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Residual momentum in Japan

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ABSTRACT

We demonstrate that the residual momentum strategy, which is constructed to hedge out the risk exposure to the Fama–French (1993) factors, is profitable in Japan for short-term holding periods ranging from three to 12 months. Residual momentum profits over long-term holding periods ranging from two to five years do not reverse, unlike traditional price momentum strategies observed in the U.S. market. The findings in both short- and long-term holding periods are attributed to investor underreaction. A comprehensive index of limited attention supports investor underreaction as an underlying cause of momentum in Japan.

1. Introduction

Since the publication of the study by Jegadeesh and Titman (1993), the existence of momentum profits has been widely documented as one of the most pronounced and prevalent anomalies in both U.S. and international stock markets. Despite ample evidence of pronounced momentum profits around the world, the failure of the momentum strategy in the Japanese market is one remarkable exception (Griffin et al., 2003; Chui et al., 2010; Fama and French, 2012; Asness et al., 2013).

The residual momentum strategy is traced to Gutierrez and Pirinsky (2007), who introduce two types of momenta: abnormal-return momentum and relative-return momentum. The latter is identical to Jegadeesh and Titman's (JT's) (1993) price momentum, whereas the former in principle is the same as the residual momentum later elaborated by Blitz et al. (2011, 2017). While observing the success of residual momentum in the U.S. market, Gutierrez and Pirinsky (2007) and Blitz et al. (2011) offer different underlying reasons. Gutierrez and Pirinsky (2007) believe that institutional investors overreact to traditional momentum strategies while they underreact to residual momentum strategies largely because of their career and reputational concerns, which lead to continuation of long-term profits without return reversals. In contrast, Blitz et al. (2011) show that short-term residual momentum strategies perform well because time-varying exposures to Fama–French factors are minimized as residual returns are used to identify winners and losers for portfolio decisions. Blitz et al. (2011) rightly credit this explanation to Grundy and Martin (2001) who observe that traditional price momentum has substantial time-varying exposures to Fama–French (1993) factors and significant profits can be attained as these exposures are hedged away. The Japanese market is a major beneficiary of this residual momentum approach as shown by Chaves (2016), but he does not investigate underlying causes for residual momentum profits in Japan.

The first goal of this paper is to investigate whether the residual momentum strategy advanced by Gutierrez and Pirinsky (2007) and Blitz et al. (2011) generates significant momentum profits exclusively focusing on the Japanese market.[1] For short-term holding

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[1] Chaves (2016) is credited for investigating the Japanese market but Japan is one of 21 countries investigated and he does not specify the length of the portfolio holding period.

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periods, the residual momentum strategy is profitable in Japan as measured by Jensen's alphas from the Fama–French 3-factor model. Sharpe ratios are consistently positive whereas the JT price momentum suffers from negative Sharpe ratios in Japan. We also find that the residual momentum profits over long-term holding periods remain insignificant. Nevertheless, an important finding is that they do not reverse in Japan while the magnitude of long-term residual momentum profits in the U.S. market remains significant and sustains (Gutierrez and Pirinsky, 2007). Naturally, the main goal of this study is to identify the sources of residual momentum profits in the short-term holding period and to examine why long-term profits do not reverse while remaining insignificant in Japan.

Our examinations of both short- and long-term holding periods lead us to conclude that investor underreaction is an underlying reason. Hence, the empirical verification of investor underreaction is the second goal of this paper, which has not been done in the past for the Japanese market.[2] Specifically, we construct a comprehensive index of investor underreaction to incorporate the information embedded in several proxies of limited attention.[3] We obtain robust evidence that the profitability of the residual momentum is attributed to investor underreaction to information and the significant momentum profits are concentrated in stocks that have limited capacity to attract investors' attention.

Our findings have important implications for the literature on the momentum strategies in Japan. First, we indicate that the time-varying exposure to risk factors is an important consideration for momentum strategies in Japan. This result is not surprising because Asness (2011) documents that returns to the JT price momentum strategy in Japan is the most volatile (with the largest standard deviation of 20.2% and with the lowest average return of 0.7% per year) among several major markets in the United States, United Kingdom, and non-U.K. European region. As the time-varying risk exposures are hedged out, the residual momentum strategies in Japan exhibit higher and more stable profitability. Second, as noted by Gutierrez and Pirinsky (2007) and Blitz et al. (2011, 2017), the pronounced profitability of the residual momentum is indicative of investor underreaction to firm-specific information rather than to public information. This finding in Japan supports the gradual-information-diffusion hypothesis: firm-specific information diffuses gradually across the investing public (Hong and Stein, 1999; Hong et al., 2000; Blitz et al., 2011).

This paper's contributions to the relevant literature are summarized in three important aspects: First, short-term residual momentum profits are significant whereas long-term profits remain insignificant with no reversals in Japan. Second, investor underreaction emerges as the main underlying force that explains short-term momentum profits while investor overreaction is not applicable in Japan because reversals are not observed in long-term momentum profits.[4] Third, the role of investor underreaction remains robust to several conditioning variables (e.g., low information discreteness, low institutional ownership, low idiosyncratic volatilities, and young firm age) that are known to lead investor limited attention.

2. Residual momentum vs. JT price momentum

2.1. Data

Our sample consists of all common stocks listed on the Tokyo Stock Exchange (TSE) (including Sections 1, 2, and Mother Section) from January 1975 to December 2011. We obtain daily and monthly returns as well as accounting variables for all sample stocks from the database compiled by the PACAP Research Center. As a proxy for the risk-free interest rate, we use a combined series of the call money rate (from January 1975 to November 1977) and the 30-day Gensaki (repo) rate (from December 1977 to December 2011). Both the call money and repo rates are also retrieved from the PACAP database.

2.2. Construction of momentum strategies

We follow the procedures proposed by Blitz et al. (2011) to construct the standard residual momentum strategy. At the beginning of each month t, we perform the time-series regression for each individual stock using the Fama–French (1993) three-factor model:

$$r_{i,t} - r_{f,t} = \alpha_i + m_i MKT_t + s_i SMB_t + h_i HML_t + \varepsilon_{i,t}, \tag{1}$$

where $r_{i,t}$ is the return on stock i in month t; $r_{f,t}$ is the risk-free rate in month t; MKT_t, SMB_t, and HML_t are the realized returns on the market and two mimicking portfolios for size and book-to-market in month t, respectively[5] ; α_i, m_i, s_i, and h_i are the coefficients to be estimated; and $\varepsilon_{i,t}$ is the residual return of stock i in month t. We use a three-year window to estimate Eq. (1): at the beginning of each month t, the regressions are estimated over the period from $t-36$ to $t-1$.[6]

[2] A recent WP by Blitz et al. (2017) came to our attention at the time of preparing this version of the paper. On the basis of their analyses of U.S. market, they also cite investor underreaction as a possible reason for the success of residual momentum. They are using the "idiosyncratic momentum" to refer to the "residual momentum".

[3] We are grateful to the anonymous referee for making a suggestion that we construct a comprehensive index of investor underreaction.

[4] No reversals in long-term profits are consistent with what George and Hwang (2004) observe in the U.S. market using the measure based on the nearness to the 52-week high. They question the traditional view that short-term momentum and long-term reversals are "sequential components of the process by which the market absorbs news".

[5] We follow the procedure of Fama and French (1993) to construct SMB and HML factors based on individual firm size and BM with an annual rebalancing starting from October of each year because many TSE-listed firms have the end of March as their fiscal year-end and the accounting information becomes available before September (Daniel et al., 2001).

[6] We also apply a five-year window to replicate the analyses following representative studies (Fama and French, 1992; Shanken, 1992; Brennan et al., 1998; Avramov and Chordia, 2006). The results remain virtually unchanged.

Table 1
Profitability of momentum strategies.

	Residual momentum				JT price momentum			
	$K = 3$	$K = 6$	$K = 9$	$K = 12$	$K = 3$	$K = 6$	$K = 9$	$K = 12$
Panel A: Momentum profits for $rMOM_{6,2}$ and $MOM_{6,2}$ strategies								
Winner	0.864***	0.856***	0.878***	0.817***	0.455	0.549	0.590*	0.547
	(2.72)	(2.72)	(2.82)	(2.60)	(1.29)	(1.58)	(1.73)	(1.61)
Loser	0.612*	0.640*	0.650*	0.658*	0.736*	0.730*	0.715*	0.774*
	(1.73)	(1.84)	(1.89)	(1.92)	(1.71)	(1.74)	(1.73)	(1.91)
Winner–Loser	0.252	0.215	0.228**	0.159*	−0.281	−0.181	−0.125	−0.227
	(1.63)	(1.65)	(2.07)	(1.66)	(−1.07)	(−0.74)	(−0.57)	(−1.18)
FF alpha	0.259*	0.260**	0.282***	0.210**	−0.189	−0.056	0.049	−0.031
	(1.80)	(2.14)	(2.72)	(2.27)	(−0.73)	(−0.25)	(0.24)	(−0.17)
Sharpe ratio	0.086	0.086	0.105	0.082	−0.052	−0.038	−0.029	−0.059
Panel B: Momentum profits for $rMOM_{12,2}$ and $MOM_{12,2}$ strategies								
Winner	0.911***	0.855***	0.783**	0.734**	0.508	0.487	0.436	0.389
	(2.85)	(2.70)	(2.46)	(2.28)	(1.44)	(1.39)	(1.25)	(1.12)
Loser	0.617*	0.640*	0.694**	0.716**	0.709	0.760*	0.835*	0.897**
	(1.77)	(1.87)	(2.03)	(2.09)	(1.60)	(1.76)	(1.96)	(2.14)
Winner–Loser	0.295*	0.215	0.089	0.018	−0.201	−0.273	−0.400	−0.509**
	(1.93)	(1.59)	(0.72)	(0.16)	(−0.68)	(−0.99)	(−1.58)	(−2.25)
FF alpha	0.307**	0.254*	0.131	0.068	0.048	0.011	−0.083	−0.174
	(2.07)	(1.92)	(1.08)	(0.60)	(0.17)	(0.04)	(−0.36)	(−0.85)
Sharpe ratio	0.098	0.080	0.036	0.008	−0.034	−0.050	−0.080	−0.114

