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Do IPO index portfolios improve the investment opportunities for mean–variance investors? ☆

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A B S T R A C T

We set out in this study to examine whether investors can improve their investment opportunity sets through the addition of an IPO index portfolio into various sets of benchmark portfolios. Using the IPOX indices from the years 1980–2006, we find that adding an IPO index portfolio does lead to a statistically significant enlargement of the investment opportunity set for investors. Our empirical findings are robust, demonstrating that there is scope for the further development of financial products relating to IPO stocks, since investors can gain diversification benefits through investing in such IPO-related products.

1. Introduction

Initial public offerings (IPOs) have received considerable attention over recent decades from both academic researchers and practitioners, with the major issues in IPOs focusing on underpricing, 'hot issue' markets and long-run performance (Ritter and Welch, 2002). Finance theory argues that non-redundant financial assets can help to improve the completeness of financial markets as well as risk

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sharing amongst investors (Huang and Litzenberger, 1988; Ingersoll, 1987). Thus, it is of importance to investors to determine whether IPO stocks, as a new investment vehicle collectively, can significantly expand the mean–variance frontier generated by the portfolios of seasoned stocks, thereby leading to diversification benefits. On the other hand, the recent trend in the development of several IPO indices can provide convenient ways of IPO investment to investors in terms of issuance of IPO mutual funds or exchange-traded funds.[1]

Our study contributes to the investment and IPO literature by examining whether some IPO index portfolios, featuring tradable financial products that are readily available to investors, can expand the mean–variance frontiers generated either by size/book-to-market portfolios or by tradable market capitalization/value–growth style index portfolios. If the outcome is affirmative, then there is room for further development of financial products relating to IPO index portfolios from which investors can gain diversification benefits through investment in such IPO-related products. On the contrary, if the outcome does not support the diversification benefits through IPO investment, the recent development of IPO indices may have limited scope to investors in the future. Thus, it is an empirical issue to determine whether IPO investment vehicles can provide diversification benefits to investors.

An IPO boutique, IPOX Schuster LLC, compiles three value-weighted IPO indices to capture the IPO activity in the US. The IPOX composite index is a dynamically reconstituted value-weighted index in which new IPO stocks are selected at their seventh trading day and retained up to 1000 trading days, or for around four years after going public. Since the IPO market fluctuates over time, the number of IPO stocks in the IPOX composite index changes accordingly.

The IPOX composite index includes only common stocks; thus, real estate investment trusts (REITs), American Depository Receipts (ADRs), preferred securities, income deposits and other similar securities are excluded. The other two value-weighted indices, the IPOX 100 and IPOX 30 indices, capture the activities of the top-100 and top-30 IPOs, ranked by market capitalization, within the IPOX composite index. The finer selection of IPO stocks typically reflects the best performing and most liquid IPOs in the IPOX composite index. Though the number of member stocks is fixed at 100 and 30, respectively, the index membership is reconstituted quarterly based on market capitalization.

The first IPO unit investment trust, based upon the IPOX 30 index, was launched in July 2005 by Van Kampen (Nasdaq symbol: VKTIDX). Thereafter, in April 2006, First Trust issued the first IPO 'exchange-traded fund' (ETF), the First Trust IPOX 100 index fund (AMEX symbol: FPX); this ETF aims to track the performance of the IPOX 100 index. These two tradable IPO portfolios, which capture the growth and innovativeness of new public US firms, provide investors with opportunities for exposure in the US IPO market.

We apply portfolio selection analysis to explore the portfolio diversification effects of these tradable IPO index portfolios. Although this approach to portfolio selection, dating back to Markowitz (1952), has become the standard approach within many of the financial textbooks, no attempts have yet been made within the literature to address a particular issue in IPO research. The question that can be examined empirically is whether an IPO index portfolio significantly enlarges the investment opportunity set relative to currently traded stocks. In order to address this issue, we employ mean–variance spanning and intersection tests to examine whether the addition of an IPO index portfolio can significantly enlarge the investment opportunity set for investors relative to different sets of benchmark portfolios.

The above issues are intriguing in their own right to academics and also have pragmatic implications for the issuance of IPO investment vehicles. Our main findings are summarized as follows. First, we compare the statistical and economic significance of the shifts in the mean–variance frontier for an investor who adds an IPO index portfolio to a set of size/book-to-market benchmark portfolios relative to an investor who invests only in the set of benchmark portfolios. We find that investors who invest in an IPO index portfolio are able to enlarge their investment opportunity set relative to the benchmark portfolios. Second, we use, as benchmark portfolios, three sets of index portfolios that are actually traded; these are the MSCI style index series, the S&P style index series and the Russell style index

[1] Examples of performance tracking of US IPOs include several IPOX indices developed by IPOX Schuster LLC and the Renaissance IPO Index developed by Renaissance Capital LLC. Dow Jones STOXX IPO indices, compiled by STOXX Ltd., track the performance of IPOs in Europe.

series. We find that five of the six cases yield statistically significant improvement in the investment opportunity set. Therefore, the addition of an IPO index portfolio produces significant benefits for mean–variance investors.

The remainder of this paper is organized as follows. Section 2 describes the methodologies for the mean–variance spanning and intersection tests, followed in Section 3 by presentation of the data and analysis of the empirical results. Finally, the conclusions drawn from this study are presented in Section 4.

