# The Predictability Characteristics and Profitability of Price Momentum Strategies: A New Approach

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*We suggest a flexible method to study the dynamic effect of common risk factors on the profitability of price momentum returns. Unlike the existing work which evaluate momentum profits under constant coefficient time-series framework, our approach helps us to incorporate serial correlations and heteroskedasticity in changes in expected momentum profit level. As a result, the expected momentum profit level differs in magnitude from its traditional counterpart. Our empirical implementation demonstrates new evidence on the predictability characteristics and profitability of price momentum portfolios using our theoretical framework.*

## INTRODUCTION

Many studies have presented strong empirical evidence that abnormal profits of momentum and contrarian strategies exists in the US and non-US equity markets. For example, DeBondt and Thaler (1985, 1987) investigate return patterns over extended period of time and find that contrarian strategies perform well over 3-5 year horizons. Jegadeesh and Titman (1993, 2001) document return continuations in intermediate horizons over 3-12 month holding periods where on average past winners continue to outperform past losers[1]. The prominence of the momentum profitability has also been substantiated by a number of subsequent works (see Asness et al. (2010) for an overview) and has generated a great deal of academic interest.

The objective of this paper is to provide a new methodology that can better characterize price momentum portfolio returns. We suggest a flexible method to study the dynamic effect of common risk factors on the profitability of price momentum strategies. Unlike the existing work which evaluate momentum profits under constant coefficient time-series framework, our framework helps us to incorporate serial correlations and heteroskedasticity in changes in expected momentum profit level. More specifically, we investigate the extent of shared variation in the returns of price momentum (and reversal) portfolios which is related to the joint presence of autocorrelaion and heteroskedasticity. We show that the net outcome is a change in expected momentum profit level that differs in magnitude from its traditional counterpart.

Even though there is ample evidence about the existence of market anomalies related to past returns and past earnings, it is not clear to what extent they share common variation. A lack of integration of various potential sources of stock return variability in a unified framework seems to be absent. This paper is an attempt bridge any such gap in the literature. In the empirical evaluation we utilize all of the NYSE-AMEX-NASDAQ firms on CRSP files with data on COMPUSTAT between the time periods of January 1990 to December 2009, and construct portfolios based on price momentum. Our empirical results demonstrate new evidence on the predictability characteristics of price momentum portfolios using our theoretical model.

The remainder of the paper is organized as follows. In section 2 we briefly discuss the research design and empirical methodology used in the paper. Section 3 discusses reconciliation with the existing works. The main empirical results are presented in section 4. Section 6 concludes.

## RESEARCH DESIGN AND EMPIRICAL METHODOLOGY: PROFITABILITY OF MOMENTUM OR CONTRARIAN STRATEGY

In order to explain time-series variability of the momentum (or contrarian) pattern in individual stock returns (or in portfolio returns), we consider a multifactor world with N stock returns or individual portfolio returns[2]. Given that there exists L factors, in order to explain the variability of individual stock returns we utilize the following multifactor linear process:

$$r_{it} = \mu_i + \sum_{k=1}^{L} b_{ik} f_{kt} + \varepsilon_{it}, \; i = 1, \dots .N, \tag{1}$$

$$E[\varepsilon_{it}] = 0, \forall i, \qquad E\left[\varepsilon_{it}, \varepsilon_{jt-1}\right] = 0, \forall i \neq j,$$

$$E[\varepsilon_{it}, f_{kt-1}] = 0, \forall \; i \neq k$$

where $r_{it}$ is the return on security $i$, $\mu_i$ is the unconditional expected return of security $i$ at time period $t$, $f_{kt}$ is the unexpected $k$th factor realization.

We assume that the unexpected kth factor realizations depends on $D_{k\,t-1}$ which is the endogenous information available at time period $t$ conditioned on the information set based up to time $t-1$. As a result our main approximation of the factors is based on the following specification

$$f_{kt} = \rho_{kt} D_{k\,t-1} + e_{kt}, \quad e_{kt} \sim (0, \phi_{kt}), \qquad k = 1, \dots .L, \tag{2}$$

where

$$\rho_{kt} = \bar{\rho} + \eta_{kt}, \phi_{kt} = \bar{\phi} + \vartheta_{kt}$$

$$\eta_{kt} \sim (0, \sigma_{11}), \vartheta_{kt} \sim (0, \sigma_{22}), \; Cov(\eta_{kt}, \vartheta_{kt}) = \sigma_{12}$$