This table reports the raw and risk-adjusted monthly returns for residual and JT price momentum strategies using individual stock's residual returns and past average returns based on all TSE-listed stocks to measure past performance. Panel A reports the monthly momentum profits for 3-, 6-, 9-, and 12-month holding periods based on individual stocks' performance of past 6-month return excluding the most recent month ($rMOM_{6,2}$ and $MOM_{6,2}$), whereas Panel B report the short-term momentum profits based on the performance of past 12 to 2 month returns ($rMOM_{12,2}$ and $MOM_{12,2}$). We report raw and risk-adjusted monthly returns of the Winner–Loser portfolio. We calculate risk-adjusted returns by obtaining the intercepts from the regression for the monthly returns of the momentum strategies on the Fama–French (1993) three-factor model. The returns are in percentage. In addition, we report the Sharpe ratios for each momentum strategies. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

Once we obtain the residual returns ($\varepsilon_{i,t}$) from Eq. (1), we calculate the average residual return over the past 12 or 6 months excluding the most recent month (i.e., from t −12 to t −2 or from t −6 to t −2) standardized by the standard deviation of the residual returns over the same period. We construct the residual momentum strategy (denoted as $rMOM_{12,2}$ and $rMOM_{6,2}$, respectively) by ranking individual stocks based on their values of the average standardized residual return into deciles. $rMOM_{6,2}$ is considered because of Novy-Marx's (2012) findings that U.S. market momentum is not driven by firms' performance six to two months prior to portfolio formation.

Stocks with an average standardized residual return ranked at the top 10% are defined as winners, and those ranked at the bottom 10% are defined as losers. These portfolios are equally weighted.[7] As performed by JT (1993, 2001), the conventional price momentum strategy involves taking a long position in the winner portfolio and taking a short position in the loser portfolio for the subsequent K months ($K = 3$, 6, 9, and 12) using the overlapping approach. Specifically, the momentum return in month t is calculated as the return difference between the winner and loser portfolios, averaged across K separate positions, each formed in one of the K consecutive prior months from t −K to t −1. We test the average returns with t-statistics adjusted for autocorrelation and heteroskedasticity using Newey and West's (1987) correction of standard errors.

To contrast with the residual momentum strategies, we construct JT's (1993) price momentum strategies (denoted as $MOM_{12,2}$ and $MOM_{6,2}$) by using the average total return over the past 12 or 6 months excluding the most recent month to measure past performance. Again, the momentum profits to the strategies involve buying the top decile stocks and short selling the bottom decile stocks with 3-, 6-, 9-, and 12-month holding periods.

2.3. Short-term profits to momentum strategies

Panels A and B of Table 1 report both raw and risk-adjusted monthly returns of the two residual and price momentum strategies formed on past 6- and 12-month performance, respectively, for the holding periods of 3, 6, 9, and 12 months. The risk-adjusted returns are measured by Jensen's alphas from the Fama–French (1993) three-factor model. Two important findings emerge from Panel A which summarizes the results for the 6-month formation period: First, Jensen's alphas of residual momentum are positive and significant for all four short-term holding periods whereas those of JT price momentum are insignificant.[8] The $rMOM_{6,2}$ strategy

[7] We also use the value-weight to confirm that our results remain robust.

[8] It is notable that some of the raw returns for the residual momentum are insignificant. As a comparison, the JT price momentum strategies also exhibit more negative magnitude in raw returns than in Jensen's alphas. Hence, the improvement of residual momentum over the JT price momentum is still substantial.

Table 2
Summary statistics of momentum profitability.

Statistic	$rMOM_{6,2}$	$MOM_{6,2}$	$rMOM_{12,2}$	$MOM_{12,2}$	MKT
Mean	0.215	−0.181	0.215	−0.273	0.199
Standard deviation	2.494	4.750	2.685	5.437	5.173
Maximum	10.043	18.443	11.893	20.819	17.281
Minimum	−15.388	−37.723	−14.037	−47.050	−20.253
Skewness	−0.661	−1.443	−0.436	−1.579	−0.151
Kurtosis	4.943	11.231	3.852	14.282	1.453
Sharpe ratio	0.086	−0.038	0.080	−0.050	0.038

This table reports the summary statistics of profits for residual and JT price momentum strategies using individual stock's residual returns and past average returns based on all TSE-listed stocks to measure past performance. The momentum profits are calculated based on the 6-month holding period. As a comparison, we also report the statistics of the market index. The statistics include mean, standard deviation, maximum, minimum, skewness, kurtosis, and Sharpe ratio.

generates Jensen's alphas ranging from 0.210% (t-statistic = 2.27) to 0.282% (t-statistic = 2.72) per month. Second, Sharpe ratios of residual momentum are all positive whereas those of JT price momentum are all negative. The results in Panel B for the 12-month formation period are qualitatively similar to those in Panel A. One exception is Jensen's alphas for residual momentum are significant for 3- and 6-month holding periods only. In contrast, the JT price momentum strategy yields no significant profits for all holding periods and displays faster and stronger reversals as indicated by negative Jensen's alphas. The stable residual momentum profits for the 6-month formation period suggest that its profitability is not transient and is more persistent over time than the JT price momentum strategy. One more observation: apparently, Novy-Marx's (2012) findings from the U.S. market are not supported in Japan.[9]

To confirm the economic significance of our results, we compare the statistical properties of the four momentum strategies. To simplify the comparisons, we focus on the 6-month holding period of momentum strategies and use the monthly market excess return as a benchmark. The summary statistics are presented in Table 2. Several interesting observations emerge. First, compared with the JT price momentum strategies and the market index, residual momentum strategies exhibit relatively stable profitability as their standard deviations are about half of the market excess returns. Residual momentum strategies also yield smaller maximum and minimum returns in absolute values than the market and the JT price momentum strategies. Second, consistent with Barroso and Santa-Clara's (2015) observation for the U.S. market, the JT price momentum in Japan shows considerably higher kurtosis and negative skewness, indicating the existence of huge losses for the strategies. One distinct advantage of the residual momentum is its lower kurtosis and negative skewness. As a comparison, the $MOM_{6,2}$ strategy has a skewness of −1.443 and a kurtosis of 11.231, while the corresponding values for the $rMOM_{6,2}$ strategy are −0.661 and 4.943, respectively. This finding reflects the fact that residual momentum strategies in Japan are less subject to the downside risk. Finally, given the similar average monthly returns of residual momentum (0.215%) and the market (0.199%), residual momentum strategies yield Sharpe ratios that are more than twice as large as the market. Thus, passive investors can take advantage of the residual momentum to obtain much higher reward-to-risk than to invest in the market portfolio.

We also plot cumulative returns of the four strategies with the 6-month holding period and the market in Fig. 1. $rMOM_{6,2}$ and $rMOM_{12,2}$ strategies exhibit upward trends in cumulative returns over our sample period, while $MOM_{6,2}$ and $MOM_{12,2}$ strategies show downward trends. The profits of the market index, however, are quite volatile and show dramatic increases and decreases over time. As a result, the $rMOM_{6,2}$ ($rMOM_{12,2}$) has a cumulative return of 112.9% (109.5%) over our sample period, while the $MOM_{6,2}$ ($MOM_{12,2}$) is subject to a cumulative loss of −71.9% (−84.6%). During the same period, the cumulative market excess return is 41.7%, which is approximately one-third of the profit generated by the $rMOM_{6,2}$ strategy. These observations thus provide evidence for the economic significance of residual momentum strategies in the Japanese market.

Our findings reveal that the failure of the traditional momentum in Japan is primarily due to the time-varying exposures to the Fama–French (1993) factors. Once the risk exposures are hedged out, we observe significant and persistent profits for the residual momentum strategy, particularly when recent past returns ($rMOM_{6,2}$) are used to evaluate a stock's performance.

2.4. *Dynamic weighting of momentum strategies*

Daniel and Moskowitz (2016) propose an approach that dynamically adjusts the weight of the momentum strategy based on its forecasted return and variance. They show that the dynamic momentum strategy doubles the abnormal return and Sharpe ratio of the JT price momentum. Despite the effectiveness of the dynamic strategy in the U.S. and several international markets including Japan, whether the dynamic strategy is applicable to residual momentum strategies in Japan remains an interesting empirical issue yet to be investigated. We address this issue in this subsection.[10]

We follow Daniel and Moskowitz (2016) by setting the optimal weight on a momentum strategy in month $t-1$ as:

$$w^*_{t-1} = \left(\frac{1}{2\lambda}\right)\frac{\mu_{t-1}}{\sigma^2_{t-1}}, \tag{2}$$

[9] This finding is consistent with the results of Goyal and Wahal (2015), who document no evidence in supporting Novy-Marx's (2012) result in international stock markets, including Japan.

[10] We would like to thank the Editor and the Associate Editor for encouraging us to conduct this analysis.

