Price distortion induced by a flawed stock market index

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Abstract

Despite the introduction of sophisticated stock market indices, investors often trade portfolios of the flawed indices to change their exposure to the market. In this study, we show that these transactions cause significant distortions in individual stock prices, especially during periods of significant market movement. As an influential, albeit flawed, stock index, we focus on the Nikkei 225. We find index constituents that are excessively weighted on the index, experience excessive buying (selling) pressure when the stock market surges (falls), and experience price corrections after such periods of change. In contrast, non-constituent stocks do not experience such trading pressure.

Keywords: Stock market index; Price-weighted index; Trading pressure; Price distortion.

JEL classification: G2; G14; G17; G23

1. Introduction

Capitalization-weighted, or cap-weighted, indices have been considered to be adequate tools to evaluate broad market performance for more than 50 years (Markowitz, 1959; Sharpe, 1965; Arnott et al., 2005). Thus, cap-weighted indices have been regarded as representative in many stock markets, and cap-weighted portfolios have been traded by investors to increase or decrease their market exposure. Lately, some stock market indices, such as the S&P 500 and TOPIX, have changed to float-adjusted cap weighting, which provides a more accurate reflection of market movements.

On the other hand, the outdated and flawed index is still influential in some stock markets: Investors not only consider this type of outdated index to be representative of the market, they also trade index portfolios to change their levels of stock market exposure. One representative example is the price-weighted stock market index. The value of a price-weighted index is generated by adding the prices of each of the stocks in the index and dividing them by the total number of stocks. Since the weighting scheme is easy to calculate, traditional stock market indices, e.g., the Dow Jones Industrial Average and Nikkei 225, are calculated on the basis of this scheme. However, the price-based weighting system has several drawbacks.

Capitalization-weighting assigns the greatest weights to the largest companies, which are typically among the largest in terms of sales, book values, cash flows, dividends, and total employment (Arnott et al., 2005). Conversely, price-based weighting seeks to assign the greatest weights to stocks with high share prices, even though firms with higher share prices do not necessarily make greater contributions to the economy. Therefore, the price-weighted index can be regarded as less adequate to measure market performance. Further, while larger-cap stocks are likely to be more liquid, stocks with higher share prices do not always have greater liquidity. Thus, the price-based weighting system is greatly disadvantageous relative to the cap-weighting system in terms of reducing the price impact of index portfolio transactions.

Considering that even the transactions of cap-weighted market portfolios have a certain price impact (Barberis, et al., 2005, and Boyer, 2011), it is highly likely that the transactions of these flawed index portfolios have an price impact, especially on stocks that are excessively weighted on the index, also known as "overweight stocks." Specifically, since investors often trade these index portfolios to change their levels of stock market exposure, a stock market rises (falls) can be accompanied with increased (decreased) demands for index portfolios. Thus, the outsized price impact on overweight stocks can be observed especially when a stock market moves. In short, investors' demands of the flawed index portfolios to change their market exposure could result in price distortions during periods of significant market movement.

Thus, in this study, we explore these price distortions during periods of significant market movement, to uncover the problem of transactions of the flawed index portfolios to change investors'

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*Publication of this paper was supported by a grant-in-aid from Zengin Foundation for Studies on Economics and Finance.

market exposure. As an example of such a market index, we focus on the Nikkei 225, the best-known Japanese stock market and one that uses the outdated price-based weighting system.

In terms of the effect of the Nikkei 225's weighting system on stock prices, Greenwood (2008) performs detailed analyses on the effects of the weighting system. The author analyzes sensitivity (beta) of each stock price to average returns of index constituents and market returns, by time series regression of stock returns on both the average returns and the market returns. The author shows that the price of an overweight stock has high sensitivity to the average returns of Nikkei 225 constituents rather than market returns. This result suggests that there are investors' demands for Nikkei 225 portfolio that are not related with market movement, and these demands cause excess comovement among the index constituents. Since this excess comovement indicates price distortions, their findings might support our prediction that investors' demands (transactions) of the flawed index portfolios to change their levels of market exposure cause significant price impact and distortion. However, these demands for market exposure are obviously associated with stock market movement. On the other hand, Greenwood (2008) analyzes on price distortions induced by investors' demands for the index portfolio unrelated to market movement. The findings cannot provide any evidence on our prediction.

