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Momentum in Weekly Industry Portfolio Returns

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1. Introduction

There is substantial domestic and international evidence of stock momentum in individual and portfolio returns of 3 to 12 months.[1] There is also evidence that stock returns exhibit reversals at longer horizons.[2] Motivated by these findings, Barberis, Shleifer, and Vishny (1998) (hereafter, "BSV"), Daniel, Hirshleifer, and Subrahmanyam (1998) ("DHS"), and Hong and Stein (1999) ("HS") have proposed behavioral models in which short-run undereaction (delayed overreaction) and long-run overreaction are sequential components of the same process by which investors react to information. The general notions in these models are: (1) momentum is caused by serial correlations in returns, and (2) momentum co-exists with reversals.[3]

One anomaly within the momentum literature is the reversals in individual stock returns of one week to one month documented by Lehmann (1990) and Jegadeesh (1990). However, Gutierrez and Kelley (2008) (hereafter, "GK") recently find that "the brief reversal that follows extreme weekly returns is itself followed by an opposing and long-lasting stream of continuation in returns". Their findings suggest that momentum in individual stock returns up to one year is a pervasive phenomenon. As a result, their study seems to provide a clearer picture of return dynamics. However, several important questions have not been addressed in their study.

First, although there is also momentum in weekly returns, is this short-horizon momentum driven by the same force as the long-horizon momentum documented by Jegadeesh and Titman (1993) (e.g. serial correlations as BSV, DHS and HS suggest)? Second, does this short-horizon momentum also reverse in the long run as does the long-horizon momentum? If so, the return dynamics are clearer and a unified theory such as those in BSV, DHS and HS may help understand investor behavior. Otherwise, we may need to explore alternative theoretical perspectives.

We investigate the above questions with US industry portfolio returns. There are several reasons motivating us to use industry portfolio returns. First, we want to examine whether the short-horizon momentum documented by GK is due to data mining. Over the past 20 years, financial economists have looked at stock return predictability every which way. With so much searching, it is likely that someone will uncover what looks to be patterns purely by chance. There are several ways of addressing the data-mining issue. Perhaps the most robust is to perform an out-of-sample test. We take this approach and

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[1] See Jegadeesh and Titman (1993), Rouwenhorst (1998), Chan, Hameed and Tong (2000), Moskowitz and Grinblatt (1999), and Lewellen (2002.

[2] See Debondt and Thaler (1985), Fama and French (1988), Poterba and Summers (1988), and Balvers, Wu, and Gilliland (2000).

[3] Jegadeesh and Titman (2001), Hong, Lim, and Stein (2000), Lee and Swaminathan (2000), and Balvers and Wu (2006) find some supporting evidence for these behavioral models.

examine the short-horizon momentum in a different sample, US industry portfolio returns. Second, focusing on portfolio returns can also mitigate the effects of micro-structure issues in individual stock returns such as the bid-ask effect of Roll (1984). This makes our results more relevant for identifying the fundamental factors underlying return dynamics. Third, the long-horizon momentum in industry portfolio returns is well documented by Moskowitz and Grinblatt (1999) and Lewellen (2002). It is interesting to compare it to the potential short-horizon momentum.

To study the sources of momentum, we employ the Lo and MacKinlay (1990) momentum strategy. The profits from this strategy can easily be tied to serial and cross-serial covariances of returns, which is important for testing the popular behavioral models in BSV, DHS and HS. To examine whether momentum exhibits reversals, we look at the returns of the momentum portfolio in the post-ranking period up to three years. Our main findings are: 1) where long-horizon momentum is mainly explained by cross-serial correlations as in Lewellen (2002), short-horizon momentum, as we find, is largely due to serial correlations; 2) momentum does not always exhibit reversals in the long run. Thus, our findings do not agree with the general notions in the popular behavioral models of BSV, DHS and HS and present a challenge to them.

The remainder of the paper is organized as follows: Section 2 describes the data and documents the momentum in weekly industry portfolio returns. Section 3 examines sources of the momentum and the long-term reversals. Section 4 concludes the manuscript.

2. Data and Momentum in Weekly Industry Portfolio Returns

2.1 Data

Thirty industry portfolios are used for empirical investigation. The daily equal-weighted returns of the industry portfolios and the Fama-French factor data from July 1, 1963 to December 29, 2006 are downloaded from Kenneth French's website.[4] Following the relevant literature (e.g. GK), weekly returns are measured from Wednesday to Wednesday. Table 1 reports the summary statistics of our weekly industry portfolio returns, with average weekly return and variance for each industry and each industry's beta with the market index.

[4] We thank Fama and French for making these data available.