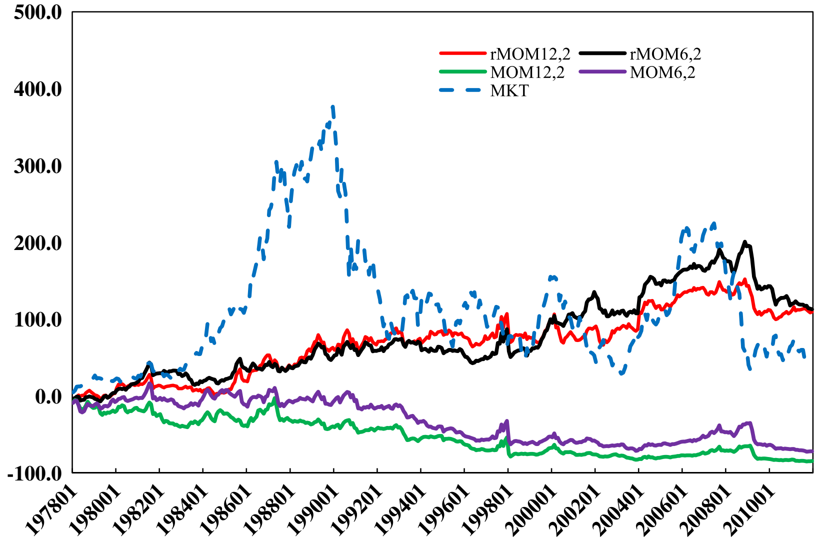


Fig. 1. Comparison between momentum strategies and the market index.

where, $\mu_{t-1} \equiv E_{t-1}\left[R_{MOM,t}\right]$ is the conditional expected return on the zero-investment momentum strategy; $R_{MOM,t}$ represents the returns of rMOM$_{12,2}$, MOM$_{12,2}$, rMOM$_{6,2}$, or MOM$_{6,2}$ across different holding periods in month t; σ^2_{t-1} is the conditional variance of the momentum strategy; and λ is the time-invariant scalar that sets the in-sample volatility of the strategy equal to that of the value-weighted market index.

The estimation of the conditional expected return, μ_{t-1}, involves the following regression:

$$R_{MOM,t} = \gamma_0 + \gamma_1 I_{B,t-1} \cdot \hat{\sigma}^2_{m,t-1} + \varepsilon_t, \tag{3}$$

where $I_{B,t-1}$ is the bear market indicator that equals one if the cumulative market return over past 24 months ending in month $t-1$ is negative and is zero otherwise, $\hat{\sigma}^2_{m,t-1}$ is the variance of the daily market return over past 126 days ending in month $t-1$. The proxy of conditional expected return is the fitted regression of $\hat{R}_{MOM,t}$ on the interaction between the bear market indicator $I_{B,t-1}$ and the market variance $\hat{\sigma}^2_{m,t-1}$ over the preceding six months.

The forecast of the conditional variance, σ^2_{t-1}, is derived from the GJR-GARCH model of Glosten et al. (1993) based on the following process:

$$R_{MOM,t} = \mu + \varepsilon_t, \tag{4}$$

where $\varepsilon_t \sim N\left(0, \sigma^2_t\right)$, and σ^2_t is governed by:

$$\sigma^2_t = \omega + \beta\sigma^2_{t-1} + \left(\alpha + \gamma I\left(\varepsilon_{t-1} < 0\right)\right)\varepsilon^2_{t-1}, \tag{5}$$

where $I\left(\varepsilon_{t-1} < 0\right)$ is an indicator that equals one if $\varepsilon_{t-1} < 0$ and zero otherwise. The parameter set $(\mu, \omega, \beta, \alpha, \gamma)$ is estimated based on maximum likelihood over the full sample period.

For each month t, we obtain above estimations and multiply the momentum profit by w^*_{t-1}, which is the return of the dynamic momentum strategy in month t. We apply the procedures for rMOM$_{12,2}$, MOM$_{12,2}$, rMOM$_{6,2}$, and MOM$_{6,2}$ strategies across different holding periods accordingly and report the raw and risk-adjusted momentum profits as well as Sharpe ratios in Table 3.

We confirm the effectiveness of the dynamic weighting strategy in enhancing the profitability of both total return and residual momentum strategies in Japan. In particular, momentum returns and Sharpe ratios reported in Table 3 are all larger than those of the static momentum strategies reported in Table 1. Taking the rMOM$_{6,2}$ strategy for example, it generates an average raw return ranging from 0.829% to 0.995% per month and Fama–French (1993) adjusted alphas ranging from 0.448% to 0.643% per month. The Sharpe ratios also range from 0.112 to 0.142.

It is also striking that under dynamic weights, the JT price momentum strategies also generate positive returns and Sharpe ratios; but their magnitudes are smaller than those under residual momentum strategies. An important finding is that residual momentum strategies remain more profitable than the JT price momentum strategies after the effect of dynamic weighting is taken into account.

2.5. Long-term profits to momentum strategies

The literature generally asserts that investor overreaction results in long-term reversals but investor underreaction does not (Daniel et al., 1998; George and Hwang, 2004; Blitz et al., 2011; Da et al., 2014). Therefore, it is important to observe that the long-term

Table 3
Profitability of momentum strategies under dynamic weighting.

	Residual momentum				JT price momentum			
	$K = 3$	$K = 6$	$K = 9$	$K = 12$	$K = 3$	$K = 6$	$K = 9$	$K = 12$
Panel A: Momentum profits for $rMOM_{6,2}$ and $MOM_{6,2}$ strategies								
Winner–Loser	0.829***	0.904**	0.995***	0.872***	0.848**	0.745*	0.671	0.644
	(2.77)	(2.56)	(3.15)	(2.61)	(2.30)	(1.72)	(1.41)	(1.49)
FF alpha	0.448*	0.516*	0.643**	0.517*	0.498	0.414	0.344	0.315
	(1.65)	(1.73)	(2.31)	(1.75)	(1.61)	(1.12)	(0.81)	(0.77)
Sharpe ratio	0.114	0.117	0.142	0.112	0.101	0.072	0.054	0.053
Panel B: Momentum profits for $rMOM_{12,2}$ and $MOM_{12,2}$ strategies								
Winner–Loser	0.895***	0.932**	0.781**	0.538*	0.691	0.595	0.547	0.575*
	(2.71)	(2.52)	(2.06)	(1.82)	(1.39)	(1.36)	(1.54)	(1.95)
FF alpha	0.549*	0.608**	0.396	0.124	0.332	0.264	0.179	0.153
	(1.94)	(2.03)	(1.26)	(0.41)	(0.80)	(0.64)	(0.51)	(0.50)
Sharpe ratio	0.122	0.121	0.091	0.053	0.058	0.047	0.047	0.059

This table reports the raw and risk-adjusted monthly returns for residual and JT price momentum strategies under dynamic weighting procedures using individual stock's residual returns and past average returns based on all TSE-listed stocks to measure past performance. We apply Daniel and Moskowitz's (2016) procedures to obtain performances of the dynamic momentum strategies. Panel A reports the short-term momentum profits for 3-, 6-, 9-, and 12-month holding periods based on individual stocks' performance of past 6-month return excluding the most recent month ($rMOM_{6,2}$ and $MOM_{6,2}$), whereas Panel B report the short-term momentum profits based on the performance of past 12 to 2 month returns ($rMOM_{12,2}$ and $MOM_{12,2}$). We report raw and risk-adjusted monthly returns of the Winner–Loser portfolio. We calculate risk-adjusted returns by obtaining the intercepts from the regression for the monthly returns of the momentum strategies on the Fama–French (1993) three-factor model. The returns are in percentage. In addition, we report the Sharpe ratios for each momentum strategies. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

Table 4
Long-term profitability of momentum strategies.

	Residual momentum				JT price momentum			
	Year 2	Year 3	Year 4	Year 5	Year 2	Year 3	Year 4	Year 5
Panel A: Long-term profits for $rMOM_{6,2}$ and $MOM_{6,2}$ strategies								
Winner	0.706***	0.709***	0.669***	0.675***	0.483*	0.564**	0.426	0.673**
	(2.99)	(2.94)	(2.64)	(2.62)	(1.94)	(2.26)	(1.60)	(2.55)
Loser	0.749***	0.633**	0.666**	0.741***	0.929***	0.853***	0.746***	0.795***
	(3.00)	(2.46)	(2.52)	(2.80)	(3.38)	(3.10)	(2.80)	(2.99)
Winner–Loser	−0.043	0.076	0.003	−0.066	−0.445***	−0.289***	−0.319***	−0.121
	(−0.70)	(1.38)	(0.05)	(−1.17)	(−4.80)	(−3.45)	(−3.91)	(−1.63)
FF alpha	−0.006	0.072	−0.001	−0.019	−0.309***	−0.181**	−0.268***	−0.076
	(−0.09)	(1.27)	(−0.02)	(−0.34)	(−3.72)	(−2.31)	(−3.32)	(−1.06)
Sharpe ratio	−0.035	0.069	0.003	−0.064	−0.257	−0.184	−0.212	−0.093
Panel B: Long-term profits for $rMOM_{12,2}$ and $MOM_{12,2}$ strategies								
Winner	0.700***	0.737***	0.616**	0.680***	0.376	0.482*	0.322	0.662**
	(2.95)	(3.03)	(2.42)	(2.61)	(1.50)	(1.90)	(1.18)	(2.51)
Loser	0.715***	0.634**	0.628**	0.759***	0.980***	0.948***	0.769***	0.808***
	(2.83)	(2.50)	(2.32)	(2.85)	(3.43)	(3.44)	(2.85)	(2.97)
Winner–Loser	−0.016	0.103	−0.012	−0.079	−0.604***	−0.466***	−0.447***	−0.146
	(−0.21)	(1.62)	(−0.16)	(−1.22)	(−4.93)	(−4.65)	(−4.40)	(−1.56)
FF alpha	0.029	0.071	0.002	−0.025	−0.394***	−0.368***	−0.352***	−0.070
	(0.38)	(1.06)	(0.02)	(−0.39)	(−3.78)	(−3.75)	(−3.78)	(−0.81)
Sharpe ratio	−0.010	0.082	−0.009	−0.068	−0.271	−0.242	−0.253	−0.091

This table reports the raw and risk-adjusted monthly returns with holding periods of the subsequent 2 to 5 years after portfolio formation for residual and JT price momentum strategies using individual stock's residual returns and past average returns based on all TSE-listed stocks to measure past performance. Panel A reports the long-term momentum profits based on individual stocks' performance of past 6-month return excluding the most recent month ($rMOM_{6,2}$ and $MOM_{6,2}$), whereas Panel B report the long-term momentum profits based on the performance of past 12 to 2 month returns ($rMOM_{12,2}$ and $MOM_{12,2}$). We report raw and risk-adjusted monthly returns of the Winner–Loser portfolio. We calculate risk-adjusted returns by obtaining the intercepts from the regression for the monthly returns of the momentum strategies on the Fama–French (1993) three-factor model. The returns are in percentage. In addition, we report the Sharpe ratios for each momentum strategies. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

residual momentum profits do not exhibit reversals and they are generated by investor underreaction in Japan. Hence, we compute the residual momentum profits for longer holding periods from two to five years after the portfolio formation. The risk-adjusted returns and Sharpe ratios to both residual and the JT price momentum strategies are reported in Panels A and B of Table 4.