To test our prediction, in this study, we first evaluate the time-varying price impact from investors' demands for the index portfolios by analyzing each day's cross sectional relation between stock returns and the level of overweighting. Then, we analyze the relation between the daily price impacts and market returns.

2. Theory

Stocks with low unit prices are regarded as distressed stocks and are sensitive to market movement (Campbell, 2008). Thus, low-priced stocks could be sensitive to market returns. In other words, high-priced stocks might experience lower (higher) returns than low-priced stocks during periods of a market surge (fall). However, we predict that overweight stocks, which tend to be high-priced, experience higher (lower) returns during periods of market surges (falls), because these stocks could experience price pressure from investors' demands for 225 index portfolios to change the level of their market exposures in the following manner.

A Nikkei 225 futures transaction is considered to be the fastest and easiest way to change exposures to the Japanese stock market. Since arbitrageurs take long (short) positions on 225 index portfolios and short (long) positions on Nikkei futures if there is a price disparity between spots and futures, future price movements can affect the spot index through short-term adjustments. In line with this prediction, a considerable number of studies show that index futures returns tend to lead stock market returns. In terms of the relation between the Nikkei 225 Index and its futures contracts, Tse (1995) finds that futures prices affect the spot index, but not vice versa. Therefore, buying (selling) pressure for Nikkei futures results in buying (selling) pressure on index portfolios.

Stock market movement could reflect investors' demands for market exposure; specifically, market surges (falls) could reflect increased (decreased) demands for market exposure. A increased (decreased) demands for exposure to the market result in the buying (selling) of Nikkei 225 futures, which induces buying (selling) pressure on index portfolios. Hence, we predict that overweight stocks will experience strong buying pressure when the stock market rises and strong selling pressure when it falls. Since stronger buying (selling) pressure results in higher (lower) stock returns, we formulate the first hypothesis as follows.

Hypothesis 1. Overweight stocks experience higher (lower) returns than other stocks when the stock market rises (falls).

As discussed, the price behavior mentioned above can be observed only among index constituents. Specifically, we predict that when the stock market surges (falls), only the index constituents that are assigned great weight on the price-based weighting system will experience higher (lower) returns, while non-index constituents assigned great weight will experience lower (higher) returns or, at least, will not experience higher (lower) returns. This leads to the second hypothesis.

Hypothesis 2. Non-index constituents that are assigned a great weight on the price-based weighting system do not experience higher (lower) returns than other stocks when the stock market rises (falls).

The return differences between overweight index constituents and other stocks during periods

of significant market movement cannot be justified by cross-sectional differences in stock fundamentals. Therefore, it is highly possible that overweight stocks are overvalued when the stock market surges and are undervalued when the market falls: Trading pressure induced by the transactions for 225 index portfolios could result in distortions in individual stock prices, during periods of significant market movement. Since misvalued stocks are likely to experience price corrections in subsequent periods, overweight stocks could experience lower (higher) stock returns, especially after the market rises (falls). This leads to the third hypothesis.
Hypothesis 3. Overweight stocks experience lower (higher) returns than other stocks in a subsequent period of a market surge (fall).

3. Data and definitions

3.1 Sample construction

We obtain our sample from the TSE database service (historical data is available from the end of July 1993). We collect data from TOPIX constituent securities, which cover all domestic common stocks listed on the First Section of the TSE. We utilize daily data from the end of July 1993 to the end of 2013. We divide the sample into three sub-periods (July 1993 to 1999, 2000 to 2006, and 2007 to 2013) and perform sub-period analysis. On average, there are approximately 1,500 firms in our sample for each day.

For market returns, we use the capitalization-weighted returns of TSE First Section stocks. Market returns coincide with TOPIX returns until the end of October 2005. After the end of October 2005, TOPIX transitioned to a free-float capitalization weighting index. To maintain consistency regarding the definition of the market index, we calculate unadjusted capitalization-weighted index returns from the beginning of November 2005 as market returns.