Table 1 Summary Statistics of Weekly Industry Portfolio Returns: 1963-2006

Industry	Mean	Variance	CAPM β
Food	0.0036	0.0003	0.6549
Beer	0.0031	0.0005	0.6499
Smoke	0.0035	0.0010	0.7764
Games	0.0042	0.0007	0.9451
Books	0.0035	0.0005	0.7792
Hshld	0.0035	0.0006	0.8793
Clths	0.0037	0.0006	0.8403
Hlth	0.0044	0.0008	1.0349
Chems	0.0036	0.0005	0.8686
Txtls	0.0028	0.0007	0.8113
Cnstr	0.0041	0.0006	0.8852
Steel	0.0032	0.0007	0.9227
FabPr	0.0038	0.0006	0.933
ElcEq	0.0046	0.0007	0.9412
Autos	0.0032	0.0007	0.9754
Carry	0.0040	0.0008	0.9221
Mines	0.0050	0.0011	0.6599
Coal	0.0033	0.0016	0.9228
Oil	0.0047	0.0009	0.8435
Util	0.0025	0.0002	0.4927
Telcm	0.0037	0.0008	1.0423
Servs	0.0044	0.0009	1.0901
BusEq	0.0046	0.0011	1.2379
Paper	0.0032	0.0005	0.8099
Trans	0.0035	0.0006	0.9178
Whlsl	0.0040	0.0006	0.8577
Rtail	0.0038	0.0006	0.8993
Meals	0.0040	0.0007	0.8595
Fin	0.0041	0.0004	0.6913
Other	0.0042	0.0006	0.8456

Table 1 reports the summary statistics of our weekly industry portfolio returns, with average weekly return and variance for each industry and each industry's beta with the market index.

2.2 Momentum Methodology

Lewellen (2002) has studied momentum as well as reversals in industry portfolio returns of 6 and 12 months with the Lo and MacKinlay (1990) momentum strategy. As he points out, this strategy is more convenient for portfolio returns than the Jegadeesh and Titman (1993) strategy for two reasons. First, the momentum portfolio invests in all assets, not just the extremes. This makes it easy to apply the strategy to all 30 portfolios. Second, it is straightforward to decompose the profits from this strategy into the components due to serial and cross-serial correlations. This makes it easy to test the popular behavioral models.

In this paper, we extend Lewellen (2002) and GK and examine the short-horizon momentum in the industry portfolios returns. The short-horizon momentum is based on assets' performance in the previous week. For comparison, we also study the long-horizon momentum, which is based on assets' performance in the previous six months or 26 weeks. We choose six months or 26 weeks for the long-horizon momentum because it is the most commonly used ranking window in the momentum literature (see for instance Jegadeesh and Titman (1993)).

Essentially, in each week *t*, the momentum portfolio goes long in the winners and short in the losers based on their past market-adjusted returns. That is, the momentum portfolio in week t is to invest in all assets with the following weights:

$$w_{i,t}^{l}(0) = \frac{1}{N}(r_{i,t-1}^{l} - r_{m,t-1}^{l}) \qquad i = 1,2\cdots,N \tag{1}$$

where $r_{i,t-1}^{l}$ is the *l*-week return of portfolio *i* ending in week t-1, $r_{m,t-1}^{l}$ is the corresponding return on the equal-weighted index, *N* is the total number of assets, and *l* is equal to 1 for the short-horizon momentum and 26 for the long-horizon momentum. By construction, the weights sum to zero. Therefore, the total investment long (or short) in week *t* is $I_t^l(0) = \frac{1}{2}\sum_{i=1}^{N} | w_{i,t}^{l}(0) |$. The profit in week t from such a strategy is

$$\pi_t^l(0) = \sum_{i=1}^{N} w_{i,t}^{l}(0) r_{i,t} \tag{2}$$

where $r_{i,t}$ is the return of asset *i* in week t. Since the total investment long (or short) changes every week, to ease the interpretation of the results, we also report a rescaled version of the profit that invests \$1 long and \$1 short in every week. The rescaled profit is equal to $\frac{\pi_t^l(0)}{I_t^l(0)}$.

To match the commonly-investigated holding period in the momentum literature, we examine the performance of our momentum portfolios up to six months or 26 weeks (e.g. from week t to week t+25). To evaluate the performance of the momentum portfolios over holding periods longer than one week, we follow GK and employ the calendar-time method. The calendar-time method avoids overlapping returns and the accompanying strongly positive serial correlation in returns while allowing all possible holding periods to be considered. The weekly calendar-time series of profits representing the performance of the momentum portfolio over the event weeks $t+p$ through $t+q$ is

$$\Pi_t^l(p,q) = \frac{1}{q-p+1}\sum_{k=p}^{q} \pi_t^l(k) \tag{3}$$

where $\pi_t^l(k) = \sum_{i=1}^{N} w_{i,t}^l(k) r_{i,t} = \frac{1}{N}\sum_{i=1}^{N}(r_{i,t-k-1}^l - r_{m,t-k-1}^l) r_{i,t}$, $r_{i,t-k-1}^l$ is the *l*-week return of portfolio *i* ending in week t-*k*-1, and $r_{m,t-k-1}^l$ is the corresponding return on the equal-weighted index. Again, *l* is equal to 1 for the short-horizon momentum and 26 for the long-horizon momentum. Let $I_t^l(k) = \frac{1}{2}\sum_{i=1}^{N} | w_{i,t}^l(k) |$. The rescaled profit is then equal to $\frac{1}{q-p+1}\sum_{k=p}^{q}\frac{\pi_t^l(k)}{I_t^l(k)}$.