The most interesting finding is that profits to the residual momentum strategies (for both $rMOM_{12,2}$ and $rMOM_{6,2}$) display no reversals for up to five years, whereas profits to the JT price momentum strategies ($MOM_{12,2}$ and $MOM_{6,2}$) exhibit significant reversals.

These trends are confirmed by the evidence that none of residual momentum profits across all long-term holding horizons is significant, whereas all JT price momentum profits are negative.[11] Overall, the lack of reversals and persistence of the residual momentum profits point to investor underreaction, which is revisited in the following section. The lack of long-term reversals also rules out the possibility of investor overreaction explanation for Japan. This evidence is also consistent with Byun, Lim, and Yun's (2016) finding that investor overreaction does not generate return continuation in Japan.

3. Why residual momentum works in Japan?

3.1. Limited attention hypothesis

We hypothesize that if the profitability of the residual momentum in Japan is induced by investor underreaction, it is stronger among stocks with features associated with limited investor attention. We consider several proxies of limited investor attention, including information discreteness (ID), institutional ownership (IO), idiosyncratic volatilities (IVOL), and firm age (AGE). We introduce ID because Da et al. (2014) propose a frog-in-the-pan (FIP) hypothesis to explain momentum profits. Motivated by the notion that a series of gradual and small price changes attracts less attention than sudden dramatic price changes, they propose a proxy for ID to capture the relative frequency of small signals.[12] We consider the ownership of institutions because stocks with higher levels of IO are expected to receive more investor attention than those with lower levels of IO. IVOL is incorporated because Da et al. (2014) indicate that winner and loser stocks with extreme returns tend to induce high IVOL. Thus, stocks with high idiosyncratic volatilities are more likely to attract more investor attentions. Finally, younger firms are less known to the public than older firms, thus attracting less attention from investors. We thus incorporate AGE as a proxy of limited investor attention.

We first consider ID as a proxy for underreaction in assuming that any signals with absolute values below a lower threshold during the first period are not processed by FIP investors until the second period when the information is realized. We follow the Da et al. (2014) approach to distinguish continuous information from discrete information during the formation period of the momentum strategy by defining the ID measure as follows:

$$ID = \mathrm{sgn}(PRET) \times [\%neg - \%pos], \tag{6}$$

where *PRET* is denoted as the cumulative return during the formation period. We use the cumulative residual return and total return calculated based on the formation periods (from $t-6$ to $t-2$) to proxy for *PRET* for residual and the JT price momentum strategies, respectively; *%neg* and *%pos* denote the percentages of days with positive and negative residual (or total) returns during the formation period. The sign of *PRET* is denoted as sgn(*PRET*), which equals $+1$ when *PRET* >0 and -1 when *PRET* <0. Because our ID measure for residual momentum strategies is constructed by focusing on information flows that are unrelated to factor risks, it serves as a better proxy for underreaction than other measures constructed using raw returns. To simplify the notations, we denote $\mathrm{ID}_{\mathrm{RES}}$ as the ID measure for residual momentum strategies and $\mathrm{ID}_{\mathrm{PR}}$ for the JT price momentum strategies.

By construction, a higher value of ID signifies discrete information, whereas a lower value signifies continuous information. According to Eq. (6), higher percentages of positive (negative) returns culminating in positive (negative) *PRET* s yield lower values of ID. In such cases, higher (lower) *PRET* is formed by a large number of small positive (negative) returns with continuous information. A higher value of ID, however, implies that the positive (negative) *PRET* is generated by a few large positive (negative) returns, whereas the majority of daily returns are negative (positive). Such small amounts of large positive (negative) returns in generating the positive (negative) *PRET* tend to be discrete information.

We define IO as the proportion of equity of the firm held by institutions. Because the IO data are reported on an annual basis in the PACAP database, we use the proportion of institutional ownership reported in previous year to classify individual stocks into IO quintiles. The estimation of IVOL involves regressing the daily stock returns on the daily market excess returns over the year ending at the portfolio formation date. We obtain the standard deviation of residual returns from the regression. To avoid potential estimation errors, we require a stock to have at least 30 observations over the estimation window. Finally, we define firm age (AGE) as the number of years the firm has been listed on TSE.

We adopt a similar approach used by Doukas et al. (2006) to construct a comprehensive index to combine the information embedded in the four measures. For every month, we rank individual firms into quintiles according to their values of each variable and assign a score of 1 to 5 for each quintile. We then calculate the score averaged across the four measures (ID, IO, IVOL, and AGE) as the combined index, with $\mathrm{INDEX}_{\mathrm{RES}}$ and $\mathrm{INDEX}_{\mathrm{PR}}$ representing for the indices constructing based on $\mathrm{ID}_{\mathrm{RES}}$ and $\mathrm{ID}_{\mathrm{PR}}$, respectively. Because lower values (rankings) of ID, IO, IVOL, and AGE signify more continuous information or lower magnitude of limited attention, firms with lower $\mathrm{INDEX}_{\mathrm{RES}}$ and $\mathrm{INDEX}_{\mathrm{PR}}$ values are subject to higher propensity of investor underreaction.

We obtain summary statistics and correlations of variables including past returns (denoted as RES6 and PRET6 for $\mathrm{rMOM}_{6,2}$ and $\mathrm{MOM}_{6,2}$ strategies, respectively) and aforementioned variables in Table 5. To compute first-order autocorrelation coefficients, we

[11] It is interesting to observe that Japanese and U.S. markets exhibit dramatic contrasts: First, for the short-term holding period, Gutierrez and Pirinsky (2007) report that both residual and JT price momentum strategies are similar by producing significant returns whereas our results indicate that only residual return momentum yields significant positive returns in Japan. For the long-term holding period, Gutierrez and Pirinsky (2007) report that JT price momentum reverse strongly while residual return momentum continues. Our results indicate that: (i) JT price momentum reverses (which is consistent with those of Gutierrez and Pirinsky, 2007); but (ii) residual momentum does not reverse whereas the U.S. market residual momentum continues.

[12] In a recent study, Huynh and Smith (2017) propose an alternative attention measure based on news of individual stocks. They compile evidence in support of investor underreaction in explaining momentum returns in four regions, including the United States, Europe, Japan, and Asia Pacific.

Table 5
Summary statistics and correlations of variables.

	Mean	Percentiles			Standard deviation	Auto-correlation
		25th	50th	75th		
Panel A: Summary statistics of variables						
RES6	−0.074	−0.335	−0.025	0.237	0.578	−0.008
PRET6	0.008	−0.023	0.003	0.033	0.092	0.001
ID_{RES}	−0.042	−0.131	−0.035	0.059	0.263	0.014
ID_{PRET}	−0.045	−0.137	−0.045	0.049	0.263	0.030
IO	0.583	0.484	0.608	0.718	0.179	0.942
IVOL	0.030	0.017	0.022	0.029	1.400	0.820
AGE	26.162	12.000	26.000	39.000	16.321	1.000
$INDEX_{RES}$	3.002	2.500	3.000	3.500	0.716	0.637
$INDEX_{PR}$	3.003	2.500	3.000	3.500	0.722	0.644

	RES6	PRET6	ID_{RES}	ID_{PRET}	IO	IVOL	AGE	$INDEX_{RES}$	$INDEX_{PR}$
Panel B: Correlations									
RES6	1	0.504	0.362	0.220	−0.016	0.003	−0.032	0.176	0.095
PRET6		1	0.260	0.293	−0.007	0.114	0.011	0.193	0.205
ID_{RES}			1	0.417	−0.009	0.010	0.011	0.410	0.165
ID_{PRET}				1	0.007	0.006	0.014	0.175	0.404
IO					1	−0.092	0.218	0.512	0.517
IVOL						1	−0.011	0.352	0.356
AGE							1	0.551	0.550
$INDEX_{RES}$								1	0.856
$INDEX_{PR}$									1

	ΔTURN	ΔCOV	$\|SUE\|$	Adj. R^2
Panel C: Regressions of investor attention				
ID_{RES}	0.728***	0.098***	0.028***	0.027
	(9.55)	(8.33)	(7.21)	
ID_{PRET}	1.141***	−0.023	−0.008	0.030
	(7.44)	(−0.91)	(−0.58)	
IO	−0.480	0.511**	0.061	0.024
	(−1.62)	(2.42)	(1.42)	
IVOL	0.142***	−0.026***	−0.002	0.052
	(3.84)	(−3.25)	(−0.95)	
AGE	0.527	0.077	0.030*	0.025
	(1.24)	(0.71)	(1.87)	
$INDEX_{RES}$	7.005***	0.921	0.203	0.020
	(3.85)	(1.27)	(1.41)	
$INDEX_{PR}$	7.927***	1.071	0.143	0.021
	(4.29)	(1.45)	(1.17)	

