IPO underpricing is positively related to the uncertainty of investors regarding its value, and investment banks have an interest in maintaining an equilibrium amount of underpricing to earn a fair rate of return on their reputation capital. Tinic (1988) finds that IPO underpricng serves as a form of insurance against legal liability and the associated damages to the reputations of investment bankers (see also Mahoney, 2001).

All the above empirical studies have used aftermarket data to infer correct price relative to the premarket offer price. This neglects the possibility that an IPO needs not be deliberately underpriced if its observed abnormally high returns are due to aftermarket fads (Aggarwal and Rivoli, 1990; Ritter, 1991) or underwriter's price support (Hanley, Kumar and Sequin, 1993; Rudd, 1993). Hunt-McCool, Koh and Francis (1996) use the stochastic frontier method to measure "inefficiency" or premarket underpricing (the difference between the efficient offer price and the actual offer price). The stochastic frontier method, however, is parametric, i.e. it assumes a particular functional form to estimate efficiency. This paper employs Chang's (1999) minimum convex input requirement set (MCIRS) approach to measure the premarket underpricing and aftermaket inefficiency in Taiwan's IPOs. The MCIRS approach is nonparametric, and can measure the premarket underpricing in each IPO. The empirical results show that first, Taiwan's IPOs appear to be deliberately underpriced, and the average levels of premarket underpricing in the hot- and nonhot-market periods are not different. Second, premarket underpricing in the electronic IPOs (purchased by both (informed) institutional investors and (uninformed) individual investors) is not different from that in the non-electronic IPOs (purchased by (uninformed) individual investors). This result may not be consistent with Rock's winner's curse explanation for IPO underpricing. Third, in the nonhot-market period, the premarket underpricing disappears after trading starts (i.e. there is no aftermarket inefficiency), and in the hot-market period, new issues are overpriced in the aftermarket (i.e. there is an aftermarket inefficiency). This paper also finds that the commonly used method of valuing IPOs with price-earnings (*P/E*), market-to-book and price-to-sales multiples of comparable firms performs poorly in Taiwan's IPOs. The predictability of the comparable firms method improves when the market values-to-sales and enterprise value-to-sales multiples are used.

The remainder of this paper is organized as follows. Section 2 describes the data and institutional features of Taiwan IPO market. Section 3 reports the results of employing the comparable firms approach. The results of measuring premarket underpricing and aftermaket inefficiency are presented in Section 4. Concluding remarks appear in Section 5.

2. Data and Institutional Features

The data employed in this analysis were adopted from the publications of Taiwan's Securities and Futures Commission (SFC) and the prospectus of IPOs. The sample consists of 84 IPOs issued in the 1991 to 1992 and 1995 to 1996 periods. Our sample is restricted to these two periods because first, market multiples may change significantly when longer periods are used (Kim and Ritter, 1999), and second, so that it is possible to tell whether the premarket underpricing in the hot-issue market period (1991 to 1992) is different from that in the nonhot-issue market period (1995 to 1996). Ibbotson and Jaffe's (1975) definition of hot-markets is used - meaning periods in which the measured aftermarket returns exceed the median aftermarket return.[1]

Taiwan's SFC has proposed a formula for pricing IPO:

$$\begin{aligned} \textit{offer price} = {} & (P/E)\ \textit{factor} \times 40\% + \textit{past dividend factor} \times 20\% + \\ & \textit{book value factor} \times 20\% + \textit{future dividend factor} \times 20\%, \end{aligned} \tag{1}$$

where (*P/E*) factor = (the median price/earnings ratio, using the most recent three years of earnings for comparable firms) × (the median after-tax earnings per share of the most recent three years of the IPO firm), past dividend factor = (the average dividend per share of the most recent three years of the IPO firm) ÷ (the median dividend yield rate of comparable firms for the most recent three years), book value factor = current net book value per share of the IPO firm, and future dividend factor = (predicted next year's dividend per share of the IPO firm) ÷ (one year risk-free interest rate). Equation (1) is a combination of the comparable firms' approach and the book value approach without adjusting for the growth and quality of the earnings. Although equation (1) is only for reference, investment banks (underwriters) in Taiwan follow it closely. Underwriters and issuers jointly determine the offer price, obtain a permit from the SFC, and then sell the new stock to the public. Before March 1995, all investors applied for IPO by sending photocopies of their IDs, and underwriters drew lots. Each investor applies for the same number of shares and has an equal probability of receiving an allocation. After March 1995, half of the shares of the IPO are sold via sealed bid auction. The offer price in the random drawing process (for the other half of the shares) is the weighted average of successful bid prices in the auction. It is commonly believed that bidders in the auction collude, and IPOs are greatly underpriced.[2]

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[1] Ibbotson et al.'s formula is: $e_{1,i,t} = R_{1,i,t} - R_{mt}$ and $e_{1,t} = \sum_{i=1}^{s} e_{1,i,t} / s$, where $R_{1,i,t}$ is the first month returns of the i-th IPO issued at month t, R_{mt} is the returns of market portfolio at month t, s is the number of the IPOs issued at month t. The hot-issued market period is defined as the month when $e_{1,t}$ is greater than the median of $e_{1,t}$'s.