3.2. Effect of the price-based weighting system

The value of the Nikkei 225 is determined by adding the stock prices of its constituents, divided by their presumed face values FV_t, multiplying by a constant, and dividing the total by the index divisor. Thus, the index weight w_{N225} is proportional to the share prices divided by their face values, as follows:

$$w_{N225i,t} = \frac{P_{i,t}}{FV_t/50} \Bigg/ \sum_{i=1}^{225} \frac{P_{i,t}}{FV_t/50}$$

To evaluate the effect of the price-based weighting system on cross-sectional returns, following the study of Greenwood (2008), we first calculate the ratio of each stock's weight in the Nikkei 225 (w_{N225}) to its weight in a capitalization-weighted index (w_{MV}). Then, we define overweighting (denoted by *OW*) as the log of one plus the ratio mentioned above ($\log(1 + \mathrm{w}_{N225}/\mathrm{w}_{MV})$). As discussed in Greenwood (2008), this is not only an intuitive measure of overweighting relative to the weight in the cap-weighted index, but also of the price impact from index portfolio transactions because stock capitalization is positively associated with liquidity. Then, we evaluate the effect of overweighting (the weighting system of the Nikkei 225) on cross-sectional stock returns by regressing stock returns on one-day lagged OW (OW for the previous working day). We report the effects of overweighting by separately regressing the stock returns of all domestic common stocks listed on the First Section of the TSE and constituents of the Nikkei 225.

In analyzing the domestic common stock returns, since the Nikkei index weight is zero for non-constituent securities, OW is zero for approximately 80% of stocks. Thus, OW might capture not only the effect of the price-based weighting system but also the effect of the constituent selection system of the Nikkei 225 (the return spread between Nikkei index constituents and non-constituents). Therefore, when we evaluate the effect of overweighting (the price impact of *OW*), we control for the effect of inclusion in the Nikkei 225 (the effect of the constituent selection system) by including a binary variable (denoted by *NK*) that has a value of one if a stock is a Nikkei 225 constituent, and zero otherwise.

In addition, we include a cap-weighting factor that is defined by the log of one plus the weight of the cap-weighted index (denoted by MW) to control for the effect of the denominator of OW. We also control for the liquidity effect and measurement errors in prices, i.e., bid-ask spreads in securities, in the following ways. To control for the liquidity effect, we include the illiquidity indicator of Amihud (2002), denoted by $ILLIQ$, which is defined as the 21-trading days average absolute value of the stock return[1], divided by the average trading value in millions of yen, as one of the control variables. When there is considerable fund flow to/from the Japanese stock market, illiquid stocks could be subject to a stronger price impact. Thus, cross-sectional differences in illiquidity could result in cross-sectional variations in stock returns, especially when the stock market moves. Furthermore, to control for the effect of the bid-ask bounce, we include the bid-ask spread (denoted by *SPREAD*) as a control variable. Since the bid-ask spread data for Japanese stocks is not available for over the entire studied period, we estimate the bid-ask spread following the methodology of Corwin and Schultz (2012). Several studies (e.g., Roll 1984, Atkins and Dyl, 1990) demonstrate and suggest that a daily cross-sectional pattern is partly attributable to the existence of bid-ask spreads in securities.

Therefore, for each day *t*, we first regress the daily returns of stock *i* over day *t* ($R_{i,t}$) on the lagged *OW* (overweighting measures as of day *t*-1) and the four variables mentioned above (lagged *NK*, *MW*, *ILLIQ*, and *SPREAD*) among all domestic common stocks listed on the First Section of the TSE:

$$R_{i,t} = \alpha_{OW1,0,t} + \beta_{\mathrm{OW1}_{0,t}} OW_{i,t-1} + \beta_{\mathrm{NK1}_{0,t}} \mathrm{NK}_{i,t-1} + \beta_{\mathrm{MW1}_{0,t}} MW_{i,t-1} + \beta_{\mathrm{ILLIQ1}_{0,t}} ILLIQ_{i,t-1} + \beta_{\mathrm{SPREAD1}_{0,t}} SPREAD_{i,t-1} + \varepsilon_{OW1,i,0,t} \quad (1)$$