To see whether momentum is due to risk, we adjust raw momentum profits by our benchmark models. The risk-adjusted returns are estimated intercepts from these models. The two benchmark models we use are the CAPM and the three factor model of Fama and French (1996).

2.3 Momentum Profits

Panel A in Table 2 reports the mean raw and risk-adjusted (rescaled) momentum profits for the short-horizon momentum. The section headed by "1963-2006" presents the results for the whole sample period. Different from individual stocks, industry portfolio returns do not exhibit reversals in the first week (week t). The momentum profits in week t are significantly positive across raw and risk-adjusted returns, averaging 30 basis points per week. Risk adjustment does not explain momentum. This is compatible with the findings of Jegadeesh and Titman (1993), Fama and French (1996), Grundy and Martin (2001) and GK for U.S. individual stocks.[5] Since the industry portfolios are well diversified and largely free from the effects of microstructure issues and firm-specific risk, this finding indicates that the short-horizon reversal in individual stock returns may be due to either microstructure issues or firm-specific idiosyncratic risk. Moreover, return momentum continues until week t+25. The raw as well as the risk-adjusted returns are all significantly positive in week t+1, week t+2, week t+3 and weeks t+4 to t+25. The mean (raw) profit from t+4 to t+25 is 6.75 basis points per week (or 3.57 percent per year) with a t-statistic of 5.44. As a comparison, the mean profit in weekly individual stock returns is 8.11 basis points per week (or 4.30 percent per year) with a t-statistic of 4.50 in GK. Our results therefore confirm GK and suggest that the short-horizon momentum (based on assets' returns in the previous week, t-1) is real and not the result of data mining.

[5] Although Conrad and Kaul (1998) find evidence that momentum is explained by the cross-sectional dispersion in unconditional means (a proxy for expected returns), Jegadeesh and Titman (2002) reject their claim and find that their results are driven by small sample bias. Contrary to Chordia and Shivakumar (2002) who find that momentum can be explained by a set of lagged macroeconomic variables, Griffin, Ji, and Martin (2003) find that momentum has little relation to those macro variables.

Table 2 Momentum Profits from Week t to Week t+25: 1963-2006

Panel A Short-Horizon Momentum

	1963 - 2006			1963-1985			1985-2006		
	Raw	CAPM	FF	Raw	CAPM	FF	Raw	CAPM	FF
t	31.28	31.66	30.99	38.88	38.94	38.67	26.40	26.93	26.22
	(7.67)	(7.83)	(7.77)	(11.07)	(11.02)	(10.71)	(3.39)	(3.50)	(3.49)
t+1	26.27	26.96	26.47	27.75	27.96	27.29	27.61	28.88	28.86
	(6.82)	(7.06)	(6.92)	(5.20)	(5.24)	(5.11)	(4.39)	(4.66)	(4.70)
t+2	24.04	24.43	24.27	24.70	24.84	25.64	29.27	30.24	29.76
	(6.23)	(6.35)	(6.29)	(5.50)	(5.70)	(6.09)	(5.25)	(5.33)	(5.21)
t+3	18.55	18.84	17.63	19.96	19.98	19.44	20.97	22.04	20.74
	(4.92)	(5.00)	(4.79)	(5.47)	(5.48)	(5.48)	(3.13)	(3.27)	(3.24)
t+4 to t+25	6.75	6.79	6.39	6.71	6.78	6.37	7.49	7.33	6.91
	(5.44)	(5.49)	(5.28)	(3.67)	(3.77)	(3.45)	(3.92)	(3.82)	(3.81)
t to t+25	**9.56**	**9.67**	**9.23**	**9.96**	**10.03**	**9.66**	**10.35**	**10.36**	**9.90**
	(7.40)	**(7.52)**	**(7.38)**	**(5.56)**	**(5.72)**	**(5.40)**	**(5.14)**	**(5.14)**	**(5.33)**

Panel B Long-Horizon Momentum

	1963 - 2006			1963-1985			1985-2006		
	Raw	CAPM	FF	Raw	CAPM	FF	Raw	CAPM	FF
t	33.82	34.21	32.05	33.76	33.91	32.30	38.35	38.78	36.20
	(7.83)	(7.97)	(7.63)	(6.05)	(6.17)	(5.89)	(5.66)	(5.75)	(5.70)
t+1	30.78	31.13	29.11	29.74	29.89	28.08	35.84	36.23	33.99
	(7.04)	(7.17)	(6.83)	(5.03)	(5.14)	(4.81)	(5.35)	(5.43)	(5.41)
t+2	28.41	28.65	26.67	26.70	26.83	24.89	34.17	34.41	32.34
	(6.46)	(6.55)	(6.23)	(4.58)	(4.67)	(4.33)	(4.99)	(5.04)	(5.06)
t+3	24.47	24.66	22.69	23.81	23.92	21.91	28.17	28.32	26.25
	(5.60)	(5.67)	(5.34)	(4.00)	(4.07)	(3.70)	(4.04)	(4.07)	(4.06)
t+4 to t+25	18.25	18.10	16.88	16.87	16.83	14.92	21.76	21.34	20.57
	(4.93)	(4.88)	(4.55)	(2.82)	(2.81)	(2.45)	(4.23)	(4.18)	(4.08)
t to t+25	**19.96**	**19.88**	**18.53**	**18.66**	**18.65**	**16.75**	**23.67**	**23.36**	**22.35**
	(5.40)	**(5.37)**	**(5.03)**	**(3.19)**	**(3.19)**	**(2.82)**	**(4.55)**	**(4.51)**	**(4.43)**