[2] Because there are too many requests for the IPOs, the random drawing process is always used with a very low probability (6%) of receiving an allocation.

3. Pricing IPOs with Comparable Firm Multiples

The IPOs literature has suggested that underwriters price a new issue by comparing its operational and financial performance with that of several firms in the same or similar industry. In this section, the same comparable firm multiples as in Kim and Ritter are used to examine how these multiples perform in Taiwan's IPO.

Table 1
Descriptive statistics for the 84 IPOs

	Minimum	Maximum	Standard deviation	Mean	Percentile of distribution 25th	50th	75th
Offer price (*OP*)	16.00	108.00	17.28	45.72	33.50	42.00	56.00
First market price	17.10	105.5	17.04	47.11	35.30	43.80	58.75
Earnings per share (*EPS*)	-2.03	55.30	5.96	3.84	2.01	2.80	4.03
Preissue book value/share	0.01	74.02	8.25	17.02	13.50	15.43	17.76
Postissue book value/share	11.56	46.62	5.01	16.73	13.88	15.39	17.74
Sales (millions)	538	4289	6242	4092	1367	2044	3645
P/E (*OP/EPS*)	-11.00	87.43	11.96	20.93	14.51	18.92	25.25
$M/B_{preissue}$	0.01	5.76	0.91	2.67	2.02	2.64	3.14
$M/B_{postissue}$	0.22	6.97	0.83	1.25	0.80	1.12	1.37
P/S (*OP*/sales per share)	0.07	3.53	0.68	0.83	0.43	0.58	1.03

Earnings per share (*EPS*) and sales are for the most recent 12 months reported in the prospectus. $M/B_{preissue} = OP/BPS_{preissue}$, where *OP* is the offer price, and $BPS_{preissue}$ is the pre-issue book value per share. $M/B_{postissue} = OP/BPS_{postissue}$, where $BPS_{postissue}$ is the post-issue book value per share. The daily price limit is 7%.

Table 1 shows descriptive statistics for 84 IPOs from 1991 to 1992 and 1995 to 1996 sample periods. All the statistics for the price-earnings (*P/E*), preissue market-to-book ($M/B_{preissue}$), postissue market-to-book ($M/B_{postissue}$), and price-to-sales (*P/S*) multiples (where price is the offer price) are lower than those in Kim and Ritter. The regression equations for the comparable firms approach with *P/E*, $M/B_{postissue}$, and *P/S* are:[3]

$$(P/E)_i = a_0 + a_1 (P/E)_{comp,i} + e_i \tag{2}$$

where $(P/E)_i$ = the *i*-th IPO's price/earnings ratio and $(P/E)_{comp,i}$ = the median price / earnings ratio, using the most recent 12 months of pre-IPO earnings for comparable IPOs;

$$(M/B_{postissue})_i = a_0 + a_1 (M/B)_{comp,i} + e_i \tag{3}$$

[3] Kim and Ritter calculate *M/B* ratios using postissue book values because (1) the proceeds affect the postissue book value per share, and (2) investors are buying the postissue shares with postissue multiples.

where $(M/B_{postissue})_i$ = the i-th IPO's postissue market-to-book ratio and $(M/B)_{comp,i}$ = the median postissue market-to-book ratio, using the most recent 12 months of postissue book value of equity for comparable IPOs;

$$(P/S)_i = a_0 + a_1 (P/S)_{comp,i} + e_i \tag{4}$$

where $(P/S)_i$ = the i-th IPO's price-to-sales ratio, $(P/S)_{comp,i}$ = the median price-to-sales ratio, using the most recent 12 months of price-to-sales for comparable IPOs and sales are the last 12 months sales.

Table 2
Distribution of multiples for IPOs and their comparable firms and regressions of IPO multiples on the comparable firm multiples with equations (2)–(4).