2. Mean–variance spanning and intersection tests

Huberman and Kandel (1987) are the first to introduce a mean–variance spanning test. The method statistically tests whether adding a set of new assets can improve the investment opportunity set relative to a set of basis assets. Mean–variance spanning tests enable us to analyze the effects on the mean–variance frontier arising from the addition of new assets to a set of benchmark assets. For ease of illustration, we define the union of both new assets and benchmark assets as 'augmented assets.' If the mean–variance frontier of the benchmark assets coincides with that of the augmented assets, then there is spanning, in which case, investors gain no benefits from the addition of new assets to their existing assets.

We go on to briefly describe the approaches, and for details we refer readers to the comprehensive surveys by Kan and Zhou (2001) and DeRoon and Nijman (2001). We assume that there are K benchmark portfolios with return R_{1t} and one IPO index portfolio with return R_{2t}.[2] Using the ordinary least-squares approach, we estimate the following model:

$$R_{2t} = \alpha + \beta R_{1t} + \xi_t, \quad t = 1, 2, \ldots T. \tag{1}$$

Following Huberman and Kandel (1987), the null hypothesis of spanning is:

$$H_{0S} : \alpha = 0, \quad \delta = 1 - \beta 1_K = 0. \tag{2}$$

We can then calculate the Wald test statistic as:

$$W = T(\lambda_1 + \lambda_2) \overset{A}{\sim} \chi^2_2.^3 \tag{3}$$

If we fail to reject the null hypothesis, the benchmark portfolios then span the mean–variance frontier of the benchmark portfolios plus an IPO index portfolio. Specifically, failure to reject the null hypothesis implies that investors are unable to enlarge their investment opportunity set through the addition of an IPO index portfolio. Cheung et al. (2009) further prove analytically that when spanning occurs, investors should not invest in the new assets due to the residual risk of those assets. Conversely, if the null hypothesis is rejected, the addition of an IPO index portfolio can improve the investment opportunity set.

In terms of geometry, the test for mean–variance spanning can be divided into two elements: (i) the spanning of the global minimum variance (GMV) portfolio and (ii) the spanning of the tangency portfolio. We can therefore rewrite the Wald test as:

$$W = T\left(\frac{(\hat{\sigma}_{R_1})^2}{(\hat{\sigma}_R)^2} - 1\right) + T\left(\frac{1 + \hat{\theta}_R\left(R_1^{GMV}\right)^2}{1 + \hat{\theta}_{R_1}(R_1^{GMV})^2} - 1\right), \tag{4}$$

[2] The expected returns on $K+1$ assets are denoted as $\mu = E[R_t] \equiv \begin{bmatrix}\mu_1 \\ \mu_2\end{bmatrix}$. The variance–covariance matrix of $K+1$ assets is $V = Var[R_t] \equiv \begin{bmatrix}V_{11} & V_{12} \\ V_{21} & V_{22}\end{bmatrix}$, where V is non-singular.

[3] We define $\widehat{G} = \begin{bmatrix}1 + \hat{\mu}_1' \widehat{V}_{11}^{-1} \hat{\mu}_1 & \hat{\mu}_1' \widehat{V}_{11}^{-1} 1_K \\ \hat{\mu}_1' \widehat{V}_{11}^{-1} 1_K & 1_K' \widehat{V}_{11}^{-1} 1_K\end{bmatrix}$ and $\widehat{H} = \begin{bmatrix}\hat{\alpha}' \widehat{\Sigma}^{-1} \hat{\alpha} & \hat{\alpha}' \widehat{\Sigma}^{-1} \hat{\delta} \\ \hat{\alpha}' \widehat{\Sigma}^{-1} \hat{\delta} & \hat{\delta}' \widehat{\Sigma}^{-1} \hat{\delta}\end{bmatrix}$, where $\widehat{\Sigma}$ stands for residual variance. We then denote by λ_1 and λ_2 the two eigenvalues of the matrix $\widehat{H}\widehat{G}^{-1}$. Since there is only one test asset in our mean–variance spanning test, the smaller eigenvalue, λ_2, equals zero.

where $(\hat{\sigma}_{R_1})^2$ and $(\hat{\sigma}_R)^2$ are the global minimum variance of the benchmark assets and augmented assets, respectively. $\hat{\theta}_{R_1}(R_1^{GMV})$ is the slope of the asymptote of the mean–variance frontier for the benchmark assets, and $\hat{\theta}_R(R_1^{GMV})$ is the slope of the tangency line of the mean–variance frontier for the augmented assets using R_1^{GMV} as a reference point. The first term measures the change of the GMV portfolios due to the addition of an IPO index portfolio. The second term measures whether there is any improvement in the squared tangency slope due to the addition of an IPO index portfolio to the set of benchmark portfolios.