The weekly calendar-time series of profits representing the performance of the momentum portfolio over the event weeks $t+p$ through $t+q$ is

$$\Pi_t^l(p,q) = \frac{1}{q-p+1}\sum_{k=p}^{q}\pi_t^l(k)$$

where $\pi_t^l(k) = \sum_{i=1}^{N} w_{i,t}^l(k) r_{i,t} = \frac{1}{N}\sum_{i=1}^{N}(r_{i,t-k-1}^l - r_{m,t-k-1}^l)r_{i,t}$, $r_{i,t-k-1}^l$ is the *l*-week return of portfolio *i* ending in week t-k-1, and $r_{m,t-k-1}^l$ is the corresponding return on the equal-weighted index. Again, *l* is equal to 1 for the short-horizon momentum and 26 for the long-horizon momentum. Let $I_t^l(k) = \frac{1}{2}\sum_{i=1}^{N}|\, w_{i,t}^l(k)\,|$ The rescaled profit is then equal to $\frac{1}{q-p+1}\sum_{k=p}^{q}\frac{\pi_t^l(k)}{I_t^l(k)}$.

Panel B in Table 2 reports the mean raw and risk-adjusted (rescaled) momentum profits for the long-horizon momentum. The section headed by “1963-2006” shows the results for the whole sample period. Consistent with Lewellen (2002), there is significant momentum based on past six months or 26 weeks returns. The mean (raw) profit from t to t+25 is 19.96 basis points per week (or 10.93 percent per year) with a t-statistic of 5.40.

We also look at the profitability of the momentum strategies in the two equal-length-sub-sample periods, 1963:7:3-1985:3:27 and 1985:4:3-2006:12:20 for robustness check. The results are reported in Table 2 under Sections “1963-1985” and “1985-2006”. As we can see, both the short-horizon and long-horizon-momentum are significantly profitable in both periods. The mean (raw) profit from t to t+25 for the short-horizon momentum is 9.96 basis points per week (t-statistic = 5.56) in the 1963-1985 period and 10.35 basis points per week (t-statistic = 5.14) in the 1985-2006 period, where that for the long--horizon momentum is 18.66 basis points per week (t-statistic = 5.56) and 23.67 basis points per week (t-statistic = 5.14) respectively. Again, risk adjustment does not explain momentum. Therefore, the evidence suggests that momentum indeed is a pervasive phenomenon at short horizons.

2.4 Relation between the Short-horizon and the Long-Horizon Momentum

Since the short-horizon momentum uses a shorter ranking window, one may wonder whether the short-horizon momentum is simply a manifestation of the long-horizon momentum. GK find that it is not the case for individual stock returns. In their cross-sectional regressions, they find that the one-week return has significant explanatory power for the future return even after controlling for the return over the past six months. We follow them and conduct a similar test with our portfolio returns. Essentially, in each week *t*, we regress the cross-section of return over t to t+25 on the return in week t-1 and the return over t-1 to t-26. That is,

$$\sum_{p=0}^{25} r_{i,t+p} = b_{ot} + b_{1t} r_{i,t-1} + b_{2t} \sum_{p=1}^{26} r_{i,t-p} + e_{i,t} \qquad (4)$$

We then average the coefficient estimates across the sample period and report this average.

The time-series averages of the week-by-week estimates of these parameters and associated t-statistics are reported in Table 3. In the whole sample period (1963-2006), the one-week return has significant explanatory power for the future return even after controlling for the return over past six months/26 weeks. The coefficient on the one-week return is 0.33 with a t-statistic of 5.72. The results for the two sub-sample periods are similar. The coefficient on the one-week return is 0.44 with a t-statistic of 5.28 in the 1963-1985 period and 0.26 with a t-statistic of 3.21 in the 1985-2006 period. Therefore, we confirm GK in that the short-horizon momentum is indeed not the simple manifestation of the long-horizon momentum. In other words, the information in the past one week return is not the same as the information in the past six months return.

Table 3 Predictive Power of Weekly Returns

	1963-2006	1963-1985	1985-2006
b_1	0.33	0.44	0.26
	(5.72)	(5.28)	(3.21)
b_2	0.22	0.22	0.25
	(6.36)	(3.68)	(5.55)

In each week *t*, we regress the cross-section of return over t to t+25 on the return in week t-1 and the return over t-1 to t-26. That is,

$$\sum_{p=0}^{25} r_{i,t+p} = b_{ot} + b_{1t} r_{i,t-1} + b_{2t} \sum_{p=1}^{26} r_{i,t-p} + e_{i,t}$$

We then average the coefficient estimates across the sample period and report this average. The time-series averages of the week-by-week estimates of these parameters and associated t-statistics are reported in Table 3.