Panel A: Distribution of multiples

	IPOs				Comparable firms medians			
	Mean	Percentile of distribution			Mean	Percentile of distribution		
		25th	50th	75th		25th	50th	75th
P/E	20.93	14.51	18.92	25.25	27.24	18.54	21.77	33.48
M/B	1.25	0.80	1.12	1.27	1.31	1.00	1.20	1.53
P/S	0.83	0.43	0.58	1.03	0.88	0.49	0.70	1.10

Panel B: OLS regressions of equations (2)–(4) and prediction errors

Dependent variable	Coefficient estimates			Absolute prediction errors		Percentage within 15% of actual multiple using	
	a_0	a_1	R^2_{adj}(%)	Mean (%)	Median (%)	*OP* (%)	P_{market} (%)
P/E	17.89 (8.19)*	0.11 (13.62)*	2.18	38.68	30.68	24.14	26.44
M/B	0.85 (3.50)*	0.31 (3.39)*	2.39	39.40	30.20	40.23	29.89
P/S	0.54 (4.68)*	0.33 (6.37)*	9.13	64.24	47.81	20.69	10.34

Panel C: Prediction errors with $a_0 = 0$ and $a_1 = 1$ in equations (2)–(4)

	Prediction errors		Absolute prediction errors		Percentage within 15% of actual multiple using	
	Mean (%)	Median (%)	Mean (%)	Median (%)	*OP* (%)	P_{market} (%)
P/E	25.66	22.85	44.17	33.08	13.79	23.81
M/B	12.46	13.08	45.12	34.15	6.90	22.99
P/S	15.97	20.76	64.35	54.13	10.34	14.94

* means significant at 5% level.

Earnings are measured for the most recent 12 months prior to going public. There are 84 IPOs with at least one prior IPO (on the filing date) with *EPS* during 12 months before it went to public to use as a comparable. If there are more than five qualifying IPOs to use as comparable firms, the five IPOs with the closest sales are used. Price-earnings (*P/E*), postissue market-to-book ($M/B_{postissue}$), and price-to-sales (*P/S*) multiples are calculated using the offer price for the IPOs, and the market prices on the day before issuing for the comparable firms. In calculating the median *P/E*, *M/B* and *P/S* ratio for the comparable firms, if there is an even number of firms, the midpoint of the adjacent ratios is used. The prediction error is measured as the natural logarithm of the predicted multiple minus the natural logarithm of the actual multiple. The absolute prediction error is the absolute value of the prediction error. The percentage of predicted valuations within 15% of the actual multiple is computed as | log (predicted) – log (actual) | < 0.15 using both the offer price (*OP*) and the first closing market price (P_{market}). *t*-statistics are in parentheses.

The mean and median of IPO and comparable multiples presented in Panel A of Table 2 are less than those in Kim et al. The comparable firms' multiples are higher than the multiples of IPO because market prices for the comparable firms and offer prices for the IPOs are used. The regression results of equations (2) to (4) are reported in Panel B of Table 2. The adjusted R^2s are (as in Kim et al.) less than 10%. The estimated slope coefficient (a_1), though, is positive and significantly different from zero, and far below unity. This finding (as in Kim et al.) rejects the functional fixation hypothesis that the market mechanically capitalizes reported EPS numbers without any adjustment. The prediction errors (the natural logarithm of the ratio of the predicted multiple to the actual multiple) are also calculated along with absolute prediction errors (the absolute value of the prediction error). The percentages of predicted multiples within 15% of the actual multiples are higher when offer price (*OP*) rather than the first market price (P_{market}) is used. In Panel C of Table 2, it is assumed that $a_0 = 0$ and $a_1 = 1$ in equations (2) to (4) to estimate mean and median prediction errors and absolute prediction errors for the three multiples. The percentages of predicted multiples within 15% of the actual multiples are higher when P_{market} is used. Unlike Kim et al.'s US results, these percentages (except the case of using *P/S* ratio and P_{market}) are lower than those from the regressions. It implies that the common industry practice of using the simple multiples approach (such as equation (1)) is inappropriate in pricing Taiwan's IPOs.