Panel A reports summary statistics of formation-period residual (RES6) and total returns (PRET6), information discreteness proxy (ID_{RES} and ID_{PRET}), institutional ownership (IO), idiosyncratic volatilities (IVOL), firm age (AGE), and the comprehensive indices ($INDEX_{RES}$ and $INDEX_{PRET}$). Summary statistics include the mean, standard deviation, the 25th, 50th, and 75th percentiles, and autocorrelation. The first-order autocorrelation coefficients are obtained in June for each year and using a pooled regression of each characteristic on its lagged value from the prior year. Panel B reports the cross-sectional correlations between the variables in Panel A. Panel C reports the Fama–MacBeth (1973) regressions of the variables in Panel A on ΔTURN, ΔCOV, and $|SUE|$. ΔTURN denotes the change in turnover, which is calculated as a stock's average turnover from month $t-11$ to $t-1$ minus its average turnover from month $t-23$ to $t-12$. ΔCOV is a stock's changes in analyst coverage over the same period as defined in ΔTURN. SUE is defined as its realized earnings in the most recent quarter with its realized earnings in the same quarter of the prior year, normalized by the standard deviation of the firm's earnings over the prior eight quarters. $|SUE|$ corresponds to the absolute value of the average SUE over month $t-11$ to $t-1$. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

follow Da et al. (2014) by obtaining variables in June for each year and using a pooled regression of each characteristic on its lagged value from the prior year. Similar to the U.S. evidence obtained by Da et al. (2014), we show in Panel A that the ID measures have average values close to zero. Moreover, ID measures are not persistent over time as they have autocorrelation coefficients of 0.014 for ID_{RES} and 0.030 for ID_{PR}. The three conditioning variables IO, IVOL, and AGE, instead, are quite consistent over time as their autocorrelation coefficients range from 0.820 to 1.000. Combining the information embedded in these variables, the comprehensive index has an autocorrelation coefficient of 0.637 for $INDEX_{RES}$ and 0.644 for $INDEX_{PR}$.

We also show in Panel B that most proxies are not highly correlated with past (residual) returns and other attention variables. This observation indicates that each variable may contain information distinct from other variables, and thus highlights the importance of the comprehensive index.

We next follow Da et al. (2014) to establish the linkage between the conditioning variables and investor attention. We estimate the following Fama–MacBeth (1973) regression using each of the conditioning variables as the dependent variable:

$$PROXY_{i,t} = \beta_0 + \beta_1 \Delta TURN_{i,t} + \beta_2 \Delta COV_{i,t} + \beta_3 |SUE|_{i,t} + \varepsilon_{i,t}. \tag{7}$$

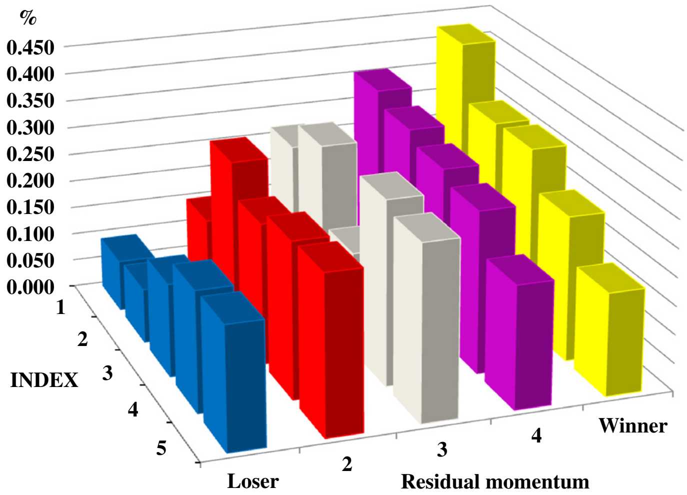


Fig. 2. Risk-adjusted 6-month holding-period returns of the 25 portfolios sorted by comprehensive INDEX and past 6-month residual returns.

$PROXY_{i,t}$ denotes each of the conditioning variables (including ID_{RES}, ID_{PR}, IO, IVOL, AGE, $\text{INDEX}_{\text{RES}}$ and INDEX_{PR}). $\Delta TURN$ denotes the change in turnover, which is calculated as a stock's average turnover from month t −11 to t −1 minus its average turnover from month t −23 to t −12.[13] We include $\Delta TURN$ because Hou et al. (2009) indicate that turnover is a better proxy of investor attention. ΔCOV is a stock's changes in analyst coverage over the same period as defined in $\Delta TURN$. ΔCOV is included because Peng and Xiong (2006) propose that retail investors are often exposed to information provided by analysts. Data on analyst coverage are obtained from the Institutional Brokers' Estimate System (I/B/E/S). *SUE* denotes a stock's standardized unexpected earnings, defined as its realized earnings in the most recent quarter with its realized earnings in the same quarter of the prior year, normalized by the standard deviation of the firm's earnings over the prior eight quarters. $|SUE|$ corresponds to the absolute value of the average *SUE* over month t −11 to t −1. We estimate the regression every month and average the coefficients over our sample period, with the results reported in Panel C.

Because higher values of $\Delta TURN$ and ΔCOV signify increased turnover from investors and more attention from analysts, positive β_1 and β_2 coefficients represent positive relation between conditioning variables and investor attention. In addition, positive β_3 coefficient represents higher attention because investors are more attentive to higher earnings surprises. Panel C reveals that ID_{RES} has significantly positive coefficients of β_1 to β_3, indicating that stocks with higher ID_{RES} are associated with increased turnover, more attention from analysts, and larger earnings surprises. That is, stocks with lower ID_{RES} are more subject to limited attention. Among other conditioning variables, ID_{PR}, IVOL, $\text{INDEX}_{\text{RES}}$ and INDEX_{PR} are positively associated with $\Delta TURN$, while IO and AGE are positively associated with ΔCOV and $|SUE|$, respectively. These observations again confirm the fact that different proxies capture different dimensions of attention from the stock markets and that the comprehensive index serves as a better proxy of investor underreaction.

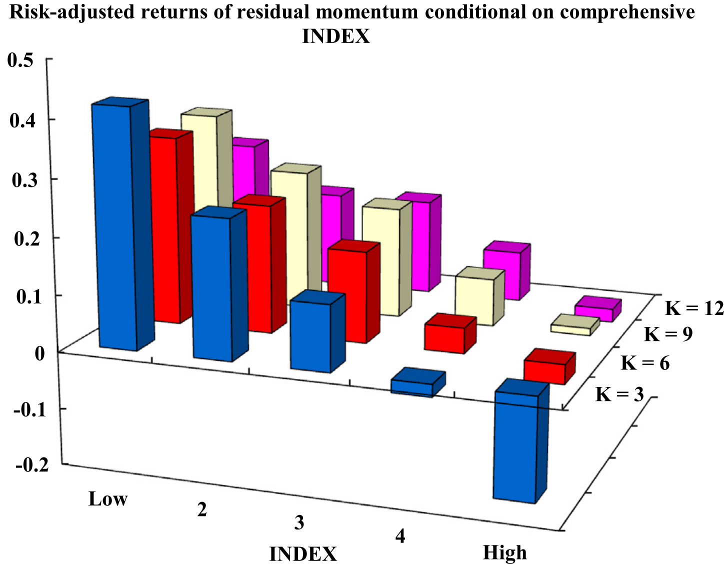
3.2. Investor underreaction and residual momentum profits

To test this hypothesis, we apply a double-sorting procedure based on individual stock INDEX values and past residual returns to observe the momentum profits within each INDEX group.[14] Because the comprehensive indices contain information embedded in different proxies, they should be more effective in explaining the profits to both residual and JT price momentum strategies. To this end, we adopt a double-sorting procedure based on individual stocks' past residual (or total) returns and INDEX values. In each month *t*, we first sort individual stocks into quintiles according to their INDEX values. Within each INDEX group, we further allocate stocks into quintiles based on their standardized residual or total returns over month t −6 to t −2 ($\text{rMOM}_{6,2}$ or $\text{MOM}_{6,2}$).[15] For each INDEX group, we calculate equally weighted momentum profits as the differences between the winner and the loser portfolios for the subsequent K months (K = 3, 6, 9, and 12) using the overlapping approach. We report abnormal momentum profits with Fama–French (1993) risk adjustment (i.e., Jensen's alpha) and Sharpe ratios of both residual and the JT price momentum strategies conditional on the INDEX measure in Panel 6. The results indicate that abnormal returns and Sharpe ratios display monotonically decreasing patterns as INDEX increases for both residual and JT price momentum across all holding periods. The residual momentum yields significantly positive abnormal returns for all holding periods, while the JT price momentum obtains significantly positive abnormal returns for 3- and 9-month holding periods in the low INDEX group. Among the low INDEX group, the residual momentum still generates higher Sharpe ratios than the JT price momentum.

13 The definition of $\Delta TURN$ is similar to the abnormal turnover measure advocated by Barber and Odean (2008) and Gervais et al. (2001).

14 We also replicate the testing procedures for each proxy of limited attention. The results are similar and are provided in the Internet Appendix.