$\beta_{\mathrm{OW1}_{0,t}}$ represents the effect of overweighting (the weighting system) on stock returns at day *t* ($R_{i,t}$); thus, we refer to $\beta_{OW1_{0,t}}$ as the effect of overweighting. A positive (negative) $\beta_{OW1_{0,t}}$ indicates that overweight stocks experience higher (lower) returns. In addition, to examine the longer-term effects of the price-based weighting system, *s*-day-ahead returns $R_{i,t+s}$ (*s*=1, 2, 3) are regressed on $OW_{i,t-1}$ as follows:

$$R_{i,t+s} = \alpha_{OW1,s,t} + \beta_{\mathrm{OW1}_{s,t}} OW_{i,t-1} + \beta_{\mathrm{NK}_{s,t}} \mathrm{NK}_{i,t-1} + \beta_{\mathrm{MW1}_{s,t}} MW_{i,t-1} + \beta_{\mathrm{ILLIQ1}_{s,t}} ILLIQ_{i,t-1} + \beta_{\mathrm{SPREAD1}_{s,t}} SPREAD_{i,t-1} + \varepsilon_{OW1i,s,t} \quad (2)$$

$\beta_{OW1_{s,t}}$ represents the effect of overweighting (the weighting system) on the *s*-day-ahead stock returns, $R_{i,t+s}$ (we refer to it as "the *s*-day-ahead effect of overweighting").

We also report the effects of overweighting by regressing the stock returns of Nikkei 225 index constituents. In this case, *OW* does not capture the effect of inclusion in the Nikkei 225. In addition, limiting the investigated stocks to Nikkei 225 index constituents can reduce the possibility that the price behavior of non-index constituents will affect the estimation of the coefficient of *OW*. Therefore, we also regress the returns on *OW* among Nikkei 225 constituents as follows:

$$R_{i,t+s} = \alpha_{OW2,s,t} + \beta_{\mathrm{OW2}_{s,t}} OW_{i,t-1} + \beta_{\mathrm{MW2}_{s,t}} MW_{i,t-1} + \beta_{\mathrm{ILLIQ2}_{s,t}} ILLIQ_{i,t-1} + \beta_{\mathrm{SPREAD2}_{s,t}} SPREAD_{i,t-1} + \varepsilon_{OW2i,s,t} \quad (s=0, 1, 2, 3) \quad (3)$$

$\beta_{OW2_{s,t}}$ can be regarded as a proxy for the *s*-day-ahead effect of overweighting at day *t*.

To test hypothesis 2, we also evaluate the price impact of the price-based weighting system on non-constituents. We should estimate weights for non-index constituents based on the price-based weighting system of the Nikkei 225. As explained, the weight is basically determined by the share price denominated by the face value of the share price. However, since 2001, Japanese stocks have not had official face values. Thus, the deemed face value, which is predicted by considering past face values, corporate events, and other index constituents, has been used to calculate the Nikkei 225. Since we do not estimate face value for non-constituents stocks, we utilize the non-face-value adjusted weight for non-constituents that are correlated with their share prices[2].

Similar to the definition of the overweighting factor for Nikkei 225 constituents, we then calculate the ratio of the weight to its weight in the capitalization-weighted index; finally, we define an overweighting factor for non-constituents, *OWN,* as the log of one plus the ratio[3]. To evaluate the effect of *OWN*, the returns $R_{i,t}$ are regressed on *OWN* in addition to the four control variables (*NK*, *MW*, *ILLIQ*, and *SPREAD*) for stocks listed on the First Section of the TSE:

$$R_{i,t} = \alpha_{OWN1_{s,t}} + \beta_{\mathrm{OWN1}_{0,t}} OWN_{i,t-1} + \beta_{\mathrm{OW3}_{0,t}} \mathrm{OW}_{i,t-1} + \beta_{\mathrm{MW3}_{0,t}} MW_{i,t-1} + \beta_{\mathrm{ILLIQ3}_{0,t}} ILLIQ_{i,t-1} + \beta_{\mathrm{SPREAD3}_{0,t}} SPREAD_{i,t-1} + \varepsilon_{OWN1_{i,0,t}} \quad (4)$$