Table 3
Regressions of IPO *MV/Sales, EV/Sales and EV/OCF* multiples on the comparable firm multiples

$(MV/Sales)_i = a_0 + a_1\,(MV/Sales)_{comp,i} + e_i$
$(EV/Sales)_i = a_0 + a_1\,(EV/Sales)_{comp,i} + e_i$
$(MV/OCF)_i = a_0 + a_1\,(EV/OCF)_{comp,i} + e_i$

$(MV/Sales)_i$ = the *i*-th IPO's market value-to-sales ratio, $(MV/Sales)_{comp,i}$ = the mean market value-to-sales ratio, using the most recent 12 months of pre-IPO sales for comparable IPOs, $(EV/Sales)_i$ = the *i*-th IPO's enterprise value-to-sales ratio, $(EV/Sales)_{comp,i}$ = the mean enterprise value-to-sales, using the most recent 12 months of enterprise value-to-sales for comparable IPOs, $(EV/OCF)_i$ = the *i*-th IPO's enterprise value-to-operating cash flow ratio, $(EV/OCF)_{comp,i}$ = the mean enterprise value-to-operating cash flow ratio, using the most recent 12 months of enterprise value-to-operating cash flow for comparable IPOs, *EV* is the market value of equity plus the book value of debt, minus cash, and *OCF* is the earnings before interest, taxes, depreciation and amortization (EBITDA). The prediction errors are measured as the natural log of the ratio of the predicted multiple to the actual multiple, using the regression for the prediction. The absolute prediction errors are absolute values of the prediction errors. The percentage of predicted valuations within 15% of the actual multiple is based on the log ratio of predicted to actual multiples with two ways: using the regression prediction ("Regression") and using a simple multiples approach ("Simple"). The simple multiples approach uses the geometric mean of the comparables' multiple as the forecast, which is equivalent to a zero intercept and slope 1 in the regression. *t*-statistics are in parentheses.

Dependent variable	Coefficient estimates			Absolute prediction errors		Percentage within 15% of actual multiple using	
	a_0	a_1	R^2_{adj} (%)	Mean (%)	Median (%)	Regression (%)	Simple (%)
MV/Sales	0.58 (2.13)*	0.73 (2.56)*	35.35	49.75	42.55	22.99	18.39
EV/Sales	-0.83 (-2.02)*	4.15 (3.42)*	58.53	54.76	36.43	19.54	28.74
EV/OCF	13.73 (17.42)*	0.03 (8.30)*	0.15	28.23	19.84	32.18	31.03

* means significant at 5% level.

Table 3 shows the regression results of using market value-to-sales (*MV/Sales*), enterprise value-to-sales (*EV/Sales*) and enterprise value-to-operating cash flow (*EV/OCF*) ratios, where *EV* is the market value (*MV*) of equity plus the book value of debt, minus cash, and *OCF* is the earnings before interest, taxes, depreciation and amortization (EBITDA). The adjusted R^2's of using *MV/Sales* and *EV/Sales* are (as in Kim et al.) much higher than those of Table 2. The adjusted R^2 of using *EV/OCF* is lower. Table 4 gives the results of using the six multiples in both hot-issue and nonhot-issue periods. The adjusted R^2 is still low when *P/E* or *M/B* ratio is used. The performance of *P/S* is good in the hot period ($R^2 = 0.2598$), but bad in the nonhot period ($R^2 = -0.007$). The *EV/Sales* multiple performs very well in the hot period ($R^2 = 0.7171$).[4]

[4] Kim et al. argue that investment banks can do superior fundamental analysis, and the difficulty of using comparable multiples for pricing IPOs leaves a large role for investment banks in valuing IPOs.

Table 4
Regressions of IPO six multiples on the comparable firm multiples for the hot-issue and nonhot-issue market periods

	Hot			Nonhot		
	a_0	a_1	R^2_{adj}(%)	a_0	a_1	R^2_{adj}(%)
P/E	21.01 (4.14)*	0.14 (5.93)*	-0.31	16.02 (7.97)*	0.04 (15.35)*	-1.26
M/B	0.85 (1.76)	0.41 (1.75)	1.11	0.88 (5.37)*	0.19 (6.45)	2.93
P/S	0.20 (1.03)	0.67 (1.95)	25.98	0.73 (5.37)*	0.11 (6.93)*	-0.7
MV/Sales	0.47 (0.82)	0.73 (1.55)	29.73	0.45 (1.49)	0.89 (0.59)	34.98
EV/Sales	-1.96 (-3.05)*	1.72 (4.23)*	71.71	0.52 (0.94)	0.92 (0.35)	24.95
EV/OCF	14.47 (19.36)*	0.44 (5.21)*	-2.49	11.75 (7.33)*	0.13 (11.27)*	4.22

* means significant at 5% level.
Price-earnings (*P/E*), postissue market-to-book ($M/B_{postissue}$), and price-to-sales (*P/S*) multiples are calculated using the offer price for the IPOs, and the market prices on the day before issuing for the comparable firms. *MV/Sales* is the market value-to-sales ratio, *EV/Sales* is the enterprise value-to-sales ratio, *EV/OCF* is the enterprise value-to-operating cash flow ratio, *EV* is the market value of equity plus the book value of debt, minus cash, and *OCF* is the earnings before interest, taxes, depreciation and amortization (EBITDA). *t*-statistics are in parentheses.