In addition, we assume that, $E[D_{mt}, D_{nt-1}] = 0, \forall \; m \neq n, E[D_{mt}, f_{kt-1}] = 0, \forall \; m \neq k$ and $E[e_{it}, D_{mt-1}] = 0, \forall \; i \neq m$. Therefore, given that $E[(.)|\mathbb{I}_{t-1}]$ is the investor's subjective expectations conditioned on the information set available at time $t-1$, we can easily derive the following expression for first two conditional moments ($\forall k = 1, \dots .L$):

$$E[f_{kt}|\mathbb{I}_{t-1}] = \bar{\rho} D_{k\,t-1}$$

$$E[((f_{kt} - \quad \bar{\rho} D_{k\,t-1})|\mathbb{I}_{t-1})^2\,] = \bar{\phi} + \sigma_{11} D_{k\,t-1}^2$$

We use the momentum strategy that buys stocks based on their returns in period $t-1$ and holds the stock in period $t$. Therefore, following Lo and MacKinlay (1990) and Jegadeesh and Titman (1995), the portfolio weight assigned to stock $i$ at time $t$ is

$$w_{it} = \frac{1}{N}(r_{it-1} - \bar{r}_{t-1})$$

where $\bar{r}_t = \frac{1}{N}\sum_{i=1}^{N} r_{it}$.

As a result, the time $t$ and $t+1$ profit of the momentum strategy is given by

$$\Pi_t = \frac{1}{N}\sum_{t=1}^{N}(r_{it-1} - \bar{r}_{t-1})\, r_{it}$$

and

$$\Pi_{t+1} = \frac{1}{N}\sum_{t=1}^{N}(r_{it-1} - \bar{r}_{t-1})\, r_{it+1}$$

respectively. Hence, using (1) and (2) the expected momentum profits is given by

$$\mathrm{E}(\Pi_t) = \sigma_\mu^2 + \Omega + \sigma_b^2(\bar{\phi} + \sigma_{11} D_{k\,t-1}^2) \qquad (3)$$

where

$$\sigma_\mu^2 = \frac{1}{N}\sum_{i=1}^{N}(\mu_i - \bar{\mu})^2, \qquad \Omega = \frac{N-1}{N}\sum_{i=1}^{N} Cov[\varepsilon_{it}, \varepsilon_{it-1}],$$

$$\sigma_b^2 = \frac{1}{N}\sum_{i=1}^{N}\left(b_{ik} - \bar{b}_k\right)^2,$$

and $\bar{b}_k$ is the average of $b_{ik}'s$.

We immediately observe that the expected profit (3) from a momentum strategy is time varying because the conditional variance of common factors is not constant over time. Using our specification (2), we assume that the changes in the k-th factors are made up of two components. One is the functions of endogenous information which exhibit conditional heteroskedasticity, and the second component is a factor specific component which represents some shocks unique to individual factors. The economic interpretation suggests that our class of random coefficient autoregressive structure is a reasonable alternative to study the time-varying volatility of average momentum returns (Adrian and Rosenberg, 2008), and it is based on portfolios past performance. The framework also helps us to detect serial correlations in changes in expected momentum (or contrarian) profit level.

## RECONCILIATION WITH EARLIER WORKS

Even though our method is more practical and realistic to implement a momentum strategy in the stock market, it is important note the link between momentum profit and serial correlation that already exists in the existing method. One of the prime examples is Jegadeesh and Titman (1993, 1995) who instead assumes that stocks follow the following factor structure:

$$r_{it} = \mu_i + b_{0,i} f_t + b_{1,i} f_{t-1} + \varepsilon_{it} \qquad (4)$$

with $Cov\left[\varepsilon_{it}, \varepsilon_{jt-1}\right] = 0, \forall i \neq j$ . So according to their definition, the expected momentum profits is given by

$$\mathrm{E}(\Pi_t) = \sigma_\mu^2 + \Omega + \delta\sigma_f^2 \qquad (5)$$

where

$$\delta = \frac{1}{N}\sum_{i=1}^{N}\left(b_{0,i} - \bar{b}_0\right)\left(b_{1,i} - \bar{b}_1\right), \qquad \sigma_f^2 = Var(f_t),$$

$\sigma_\mu^2$ and $\Omega$ are as defined in (3), and $\bar{b}_0$ and $\bar{b}_1$ are the averages of $b_{0,i}$'s and $b_{1,i}$'s respectively.
In contrast, Lo and MacKinlay (1990) present a different version of expected momentum profit based on (4) and is given by the following expression

$$\mathrm{E}(\Pi_t) = \sigma_\mu^2 + \mathrm{O} - \mathrm{C} \qquad (6)$$

where

$$\mathrm{O} = \frac{N-1}{N^2}\sum_{i=1}^{N} E(r_{it}r_{it-1} - \mu_i^2), \qquad C = E(\bar{r}_t\bar{r}_{t-1}) - \bar{\mu}^2 - \frac{1}{N^2}\sum_{i=1}^{N} E(r_{it}r_{it-1} - \mu_i^2)$$