In order to identify the source of mean–variance frontier expansion, Kan and Zhou (2001) suggest a step-down procedure that requires us to initially test $\alpha = 0$, followed by a test of $\delta = 0$, conditional on $\alpha = 0$. If the rejection is due to the first test, we know that this is because the two tangency portfolios are statistically very different. If the rejection is due to the second test, then it is because the two GMV portfolios are statistically very different.[4]

A further concept relevant to the assessment of movement, or change, in the tangency portfolio, is the mean–variance intersection test proposed by Huberman and Kandel (1987). If the mean–variance frontier of the benchmark assets and the mean–variance frontier of the augmented assets have only one point in common, which is known as intersection. Using Eq. (1), the null hypothesis of intersection is:

$$H_{0I} : \alpha - \eta(1 - \beta 1_K) = 0, \tag{5}$$

where η is the risk-free rate. Following DeRoon and Nijman (2001), the test statistic for testing the intersection hypothesis can be rewritten in terms of the maximal Sharpe ratios as:

$$W_I = T\left(\frac{1 + \hat{\theta}_R(\eta)^2}{1 + \hat{\theta}_{R_1}(\eta)^2} - 1\right) = T\left(\frac{\hat{\theta}_R(\eta)^2 - \hat{\theta}_{R_1}(\eta)^2}{1 + \hat{\theta}_{R_1}(\eta)^2}\right) \overset{A}{\sim} \chi_1^2, \tag{6}$$

where $\hat{\theta}_{R_1}(\eta)$ is the maximal Sharpe ratio attainable for the benchmark assets, and $\hat{\theta}_R(\eta)$ is the maximal Sharpe ratio attainable for the augmented assets.

Intuitively, the empirical results from the intersection test would be very similar to the results from the first test of the step-down test. Furthermore, the test statistic specified in Eq. (6) indicates that the numerator is related to the difference in the squared maximal Sharpe ratios attainable for benchmark assets and augmented assets. The rejection of the null hypothesis of the intersection test implies that, based upon the risk-free rate as the reference point, the mean–variance frontier of the augmented assets has no point in common with the mean–variance frontier of the benchmark assets. Thus, there are differences in the maximal Sharpe ratios between the augmented assets and the benchmark assets.

3. Empirical results

3.1. Data description

Our sample of IPO index portfolios, which is provided by IPOX Schuster LLC,[5] comprises IPOX 100 and IPOX 30 indices covering the period from January 1980 to December 2006.[6] Table 1 presents the summary statistics of the two IPOX indices, showing that the mean monthly return of the IPOX 100 (IPOX 30) index is 1.21% (1.34%), with a standard deviation of 7.06% (7.16%). Although the IPOX 30 index does perform slightly better than the IPOX 100 index, it is nevertheless riskier.

For the benchmark portfolios, we use 25 Fama–French value-weighted size/book-to-market portfolios comprising NYSE, AMEX and Nasdaq stocks, with the means and standard deviations of these

[4] For the purpose of brevity, we do not specify the exact test statistics for the step-down tests since these are discussed at length in Kan and Zhou (2001).

[5] We thank Josef Schuster, the founder of IPOX Schuster LLC, for providing us with data on the IPOX indices; further information can be found on the website: http://www.ipoxschuster.com.

[6] We do not use the IPOX composite index, essentially because there are no tradable financial products tracking the performance of that index within the US market.

Table 1
Summary statistics of the IPO Index portfolios. The table presents the descriptive statistics of the monthly IPO index portfolio returns from January 1980 to December 2006. All figures are percentages.

Index portfolio	Mean	Standard deviation	Maximum	Minimum
IPOX 100 index	1.21	7.06	23.74	−29.40
IPOX 30 index	1.34	7.16	25.10	−28.01

Table 2
Summary statistics of the size/book-to-market portfolios. The table presents the percentage means and standard deviations of the monthly value-weighted size/book-to-market portfolio returns based upon all firms trading on the NYSE, AMEX and Nasdaq.

Book-to-market	Size									
	Smallest		2		3		4		Largest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Lowest	0.49	8.15	0.86	7.37	1.00	6.78	1.21	6.13	1.10	4.80
2	1.36	6.76	1.24	5.71	1.33	5.24	1.24	5.01	1.22	4.68
3	1.48	5.41	1.51	4.84	1.30	4.60	1.34	4.74	1.16	4.41
4	1.65	4.98	1.56	4.71	1.37	4.46	1.36	4.34	1.20	4.12
Highest	1.69	5.14	1.51	5.17	1.61	4.80	1.46	4.69	1.30	4.70

25 portfolios presented in Table 2 .[7] The monthly average returns of the 25 portfolios range between 0.49% and 1.69%, whilst their standard deviations range between 4.12% and 8.15%. We find that during the period under examination, the small or value stocks perform better, with the exception of the lowest book-to-market quintile. Furthermore, small or growth stocks are riskier than large or value stocks.

3.2. Mean–variance frontier expansion by IPO index portfolios

We begin by testing whether the addition of an IPO index portfolio into the 25 Fama–French value-weighted size/book-to-market portfolios enlarges the investment opportunity set for mean–variance investors. Panel A of Table 3 presents the empirical results from mean–variance spanning and intersection tests for the whole sample period.[8] We reject the null hypothesis that the benchmark portfolios can span both the IPOX 100 and IPOX 30 indices at the 1% significance level. Based on the step-down spanning tests, we further find that, for both the IPOX 100 and IPOX 30 indices, the first step-down test (W_1) is not statistically significant, whilst the second step-down test (W_2) is highly significant. The results indicate that the expansion comes mainly from the change in the global minimum variance (GMV) portfolio.