However, if BSV, DHS and HS were right, we would expect that investors would under-react to both types of information in the short run and over-react in the long run (after all, they are both based on past returns). Such reaction pattern would generate positive and then negative autocorrelations in returns, which in turn would result in momentum and reversals. In other words, although the short-horizon momentum is not the manifestation of the long-horizon momentum, if the popular behavioral models were true, we would still expect that: 1) both types of momentum were due to serial correlations, and 2) both would reverse in the long run. To test the popular behavioral models, we next examine the sources of momentum and the long-run reversals.

3. Sources of Momentum and Reversals

3.1 Sources of Momentum

Based on Lo and MacKinlay (1990), it is easy to show that the expected profit from the momentum strategy with one-week holding period can be written as

$$E[\pi_t^l(k)] = \frac{1}{N}\sum_{i=1}^{N} Cov(r_{i,t-k-1}^l, r_{i,t}) - \left[Cov(r_{m,t-k-1}^l, r_{m,t}) - \frac{1}{N^2}\sum_{i=1}^{N} Cov(r_{i,t-k-1}^l, r_{i,t}) \right]$$

$$+ \frac{l}{N}\sum_{i=1}^{N}(\mu_i - \mu_m)^2$$

$$= O^l(k) + C^l(k) + \sigma^{2^l}(\mu) \qquad (5)$$

where $r_{i,t-k-1}^l$ is the *l*-week return of asset *i* ending in week t-*k*-1, $r_{m,t-k-1}^l$ is the corresponding return on the equal-weighted index, $r_{i,t}$ is the return of asset *i* in week *t*, $r_{m,t}$ is the corresponding return on the equal-weighted index, μ_i is the expected return of asset *i*, and μ_m is the expected return of the equal-weighted index. Again, l is equal to 1 for the short-horizon momentum and 26 for the long-horizon momentum. Equation (5) indicates that there are three sources of momentum profits: (1) positive autocovariances between the week t return and the lagged return ($O^l(k)$), (2) negative cross-serial covariances at the same horizon ($C^l(k)$), and (3) the variance of the mean returns ($\sigma^{2^l}(\mu)$).

The expected profit representing the performance of the momentum portfolio over holding periods longer than one week, over the weeks $t+p$ through $t+q$ then is

$$E[\Pi_t^l(p,q)] = \frac{1}{q-p+1}\sum_{k=p}^{q} E[\pi_t^l(k)]$$

$$= \frac{1}{q-p+1}\left[\sum_{k=p}^{q} E[O^l(k)] + \sum_{k=p}^{q} E[C^l(k)] + \sum_{k=p}^{q} \sigma^{2^l}(\mu)\right]$$

$$= \frac{1}{q-p+1}\sum_{k=p}^{q} E[O^l(k)] + \frac{1}{q-p+1}\sum_{k=p}^{q} E[C^l(k)] + \sigma^{2^l}(\mu)$$

$$= O^l(p,q) + C^l(p,q) + \sigma^{2^l}(\mu) \qquad (6)$$

Thus, the performance of the momentum portfolio over holding periods longer than one week also depends on serial covariances, cross-serial covariances, and the variance of the mean returns over the corresponding horizons. These three components are closely tied to alternative explanations of momentum. The popular behavioral models of BSV, DHS, and HS emphasize the role of autocovariances. The lead-lag model of Lo and MacKinlay (1990) stresses the importance of cross-serial covariances. Finally, the rational argument of Conrad and Kaul (1988) focuses on the dispersion in unconditional means. A decomposition of momentum profits can shed considerable light on the validity of these alternative explanations.

Table 4 reports the (un-rescaled) mean momentum profits as well as its three sources over various holding periods in the whole sample period 1963-2006. Panel A of Table 4 shows the sources of the short-horizon momentum over holding periods week t to week t+25. As we can see, for the commonly-investigated six months holding period, the auto-covariance component is significantly positive, while the cross-serial covariance component is insignificantly negative. $O^1(0, 25)$ is equal to 0.119 with a t-statistic of 2.35, where $C^1(0, 25)$ is -0.072 with a t-statistic of -1.49. This suggests that autocorrelations are the major driving force of the short-horizon momentum. Cross-serial correlations do not create but reduce the short-horizon momentum. Furthermore, dispersion in expected returns is not an economically important factor of the short-horizon momentum. It explains less than 10% of the momentum profit.

Panel B of Table 4 shows the sources of the long-horizon momentum in the whole sample period 1963-2006. For the six months holding period, the auto-covariance component is (insignificantly) negative, while the cross-serial covariance component is (insignificantly) positive. $O^{26}(0, 25)$ is equal to -0.228 with a t-statistic of -0.19, where $C^{26}(0, 25)$ is 0.846 with a t-statistic of 0.77. This suggests that cross correlations are the major driving force of the long-horizon momentum. Serial correlations do not create but reduce the long-horizon momentum. Again, the dispersion in expected returns is not an economically important factor of the long-horizon momentum. It explains less than 14% of the momentum profit. This finding is consistent with Lewellen (2002) who finds that the long-horizon momentum based on past 12-month returns in industry portfolio returns is mainly explained by cross-serial correlations.