Recently, Chen and Hong (2002) argue that Lo and MacKinlay (1990) type decomposition in general is not informative enough about the economic sources of momentum. Instead, Chen and Hong (2002) suggest the following one-factor constant coefficient autoregressive structure:

$$r_{it} = \mu_i + b_i f_t + \varepsilon_{it}$$
$$f_t = \rho f_{t-1} + e_t, \quad \varepsilon_{it} \sim (0, \sigma_\varepsilon^2), \quad E[\varepsilon_{it}, \varepsilon_{it-1}] = k\sigma_\varepsilon^2 > 0$$

So the expected momentum profit according to Chen and Hong (2002) should take the following form

$$\mathrm{E}(\Pi_t) = \frac{N-1}{N}k\sigma_\varepsilon^2. \qquad (7)$$

It is obvious (from our specification (2)) that the existing approach by Chen and Hong (2002) and Jegadeesh and Titman (1993, 1995) is less flexible way to study the dynamic effect of common factors under a constant coefficient time-series framework. If we misspecify the factor generating process, maximum likelihood will give a biased estimator for the conditional mean part in equation (1).

In our approach the last term in the expected profit level (3) are large compared to the fixed autoregressive coefficient model and as a result will lead to more sharp fluctuations in the momentum or contrarian profit level. In addition, the conditional variance specification of the random coefficient autoregressive process will allow both the magnitude and sign of the past endogenous information to affect the conditional variance.

The literature on the time-series of market risk shows that aggregate volatility is subject to shocks at different frequencies (Engle and Ng 1993). Also, intertemporal asset pricing models predict that the set of state variables that determines systematic risk also determines expected returns of individual assets or portfolios of assets (Merton (1973)). As mentioned by Adrian and Rosenberg (1998, p.2997) "when market volatility is stochastic, intertemporal models predict that asset risk premia are not only determined by covariation of returns with the market return, but also by covariation with the state variables that govern market volatility." Given that financial data requires a modeling in which volatility is related to both the size and the direction of price movements (Nelson 1991, Engle and Ng 1993, Gulen et al. 2011 ), our approach seems to suggest a substantial gain in information about underlying dynamics of average stock returns based on past performance.

## EMPIRICAL RESULTS

This section details the evidence of the positive momentum profit, following the existing approach and our method. We investigate the existence of momentum profit at the individual stock level. In particular, we analyze the sources of momentum profit using the decomposition method in Jegadeesh and Titman (1993, 2001), Lo and MacKinlay (1990), Chen and Hong (2002) , and our approximation (given by (5), (6), (7), and (3) respectively) side by side.

Table 1 presents the average monthly returns for momentum portfolios formed on past J-month returns and held for K months. Our sample includes all stocks traded on the NYSE, AMEX, or NASDAQ universe between January 1990 and December 2009. It excludes stocks priced less than $5 at the beginning of the holding period and stocks in the smallest market cap decile (NYSE size decile cutoff). We basically follow different methodology as described in the main text. P1 is the equal-weighted portfolio of 10 percent of the stocks with the highest returns over the previous J-month returns, P2 is the equal-weighted portfolio of 10 percent of the stocks with the next highest returns, and so on. Returns are measured in percent and 5% statistical significance is indicated in (*).