The effect is also evaluated by regressing *OWN* among non-index constituents, as follows:

$$R_{i,t} = \alpha_{OWN2_{s,t}} + \beta_{\mathrm{OWN2}_{0,t}} OWN_{i,t-1} + \beta_{\mathrm{MW4}_{0,t}} MW_{i,t-1} + \beta_{\mathrm{ILLIQ4}_{0,t}} ILLIQ_{i,t-1} + \beta_{\mathrm{SPREAD4}_{0,t}} SPREAD_{i,t-1} + \varepsilon_{OWN2_{i,0,t}} \quad (5)$$

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[1] Approximately, the number of trading days over one month.

[2] The unadjusted weights are likely to be highly correlated with face-value adjusted weights; the unadjusted weights for Nikkei 225 constituents have an approximately 0.8 correlation with official index weights.

[3] *OWN* has a value of zero for Nikkei 225 constituents.

$\beta_{OWN1_{0,t}}$ and $\beta_{OWN2_{0,t}}$ can be regarded as the effects of the price-based weighting system on non-constituents. Positive (negative) values for $\beta_{OWN1_{0,t}}$ and $\beta_{OWN2_{0,t}}$ mean that non-constituents, which are assigned greater weights in the price-based weighting system, experience higher (lower) returns.

4. Results

4.1. Price impact of overweighting

In this section, we show the analysis used to test *Hypothesis 1*. First, we run the following regression to analyze the association between market returns and the effect of overweighting:

$$\beta_{OW1_{0,t}} = a_{OW1_0} + b1_{OW1_0} MR_t + e_{OW1_{0,t}}$$
$$\beta_{OW2_{0,t}} = a_{OW2_0} + b1_{OW2_0} MR_t + e_{OW2_{0,t}} \qquad (6)$$

The coefficients of MR_t ($b1_{OW1_0}$ and $b1_{OW2_0}$) are estimated using the weighted least squares (WLS) method, where the values for the reciprocal of the square of the standard error of the coefficient $\beta_{OW1_{0,t}}$ in Equation (1) and that of $\beta_{OW2_{0,t}}$ in Equation (3), respectively, are used as weights. Positive coefficients ($b1_{OW1_0}>0$ and $b1_{OW2_0}>0$) indicate that the price impact caused by the price-based weighting system is positively associated with concurrent market returns. In other words, positive coefficients indicate that overweight stocks experience stronger buying pressure (higher returns) when the stock market rises and stronger selling pressure (lower returns) when the stock market falls.

The results are shown in Table 1 shows that β_{OW1} and β_{OW2} have a significantly positive association with market returns. This result can be understood to indicate that overweight stocks experience higher returns than other stocks when the stock market rises. These findings strongly support *Hypothesis 1*.

Table 1 Effect of overweighting

	1993-1999		2000-2006		2007-2013		Whole period	
$\beta_{OW1_{0,t}}$	0.417 (11.74)	***	0.133 (4.84)	***	0.135 (6.75)	***	0.222 (13.81)	***
$\beta_{OW2_{0,t}}$	0.107 (3.08)	***	0.148 (4.93)	***	0.156 (6.82)	***	0.143 (8.88)	***

4.2. Effect on non-constituents

To test hypothesis 2, we examine whether the effects of the price-based weighting system on non-constituents, i.e., $\beta_{OWN1_{0,t}}$ and $\beta_{OWN2_{0,t}}$, are not positively associated with concurrent market returns by regressing those on MR_t. The coefficients for each regression are estimated using the WLS method, where the values for the reciprocal of the square of the standard error of the coefficients $\beta_{OWN1_{0,t}}$ and $\beta_{OWN2_{0,t}}$ in Equations (4) and (5), respectively, are used as weights.