15 Untabulated analysis indicates that the results are robust to the independent sorting procedure.



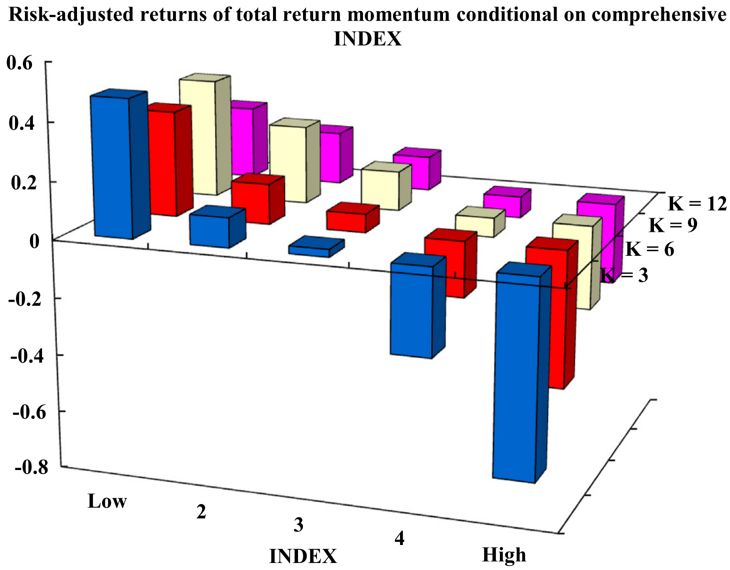


Fig. 3. Risk-adjusted returns of momentum strategies conditional on comprehensive index of investor underreaction.

We show graphical presentations of Jensen's alphas for each of the 25 portfolios formed on $rMOM_{6,2}$ and INDEX with the 6-month holding period in Fig. 2. Within each subgroup of residual returns, we do not observe particular pattern across different levels of INDEX. In particular, for stocks with lower residual returns (losers), the Jensen's alpha increases with INDEX. For stocks with higher residual returns (winners), however, the Jensen's alpha exhibits a decreasing pattern with INDEX. This evidence indicates that the comprehensive index does not have uniform influence on future stock returns after controlling for residual momentum.

Figs. 3 and 4 present graphical illustrations of the risk-adjusted returns and Sharpe ratios of residual and JT price momentum strategies across several holding horizons and INDEX groups. Specifically, the residual momentum profits and corresponding Sharpe ratios are remarkably higher in the low INDEX group than in the rest of the INDEX groups. Despite the differences across INDEX groups, the residual momentum generates positive returns and Sharpe ratios in most cases. In contrast, the returns and Sharpe ratios of the JT price momentum are negative for the two highest INDEX groups and are positive for the two lowest INDEX groups.

3.3. Fama–MacBeth (1973) cross-sectional regressions

Our evidence from Table 6 indicates that the comprehensive index explains the profitability of the residual momentum. To contrast with these alternative explanations, we perform Fama–MacBeth (1973) cross-sectional regressions to evaluate the impact of each

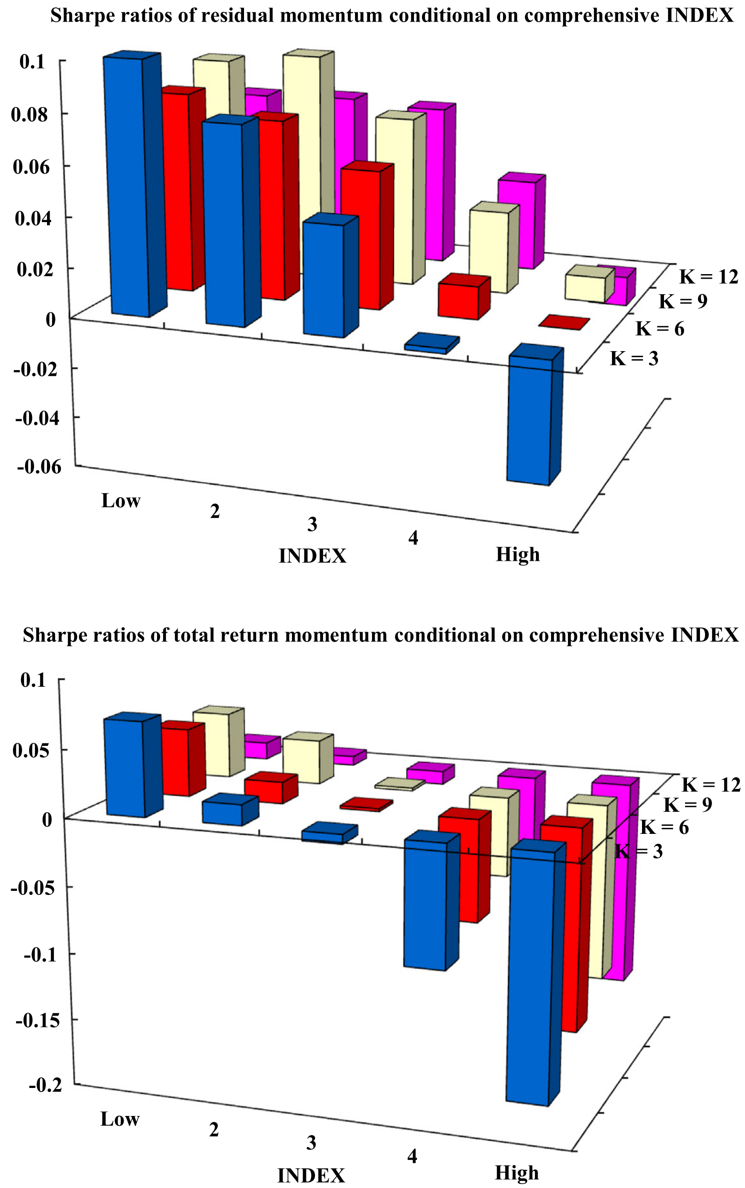


Fig. 4. Sharpe ratios of momentum strategies conditional on comprehensive index of investor underreaction.

variable on future returns separately for residual and JT price momentum strategies, expressed in the following form:

$$r_{i,t+6} = \beta_0 + \beta_1 X_{i,t} + \beta_2 \mathrm{PRET}_{i,t} + \beta_3 \mathrm{PRET}_{i,t} \times X_{i,t} + \alpha Y_{i,t} + \alpha_I \mathrm{PRET}_{i,t} \times Y_{i,t} + \varepsilon_{i,t}, \tag{8}$$

where $r_{i,t+6}$ is the subsequent 6-month cumulative residual or total return of stock *i*. $X_{i,t}$ is a set of variables that are associated with the cross-sectional differences in momentum profits, including ID, IO, IVOL, AGE, and INDEX. $Y_{i,t}$ is a set of control variables, including BM, SIZE, and TURN. In addition to incorporating each conditioning variable as one specification, we also include ID, IO, IVOL, and AGE in one specification to compare the relative explanatory power of variables for the profits of residual and JT price momentum strategies. In particular, a negative β_3 coefficient supports the FIP or limited attention hypothesis because it implies that continuous information or less attention leads to higher momentum profits than discrete information or more attention.

Table 7 reports the coefficient estimates from Eq. (8) for residual and JT price momentum strategies. For the residual momentum presented in Panel A, coefficients on PRET×ID and PRET×IVOL are significantly negative, indicating that ID and IVOL are two prominent determinants for the profitability of the residual momentum in Japan. For the JT price momentum presented in Panel B, not only ID and IVOL but also AGE shows significantly negative coefficient on its interaction term with PRET. In addition to proxies of investor underreaction, BM also provides incremental explanatory power for both momentum strategies. This power is

Table 6
Investor underreaction and momentum profits.

	Residual momentum								JT price momentum							
	$K = 3$		$K = 6$		$K = 9$		$K = 12$		$K = 3$		$K = 6$		$K = 9$		$K = 12$	
	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe	FF alpha	Sharpe
Low	0.419**	0.100	0.333**	0.080	0.340***	0.087	0.251**	0.066	0.475*	0.069	0.368	0.050	0.418**	0.049	0.258	0.013
	(2.56)		(2.31)		(2.67)		(2.19)		(1.82)		(1.61)		(2.02)		(1.34)	
2	0.245	0.078	0.227	0.072	0.248**	0.091	0.169	0.067	0.102	0.015	0.140	0.016	0.274	0.033	0.187	0.007
	(1.55)		(1.64)		(2.02)		(1.56)		(0.41)		(0.63)		(1.41)		(1.09)	
3	0.116	0.043	0.161	0.055	0.196	0.068	0.170	0.065	0.026	−0.007	0.064	0.002	0.138	0.002	0.122	−0.010
	(0.69)		(1.12)		(1.51)		(1.44)		(0.11)		(0.29)		(0.71)		(0.69)	
4	−0.022	−0.002	0.045	0.013	0.084	0.033	0.090	0.037	−0.304	−0.090	−0.195	−0.076	−0.068	−0.060	−0.077	−0.077
	(−0.17)		(0.41)		(0.83)		(0.99)		(−1.38)		(−1.01)		(−0.40)		(−0.50)	
High	−0.181	−0.048	−0.035	0.000	0.013	0.010	−0.024	−0.012	−0.683***	−0.179	−0.476***	−0.150	−0.296*	−0.132	−0.291**	−0.156
	(−1.36)		(−0.30)		(0.13)		(−0.25)		(−3.38)		(−2.69)		(−1.90)		(−2.11)	

This table reports the risk-adjusted monthly returns from double-sorted portfolios involving several cross-sectional determinants of residual and JT price momentum based on all TSE-listed stocks. In each month, we first sort individual stocks into quintiles according to their values of the comprehensive index (INDEX). Within each of the characteristic groups, we further allocate stocks into quintiles based on their past performances. The winner (loser) portfolio consists of top (bottom) 20% stocks with the highest (lowest) past performance within each characteristic group. The Winner−Loser portfolio is the zero-cost investment portfolio which involves buying winners and short selling losers. We calculate the risk-adjusted returns by obtaining the intercepts from the regression for the returns of the momentum strategies on the Fama–French (1993) three-factor model. We also report the Sharpe ratios for each momentum strategy. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

Table 7
Fama–MacBeth (1973) cross-sectional regressions.