We then carry out additional mean–variance spanning and intersection tests for the periods before and after the end of 1998, in order to examine the effect of the Internet bubble. Panel B of Table 3 reports the results for the pre-Internet bubble period. The mean–variance frontiers expand at the 1% significance level for both the IPOX 100 and IPOX 30 indices. The mean–variance intersection test and W_1 are highly significant, whilst the significance level for W_2 is 1%. The findings suggest that the expansion between January 1980 and December 1998, arising from the addition of IPO index portfolios, comes from changes in both the tangency portfolio and the GMV portfolio.

The results of the tests of the post-Internet bubble period are reported in Panel C of Table 3. We find statistically insignificant results for the IPOX 100 index, whilst the mean–variance spanning test for

[7] These are obtained from the French website at: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. We are grateful to Ken French for providing the data. See also Fama and French (1992, 1993) for details.

[8] Within the mean–variance spanning tests, we also calculate the statistics for the finite sample, the likelihood ratio, the Lagrange multiplier tests, and tests under non-normality and heteroskedasticity (see Kan and Zhou (2001) for details). The results are qualitatively similar; thus, they are not reported here for the purpose of brevity. In addition, the risk-free rate used is the average one-month T-bill return from the test periods, obtained from Ibbotson and Associates, Inc., details of which are also available from the French website.

Table 3
Mean–variance spanning and intersection tests of the IPO index portfolios. The table reports the mean–variance spanning and intersection test results arising from the addition of IPO index portfolios into the benchmark portfolios. The IPO index portfolios are the IPOX 100 and IPOX 30 indices, whilst the benchmark portfolios are the 25 Fama–French value-weighted size/book-to-market portfolios which are based upon all firms trading on the NYSE, AMEX and the Nasdaq. W refers to the asymptotic Wald test for spanning; W_1 and W_2 are the step-down Wald tests for spanning; and W_I represents the asymptotic Wald test for intersection. The risk-free rate refers to the rate used in the intersection test.

Index portfolios	Wald tests								Risk-free rate (%)
	W		W_1 step-down		W_2 step-down		W_I		
	Wald stats.	*p*-Value	Wald stats.	*p*-Value	Wald stats.	*p*-Value	Wald stats.	*p*-Value	
Panel A: Jan 1980–Dec 2006 (whole sample period)									
IPOX 100 index	13.816	0.001***	0.613	0.434	13.718	0.000***	1.644	0.204	0.48
IPOX 30 index	14.195	0.001***	1.191	0.275	12.957	0.000***	2.469	0.116	
Panel B: Jan 1980–Dec 1998 (pre-Internet bubble period)									
IPOX 100 index	17.568	0.000***	4.660	0.031**	12.650	0.000***	6.682	0.010***	0.57
IPOX 30 index	16.364	0.000***	5.373	0.020**	10.738	0.001***	7.339	0.007***	
Panel C: Jan 1999–Dec 2006 (post-Internet bubble period)									
IPOX 100 index	3.713	0.156	0.021	0.885	3.691	0.055*	0.093	0.760	0.27
IPOX 30 index	5.276	0.072*	0.053	0.817	5.219	0.022**	0.178	0.673	

* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

the IPOX 30 index is only marginally significant. Specifically, W_2 is significant at the 5% level, whereas W_1 is not significant. In general, the empirical results show much greater significance for the period prior to the Internet bubble. However, we note that even in the post-Internet bubble period, to some extent, the IPOX 30 index, with its finer selection of larger IPO stocks, can still improve the investor opportunity set.

Finally, Fig. 1 illustrates the mean–variance frontiers before and after the addition of the IPOX 100 and 30 indices to the benchmark portfolios. It helps us to more readily identify the fact that the changes in the mean–variance frontiers are most noticeable during the pre-Internet bubble period, followed by the whole sample period, and finally the post-Internet bubble period.

The previous mean–variance spanning tests only examine whether the expansion of the mean–variance frontier is statistically significant. However, as Bekaert and Urias (1996) suggest, we can assess the economic significance of the shift in the mean–variance frontier by evaluating the change in the Sharpe ratio. The Sharpe ratio, which is also known as the 'reward to variability' ratio, measures the slope of the line from the risk-free rate to any portfolio in the mean–standard deviation plane (Sharpe (1994)). Intuitively, the values of the percentage change in the Sharpe ratio are inversely related to the *p*-values associated with the first step-down test (W_1) or with the intersection test, where the test statistic involves the difference in the squared maximal Sharpe ratios. In other words, if the first step-down test fails to reject the mean–variance spanning hypothesis, or if there is a failure to reject the intersection hypothesis, then we will find a small percentage change in the Sharpe ratio.

Earlier, in Table 3, we report that the addition of either the IPOX 100 or IPOX 30 index to the benchmark portfolios for the period 1980–2006 results in no improvement in the tangency portfolio. However, there is significant improvement in the tangency portfolio for the period 1980–1998. Further evidence is provided in Panels A and B of Table 4, which is consistent with the evidence found in the spanning and intersection tests.