The results in Table 2 reveal that $\beta_{OWN1_{0,t}}$ and $\beta_{OWN2_{0,t}}$ are significantly negatively associated with market returns (MR_t). These results indicate that non-constituent stocks, which are assigned great weights on the price-based weighting system, experience lower (higher) returns than other stocks when the stock market rises (falls). These findings are consistent with the arguments of Campbell (2011) and Liu et al. (2012), which show the high-beta characteristic of low priced stocks. The findings support our view that high market sensitivity of stocks that are assigned a great weight on the weighting system is only observed among the index constituents, supporting *Hypothesis 2*.

Table 2 Price impact of overweighting on non-constituents

	1993-1999		2000-2006		2007-2013		Whole period	
$\beta_{OWN1_{0,t}}$	-0.330 (19.26)	***	-0.053 (5.07)	***	-0.142 (24.84)	***	-0.131 (28.25)	***
$\beta_{OWN2_{0,t}}$	-0.315 (18.00)	***	-0.057 (5.50)	***	-0.143 (24.63)	***	-0.132 (28.24)	***

4.3. Price correction

To test *Hypothesis 3*, we analyze whether the *s*-day-ahead effect of overweighting is negatively associated with market returns (MR_t). We analyze the one-day-ahead effects by running the following regressions:

$$\beta_{OW1_{1,t}} = a_{OW1_1} + b1_{OW1_1} MR_t + b2_{OW1_1} MR_{t+1} + e_{OW1_{1,t}}$$
$$\beta_{OW2_{1,t}} = a_{OW2_1} + b1_{OW2_1} MR_t + b2_{OW2_1} MR_{t+1} + e_{OW2_{1,t}} \quad (7)$$

Negative coefficients ($b1_{OW1_1}$<0 and $b1_{OW2_1}$<0) indicate that overweight stocks experience lower returns in a subsequent market surge and higher returns in a subsequent market fall. As shown in the previous section, the effect of overweighting is positively associated with concurrent market returns. Thus, the one-day-ahead effects of overweighting ($\beta_{OW1_{1,t}}$ and $\beta_{OW2_{1,t}}$) could be associated with one-day-ahead market returns MR_{t+1}. As a control variable, we include one-day-ahead market returns. The coefficients for the models are estimated using the WLS method, where the reciprocal of the square of the standard error of coefficient $\beta_{OW1_{1,t}}$ in Equation (2) and that of coefficient $\beta_{OW2_{1,t}}$ in Equation (3) are used as weights.

Since the prices might be slowly corrected, we also examine the association between market returns and the two- and three-day-ahead effects of overweighting by running the following regressions:

$$\beta_{OW1_{2,t}} = a_{OW1_2} + b1_{OW1_2} MR_t + b2_{OW1_2} MR_{t+1} + b3_{OW1_2} MR_{t+2} + e_{OW1_{2,t}}$$
$$\beta_{OW2_{2,t}} = a_{OW2_2} + b1_{OW2_2} MR_t + b2_{OW2_2} MR_{t+1} + b3_{OW1_2} MR_{t+2} + e_{OW2_{2,t}} \quad (8)$$
$$\beta_{OW1_{3,t}} = a_{OW1_3} + b1_{OW1_3} MR_t + b2_{OW1_3} MR_{t+1} + b3_{OW1_3} MR_{t+2} + b4_{OW1_3} MR_{t+3} + e_{OW1_{3,t}}$$
$$\beta_{OW2_{3,t}} = a_{OW2_3} + b1_{OW2_3} MR_t + b2_{OW2_3} MR_{t+1} + b3_{OW1_3} MR_{t+2} + b4_{OW1_3} MR_{t+3} + e_{OW2_{3,t}} \quad (9)$$

The results in Table 3 reveal that the one-day-ahead effects of overweighting ($\beta_{OW1_{1,t}}$ and $\beta_{OW2_{1,t}}$) have a significantly negative association with market returns (MR_t). This negative association between market returns and the one-day-ahead effect can be observed in each sub-period. On the other hand, the two- and three-day-ahead effects of overweighting are positively associated with market returns. However, the absolute values of these coefficients are much smaller than that of the one-day-ahead effect. In sum, these results indicate that although stock returns are higher (lower) for overweight stocks when the market is up (down), this performance is totally reversed in a subsequent day. This result can be understood from the perspective that overweight stocks experience strong trading pressure, which causes significant individual stock price distortion, especially during periods of significant market movement, and this price distortion is corrected on a subsequent day.