Table 4 Sources of Industry Momentum 1963-2006

	Panel A Short-horizon Momentum						
	E[Π]	O	C	$\sigma^2(\mu)$	%O	%C	%$\sigma^2(\mu)$
t	0.183	1.221	-1.041	0.003	667.2	-568.9	1.6
	(4.97)	(6.80)	(-6.32)				
t+1	0.160	0.585	-0.428	0.003	365.6	-267.5	1.9
	(5.28)	(4.13)	(-3.33)				
t+2	0.129	0.668	-0.542	0.003	517.8	-420.2	2.3
	(4.56)	(5.06)	(-4.41)				
t+3	0.096	0.319	-0.226	0.003	332.3	-235.4	3.1
	(3.82)	(2.74)	(-2.12)				
t+4 to t+25	0.033	0.013	0.017	0.003	39.4	51.5	9.1
	(4.41)	(0.25)	(0.33)				
t to t+25	**0.050**	**0.119**	**-0.072**	**0.003**	**238.0**	**-144.0**	**6.0**
	(5.97)	**(2.35)**	**(-1.49)**				

	Panel B Long-Horizon Momentum						
	E[Π]	O	C	σ^2	%O	%C	%σ^2
t	1.301	3.083	-1.863	0.084	237.0	-143.2	6.5
	(5.97)	(2.35)	(-1.49)				
t+1	1.151	1.873	-0.803	0.084	162.7	-69.8	7.3
	(5.64)	(1.41)	(-0.64)				
t+2	1.011	1.073	-0.144	0.084	106.1	-14.2	8.3
	(5.20)	(0.81)	(-0.11)				
t+3	0.841	0.231	0.529	0.084	27.5	62.9	10.0
	(4.46)	(0.17)	(0.42)				
t+4 to t+25	0.631	-0.554	1.103	0.084	-87.8	174.8	13.3
	(4.19)	(-0.46)	(0.97)				
t to t+25	**0.699**	**-0.228**	**0.846**	**0.084**	**-32.6**	**121.0**	**12.0**
	(4.57)	**(-0.19)**	**(0.77)**				

Table 4 reports the (un-scaled) mean momentum profits as well as its three sources over various holding periods in the whole sample period 1963-2006.

Thus, the driving force behind the short-horizon momentum is different from that behind the long-horizon momentum. This is one of the central findings of the current paper. This finding presents a challenge to the popular behavioral models and other existing models of momentum, because they all predict that momentum has the same sources. The popular behavioral models of BSV, DHS, and HS suggest that momentum is due to autocovariances. The lead-lag model of Lo and MacKinlay (1990) indicates that momentum is caused by cross-serial covariances. Finally, the rational explanation of Conrad and Kaul (1988) argues that momentum is generated by the dispersion in unconditional means. Our results therefore do not support any existing explanations for momentum and call for a new explanation.

The results so far are based on the whole sample period from 1963 to 2006. Using the whole sample does not allow for time variation in unconditional means, autocorrelations, and cross-serial correlations. This could lead to bias in analyzing the sources of momentum if they indeed were time varying. These observations motivate us to repeat our exercises in two equal-length sub-samples, 1963:7:3-1985:3:27 and 1985:4:3-2006:12:20.

Table 5 presents the sources of the momentum strategies in both sub periods. When we allow time variation in unconditional means, autocorrelations, and cross-serial correlations, the sources of industry momentum exhibit some time variation. However, the general pattern seems to be consistent with the results based on the whole sample period. That is, the short-horizon momentum seems to be mainly driven by serial correlations, while the long-horizon momentum seems to be more related with cross-serial correlations. For the short-horizon momentum in Panel A, the serial-correlation component explains 472.1% of the profit in the 1963-1985 period and 81.5% of the profit in the 1985-2006 period. For the long-horizon momentum in Panel B, the cross-serial-correlation component explains 36.8% of the profit in the 1963-1985 period and 98.1% of the profit in the 1985-2006 period.

3.2. Long-term Reversals

To test the popular notion in BSV, DHS, and HS that momentum and reversals are integrated components of the market's response to news, we examine the returns of the momentum portfolio in the post-ranking period up to three years. Figure 1 presents the results for the whole sample period as well as for the two sub-sample periods. The solid line SHM represents the (raw) cumulative (rescaled) momentum profit for the short-horizon momentum, where the dashed line LHM represents that for the long-horizon momentum.