For the whole sample period, the percentage change in the Sharpe ratio in the tangency portfolio as a result of the addition of the IPOX 100 index is 0.64%, whilst the percentage change attributable to the addition of the IPOX 30 index is 1.01%. However, for the pre-Internet bubble period, the percentage

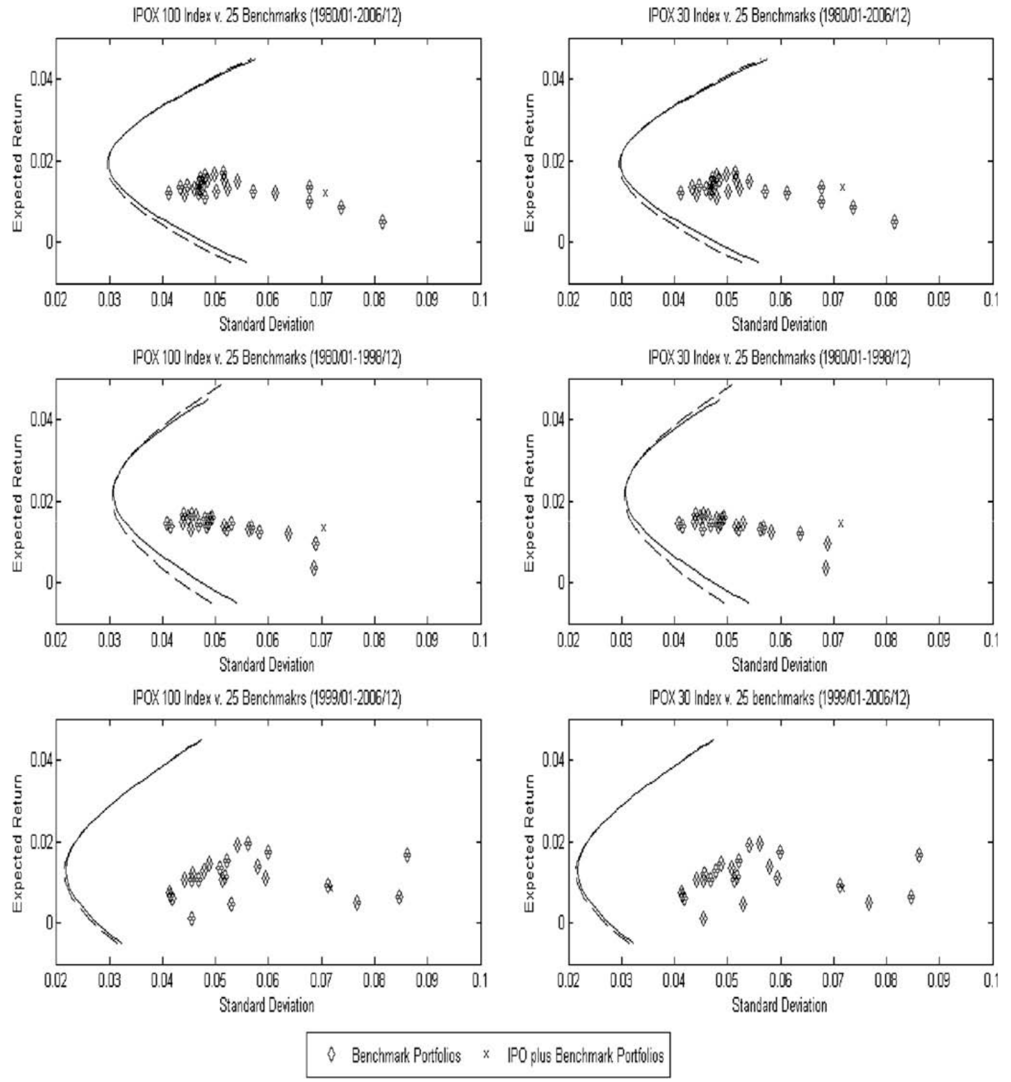

Fig. 1. Mean–variance frontiers of benchmark assets and augmented assets. The figure plots the mean–variance frontier (the inner solid frontier) of the benchmark portfolios, i.e., the 25 Fama–French size/book-to-market portfolios which are based upon all firms trading on the NYSE, AMEX and Nasdaq; and the mean–variance frontier (the outer dashed frontier) of the augmented assets, comprising the benchmark portfolios plus an IPO index portfolio. The IPO index portfolios are the IPOX 100 and IPOX 30 indices. The sample periods examined are the whole sample period (Jan 1980–Dec 2006), and two sub-sample periods (Jan 1980–Dec 1988 and Jan 1999–Dec 2006).

change in the Sharpe ratio in the tangency portfolio is much higher, at 3.64% for the IPOX 100 index, and at 3.99% for the IPOX 30 index.

As expected, with the insignificant results of the intersection test and the first step-down test during the post-Internet bubble period, Panel C of Table 4 shows a very small percentage changes in the Sharpe ratio for the tangency portfolio. We further note that the risk reduction rates for the GMV portfolio across these three test periods are similar, ranging between −0.02% and −0.05%. These figures are in line with those of the second step-down test in Table 3, and are, in general, statistically significant.

Table 4
Sharpe ratios and properties of tangency and global minimum variance portfolios. The table reports the mean returns and standard deviations of the tangency and global minimum variance (GMV) portfolios before and after the addition of the IPO index portfolios. The table also presents the Sharpe ratio and percentage changes in the Sharpe ratios before and after the addition of the IPO index portfolios. The IPO index portfolios are the IPOX 100 and IPOX 30 indices, whilst the benchmark portfolios are the 25 Fama–French value-weighted size/book-to-market portfolios which are based upon all firms trading on the NYSE, AMEX and the Nasdaq. The risk-free rate refers to the rate used for the computation of the tangency portfolio weights and the Sharpe ratios.