4. Premarket Underpricing and Aftermarket Inefficiency

In this section Chang's minimum convex input requirement set (MCIRS) approach is employed to measure the premarket underpricing and aftermarket inefficiency in Taiwan's IPOs. Consider *n* observations (decision-making-units: DMUs), the MCIRS approach suggests minimum convex input requirement set for any real *y*:

$$L(y) = \{X : 0 \le y \le y_j, j = 1,\ldots, n; \sum_{j=1}^{n} \lambda_j X_j \le X, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \ge 0, j = 1,\ldots, n\} \quad (5)$$

It indicates that for any given output level $y = \overline{y}$ we choose only those DMUs having output level greater or equal to $\overline{y}$, and use their inputs (X_j's) to construct $L(\overline{y})$. The input set $L(y)$ is closed and convex. Because $L(y)$ is the minimum input requirement set, the production frontier derived is the closest quasiconcave production frontier, i.e. it is the closest to the DMUs and will give each DMU as the highest efficiency score as possible. The input set $L(y)$ imposes no restriction on returns to scale, and the production possibility set derived is not necessarily convex. Also, $L(y)$ satisfies the weak disposability property.

For efficiency evaluation relative to the input set $L(y)$ of equation (5) we have the following linear program: for the *k*-th DMU:

$$
\begin{aligned}
&\textit{Maximize} \quad && u_k \\
&\textit{subject to} && \sum_{i=1}^{m} v_i x_{ik} = 1 \qquad (6)\\
& && \sum_{i=1}^{m} v_i x_{ij} - u_k \geq 0 \\
& && \text{for all } j \in \bar{M}_k = \{j' : 1 \leq j' \leq n;\ y_{j'} \geq y_k\} \\
& && u_k,\ v_i \geq 0,\ i = 1, \ldots, m.
\end{aligned}
$$

To evaluate the k-th DMU's efficiency, the model, first, includes the DMUs having output level greater or equal to y_k as constraints, and then set all output quantities equal to one (i.e. $y_k = y_j = 1,\ j \in \bar{M}_k$). Since DMUs' output quantities do not enter the model and only the order (ranking) of output quantities matters, the efficiency measure u_k is translation invariant with respect to output measures.[5] The estimated u_k is constrained to lie between [0, 1], where one is the highest score, and zero, the lowest. The shape (functional form) of the derived efficient frontier will depend on the data used.

Equation (6) is used to examine whether Taiwan's IPOs are fully priced, i.e. whether the underwriters and issuers have "efficiently" employed the inputs (book value, sales, age of the firm and insider fraction) to produce the output (offer price).[6] The input and output variables are all premarket variables containing no aftermarket information. The percentage of premarket underpricing in the k-th IPO is denoted as $(1 - u_k) \times 100\%$. Sales is used as a proxy variable for the profitability of a firm, and book value is used as a measure of the level of firm operations (Krinsky and Rottenberg, 1989, and Ritter, 1984). Insider fraction signals to investors private information, and it should be increasing with offer price (Downes and Heinkel, 1982; Grinblatt and Hwang, 1989).

The empirical results of measuring premarket underpricing are presented in Table 5. For the whole sample of 84 IPOs, the median efficiency score is 0.8434, and the median premarket underpricing is 15.66% $(= 1 - 0.8434) \times 100\%)$.[7] Aggarwal and Rivoli, Hanley, Kumar and Sequin, Ritter, and Rudd argue that IPOs are priced at their intrinsic value and it is the aftermarket inefficiencies (fads, speculative bubbles and underwriter's price support) that lead to underpricing in IPOs. If this is the case, most of the IPOs should be found to have a unity efficiency score (i.e. $u_k = 1$). However, in our results, only 27 out of 84 IPOs have unity efficiency score, and 30 out of 84 have efficiency score higher than 0.95.

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[5] Translation invariance is defined as: Optimal solutions to the model are independent of the displacement of measurement employed. For example, when all the n DMUs' output measures $(y_1, \ldots, y_n)$ are displaced by $w \in R$ (i.e. $(y_1 + w, \ldots, y_n + w)$), the optimal solutions of (6) do not change.

[6] Hunt-McCool, Koh and Francis (1996) add four other inputs in their analysis: number of risks on prospectus, commission rate, proceeds from issue, and S&P *P/E* ratio.