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Panel A: Residual momentum						
Intercept	−0.062	−1.004	0.498***	−0.317	−0.998	−0.041
	(−0.27)	(−0.74)	(2.89)	(−1.29)	(−0.58)	(−0.21)
PRET	0.090	2.752	0.514***	0.353***	4.359	0.944***
	(1.34)	(0.96)	(5.37)	(2.98)	(1.19)	(6.00)
ID	−0.118***				−0.082**	
	(−2.84)				(−2.08)	
IO		0.918			1.284	
		(0.68)			(0.74)	
IVOL			−0.240***		−0.234***	
			(−3.80)		(−3.70)	
AGE				0.992***	0.945***	
				(2.90)	(2.79)	
INDEX						−0.001
						(−0.06)
BM	0.959***	0.967***	0.894***	0.983***	0.891***	0.945***
	(7.46)	(7.43)	(7.11)	(7.50)	(7.24)	(7.22)
SIZE	−0.166	−0.163	−0.205	−0.247	−0.297**	−0.157
	(−0.83)	(−0.81)	(−1.30)	(−1.23)	(−2.00)	(−0.79)
TURN	−0.362***	−0.348***	−0.304***	−0.367***	−0.331***	−0.365***
	(−7.23)	(−6.83)	(−6.25)	(−7.31)	(−7.04)	(−7.51)
PRET×ID	−0.645***				−0.270*	
	(−4.35)				(−1.94)	
PRET×IO		−2.609			−3.622	
		(−0.91)			(−0.99)	
PRET×IVOL			−0.150***		−0.173***	
			(−5.65)		(−4.54)	
PRET×AGE				−1.010	−1.035*	
				(−1.55)	(−1.71)	
PRET×INDEX						−0.067***
						(−5.88)
PRET×BM	−0.255***	−0.321***	−0.368***	−0.376***	−0.363***	−0.436***
	(−3.49)	(−4.30)	(−4.98)	(−5.17)	(−4.68)	(−5.63)
PRET×SIZE	−0.580	−0.819	−0.706	−0.273	−3.012	0.656
	(−1.09)	(−1.05)	(−1.19)	(−1.20)	(−1.05)	(0.96)
PRET×TURN	−1.214	−1.332	−1.509	0.635	1.754	−1.516
	(−0.93)	(−0.93)	(−0.94)	(1.22)	(1.07)	(−0.92)

(*continued on next page*)

indicated by the significantly negative coefficients on it interaction term with PRET. Finally, the interaction terms of PRET and INDEX are significantly negative for both residual and JT price momentum strategies. This observation confirms the creditability of the comprehensive index capture investors' underreaction in the Japanese market.

3.4. Direct evidence on investor underreaction: earnings forecast errors

Although our results in Tables 6 and 7 confirm that the limited attention hypothesis explains the residual momentum profits, a direct link has yet to be established between investor underreaction and residual momentum profits in Japan. To establish this link, we follow Da et al. (2014) by examining whether continuous information is associated with larger analyst forecast errors. The intuition underlying this test is that, if our conditioning variables indeed capture investor attention, analysts would be slow in adjusting their forecasts for firms with low ID, IO, IVOL, and AGE, resulting in larger forecast errors for such firms. To confirm this prediction, we obtain analysts' annual earnings per share (EPS) forecasts for Japan from the I/B/E/S. Following Livnat and Mendenhall (2006) and Da et al. (2014), we define earnings surprises (denoted as SURP) as the difference between a firm's actual EPS and the median of analyst forecasts issued within 90 days before the earnings announcement. This difference is then standardized by the firm's share price on its earnings announcement date.

We then perform cross-sectional regressions of SURP on past performance and a set of conditioning variables including ID, IO, IVOL, AGE, and INDEX in the following forms:

$$\mathrm{SURP}_{i,t} = \beta_0 + \beta_1 X_{i,t} + \beta_2 \mathrm{PRET}_{i,t} + \beta_3 X_{i,t} \times \mathrm{PRET}_{i,t} + \varepsilon_{i,t}, \tag{9}$$

where $X_{i,t}$ includes ID, IO, IVOL, AGE, and the comprehensive index. PRET is residual or total returns. COV is analyst coverage, which is the number of analysts following the firm. The limited attention hypothesis predicts a negative β_3 coefficient for the interaction between the conditioning variable and PRET. In particular, a negative β_3 coefficient indicates that past winners (losers) with more continuous or limited attention have larger positive (negative) forecast errors, implying analysts' underreaction to the earnings forecasts.

Table 7 (*continued*)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Panel B: JT price momentum						
Intercept	−0.195	−0.545	−0.067	−0.499**	−0.050	−0.705***
	(−0.87)	(−1.00)	(−0.40)	(−2.16)	(−0.11)	(−3.79)
PRET	−2.895**	3.514	11.194***	4.060**	13.796**	22.366***
	(−2.11)	(0.59)	(4.64)	(2.54)	(2.35)	(6.10)
ID	0.387***				0.356***	
	(5.69)				(5.98)	
IO		0.269			0.020	
		(0.54)			(0.04)	
IVOL			−0.176***		−0.166**	
			(−2.73)		(−2.58)	
AGE				0.933***	0.855***	
				(2.85)	(2.65)	
INDEX						0.041**
						(2.36)
BM	1.160***	1.214***	1.149***	1.219***	1.103***	1.217***
	(8.27)	(8.30)	(8.21)	(8.45)	(8.15)	(8.19)
SIZE	−0.283	−0.275	−0.306**	−0.328*	−0.312**	−0.256
	(−1.47)	(−1.35)	(−2.11)	(−1.69)	(−2.21)	(−1.31)
TURN	−0.285***	−0.260***	−0.284***	−0.271***	−0.303***	−0.307***
	(−5.00)	(−4.45)	(−4.91)	(−4.65)	(−5.44)	(−5.63)
PRET×ID	−17.385***				−7.943***	
	(−6.53)				(−4.19)	
PRET×IO		−4.567			−3.735	
		(−0.79)			(−0.70)	
PRET×IVOL			−2.521***		−2.478***	
			(−4.89)		(−4.73)	
PRET×AGE				−19.407***	−16.282***	
				(−5.42)	(−4.98)	
PRET×INDEX						−1.839***
						(−8.71)
PRET×BM	−3.433***	−4.405***	−6.580***	−5.791***	−6.115***	−6.651***
	(−2.82)	(−3.53)	(−5.73)	(−5.13)	(−5.51)	(−5.22)
PRET×SIZE	1.681	2.123	0.815	3.585	−0.276	1.095
	(0.53)	(0.67)	(0.32)	(1.17)	(−0.11)	(0.42)
PRET×TURN	0.607	0.406	1.088***	0.672	1.197***	1.071**
	(1.42)	(0.96)	(2.93)	(1.60)	(3.22)	(2.58)

This table reports the estimation results from Fama–MacBeth (1973) cross-sectional regressions based on all TSE-listed stocks. In each month, we perform the following forms of regressions:

$$r_{i,t+6} = \beta_0 + \beta_1 PRET_{i,t} + \beta_2 X_{i,t} + \beta_3 PRET_{i,t} \times X_{i,t} + \alpha Y_{i,t} + \alpha_I PRET_{i,t} \times Y_{i,t} + \varepsilon_{i,t},$$

where $r_{i,t+6}$ is subsequent 6-month cumulative return of stock i, $X_{i,t}$ is a set of conditioning variables that are associated with the cross-sectional differences in momentum profits, including ID, IO, IVOL, AGE, and INDEX. $Y_{i,t}$ is a set of control variables, including BM, SIZE, and TURN. We define PRET and ID using residual or total returns for residual or JT price momentum strategies, respectively. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

Panel A of Table 8 indicates that firms with lower values of the comprehensive index are subject to higher earnings forecast errors, which is observed from the fact that the coefficient on INDEX×PRET of Eq. (9) is significantly negative at −0.005, with a t-statistic of −2.32. The negative coefficient suggests that the combined information embedded in different variables is related to analyst underreaction. Taking a closer look at the results for each proxy of limited attention, the coefficient on ID×PRET is significantly negative at −0.153, with a t-statistic of −4.23, confirming the prediction that analysts are slower in incorporating continuous residual information into their forecasts than discrete residual information. The significance remains when all conditioning variables are incorporated in one regression. Coefficients on the interaction terms based on other limited attention proxies, however, are all insignificant. This evidence indicates that the underreaction of analysts to continuous residual information is a special channel that drives the relation between residual momentum and ID. The same applies for the JT price momentum, which is reported in Panel B. The coefficient on ID×PRET is significantly negative at −2.756 with a t-statistic of −3.44 when it is considered alone, suggesting that the results of Da et al. (2014) regarding analyst underreaction to the information embedded in total return are also robust in Japan.

3.5. A horse race between investor underreaction and disposition effect

In a seminal paper, Grinblatt and Han (2005) propose that prospect theory along with mental accounting serves as a sound explanation of momentum that is distinct from investor underreaction. Based on the notion that investors tend to hold on to their

Table 8
Analyst forecasts and proxies of investor underreaction.