Index portfolios	Tangency portfolio returns				GMV portfolio returns		Risk-free rate (%)
	Mean (%)	SD (%)	Sharpe ratio	% Change in sharp ratio	Mean (%)	SD (%)	
Panel A: Jan 1980–Dec 2006 (whole sample period)							
IPOX 100 index							
Before	3.58	4.35	0.714	0.64	1.94	2.99	0.48
After	3.71	4.49	0.719		1.87	2.95	
IPOX 30 index							
Before	3.58	4.35	0.714	1.01	1.94	2.99	0.48
After	3.74	4.52	0.721		1.87	2.96	
Panel B: Jan 1980–Dec 1998 (pre-Internet bubble period)							
IPOX 100 index							
Before	4.34	4.68	0.807	3.64	2.20	3.07	0.57
After	4.85	5.12	0.837		2.09	3.05	
IPOX 30 index							
Before	4.34	4.68	0.807	3.99	2.20	3.07	0.57
After	4.85	5.10	0.840		2.11	3.05	
Panel C: Jan 1999–Dec 2006 (post-Internet bubble period)							
IPOX 100 index							
Before	3.94	4.11	0.894	0.11	1.30	2.18	0.27
After	4.01	4.18	0.895		1.25	2.14	
IPOX 30 index							
Before	3.94	4.11	0.894	0.21	1.30	2.18	0.27
After	4.05	4.22	0.895		1.24	2.13	

3.3. Two-factor model analysis and variance decomposition

In an attempt to gain a complete understanding of the return behaviour of IPO index portfolios, we employ a simple two-factor model (similar to the model adopted by Eun et al. (2008)), which assumes that the IPO index portfolio returns are driven by a market portfolio and one of the 25 Fama–French value-weighted size/book-to-market portfolios. This two-factor model is estimated as:

$$R_{IPOX,t} = \alpha + \beta^{CRSP} R_{CRSP,t} + \beta^{FF} R_{FF,t} + \xi_t, \tag{7}$$

where R_{IPOX} is the return on the IPOX 100 or IPOX 30 index, R_{CRSP} is the return on the value-weighted CRSP market index, and R_{FF} is the residual obtained from regressing each of the 25 Fama–French value-weighted size/book-to-market portfolios on R_{CRSP}.

Based on the estimated market and size/book-to-market portfolio betas, we can then decompose the variance for the IPO index portfolios into three components: (i) the proportion attributable to the volatility of the market portfolio, (ii) the proportion attributable to the volatility of each of the 25 size/book-to-market portfolios and (iii) the idiosyncratic volatility of the IPO index portfolio itself. Specifically, the variance of an IPO index portfolio is written as:

$$Var(R_{IPOX}) = \left(\beta^{CRSP}\right)^2 \times Var(R_{CRSP}) + \left(\beta^{FF}\right)^2 \times Var(R_{FF}) + Var(\xi). \tag{8}$$

Each part of the decomposition can be calculated as:

$$\left(\beta^{CRSP}\right)^2 \times Var(R_{CRSP})/Var(R_{IPOX}) \text{ for the market portfolio proportion}, \tag{9}$$

$$\left(\beta^{FF}\right)^2 \times Var(R_{FF})/Var(R_{IPOX}) \text{ for the size/book-to-market portfolio proportion}, \tag{10}$$

$$Var(\xi)/Var(R_{IPOX}) \text{ for the idiosyncratic proportion of the IPO index portfolio}. \tag{11}$$

Table 5

Two-factor model analysis and variance decomposition of IPO index portfolios. The table reports the results of the two-factor model estimation and variance decomposition for the IPO index portfolios. The two-factor model used is shown as:

$$R_{IPOX,t} = \alpha + \beta^{CRSP} R_{CRSP,t} + \beta^{FF} R_{FF,t} + \xi_t,$$

where R_{IPOX} is the return on the IPOX 100 or IPOX 30 index, R_{CRSP} is the return on the value-weighted CRSP market index, and R_{FF} is the residual obtained from regressing each of the 25 Fama–French value-weighted size/book-to-market portfolios on R_{CRSP}. The decomposition of the variance for the IPOX 100 and 30 indices consists of three components: (i) the proportion attributable to the volatility of the market portfolio, (ii) the proportion attributable to the volatility of each of the 25 size/book-to-market portfolios and (iii) the idiosyncratic volatility of the IPO index portfolio itself.