[7] With the traditional method, i.e. [(aftermarket price – actual offer price)/(actual offer price)] x 100%, the mean underpricings in the IPOs are: 5.42% (the issuing day), 14.20% (one week after trading), and 28.84% (one month after trading).

Table 5
Distribution of efficiency scores (and premarket underpricings) and test statistics for full sample, hot-issue and nonhot-issue market periods, and electronic and non-electronic IPOs

	Minimum	Maximum	Standard deviation	Mean	Percentile of distribution 25th	50th	75th
All	0.3818	1.0000	0.1728	0.8256	0.7116	0.8434	1.0000
Hot	0.3814	1.0000	0.1828	0.8466	0.7187	0.9249	1.0000
Nonhot	0.3928	1.0000	0.1635	0.8074	0.7107	0.8265	0.9517
Electronic	0.4210	1.0000	0.1742	0.8589	0.7212	0.9756	1.0000
Non-electronic	0.3818	1.0000	0.1716	0.8107	0.7091	0.8343	0.9833

	Hot versus non-hot market	Electronic versus non-electronic
t-test (*t*)	1.0297	1.1846
Median test (χ^2)	3.0632	0.3160
Wilcoxon-Mann-Whitney test (*Z*)	0.8745	0.9772

* means significant at 5% level.
The number of observations: full sample (N = 84), hot-issue market period (N = 40), nonhot-issue market period (N = 44), electronic IPOs (N = 26), non-electronic IPOs (N = 58). The efficiency scores are estimated from the MCIRS approach (i.e. equation (6)). The premarket underpricing is denoted as: (1 – efficiency score) x100%.

The median underpricing in the hot-issue and nonhot-issue market periods are 8.51% and 17.35%, respectively, which are higher than those in Hunt-McCool et al.'s US results (hot-issue: 8.0%, nonhot-issue: 8.86%). Table 5 also shows that with the *t* test, the null hypothesis that both the hot-issue and nonhot-issue markets have the same mean efficiency score (and premarket underpricing) cannot be rejected. Because the efficiency scores are restricted between 0 and 1, non-parametric tests are also employed (median and Wilcoxon-Mann-Whitney tests), and find that the efficiency scores (premarket underpricings) of the hot-issue and nonhot-issue groups are not different.[8]

Rock's winner's curse model argues that informed investors only subscribe stocks in issues they know to be underpriced, and uninformed investors subscribe to every IPO indiscriminately and end up purchasing disproportionately large shares of overpriced issues. To keep the uninformed investors in the IPO markets, the underwriters must offer the securities at discounts from their expected aftermarket prices. In Taiwan, institutional investors (especially foreign institutional investors) mainly buy and hold electronic stocks. Electronic IPOs are requested by both institutional and individual investors, and non-electronic IPOs are mainly bought by individual investors.[9] If, as argued by Rock,

[8] Ibbotson and Jaffe, and Ibbotson, Sindelar and Ritter find that issuers obtain a higher offer price in hot-issue than in nonhot-issue markets.

[9] Taiwan's individual investors account for approximately 90% of total daily trading value. The market value of electronic stocks is about 50% of total market value.

information asymmetry between (informed) institutional and (uninformed) individual investors causes the adverse selection problem, then, on average, Taiwan's electronic IPOs should be underpriced more than non-electronic IPOs.[10] Table 5, however, shows that the mean and median efficiency scores of electronic IPOs are greater than those of non-electronic IPOs. The *t* and non-parametric tests conclude that the average levels of efficiency score (premarket underpricing) of electronic and non-electronic IPOs are not different. These results may not be consistent with Rock's winner's curse explanation for underpricing. Table 6 reports the *t* and non-parametric tests for high versus low sales, book value, insider fraction, age of firm, and offer price. Low offer price seems to underprice more than high offer price. With the median test, the null hypothesis that there is no difference in underpricing in high versus low sales, book value, insider fraction and age cannot be rejected.

Table 6
Summary of test statistics of efficiency scores (premarket underpricings) of high versus low sales, book value, insider fraction, age of the firm and offer price

		Mean efficiency	Standard deviation	*t*-test (*t*)	Median test (χ^2)	Wilcoxon-Mann-Whitney test (*Z*)
Sales	High	0.7767	0.1865			
	Low	0.8845	0.1364	-3.3047*	2.3333	-1.5280*
Book value	High	0.7849	0.1934			
	Low	0.8664	0.1315	-2.2112*	1.1905	-0.9824
Insider fraction	High	0.7840	0.2002			
	Low	0.8672	0.1300	-2.2587*	0.4286	-1.2007
Age of the firm	High	0.7672	0.1895			
	Low	0.8840	0.1327	-3.2737*	2.3333	-1.6374*
Offer price	High	0.8662	0.1637			
	Low	0.7851	0.1741	2.1994*	3.8571*	1.8786*

* means significant at 5% level.
Mean efficiency scores are estimated from the MCIRS approach (i.e. eq (6)). Mean premarket underpricing is denoted as: (1 – mean efficiency score) x 100%.