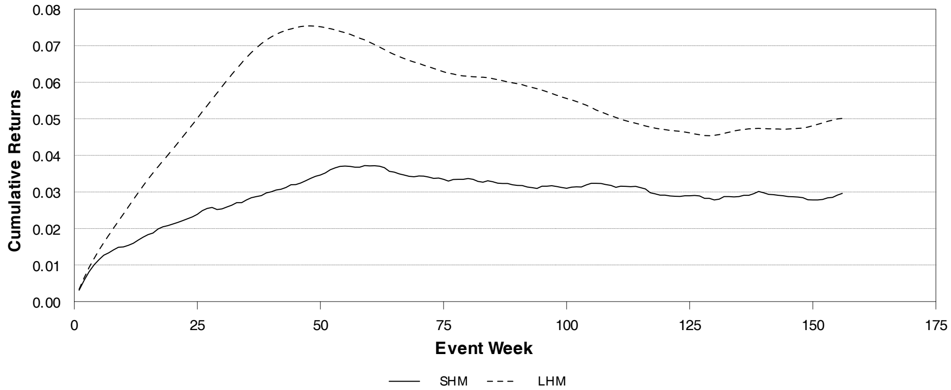
Table 5 Sources of Industry Momentum: Sub-samples

	E[Π]	O	C	σ^2	%O	%C	%σ^2
				Panel A Short-horizon Momentum			
1963-1985	E[Π]	O	C	σ^2	%O	%C	%σ^2
t	0.172	1.507	-1.337	0.001	876.2	-777.3	0.60
	(8.04)	(5.82)	(-5.46)				
t+1	0.144	0.785	-0.643	0.001	545.1	-446.5	0.70
	(4.53)	(3.59)	(-3.23)				
t+2	0.112	0.792	-0.681	0.001	707.1	-608.0	0.90
	(4.43)	(3.39)	(-3.05)				
t+3	0.097	0.508	-0.412	0.001	523.7	-424.7	1.00
	(4.56)	(2.83)	(-2.40)				
t+4 to t+25	0.027	0.077	-0.052	0.001	285.2	-192.6	3.70
	(3.28)	(0.98)	(-0.68)				
t to t+25	**0.043**	**0.203**	**-0.162**	**0.001**	**472.1**	**-376.7**	**2.3**
	(5.25)	**(2.65)**	**(-2.17)**				
1985-2006	E[Π]	O	C	σ^2	%O	%C	%σ^2
t	0.215	0.867	-0.665	0.014	403.3	-309.3	6.50
	(2.83)	(3.90)	(-3.75)				
t+1	0.198	0.529	-0.344	0.014	267.2	-173.7	7.10
	(3.55)	(3.13)	(-2.33)				
t+2	0.181	0.602	-0.435	0.014	332.6	-240.3	7.70
	(3.65)	(3.79)	(-3.04)				
t+3	0.114	0.168	-0.068	0.014	147.4	-59.6	12.3
	(2.39)	(0.99)	(-0.45)				
t+4 to t+25	0.044	-0.036	0.067	0.014	-81.8	152.3	31.8
	(3.22)	(-0.48)	(0.93)				
t to t+25	**0.065**	**0.053**	**-0.002**	**0.014**	**81.5**	**-3.10**	**21.5**
	(4.24)	**(0.75)**	**(-0.03)**				
				Panel B Long-Horizon Momentum			
1963-1985	E[Π]	O	C	σ^2	%O	%C	%σ^2
t	1.117	5.287	-4.208	0.039	473.3	-376.7	3.50
	(5.25)	(2.65)	(-2.17)				
t+1	0.950	3.722	-2.810	0.039	391.8	-295.8	4.10
	(4.33)	(1.88)	(-1.46)				
t+2	0.792	2.722	-1.967	0.039	343.7	-248.4	4.90
	(3.72)	(1.38)	(-1.02)				
t+3	0.687	1.773	-1.123	0.039	258.1	-163.5	5.70
	(3.17)	(0.91)	(-0.59)				
t+4 to t+25	0.542	-0.214	0.718	0.039	-39.5	132.5	7.20
	(2.54)	(-0.12)	(0.43)				
t to t+25	**0.595**	**0.338**	**0.219**	**0.039**	**56.8**	**36.8**	**6.60**
	(2.84)	**(0.20)**	**(0.14)**				
1985-2006	E[Π]	O	C	σ^2	%O	%C	%σ^2
t	1.678	1.368	-0.045	0.367	81.5	-2.7	21.9
	(4.24)	(0.75)	(-0.03)				
t+1	1.522	0.533	0.634	0.367	35.0	41.7	24.1
	(4.25)	(0.29)	(0.36)				
t+2	1.387	-0.268	1.300	0.367	-19.3	93.7	26.5
	(4.12)	(-0.14)	(0.72)				
t+3	1.107	-1.081	1.832	0.367	-97.7	165.5	33.2
	(3.32)	(-0.55)	(0.98)				
t+4 to t+25	0.807	-0.424	0.877	0.367	-52.5	108.7	45.5
	(3.37)	(-0.26)	(0.57)				
t to t+25	**0.902**	**-0.338**	**0.885**	**0.367**	**-37.5**	**98.1**	**40.7**
	(3.66)	**(-0.21)**	**(0.57)**				