Portfolios (size, book-to-market)	Two-factor model			Variance decomposition	
	β^{FF}		Adjusted R^2 (%)	Volatility attributable to size/BM portfolio (%)	Volatility attributable to IPO index portfolio (%)
	Coefficient	*t*-stats			
Panel A: (dependent variable IPOX 100 index)					
β^{CRSP} = 1.422***; *variance of IPO index portfolio = 0.0050; volatility attributable to market portfolio = 78.19%*					
(1,1)	0.329	11.01***	84.07	5.98	15.84
(1,2)	0.348	9.58***	82.93	4.85	16.96
(1,3)	0.431	8.81***	82.33	4.25	17.56
(1,4)	0.346	6.43***	80.56	2.49	19.32
(1,5)	0.234	4.43***	79.32	1.25	20.56
(2,1)	0.519	13.75***	86.19	8.09	13.72
(2,2)	0.486	8.85***	82.36	4.28	17.53
(2,3)	0.375	5.50***	79.94	1.88	19.93
(2,4)	0.195	2.91***	78.62	0.56	21.25
(2,5)	0.158	2.73***	78.55	0.49	21.32
(3,1)	0.640	15.55***	87.48	9.37	12.44
(3,2)	0.478	6.41***	80.54	2.47	19.34
(3,3)	0.075	0.94	78.11	0.06	21.75
(3,4)	−0.086	−1.19	78.15	0.10	21.71
(3,5)	−0.168	−2.63***	78.52	0.46	21.35
(4,1)	0.781	13.54***	86.03	7.93	13.88
(4,2)	0.126	1.34	78.18	0.12	21.69
(4,3)	−0.176	−2.21**	78.38	0.33	21.48
(4,4)	−0.297	−3.81***	79.00	0.94	20.87
(4,5)	−0.272	−4.25***	79.22	1.16	20.65
(5,1)	−0.184	−1.70*	78.25	0.19	21.62
(5,2)	−0.614	−6.64***	80.71	2.64	19.17
(5,3)	−0.538	−6.66***	80.72	2.65	19.16
(5,4)	−0.567	−8.65***	82.20	4.12	17.69
(5,5)	−0.427	−8.17***	81.83	3.76	18.05
Average	0.088		80.89	2.82	18.99
Panel B: (dependent variable IPOX 30 index)					
β^{CRSP}= 1.400***; variance of IPO index portfolio = 0.0051; volatility of market portfolio = 73.70%					
(1,1)	0.288	8.09***	78.02	4.46	21.84
(1,2)	0.290	6.76***	76.83	3.27	23.03
(1,3)	0.375	6.57***	76.67	3.12	23.18
(1,4)	0.280	4.55***	75.14	1.59	24.71
(1,5)	0.163	2.73***	74.13	0.59	25.71
(2,1)	0.437	9.29***	79.15	5.58	20.72
(2,2)	0.369	5.67***	75.94	2.39	23.91
(2,3)	0.260	3.34***	74.42	0.88	25.42
(2,4)	0.112	1.48	73.71	0.18	26.12
(2,5)	0.085	1.31	73.67	0.14	26.16
(3,1)	0.563	10.82***	80.61	7.03	19.27
(3,2)	0.401	4.70***	75.24	1.69	24.61
(3,3)	0.021	0.23	73.54	0.00	26.30
(3,4)	−0.148	−1.84*	73.81	0.27	26.03
(3,5)	−0.240	−3.41***	74.46	0.92	25.38
(4,1)	0.726	10.43***	80.24	6.66	19.64
(4,2)	0.086	0.83	73.59	0.06	26.25

(*continued on next page*)

Table 5 (*continued*)

Portfolios (size, book-to-market)	Two-factor model			Variance decomposition	
	β^{FF}		Adjusted R^2 (%)	Volatility attributable to size/BM portfolio (%)	Volatility attributable to IPO index portfolio (%)
	Coefficient	*t*-stats			
(4,3)	−0.190	−2.16**	73.91	0.38	25.93
(4,4)	−0.306	−3.51***	74.51	0.97	25.33
(4,5)	−0.284	−3.97***	74.77	1.23	25.07
(5,1)	−0.153	−1.27	73.67	0.13	26.17
(5,2)	−0.587	−5.60***	75.89	2.34	23.96
(5,3)	−0.484	−5.25***	75.63	2.08	24.22
(5,4)	−0.510	−6.73***	76.80	3.25	23.05
(5,5)	−0.394	−6.55***	76.65	3.10	23.21
Average	0.046		75.64	2.09	24.21

* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

Panels A and B of Table 5 present the results of the two-factor model analysis, as well as the variance decomposition for the IPOX 100 and IPOX 30 indices. Since the dependent variable is the same for each panel, the market portfolio beta (β^{CRSP}) is the same for each of the 25 regressions. β^{CRSP} is 1.422 for the IPOX 100 index and 1.400 for the IPOX 30 index; both of which are highly significant. We also note that the size/book-to-market portfolio betas (β^{FF}) are in general statistically significant, and that they tend to be positive (negative) for small (large) size portfolios. The explanatory power of the two-factor model is also generally high, with an average adjusted R^2 of 81% for the IPOX 100 index and 76% for the IPOX 30 index. The variance of the IPOX 100 index is 0.0050, whilst that of the IPOX 30 index is 0.0051. With the same dependent variable for each panel, we again have the same proportion of volatility attributable to the market portfolio; that is, 78% for the IPOX 100 index and 73% for the IPOX 30 index.

There are two aspects that are worthy to be noted in the variance decomposition. First, for both the IPOX 100 and IPOX 30 indices, the proportion of volatility attributable to the size/book-to-market portfolios is high for growth (low book-to-market ratio) portfolios, with the exception of the largest size quintile (the (5,1) portfolio). However, the variance pattern within the IPO index portfolios seems to be unrelated to market capitalization. This result suggests that the variances in the IPO index portfolios are more related to growth stocks, regardless of the size characteristics of the firms. Second, the volatility of the size/book-to-market portfolios accounts, on average, for only 3% of the total variance for the IPOX 100 index, and only 2% for the IPOX 30 index. Conversely, the idiosyncratic volatility accounts for 19% of the variance in the IPOX 100 index, and 24% of the variance in the IPOX 30 index. Based on the above analysis, we can again justify the significant expansion of mean–variance frontier following the addition of an IPO index portfolio to the 25 benchmark portfolios. The higher proportion of idiosyncratic volatility for the IPOX 30 index, as compared to that for the IPOX 100 index, also explains why we have slightly more significant test results for the IPOX 30 index.