To test the aftermarket inefficiency in Taiwan's IPOs we examine the performance of the IPOs on the issuing day, one week after market trading, and one month after trading with the formula (where the daily price limit is 7%): [(aftermarket price – efficient offer price)/(efficient offer price)] x 100%, where the efficient offer price is the ratio of actual offer price to efficiency score. Table 7 reports that with the whole sample, on the issuing day, the mean underpricing is 12.86%. On the one week after trading, the mean overpricing (mean = 3.89%) is insignificantly different from zero (*t*-statistics = 1.1496).

[10] To test Rock's model, it will be necessary to show that IPO shares rationing occurs asymmetrically for IPO issues that were under- and over-subscribed, i.e. the disproportional existence of undersubscription, compared to oversubscription levels.

Table 7
Distribution of aftermarket performance and *t*-tests for full sample, and hot-issue and nonhot-issue market periods

	Mean (*t*-statistics)	Minimum	Maximum deviation	Percentile of distribution 25th	50th	75th
All:						
Issuing day	-12.86 (-6.2314)*	-60.86	7.00	-24.17	-10.32	6.44
One week after trading	3.89 (1.1496)	-60.85	58.83	-16.98	2.20	28.90
One month after trading	6.86 (1.5761)	-60.01	142.11	-22.68	-0.49	26.24
Nonhot:						
Issuing day	-15.66 (-5.7910)*	-60.86	7.00	-25.18	-16.33	1.37
One week after trading	-7.40 (-1.7200)	-60.85	58.59	-27.39	-10.31	5.81
One month after trading	-6.39 (-1.1379)	-60.01	142.11	-26.88	-15.34	5.92
Hot:						
Issuing day	-9.64 (-3.1234)*	-59.19	6.98	-23.16	-1.16	6.84
One week after trading	16.93 (3.7502)*	-55.98	58.83	-4.56	17.60	36.17
One month after trading	22.15 (3.7051)*	-56.31	123.53	-3.45	23.85	42.01

	All	Hot	Nonhot
t-test of one month versus one week after trading	0.5388	0.6969	0.1431

	Issuing day	One week after trading	One month after trading
t-test of hot versus nonhot market period	1.4725	3.8986*	3.4803*

* means significant at 5% level.
The number of observations: full sample (N = 84), hot-issue market period (N = 40), nonhot-issue market period (N = 44). The measure for the aftermarket performance is calculated by [(aftermarket price – efficient offer price)/(efficient offer price)] x 100%, where the efficient offer price is the ratio of actual offer price to efficiency score. The daily price limit is 7%.

On the one month after trading, the mean overpricing (6.86%) is also insignificantly different from zero (*t*-statistics = 1.5761). In the nonhot-issue market period, there is no aftermarket inefficiency: the mean underpricings on the one week after trading (–7.40%) and on the one month after trading (–6.39%) are insignificantly different from zero (*t*-statistics = –1.72 and –1.1379, respectively). In the hot-issue market period, there is a significant overpricing (i.e. aftermarket inefficiency) on the one week after trading (mean = 16.93% and *t*-statistics = 3.7502) and on the one month after trading (mean = 22.15% and *t*-statistics = 3.7051). It was also found that in the whole, hot-issue or nonhot-issue period, the average level of the aftermarket performance on the one week after trading is not different from that on the one month after trading (*t*-statistics = 0.5388, 0.6969, and 0.1431, respectively).[11]

[11] We have also used market-adjusted returns ($R_{it} - R_{mt}$), where R_{it} is the raw return of security *i* at aftermarket month *t*, and R_{mt} is the returns of market portfolio at aftermarket month *t*. The results are the same.

Table 8 presents the aftermarket performances of electronic versus non-electronic, high versus low sales, book value, insider fraction, age of the firm and offer price. It shows that on the issuing day, one week and one month after trading, low sales outperforms high sales, and high offer price outperforms low offer price. There is no difference in the aftermarket performance between electronic and non-electronic, high and low insider fraction and age on the one week and one month after trading.