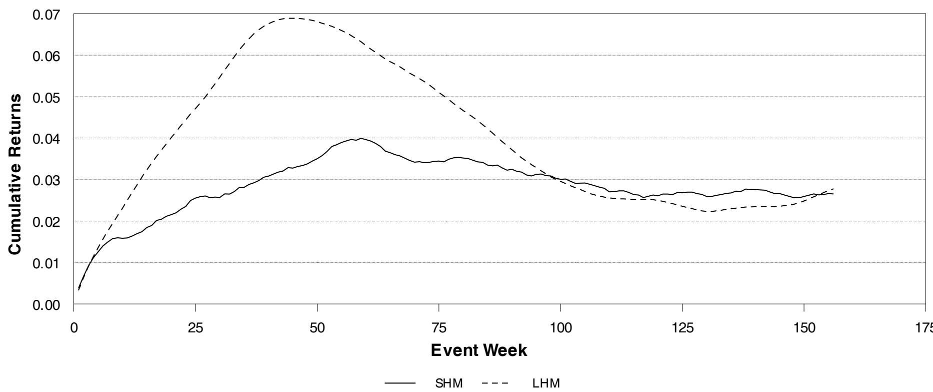
Table 5 presents the sources of the momentum strategies in both sub periods.

Figure 1 Momentum and Reversals in Industry Portfolio Returns 1963-2006

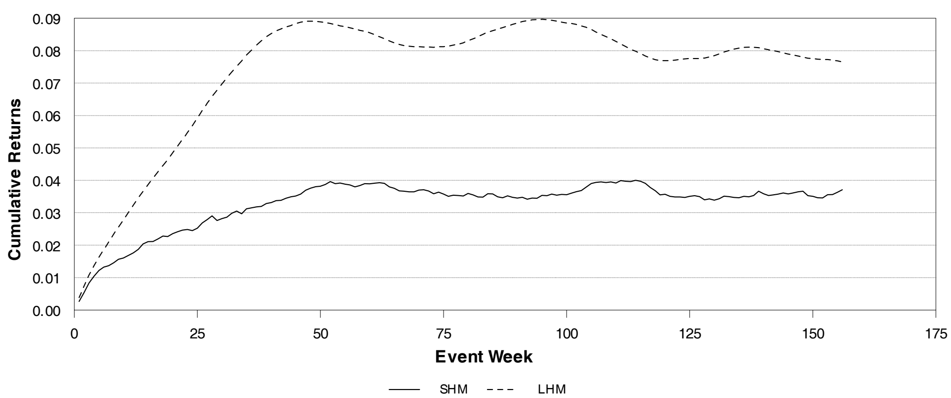
Panel A 1963-2006



Panel B 1963-1985



Panel C 1985-2006



We examine the returns of the momentum portfolio in the post-ranking period up to three years. Figure 1 presents the results for the whole sample period as well as for the two sub-sample periods. The solid line SHM represents the (raw) cumulative (rescaled) momentum profit for the short-horizon momentum, where the dashed line LHM represents that for the long-horizon momentum.

Panel A presents the results for the whole sample period. As we can see, although both exhibit reversals, it seems that the short-horizon momentum has weaker reversals than the long-horizon momentum. For the short-horizon momentum, cumulative profits increase until they reach 3.71 percent at the end of Week 55. From Week 56, cumulative profits decrease until they become 2.96 percent at the end of Week 156. For the long-horizon momentum, cumulative profits increase until they reach 7.54 percent at the end of Week 48. From Week 49, cumulative profits decrease until they become 5.02 percent at the end of Week 156.

Jegadeesh and Titman (2001) find that the long-horizon momentum in individual stock returns does not exhibit reversals since 1982. The implication is that the relationship between momentum and reversals may be time varying. We therefore also look at the two sub-sample periods, 1963:7:3-1985:3:27 and 1985:4:3-2006:12:20. The results are in Panels B and C. Consistent with Jegadeesh and Titman (2001), we also find that both short-horizon momentum and long-horizon momentum do not exhibit reversals in the second sample period, 1985-2006. In the 1963-1985 period, cumulative profits first increase to 4.00(6.89) percent then decrease to 2.66(2.77) percent for the short-horizon momentum (the long-horizon momentum). However, in the 1985-2006 period, cumulative profits first increase to 3.96 (8.91) percent then stay at about the similar lever until Week 156 for the short-horizon momentum (the long-horizon momentum). This suggests that momentum and reversals are not necessarily integrated components of the market's response to news.[6] This is another key finding of this paper and presents a challenge to the popular behavioral models of BSV, DHS, and HS.

4. Conclusion

In this paper, we examine the momentum in industry portfolio returns. Our main findings are: 1) where long-horizon momentum is mainly explained by cross-serial correlations, short-horizon momentum is largely due to serial correlations; 2) momentum does not always exhibit reversals in the long run. Our findings do not agree with the general notions in the popular behavioral models of BSV, DHS and HS and present a challenge to them. Given that the source of industry momentum profits is not unique and momentum may not reverse, the significance of momentum profitability can be a bit misleading, This may provide clues regarding why momentum profits have remained significant, even though they are an apparent contradiction to market efficiency (see Lewellen (2002)). The presence of these profits in the face of changing investor sentiment creates a bound to the ability of arbitrageurs to take advantage of the apparent inefficiency. Such bounds calibrate the profitability of this trading strategy with the risk inherent in volatile investor behavior.

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[6] George and Hwang (2004) find that momentum based on the 52-week high also does not exhibit reversals in the long run.

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