Intercept	PRET	ID	PRET×ID	IO	PRET×IO	IVOL	PRET×IVOL	AGE	PRET×AGE	INDEX	PRET×INDEX
Panel A: Regressions on residual returns											
−0.020***	−0.006	0.012	−0.153***								
(−4.47)	(−1.31)	(0.50)	(−4.23)								
0.088***	0.032			−4.843***	−0.249						
(3.16)	(0.61)			(−3.78)	(−0.08)						
−0.084***	0.069					0.103***	−0.099				
(−3.99)	(1.12)					(3.55)	(−1.15)				
−0.029***	0.013*							0.017	−0.012		
(−3.36)	(1.80)							(0.89)	(−0.55)		
0.056**	0.087*	0.033*	−0.090**	0.064**	−0.097	−4.674***	−0.986	−0.027	0.020		
(2.26)	(2.05)	(1.72)	(−2.17)	(2.67)	(−1.20)	(−3.64)	(−0.34)	(−1.44)	(0.40)		
−0.019	0.068**									0.000	−0.005**
(−1.08)	(2.69)									(−0.20)	(−2.32)
Panel B: Regressions on total returns											
−0.010**	0.121	−0.032*	−2.756***								
(−2.24)	(0.76)	(−1.80)	(−3.44)								
0.064***	0.669			−3.558***	−12.403						
(3.17)	(0.99)			(−3.90)	(−0.44)						
−0.023	1.032					0.023	−1.379				
(−1.50)	(0.75)					(1.09)	(−0.73)				
−0.014***	0.371							0.004	0.015		
(−3.42)	(1.61)							(0.28)	(0.03)		
0.073***	1.678*	−0.016	−0.913	−0.001	−2.086	−3.618***	−14.614	−0.019	0.859		
(2.90)	(1.88)	(−0.83)	(−1.57)	(−0.06)	(−1.09)	(−3.75)	(−0.50)	(−1.52)	(0.74)		
0.029*	1.840**									−0.003**	−0.120**
(1.73)	(2.68)									(−2.15)	(−2.38)

This table reports relation between earnings forecast errors and proxies of investor underreaction based on all TSE-listed stocks for the sample period from 1988 to 2011. We perform the cross-sectional regressions in the following specifications:

$$\mathrm{SURP}_{i,t} = \beta_0 + \beta_1 \mathrm{PRET}_{i,t} + \beta_2 X_{i,t} + \beta_3 X_{i,t} \times \mathrm{PRET}_{i,t} + \varepsilon_{i,t},$$

where $X_{i,t}$ is the proxy of investor underreaction, and $\mathrm{PRET}_{i,t}$ is past performance. Panels A and B report the β coefficients on corresponding variables with past performance, ID, and the comprehensive index defined by residual and total returns, respectively. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

losing stocks too long and realize their gains from selling winners too soon, they construct a measure of unrealized capital gains (UCG) to capture investors' disposition effect. Grinblatt and Moskowitz (2004) also propose a measure of return consistency (RC) as a resolution of investor-specific reference prices. To ensure that our evidence in support of investor underreaction is not resulted by the disposition effect, we follow Da et al. (2014) to implement a horse race between the two explanations. We form the three-factor adjusted six-month holding-period returns from residual and JT price momentum strategies based on the lowest quintile of underreaction proxy, which is denoted as $\mathrm{URet}_{t+1,t+6}$. We then perform the following time-series regression:

$$\mathrm{URet}_{t+1,t+6} = \beta_0 + \beta_1 \mathrm{Trend}_t + \beta_2 \mathrm{Log(NUMST)}_{t-1} + \beta_3 \mathrm{AGG\ MKT}_{t-1} + \beta_4 \mathrm{AGG\ UCG}_{t-1} + \beta_5 \mathrm{AGGRC}_{t-1} + \varepsilon_t, \tag{10}$$

where Trend_t is a time index that starts at 1 in the beginning month of our sample; $\mathrm{Log(NUMST)}_{t-1}$ is the log number of listed stocks over past 12 months ending in month $t-1$, with larger number of listed stocks representing lower investor attention; $\mathrm{AGG\ MKT}_{t-1}$ is the aggregate market return over past 12 months ending in month $t-1$; $\mathrm{AGG\ UCG}_{t-1}$ is the equally-weighted difference between the UCG of past winners and past losers conditional on stocks in the lowest underreaction quintile, with UCG calculated based on the period over past 12 months ending in month $t-1$; $\mathrm{AGG\ RC}_{t-1}$ is the equally-weighted sum of RC for past winners and past losers conditional on stocks in the lowest underreaction quintile, with RC calculated based on the period over past 12 months ending in month $t-1$. We follow Grinblatt and Han (2005) and Grinblatt and Moskowitz (2004) to calculate UCG and RC at the individual firm level.

In particular, the disposition effect predicts significantly positive coefficients (β_4 and β_5) on $\mathrm{AGG\ UCG}_{t-1}$ and $\mathrm{AGG\ RC}_{t-1}$ because momentum profits are expected to be higher when investors have higher unrealized capital gains (losses) on winner (loser) stocks or when stocks have more consistent returns. The underreaction hypothesis, however, predicts a significantly positive coefficient (β_2) on Log(NUMST) because the allocation of investors' attention to each stock is lower when the number of stocks available for investment is larger. We repeat the regression for the momentum strategies based on each of the underreaction measures and report the estimation results in Table 9.

Confirming the underreaction hypothesis, we document strong evidence in Table 9 that coefficients β_2 are significantly positive in all specifications, regardless of the momentum strategy or underreaction measure adopted. Coefficients on AGG UCG and AGG RC

Table 9
Investor underreaction versus the disposition effect.

	Residual momentum					JT price momentum				
	ID	IO	IVOL	AGE	INDEX	ID	IO	IVOL	AGE	INDEX
Intercept	1.343*	2.600***	1.736***	1.199	2.722***	2.339*	5.107***	2.538***	4.751***	4.469**
	(1.83)	(3.36)	(2.69)	(1.56)	(2.87)	(1.76)	(2.92)	(2.62)	(2.88)	(2.58)
Trend	−0.002	−0.003**	−0.003**	−0.002	−0.004**	−0.005*	−0.006**	−0.004**	−0.006**	−0.006*
	(−1.47)	(−2.15)	(−2.57)	(−1.42)	(−2.36)	(−1.83)	(−2.14)	(−2.34)	(−2.22)	(−1.91)
Log(NUMST)	0.456**	0.735***	0.278*	0.515**	0.711***	1.026**	1.410***	0.552**	1.333***	1.397***
	(2.04)	(3.30)	(1.87)	(2.38)	(2.76)	(2.47)	(2.98)	(2.39)	(2.94)	(2.89)
AGG_MKT	0.015**	0.011	0.004	0.011*	0.007	0.036***	0.023*	0.012	0.023*	0.030**
	(2.29)	(1.52)	(0.74)	(1.69)	(0.99)	(2.61)	(1.76)	(1.38)	(1.75)	(2.12)
AGG_UCG	0.653**	0.403	0.314	0.599	1.060**	−0.026	−0.019	0.321	−0.341	−0.246
	(2.18)	(0.69)	(0.65)	(1.64)	(2.44)	(−0.06)	(−0.05)	(1.51)	(−0.81)	(−0.48)
AGG_RC	−0.601	−2.496	−1.638	−0.045	−2.286	−0.229	−5.027*	−2.352	−3.184	−2.577
	(−0.74)	(−1.62)	(−1.47)	(−0.04)	(−1.57)	(−0.14)	(−1.68)	(−1.29)	(−1.35)	(−1.02)

This table reports the estimation results of time-series regressions of the three-factor adjusted six-month holding-period returns from residual and JT price momentum strategies based on the lowest quintile of underreaction proxy, which is denoted as $\text{URet}_{t+1,t+6}$. In particular, we perform the following regression:

$$\text{URet}_{t+1,t+6} = \beta_0 + \beta_1 \text{Trend}_t + \beta_2 \text{Log(NUMST)}_{t-1} + \beta_3 \text{AGG MKT}_{t-1} + \beta_4 \text{AGG UCG}_{t-1} + \beta_5 \text{AGG RC}_{t-1} + \varepsilon_t,$$

where Trend_t is a time index that starts at 1 in the beginning month of our sample; Log(NUMST)_{t-1} is the log number of listed stocks over past 12 months ending in month t −1, with larger number of listed stocks representing lower investor attention; AGG MKT_{t-1} is the aggregate market return over past 12 months ending in month t −1; AGG UCG_{t-1} is the equally-weighted difference between the UCG of past winners and past losers conditional on stocks in the lowest underreaction quintile, with UCG calculated based on the period over past 12 months ending in month t −1; AGG RC_{t-1} is the equally-weighted sum of RC for past winners and past losers conditional on stocks in the lowest underreaction quintile, with RC calculated based on the period over past 12 months ending in month t −1. Numbers in the parentheses are the t-statistics calculated using Newey and West's (1987) robust standard errors.

*** Denote significance at the 1% level.

** Denote significance at the 5% level.

* Denote significance at the 10% level.

are mostly insignificant with the only two exceptions of the β_4 coefficients for the residual momentum conditional on ID and INDEX. Thus, our results indicate that the momentum profits in Japan are more likely to be the result of investor underreaction rather than the disposition effect.

4. Conclusions

Using a sample of all stocks listed on the TSE covering the sample period from 1975 to 2011, we demonstrate that the residual momentum strategy, which is constructed to hedge out the risk exposure to Fama–French (1993) factors, is profitable in Japan for short-term holding periods ranging from three to 12 months. We also demonstrate that the residual momentum profits over long-term holding periods ranging from two to five years do not reverse, unlike traditional JT price strategies.

The findings in both short- and long-term holding periods are attributed to investor underreaction. Consistent with the FIP hypothesis of Da et al. (2014) and the limited attention argument, we find that the profits to the residual momentum in Japan are concentrated in stocks with more continuous information, low institutional ownership, low idiosyncratic volatilities, and young age. In addition, this pronounced momentum profit is not followed by long-term reversals, consistent with the prediction of the underreaction hypothesis. Finally, we find that the underreaction-driven residual momentum displays predictable time-varying patterns according to the business cycle, market state, market volatilities, return dispersion, market liquidity, and momentum crashes. The results of time-varying predictability of the residual momentum are provided in the internet appendix due to space limitation.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://10.1016/j.jempfin.2017.11.005.

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