Table 8
Mean aftermarket performances and *t*-tests for electronic versus non-electronic IPOs, and high versus low sales, book value, insider fraction, age of the firm and offer price

	Issuing day Mean (*t*-statistics)	**One week after trading Mean (*t*-statistics)**	**One month after trading Mean (*t*-statistics)**
Electronic	-8.95 (-2.4037)*	13.20 (1.9682)	18.23 (2.0340)
Non-electronic	-14.62 (-5.9253)*	-0.28 (-0.0734)	1.76 (0.3658)
High sales	-19.49 (-6.2255)*	-6.36 (-1.2949)	-2.42 (-0.3641)
Low sales	-6.23 (-2.7057)*	14.16 (3.4175)*	16.14 (2.9860)*
High book value	-17.49 (-5.3815)*	-2.87 (-0.5705)	0.58 (0.0889)
Low book value	-8.23 (-3.6445)*	10.66 (2.4472)*	13.14 (2.2743)*
High insider fraction	-17.06 (-5.1292)*	1.97 (0.3564)	4.64 (0.6810)
Low insider fraction	-8.66 (-3.7542)*	5.82 (1.4667)	9.08 (1.6289)
High age of the firm	-18.67 (-5.8226)*	-1.13 (-0.2485)	3.31 (0.5629)
Low age of the firm	-7.06 (-3.0607)*	8.92 (1.7609)	10.42 (1.5958)
High offer price	-8.12 (-2.9475)*	13.86 (2.8605)*	15.22 (2.4993)*
Low offer price	-17.61 (-6.0152)*	-6.07 (-1.4233)	-1.50 (0.2460)
	Issuing day	**One week after trading**	**One month after trading**
t-test of electronic versus non-electronic IPOs	1.27	1.87	1.76
t-test of high versus low sales	-3.41*	-3.19*	-2.17*
t-test of high versus low book value	-2.30*	-2.03*	-1.44
t-test of high versus low insider fraction	-2.08*	-0.57	-0.51
t-test of high versus low age of the firm	-2.94*	-1.49	-0.81
t-test of high versus low offer price	2.36*	3.09*	1.97*

* means significant at 5% level.
The measure for the aftermarket performance is calculated by [(aftermarket price – efficient offer price)/(efficient offer price)] x 100%, where the efficient offer price is the ratio of actual offer price to efficiency score. The daily price limit is 7%.

5. Concluding Remarks

Tinic and Logue argue that IPO underpricing is a form of insurance against legal liability and the associated damages to the reputations of underwriters. Mahoney also finds that institutional factors matter: enacting the 1933 Security Act in the US has reduced competition among investment banks, and raised costs to issuers and investors. In Taiwan, although the SFC's IPO pricing formula (equation (1)) is not explicitly enforced, investment banks still abide by. If the aftermarket price of an IPO goes substantially below its offer price, the underwriter will be penalized (even lose its license) by the SFC.[12] This article finds that in Taiwan's IPOs, the commonly used method of valuing IPOs with price-earnings, market-to-book and price-to-sales multiples of comparable firms performs poorly. The predictability of the comparable firms method improves when market values-to-sales and enterprise value-to-sales multiples are used.

Chang's minimum convex input requirement set (MCIRS) approach has been employed to measure the premarket underpricing and aftermaket inefficiency in Taiwan's IPOs. The MCIRS approach is non-parametric, i.e. it does not need to assume any particular functional form. The empirical results show that first, the average level of underpricing in the IPO premarket is 15.66%, and premarket underprices in the hot- and nonhot-market periods are not different. Second, premarket underpricing in the electronic IPOs (purchased by both (informed) institutional investors and (uninformed) individual investors) is not different from that in the non-electronic IPOs (purchased by (uninformed) individual investors). This result may not be consistent with Rock's winner's curse explanation for IPO underpricing. Third, in the nonhot-issue market period, the premarket underpricing disappears on one week (and one month) after trading, i.e. there is no aftermarket inefficiency. In the hot-issue market period, new issues are overpriced on one week (and one month) after trading, i.e. there is an aftermarket inefficiency. IPOs with low sales outperforms those with high sales in the aftermarket. IPOs with high offer price underprice less in the premarket and perform better in the aftermarket than those with low offer price.

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[12] Taiwan's government has a long history of trying to stabilize rather than liberalize its stock market. In the early 1960's, part of the shares of the publicly-owned Taiwan Sugar Company was sold to the public. But in 1964, when the sharp drop in world sugar prices triggered a crash in the stock market, the government was forced to buy back the shares to please the investors.

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