**TABLE 1**
**VARIOUS TYPES OF MOMENTUM PROFITS BETWEEN JANUARY 1990 AND DECEMBER 2009**

| Type | Deciles | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | P1 (Winners) | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 (Losers) |
| Jegadeesh and Titman (1995) | | | | | | | | | | |
| (J=1/K=6) | 1.20* | 1.17* | 1.16* | 1.09* | 1.03* | 1.01* | 0.95* | 0.84 | 0.79 | 0.70 |
| (J=6/K=6) | 1.34* | 1.30 | 1.24* | 1.19* | 1.17* | 1.11* | 1.07* | 1.02* | 0.97 | 0.91 |
| Lo and MacKinlay (1990) | | | | | | | | | | |
| (J=1/K=6) | 0.91* | 0.87* | 0.85* | 0.80* | 0.74* | 0.68* | 0.65* | 0.62 | 0.59 | 0.58 |
| (J=6/K=6) | 1.14* | 1.08* | 1.06* | 1.05* | 1.00* | 0.98* | 0.95* | 0.93 | 0.90 | 0.81 |
| Chen and Hong (2002) | | | | | | | | | | |
| (J=1/K=6) | 1.28* | 1.24* | 1.23* | 1.19* | 1.16* | 1.13* | 1.10* | 1.07 | 1.00 | 0.96 |
| (J=6/K=6) | 1.41* | 1.35* | 1.34 | 1.31* | 1.26* | 1.22* | 1.17* | 1.15* | 1.03 | 1.01 |
| Our method | | | | | | | | | | |
| (J=1/K=6) | 1.11* | 1.05* | 1.03* | 1.02* | 0.97* | 0.95* | 0.91* | 0.88* | 0.86* | 0.82 |
| (J=6/K=6) | 1.23* | 1.19* | 1.16* | 1.11* | 1.05* | 0.98* | 0.97* | 0.93* | 0.90* | 0.87* |

Note: This table reports the average monthly returns for momentum portfolios formed on past *J*-month returns and held for *K* months, following different methodology as described in the main text. P1 is the equal-weighted portfolio of 10 percent of the stocks with the highest returns over the previous *J*-month returns, P2 is the equal-weighted portfolio of 10 percent of the stocks with the next highest returns, and so on. The sample includes all stocks traded on the NYSE, AMEX, or Nasdaq excluding stocks priced less than $5 at the beginning of the holding period and stocks in the smallest market cap decile (NYSE size decile cutoff). Returns are measured in percent. 5% statistical significance is indicated in (*).The sample period is January 1990 to December 2009.

The 1-month/6-month strategy yields 1.20% per month for the winner portfolio and 0.70% for the loser portfolio using Jegadeesh and Titman strategy. In contrast, the same 1-month/6-month strategy yields 0.91% and 1.28% for the winner portfolio using Lo and MacKinlay, and Chen and Hong strategies respectively. The 6-month/6-month strategy yields 1.41% per month for the winner portfolio using Chen and Hong strategy and it is highest among all the numbers reported in Table 1. Note that, Lo and MacKinlay decompose the profit into autocovariance, cross-serial covariance, and cross-sectional variance of unconditional expected returns. It produces identical return of 0.33% per month for the long-short momentum portfolio using either 1-month/6-month or 6-month/6-month strategy. The highest zero-investment portfolio return is 0.50% (0.43%) for 1-month/6-month (6-month/6-month) strategy for Jegadeesh and Titman.

In contrast to all of the above method, we show that the momentum profit is possible if autocorrelation is positive or shocks unique to individual factors are non-zeros. The empirical evidence in the last two rows is direct evidence of that argument. Our 1-month/6-month strategy produces long-short portfolio return of 0.29% and the same for 6-month/6-month strategy is 0.36% per month. Our method support that the momentum strategies are profitable and are consistent with the existing literature. Across individual portfolios, we see a wide dispersion of the momentum returns in sensitivity to the volatility components. Our returns of all the momentum portfolios are statistically significant except for the 1-month/6-month loser portfolio. Our 6-month/6-month strategy of winner portfolio shows that a quarter of the momentum profit is due to shocks unique to individual factors. Overall, we confirm that momentum profit is not dependent on calculation methods such as Jegadeesh and Titman (2001) or Lo and MacKinlay (1990). There is more information content in the momentum return generating process than the existing procedure recovers.

## CONCLUSIONS

The objective of this paper is to provide a new methodology that can deepen our understanding of the relationship between better risk and price momentum returns. We suggest that volatility risk premia compensate investors for the risk that momentum (or contrarian) volatility might go up in the near future. The framework of this paper helps us to incorporate both serial correlations and heteroskedasticity in changes in expected momentum profit level. Contrary to the existing literature, our empirical finding show that the volatility component have highly positive price of momentum risk across decile sets of portfolios.

## ENDNOTES

1. In other related studies, Ahmet and Nusret (1999) find abnormal profits of long-term contrarian strategies in the stock markets of seven non-US industrialized countries. Chang et al. (1995) find abnormal profits of long-term contrarian strategies in the Japan market. Rouwenhorst (1998) examines the momentum return patterns of twelve European markets over the period of 1978 through 1995 and finds the existence of momentum profits. Hameed and Kusnadi (2002) find that a momentum strategy generates small but statistically significant profits in six Asian stock markets. Shen et al. (2005) investigates linkages between value versus growth investment styles and momentum strategies in international markets and find the evidence of profitability of momentum strategies.
2. A similar methodology and approach can be found in many works on price momentum; a prime example is Chordia and Shivakumar (2002).

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