3.4. Robustness check using traded index portfolios as benchmarks

We use the size/book-to-market portfolios as the benchmarks essentially because of the popularity amongst investors of a strategy of style index investment. However, in the US ETF market, we usually find that style indices categorize stocks into six or nine market capitalization and value/growth portfolios, as opposed to 25 portfolios. Thus, we now conduct the mean–variance spanning and intersection tests using, as the benchmark portfolios, three sets of index portfolios that are actually traded. They are the MSCI style index series, the S&P style index series and the Russell style index series; each of which comprises six portfolios based on the market capitalization and value/growth style.

The results presented in Table 6 reveal that five of the six cases yield statistically significant improvement in the investment opportunity set, with a significance level of at least 5%. In four cases, where the S&P and Russell indices are used as benchmarks, the improvement comes from the global minimum variance portfolio. Furthermore, the source of improvement is found in the tangency portfolio when the IPOX 30 index is added to the MSCI and Russell indices. In summary, our conclusion that the addition of an IPO index portfolio provides significant benefits to mean–variance investors remains robust.

4. Conclusion

In this paper, we employ mean–variance spanning and intersection tests to determine whether the addition of an IPO index portfolio can significantly enlarge the investment opportunity set, relative to currently traded stocks. To the best of our knowledge, none of the prior studies on IPO research have attempted to address this issue.

The empirical results of this study are summarized as follows. Using the IPOX 100 and IPOX 30 indices, we find that investors who invest in an IPO index portfolio are able to enlarge their investment opportunity set, relative to the 25 size/book-to-market benchmark portfolios. Our empirical results are robust in the sense that when using, as alternative benchmark portfolios, three sets of index portfolios that are actually traded, in five of the six cases we find statistically significant improvement in the investment opportunity set. These three sets of index portfolios are the MSCI style index series, the S&P style index series and the Russell style index series.

There are also two findings of this study which are worthy to be noted. First, the expansion of the mean–variance frontier following the addition of an IPO index portfolio is much more significant during the pre-Internet bubble period than the post-Internet bubble period. Second, based upon the variance decomposition on the IPO index portfolios, we find that the proportion of the volatility attributable to the size/book-to-market portfolios is high for growth portfolios, but it is unrelated to market capitalization. In addition, the idiosyncratic volatility for the IPO index portfolios is much higher than the volatility attributable to the size/book-to-market portfolios.

Table 6

Mean–variance spanning and intersection tests of the IPO index portfolios using traded index portfolios as benchmark portfolios. The table reports the mean–variance spanning and intersection test results after the addition of IPO index portfolios into the benchmark portfolios. The IPO index portfolios are the IPOX 100 and IPOX 30 indices, whilst the benchmark portfolios are actually traded index portfolios, including six MSCI style indices (small/growth, small/value, mid/growth, mid/value, prime/growth, prime/value), six S&P style indices (600/growth, 600/value, midcap/growth, midcap/value, 500/growth, 500/value) and six Russell style indices (2000/growth, 2000/value, midcap/growth, midcap/value, 1000/growth, 1000/value). The differences in the sample periods for each set of benchmarks arise as a result of the variations in the starting dates of the indices. W refers to the asymptotic Wald test for spanning; W_1 and W_2 are the step-down Wald tests for spanning; and W_I represents the asymptotic Wald test for intersection. The risk-free rate used in the intersection test also differs slightly for each set of benchmarks due to the variations in the sample periods.

Index portfolios	Wald tests							
	W		W_1 step-down		W_2 step-down		W_I	
	Wald stats.	*p*-Value	Wald stats.	*p*-Value	Wald stats.	*p*-Value	Wald stats.	*p*-Value
Panel A: Jun 1992–Dec 2006 (MSCI indices as the benchmarks)								
IPOX 100 index	3.241	0.198	1.859	0.173	1.367	0.242	2.150	0.143
IPOX 30 index	6.543	0.038**	4.608	0.038**	1.886	0.170	5.134	0.024**
Panel B: Apr 1997–Dec 2006 (S&P indices as the benchmarks)								
IPOX 100 index	10.752	0.005***	0.369	0.544	10.350	0.001***	0.696	0.404
IPOX 30 index	7.302	0.026**	2.385	0.123	4.819	0.028**	2.881	0.090*
Panel C: Jun 1995–Dec 2006 (Russell indices as the benchmarks)								
IPOX 100 index	17.398	0.000***	2.423	0.120	14.864	0.000***	3.318	0.069*
IPOX 30 index	13.824	0.001***	4.254	0.039**	9.445	0.002***	5.165	0.023**

* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

Our study contributes to the investment and IPO literature by providing evidence to show that the availability to investors of IPO index portfolios featuring tradable financial products can improve the investment opportunity set generated by either size/book-to-market portfolios or tradable market capitalization/value–growth style index portfolios. We therefore suggest that there is room for the further development of financial products relating to IPO index portfolios, and that investors can gain diversification benefits from investing in such IPO-related products.

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