Table 3 One-, two-, and three-day-ahead effects of overweighting

(a) Regression analysis for $\beta_{OW1_{s,t}}$

	1993-1999		2000-2006		2007-2013		Whole period	
$\beta_{OW1_{1,t}}$	-0.375 (11.06)	***	-0.186 (6.93)	***	-0.128 (6.52)	***	-0.220 (14.07)	***
$\beta_{OW1_{2,t}}$	0.100 (3.00)	***	0.054 (2.01)	**	-0.008 (0.42)		0.042 (2.70)	***
$\beta_{OW1_{3,t}}$	-0.010 (0.31)		0.080 (3.02)	***	0.004 (0.20)		0.023 (1.48)	

(b) Regression analysis: $\beta_{OW2_{s,t}}$

	1993-1999		2000-2006		2007-2013		Whole period	
$\beta_{OW2_{1,t}}$	-0.176 (5.20)	***	-0.185 (6.28)	***	-0.119 (5.30)	***	-0.151 (9.56)	***
$\beta_{OW2_{2,t}}$	0.090 (2.74)	***	0.039 (1.33)		-0.008 (0.37)		0.026 (1.69)	
$\beta_{OW2_{3,t}}$	-0.006 (0.19)		0.096 (3.26)	***	0.025 (1.12)		0.040 (2.56)	**

5. Conclusion

Despite the introduction of several sophisticated market indices, some stock market indices that apply outdated flawed weighting systems are still influential and representative. Investors trade the flawed index portfolios to change their levels of stock market exposure.

In this study, to highlight the problem of investors' transaction of the flawed index portfolios to adjust their exposure to the market, we explore whether these transaction result in price distortions during periods of significant market movement. As a flawed, albeit influential, market index, we focus on the Nikkei 225 that uses the outdated price-based weighting system.

Investors' demands for Nikkei 225 index portfolios to have the market exposure could be higher (lower) when market return is higher (lower). In addition, overweight stocks do not always have the higher liquidity required to better absorb higher trading pressure than other stocks. Thus, overweight stocks, i.e., stocks that are overweighted on the index, could experience more buying (selling) pressure when the stock market surges (falls). These excessive trading pressures during periods of significant market movement could result in price distortion for those stocks.

Consistent with our prediction, we first find that overweight stocks experience higher (lower) returns when the market rises (falls). Second, they experience lower (higher) returns after such periods, i.e., their performance is reversed. These findings suggest that overweight stocks could experience significant trading pressure, resulting in individual stock price distortion, when the stock market moves considerably. In addition, we find that non-constituent stocks which are assigned great weight on the price-based weighting system do not experience such trading pressure; this result suggests that price distortion among overweight stocks is attributed to price-weighted index portfolio transactions.

The study of Greenwood (2008) shows that the existence of the flawed but influential stock indices creates investors' demands for the index portfolio which are not associated with market movement, and these demands cause individual stock price distortion. On the other hand, we focus on the demands for the index portfolio to change their levels of stock market exposure, which are strongly associated with market movement; our study further extends his argument by showing that these demands for market exposure also play a key role in the price distortions.

In addition, our study raises another problem regarding the use of outdated and flawed indices as stock market indices. The price-weighted index, on which we focus as a representative flawed index, has been regarded as being less adequate to measure market performance because stocks with higher share prices do not always make greater contributions to the economy. In addition, our analyses show that when the market is up (down), the index value could be upwardly (downwardly) biased due to the overvaluation (undervaluation) of overweight stocks. Thus, the daily returns of the flawed index are biased by not only by the inadequate evaluation of market movement but also by the price distortion induced by the inadequate weighting system.

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